ISSN 2029-1280
eISSN 2669-0071

PANEVĖŽIO KOLEGIJA

# TAIKOMIEJI TYRIMAI
## STUDIJOSE IR PRAKTIKOJE

# APPLIED RESEARCH IN STUDIES AND PRACTICE

**No. 20**

Panevėžys, 2024

**T A I K O M I E J I  T Y R I M A I  S T U D I J O S E  I R  P R A K T I K O J E**
APPLIED RESEARCH IN STUDIES AND PRACTICE

Published since 2008



Editorial office:

**Panevėžio kolegija/State Higher Education Institution**
Laisvės sq. 23, LT35200, Panevėžys, Lithuania

E-mail: mtt@panko.lt

ISSN 2029-1280
eISSN 2669-0071

# CONTENTS



PANEVĖŽIO KOLEGIJA ISSN 2029-1280, eISSN 2669-0071. Taikomieji tyrimai studijose ir praktikoje – Applied Research in Studies and Practice, 2024, 20.

# PUBLIC EXPENDITURE ON EDUCATION IN EU COUNTRIES VS. ECONOMIC GROWTH

***Robert MUSIAŁKIEWICZ***

*University of Applied Science in Wloclawek, Poland*

**Abstract.** Education is one of the most important tasks of the state. According to the Treaty on the Functioning of the European Union (EU), education remains the exclusive competence of member states. There is organizational diversity in the education process in the various EU countries, as well as a different scale of its public financing. The purpose of this article is to confirm the thesis that the degree of public spending on education translates into state economic growth. The article presents the results of a study of the extent of public spending of the European Union member states on education covering primary, secondary and higher education in 1996-2022. The results obtained were compared with economic indicators of individual EU countries. An attempt was also made to distinguish groups of countries based on the criterion of the level of spending on education in relation to their total public spending and based on the criterion of the amount of GDP growth in 1996-2022.

**Keywords**: public expenditure, education spending, gross domestic product, education system

## INTRODUCTION

Education is one of the key areas of state activity, aimed at providing citizens with access to learning and comprehensive development. It is an obligation that stems from the state's responsibility for the well-being of society, since education affects citizens' quality of life, competence, civic awareness and ability to take up work (Hanushek, Woessmann, 2020). Education, as a task of the state, includes various types and forms of education to promote the development of citizens, build social competence and prepare them for professional and social life. The educational system is diversified to respond to the needs of people at different stages of life and development (Field, 1997).

In the European Union, education remains the exclusive competence of member states (according to Articles 165 and 166 of the Treaty on the Functioning of the European Union). The Treaty on the Functioning of the EU grants the EU only soft powers in this area, mainly focusing on coordinating, complementing and assisting the activities of member states (Cankaya, Kutlu, Cebeci, 2015). In accordance with the principle of subsidiarity, higher education policies in Europe are determined at the level of individual member states (Dakowska, 2019). The European Union primarily plays a supporting and coordinating role. The formal education system of European countries includes: pre-school education, primary education, secondary education and higher education. European Union member states are free to shape their education policies, including financially.

Studies conducted by Hanushek & Woessmann have shown that the degree of educational development has a direct bearing on a country's economic development indicators. In particular, Hanushek & Woessmann point out the need to ensure not only access to universal education, but also to nurture the quality of education (Hanushek, Woessmann 2015). The literature highlights the links between public spending on education and the rate of economic growth. Kao's (1999) and Pedroni's Residual-Based Panel Cointegration Test (1999) suggest a long-run relationship between these factors. Sabah and Wasif show that investments in education are key to economic progress. Not only do they build human capital, but they also help implement new technologies, lowering the cost of adoption. Zoran, based on his analysis for the European Union, the US, Japan and the BRICS countries, concluded that there is a positive correlation between the amount of public spending on education and economic growth in these countries (Zoran, 2015).

The purpose of this article is to confirm the thesis that the degree of public spending on education translates into national economic growth. The article analyzes the extent to which European Union member states finance education covering primary, secondary and tertiary education between 1996 and 2022, and then compares the results obtained with the economic indicators of each country during this period. An attempt was also made to identify groups of countries with similar levels of spending on education in relation to their total public spending for this purpose.

## RESEARCH MATERIAL AND METHODS

The article relies on a statistical survey based on data collected by Eurostat. Data on public spending by the general government (all levels of government) on “education” (according to the Classification of Government Functions - COFOG) within the European System of National Accounts (ESA 2010) was analyzed. The COFOG Classification of Government Functions, was developed in its current version in 1999 by the Organization for Economic Cooperation and Development and published by the United Nations Statistical Division as a standard for classifying the purposes of government activities. It first presents education spending rates by stage for all EU countries for 2022. Then, for each country separately, the average of public spending on education from 1996-2022 to the average GDP for that period was calculated. The average of public spending on education from 1996-2022 for each EU member state to the average of

their total public spending from that period was also calculated. The results were compared with the GDP growth rates of each country for the period 1996-2022.

## THE RESULTS

In 2022, government spending on education in the EU amounted to €746 billion, or 4.7% of GDP. Of this, 'pre-primary and primary education' accounted for 1.6% of GDP (€254 billion) and secondary education accounted for 1.7% of GDP (€274 billion). For tertiary education, 0.8% of GDP (€124 billion) was reported in the EU, while 'subsidiary services to education' (e.g. school transport) amounted to 0.3% of GDP (€51 billion). Detailed public spending of the European Union countries on education as % of GDP is presented in Table 1 (Eurostat, 2024).

Table 1

**General government total expenditure on education, 2022, % of GDP**

| | Education | Pre-primary and primary education | Secondary education | Post-secondary non-tertiary | Tertiary education | Education not definable by level | Subsidiary services to education | R&D Education | Education n.e.c. |
|---|---|---|---|---|---|---|---|---|---|
| EU | 4,7 | 1,6 | 1,7 | 0,0 | 0,8 | 0,1 | 0,3 | 0,0 | 0,1 |
| Belgium | 6,3 | 2,0 | 2,4 | 0,0 | 0,9 | 0,6 | 0,2 | 0,0 | 0,1 |
| Bulgaria | 3,9 | 0,8 | 2,0 | : | 0,8 | 0,0 | 0,1 | 0,0 | 0,2 |
| Czechia | 4,9 | 1,2 | 2,3 | 0,0 | 0,7 | 0,1 | 0,2 | 0,3 | 0,1 |
| Denmark | 5,3 | 2,5 | 1,2 | 0,0 | 1,3 | 0,1 | 0,1 | 0,0 | 0,1 |
| Germany | 4,5 | 1,4 | 1,6 | 0,1 | 0,8 | 0,1 | 0,4 | 0,0 | 0,1 |
| Estonia | 5,8 | 2,4 | 1,6 | 0,1 | 1,0 | 0,3 | 0,3 | 0,1 | 0,2 |
| Ireland | 2,7 | 1,0 | 1,0 | 0,0 | 0,5 | 0,0 | 0,1 | 0,0 | 0,0 |
| Greece | 3,8 | 1,2 | 1,2 | 0,0 | 0,9 | 0,0 | 0,1 | 0,4 | 0,1 |
| Spain | 4,4 | 1,7 | 1,7 | 0,0 | 0,6 | 0,1 | 0,1 | 0,1 | 0,1 |
| France | 5,2 | 1,4 | 2,2 | 0,0 | 0,7 | 0,2 | 0,7 | 0,0 | 0,0 |
| Croatia | 4,8 | 2,5 | 0,9 | 0,0 | 0,9 | 0,0 | 0,2 | 0,1 | 0,1 |
| Italy | 4,1 | 1,5 | 1,8 | 0,0 | 0,3 | 0,0 | 0,2 | 0,0 | 0,1 |
| Cyprus | 5,1 | 1,7 | 1,7 | 0,0 | 0,9 | 0,3 | 0,4 | 0,0 | 0,1 |
| Latvia | 5,3 | 2,0 | 1,2 | 0,0 | 0,9 | 0,5 | 0,2 | 0,1 | 0,4 |
| Lithuania | 4,9 | 1,1 | 1,8 | 0,2 | 0,8 | 0,4 | 0,0 | 0,2 | 0,4 |
| Luxembourg | 4,7 | 1,7 | 1,7 | 0,0 | 0,4 | 0,4 | 0,4 | 0,0 | 0,0 |
| Hungary | 5,1 | 1,0 | 1,4 | 0,0 | 1,9 | 0,1 | 0,4 | 0,0 | 0,1 |
| Malta | 5,0 | 1,2 | 1,6 | 0,0 | 0,8 | 0,1 | 0,3 | 0,4 | 0,6 |
| Netherlands | 5,1 | 1,5 | 2,0 | 0,0 | 1,2 | 0,0 | 0,2 | 0,0 | 0,0 |
| Austria | 4,8 | 1,5 | 1,9 | 0,0 | 0,8 | 0,2 | 0,2 | 0,0 | 0,1 |
| Poland | 4,6 | 2,1 | 0,9 | 0,0 | 1,1 | 0,1 | 0,3 | 0,1 | 0,1 |
| Portugal | 4,3 | 1,6 | 1,7 | 0,0 | 0,7 | 0,1 | 0,1 | 0,0 | 0,1 |
| Romania | 3,2 | 0,8 | 1,3 | 0,0 | 0,7 | 0,1 | 0,1 | 0,0 | 0,2 |
| Slovenia | 5,6 | 2,1 | 2,0 | 0,0 | 1,0 | 0,1 | 0,3 | 0,0 | 0,1 |
| Slovakia | 4,5 | 1,3 | 1,5 | 0,0 | 0,6 | 0,3 | 0,6 | 0,0 | 0,2 |
| Finland | 5,6 | 1,2 | 2,4 | 0,0 | 1,6 | 0,2 | 0,0 | 0,0 | 0,1 |
| Sweden | 6,3 | 3,9 | 1,0 | 0,0 | 1,1 | 0,3 | 0,0 | 0,0 | 0,1 |

There are differences in the scale of government expenditures as a proportion of GDP across European Union member states (Musialkiewicz, 2024). As a ratio to GDP in 2022, the highest levels of government expenditure were found in France (58.3% of GDP), followed by Italy (56.1% of GDP), Finland (53.5% of GDP), Austria and Belgium (both 53.2% of GDP) and Greece (52.9% of GDP), while the lowest levels were found in Ireland (21.2% of GDP), Lithuania (36.4% of GDP), Cyprus (38.8% of GDP) and Malta (39.3% of GDP). Therefore, in determining the priorities of state tasks in the classification of public spending, and in our case the role of education in state tasks, it is necessary to examine the ratio of education spending to total public spending (Eurostat, 2024b).

Analyzing the average of public spending of EU countries from 1996-2022, it is necessary at the outset to present the level of public spending of each country in relation to GDP, as shown in Figure 1.

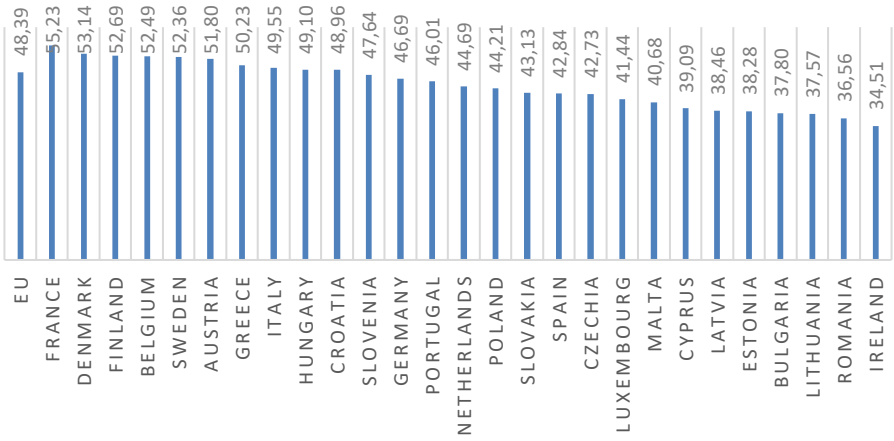



Figure 1. **General government total expenditure, 1996-2022, % of GDP**

The above figures illustrate that the level of public spending between 1996 and 2022 was higher in Western and Northern European countries such as France (55.23%), Denmark (53.14%) and Finland (52.69%), while it was lowest in Ireland (34.51%) and Central and Eastern European countries such as Romania (36.56%), Lithuania (37.57%) and Bulgaria (37.8%).

Public spending on education from 1996 to 2022 as a percentage of GDP averaged 4.86% for the EU as a whole. They were highest in Sweden (7.33%), Denmark (6.49%), Estonia (6.22%), Finland (6.07%) and Slovenia (6.05%), and lowest in Romania (3.47%), Bulgaria (3.75%) and Slovakia (3.95%). The above figures are shown in Figure 2.

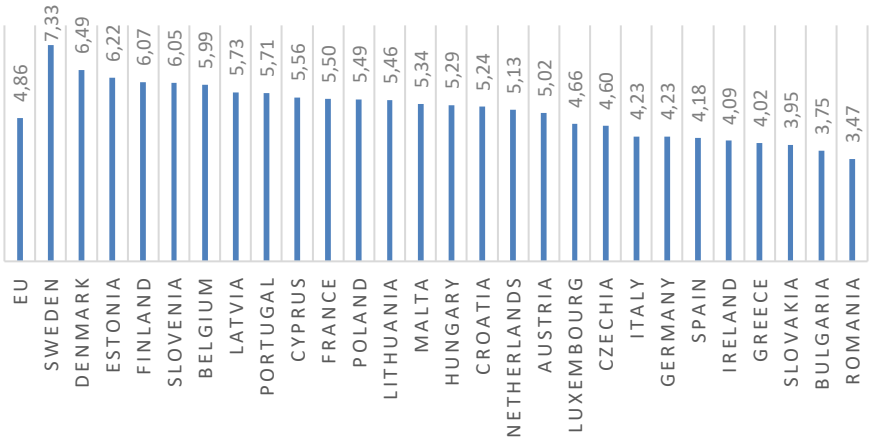



Figure 2. **General government total expenditure on education, 1996-2022, % of GDP**

Due to the large differences in the level of public spending within EU countries in relation to GDP, a more meaningful indicator representing the importance of education in state policy is the ratio of public spending on education to all public spending. Figure No. 3 shows the total public spending on education between 1996 and 2022 to all public spending by country.

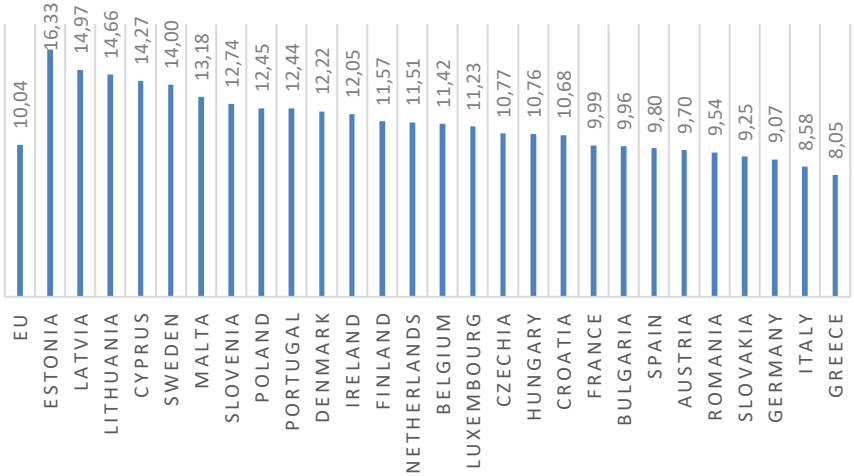



Figure 3. **Education expenditure, 1996-2022, % of total public expenditure**

Spending on education averaged 10.04% of all public spending in the EU between 1996 and 2022. They were highest in the Baltic countries, Estonia (16.33%), Latvia (14.97%) and Lithuania (14.66%). The lowest were in Greece (8.05%), Italy (8.58%) and Germany (9.07%).

Based on the above data, five groups of countries with similar public education financing policies can be distinguished, as shown in Table 2. The groups were formed based on the division into five parts of the subtraction result between the second highest and penultimate indicator (extreme values were eliminated).

Table 2

**Groups of EU countries with similar education expenditure**

| **Very high spending on education (VH)** (above 13.7% of total public spending) | **High spending on education (H)** (between 13.7% and 12.4% of total public spending) | **Medium spending on education (M)** (between 12.4% and 11.1% of total public spending) | **Low spending on education (L)** (between 11.1% and 9.8% of total public spending) | **Very low spending on education (VL)** (less than 9.8% of total public spending) |
|---|---|---|---|---|
| Estonia, Latvia, Lithuania, Cyprus, Sweden, | Malta, Slovenia, Poland, Portugal, | Denmark, Ireland, Finland, Netherlands, Belgium, Luxembourg, | Czechia, Hungary, Croatia, France, Bulgaria, | Spain, Austria, Romania, Slovakia, Germany, Italy, Greece |

When analyzing the economic development of countries, we most often use a measure in the form of gross domestic product (GDP). GDP is the total monetary value of goods and services produced in a given period. It is calculated as the sum of the monetary value of consumption, investment, government spending and net exports. The next table shows the total gross domestic product (in million Euros) of the current EU member countries in 1996 and in 2022 and the difference between 1996 and 2022 expressed as a percentage.

Table 3

**GDP of EU countries in 1996 and in 2022 (million Euros)**

| | 1996 | 2022 | % |
|---|---|---|---|
| EU | 8 540 233,3 | 13 146 883,2 | 54,00 |
| Belgium | 269 779,9 | 434 113,3 | 61,00 |
| Bulgaria | 28 645,7 | 49 991,8 | 74,52 |
| Czechia | 112 583,1 | 201 146,3 | 78,66 |
| Denmark | 199 924,2 | 304 744,0 | 52,43 |
| Germany | 2 192 680,2 | 3 074 843,4 | 40,23 |
| Estonia | 8 166,2 | 21 477,7 | 163,01 |
| Ireland | 86 744,1 | 401 929,7 | 363,35 |
| Greece | 158 431,9 | 200 557,0 | 26,59 |
| Spain | 739 640,6 | 1 207 453,5 | 63,25 |
| France | 1 530 362,5 | 2 283 328,3 | 49,20 |
| Croatia | 32 040,6 | 57 325,7 | 78,92 |
| Italy | 1 435 173,2 | 1 691 724,6 | 17,88 |
| Cyprus | 11 528,9 | 26 278,0 | 127,93 |
| Latvia | 9 454,6 | 24 599,3 | 160,18 |
| Lithuania | 15 401,3 | 43 880,9 | 184,92 |
| Luxembourg | 24 361,9 | 56 252,8 | 130,90 |
| Hungary | 70 267,1 | 139 703,4 | 98,82 |
| Netherlands | 469 897,5 | 794 222,8 | 69,02 |
| Austria | 223 042,5 | 349 044,8 | 56,49 |
| Poland | 203 841,0 | 559 221,6 | 174,34 |
| Portugal | 141 699,5 | 198 622,6 | 40,17 |
| Romania | 89 149,9 | 190 896,2 | 114,13 |
| Slovenia | 23 407,1 | 45 954,4 | 96,33 |
| Slovakia | 38 541,0 | 89 940,3 | 133,36 |
| Finland | 127 466,6 | 207 437,0 | 62,74 |
| Sweden | 259 296,7 | 474 061,3 | 82,83 |

The data in Table 3 shows that the economies of the various countries grew at very different rates between 1996 and 2022. Ireland experienced the highest GDP growth, but this is mainly due to the fact that large multinationals based in Ireland are responsible for this growth, taking advantage of the tax preferences Ireland offered them (Morgenroth, 2010). In the countries of continental Europe, the largest increases were in the countries of Central and Eastern Europe, in Lithuania 185%, Poland 174%, Estonia 163%, Latvia 160% and Slovakia 133%. The lowest increases were in southern

European countries, Italy (18%), Greece (27%) and Portugal (40%). The differences between GDP in 1996 and 2022 are shown in Figure No. 4.

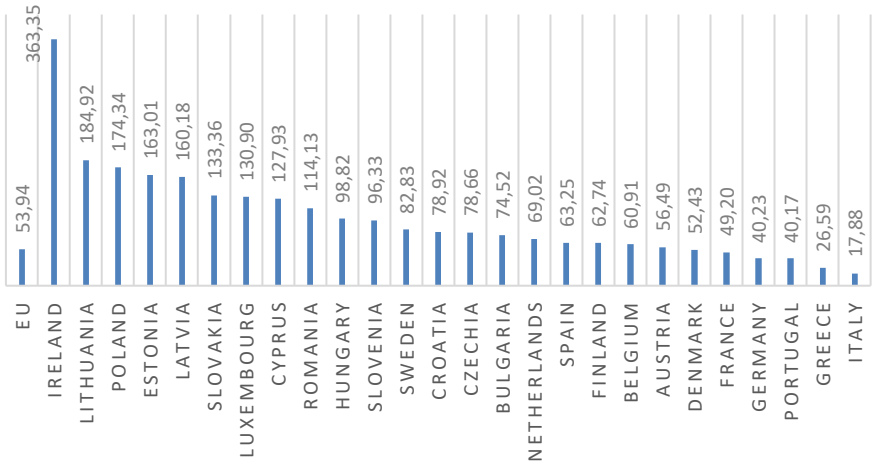



Figure 4. **GDP growth of EU countries between 1996 and 2022 in %**

The following table identifies five groups of countries with similar GDP growth rates from 1996 to 2022. The groups were formed based on the division into five parts of the subtraction result between the second highest and penultimate indicator (extreme values were eliminated).

Table 4

**Groups of countries with similar GDP growth from 1996 to 2022**

| **Very high GDP growth (VH)** (above 153%) | **High GDP growth (H)** (between 153% and 122%) | **Medium GDP growth (M)** (between 122% and 90%) | **Low GDP growth (L)** (between 90% and 59%) | **Very low GDP growth (VL)** (below 59%) |
|---|---|---|---|---|
| Ireland, Lithuania, Poland, Estonia, Latvia | Slovakia, Luxembourg, Cyprus | Romania, Hungary, Slovenia | Sweden, Croatia, Czechia, Bulgaria, Netherlands, Spain, Finland, Belgium, | Austria, Denmark, France, Germany, Portugal, Greece, Italy |

Table No. 5 shows the types of groups (VH, H, M, L VL) into which each country has been classified based on the ratio of the value of education spending to the value of public spending and the rate of GPD growth from 1996 to 2022.

Table 5

**Comparison of the classification of countries in terms of public spending on education and GDP growth**

| | Expenditure on education | GPD goowth |
|---|---|---|
| Belgium | M | L |
| Bulgaria | L | L |
| Czechia | L | L |
| Denmark | M | VL |
| Germany | VL | VL |
| Estonia | VH | VH |
| Ireland | M | VH |
| Greece | VL | VL |
| Spain | VL | L |
| France | L | VL |
| Croatia | L | L |
| Italy | VL | VL |
| Cyprus | VH | H |
| Latvia | VH | VH |
| Lithuania | VH | VH |
| Luxembourg | M | H |
| Hungary | L | M |
| Netherlands | M | L |
| Austria | VL | VL |
| Poland | H | VH |
| Portugal | H | VL |

| | | |
|---|---|---|
| Romania | VL | M |
| Slovenia | H | M |
| Slovakia | VL | H |
| Finland | M | L |
| Sweden | VH | L |

There are 10 countries belonging to the same groups distinguished by the level of public spending on education and GDP growth (Bulgaria, Czechia, Germany, Estonia, Greece, Croatia, Italy, Latvia, Lithuania, Austria). Another 10 countries are characterized by similar levels of education spending and GDP growth (Belgium, Spain, France, Cyprus, Luxemburg, Hungary, Netherlands, Poland, Slovenia, Finland). For 3 countries, the relationship of these indicators varies (Denmark, Ireland, Romania) or is very different (Portugal, Sweden, Slovakia).

## CONCLUSIONS

An analysis of public spending on education in EU countries has shown that the level of spending by individual countries for this purpose varies widely. The highest spending on education between 1996 and 2022 was in the Baltic countries, Estonia (16.33% of all public spending), Latvia (14.97%) and Lithuania (14.66%). The lowest were in Greece (8.05%), Italy (8.58%) and Germany (9.07%).

A comparison of the public spending on education of EU countries in 1996-2002 to the growth in the level of GDP, shows that the countries with the highest GDP growth were mostly (with the exception of Slovakia) characterized by high public spending on education. In contrast, the countries with the lowest GDP growth between 1996 and 2022 were among those with the lowest public spending on education (with the exception of Portugal). It can be concluded that there is a correlation between public spending on education and gross domestic product growth, but high spending on education does not necessarily lead to GDP growth.

## REFERENCES

Cankaya S., Kutlu Ö, Cebeci E., (2015), The Educational Policy of European Union, Procedia - Social and Behavioral Sciences, vol. 174, https://doi.org/10.1016/j.sbspro.2015.01.706.

Dakowska D., (2019). Higher Education Policy in the European Union, Oxford Research Encyclopedia of Politics, doi: 10.1093/acrefore/9780190228637.013.1480.

Field J., (1997), European Dimensions: Education, Training and the European Union, Jessica Kingsley Publ Inc.

Hanushek, E. A., Woessmann, L. (2015), The knowledge capital of nations: Education and the economics of growth, Cambridge, MA: MIT Press.

Hanushek E.A, Woessmann L., (2020), Chapter 14 - Education, knowledge capital, and economic growth, The Economics of Education (Second Edition), Academic Press, doi: 10.1016/B978-0-12-815391-8.00014.

Idrees, A. S; Siddiqi, M W., (2013), Does public education expenditure cause economic growth? Comparison of developed and developing countries, Journal of Commerce and Social Sciences (PJCSS), Johar Education Society, Lahore, vol. 7, iss.1.

Kao, C., (1999), Spurious Regression and Residual Based Tests for Cointegration in Panel Data, Journal of Econometrics, 90.

Pedroni, P., (1999), Critical Values for Cointegration tests in Heterogeneous Panels with Multiple Regressors, Oxford Bulletin of Economics and Statistics, 61.

Morgenroth, E., (2008), Regional Dimension of Taxes and Public Expenditure in Ireland, Regional Studies, 44(6), doi: 10.1080/00343400802093839.

Musiałkiewicz R., (2024), Systemy podatkowe w krajach Europy Środkowo-Wschodniej, Diffin, Warszawa.

Zoran T., (2015), Analysis of the Impact of Public Education Expenditure on Economic Growth of European Union and BRICS, Economic Analysis, vol 48, no 1-2.

Eurostat, 2024a, General government total expenditure in EU, https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Government_expenditure_by_function_%E2%80%93_COFOG#General_overview

Eurostat, 2024b, Government expenditure by function,https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Government_expenditure_on_education

Eurostat, 2024c, GDP and main components; https://ec.europa.eu/eurostat/databrowser/product/page/nama_10_gdp__custom_13687321

PANEVĖŽIO KOLEGIJA ISSN 2029-1280, eISSN 2669-0071. Taikomieji tyrimai studijose ir praktikoje – Applied Research in Studies and Practice, 2024, 20.

# DESIGN AND ANALYSIS OF BREAD COOLING CONVEYOR HANGER USING SOLIDWORKS SIMULATION

*Aurimas ČESNULEVIČIUS*[a,b], *Dainius VAIČIULIS*[a,b]

[a]*Panevėžio kolegija / State Higher Education Institution, Lithuania*
[b]*Kaunas university of technology Panevėžys Faculty of Technologies and Business*

**Abstract**. The cooling conveyor is designed to cool the bread before it is packaged. This article analyses two alternative conveyor hanger designs using Solidworks Simulation. The purpose of the study is to evaluate the strength characteristics in terms of stresses and deformations of both alternative designs, taking into account the forces acting on the hanger, its own weight and the effect of temperature.

**Keywords**: FEM, cooling conveyor

## INTRODUCTION

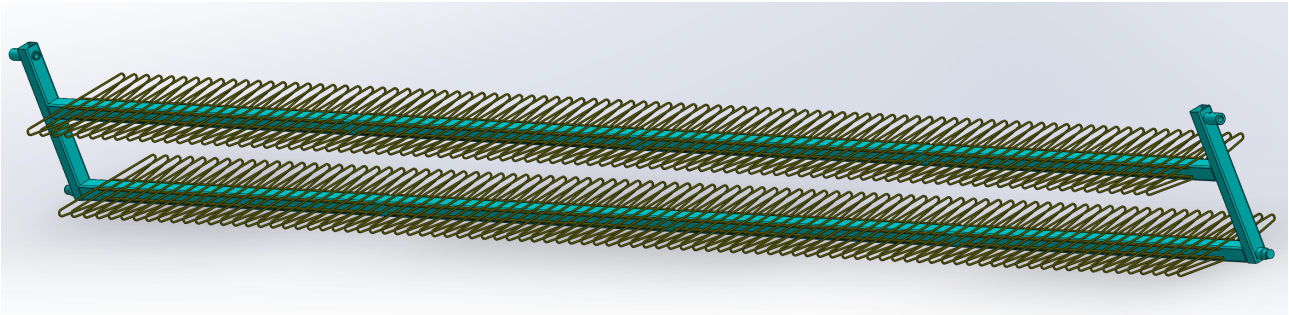
Currently, a 3D model of the product is typically created using CAD and validated using CAE techniques before a new product or its components can be manufactured [1, 2, 3, 4]. Based on these principles, a study was carried out for UAB "Techninis projektas" in order to select the most rational design for the cooling conveyor hanger. A bread cooling conveyor is a chain conveyor with hangers attached to the chain on which the bread is placed when it comes out of the oven (Fig. 1). During transport, the bread is cooled before the packaging operation.

Figure 1. **Cooling conveyor hanger with bread**

Two alternative hanger designs were analysed. The frame used for both hangers was identical, with only the design of the shelves being changed. With more than 200 hangers typically installed on a cooling conveyor, the hanger is one of the most important components of a cooling conveyor. The aim of the study was to assess the strength characteristics of the two hanger variants: stresses and deformations.

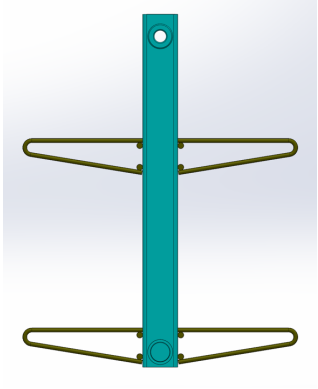
## DESIGN OF THE HANGER

In the initial phase, the design of the cooling conveyor hanger was chosen, as shown in Figure 2. The frame of the hanger is made of a square tube 35x35x2 mm. The hanger shelves are fabricated individually as separate segments and then welded to the frame. In this way, the whole hanger structure is fully welded.



(a)



(b)

Figure 2. **Hanger No 1**

The shelf of hanger No 1 is composed of several segments. The shelf segment (Fig. 3) consists of round bars of 6 mm and 4 mm. The 6 mm bars are used as the load-bearing structure and the 4 mm bars are bent and welded to the load-bearing 6 mm diameter bars. The required number of segments is then welded to the hanger frame.

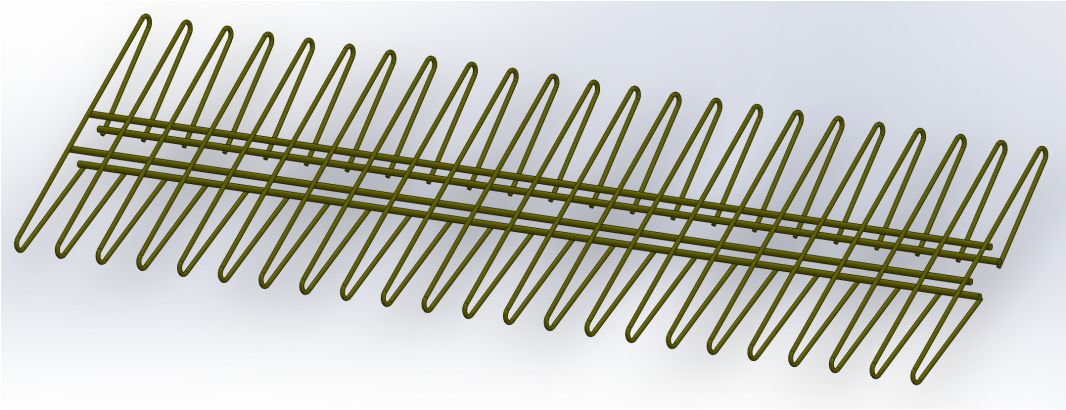
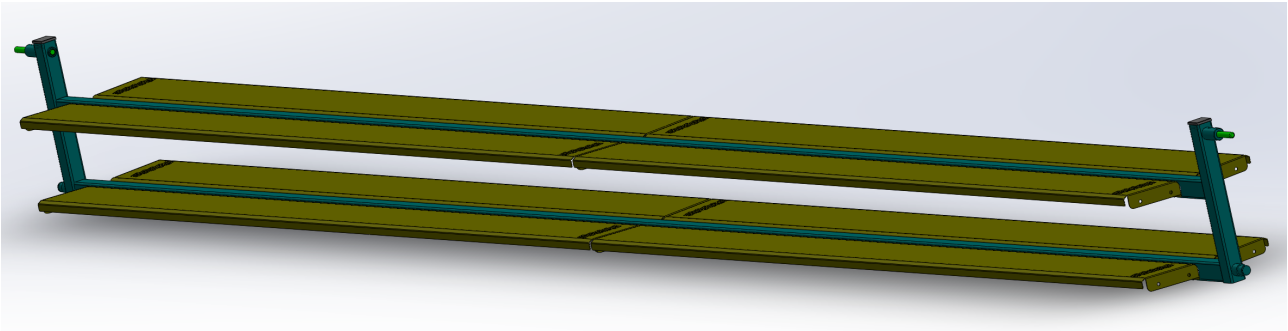


Figure 3. **Hanger No 1 shelf segment**

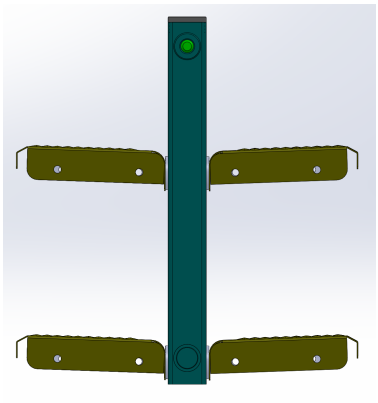
The main advantage of this design is the small contact area with the baked goods. In addition, the design does not restrict air circulation during the cooling of the baked products. The main disadvantage of this design is the high welding time and, consequently, the cost.

An alternative design has been proposed to reduce the amount of welding work. The frame of hanger No 2 was chosen to be identical. The main difference from the original design is that in this case the shelves are bolted to the frame rather than welded (Fig. 4).



(a)



(b)

Figure 4. **Hanger No 2**

The shelves were made of 1 mm thick sheet steel. Compared to the original hanger option, the disadvantage in this case is the increased contact area between the hanger shelves and the bakery products. To reduce the contact area, riffled sheet steel was chosen (Fig. 5).

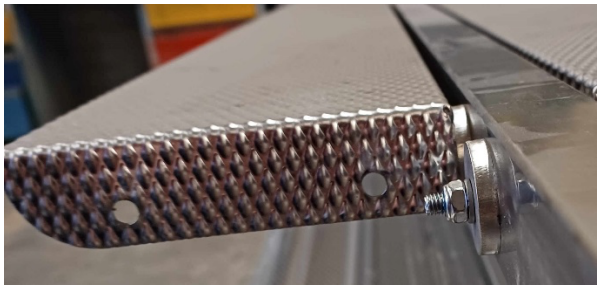


Figure 5. **Shelf of hanger No 2**

## FEM ANALYSIS OF THE HANGER

The analysis of both structures was carried out using SolidWorks Simulation software.

The material for both hangers was stainless steel AISI 304. The calculations take into account the weight of the hanger and the mass of the bakery products. One loaf of bread has a mass of 1 kg and dimensions 295x120x115 mm. During the tests, one shelf of the rack was loaded with 29 kg, corresponding to 29 loaves. As the hanger has two shelves, the total load was 58 kg or 570 N. The loaves are pushed onto the hangers during the operation of the conveyor and therefore the dynamic components of the loads were not considered in the calculation.

In addition, the effect of temperature on the strength characteristics of the hangers was analysed, as the temperature of the bread at the starting point is 90 °C. The ambient temperature is assumed to be 20 °C, so a 70 °C temperature load was added to the surfaces of the hangers that are in contact with the bakery products for the calculations. It must also be stressed that under realistic conditions not only the contact surfaces but also the deeper layers will be affected by temperature. For this purpose, heat exchange and convection phenomena should be considered. Solidworks Simulation does not have these capabilities, so the temperature load was only added to the contact surfaces. Therefore, the results of the calculations are less accurate when temperature is taken into account than when it is not.

Before the calculations were carried out, the models for both hangers were simplified. As the hanger models have two planes of symmetry, one quarter of the models were analysed.

Initially, the calculations were made without taking temperature into account. The resulting stress intensities (von Mises) are given in Figures 6 and 7. The results show that the maximum calculated stresses exceed the yield strength at the tube joints of the frame. The size of the area where the stresses exceed the yield stress is close to the wall thickness of the frame tubes (2 mm). These areas are located in the stress concentration zone. In a real structure there will be no such stress concentrators as the tubes will be welded and the welds will significantly reduce the stresses in these areas. In the rest of the structure, the stresses are around 80 MPa. The strength of the structure can be considered adequate. This assumption has been confirmed by the fabrication of the hangers and their operation under realistic conditions.

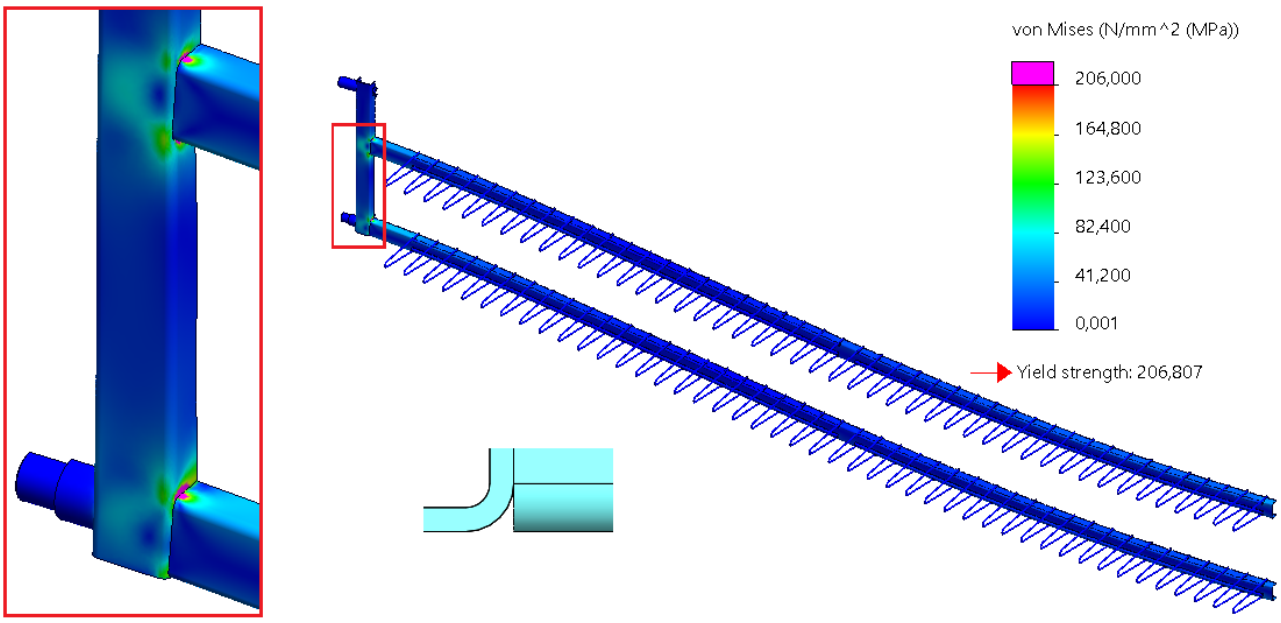



Figure 6. **Stress distribution of hanger No 1**

In the second design, the maximum stresses in the stress concentration region were 51 per cent lower (Fig. 7) than in the first design (Fig. 6).

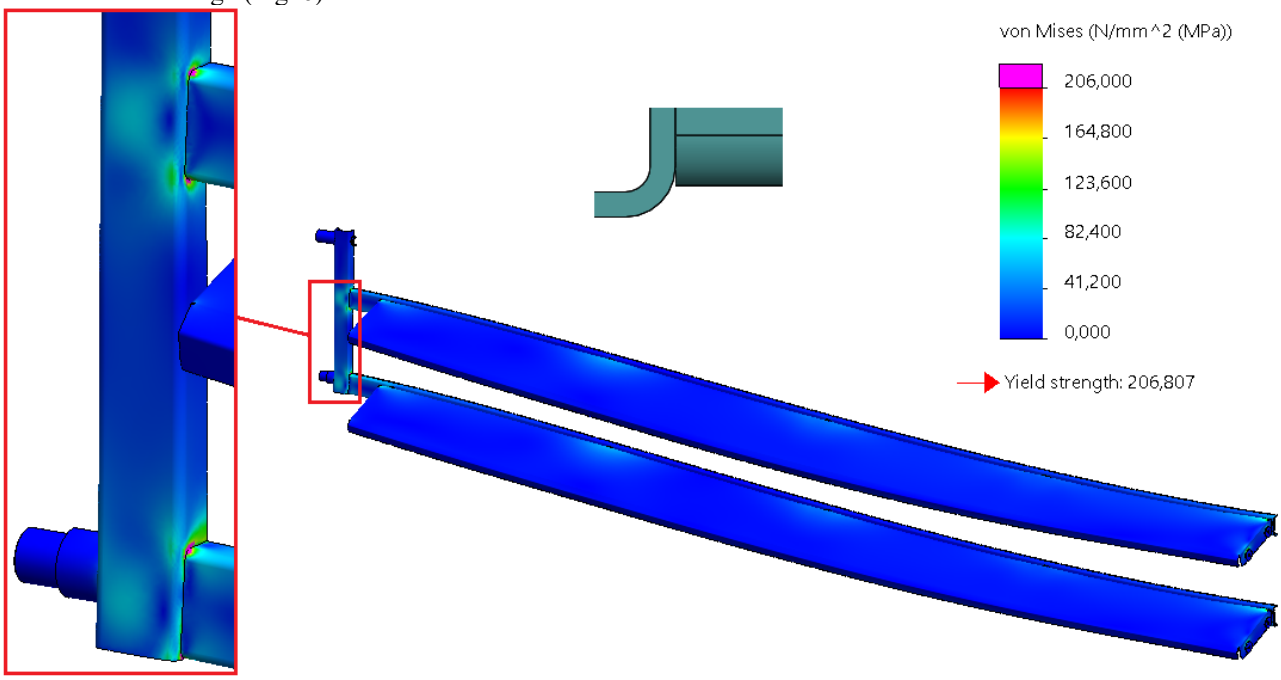



Figure 7. **Stress distribution of hanger No 2**

The calculated total deflections are shown in Figures 8 and 9. The deflections are shown here at a scale of 20:1. The maximum deflections of the analysed structures differ only slightly (12.171 mm (Fig. 8) and 12.599 mm (Fig. 9) respectively). Although visually the second structure appears to be more rigid, the deflections (Fig. 9) are larger. This is due to the fact that the mass of the second structure (44 kg) is higher than that of the first structure (19 kg). The first structure has maximum deflections (Fig. 8) evenly distributed in the central section of the frame, while the second structure has maximum deflections (Fig. 9) in the central section, but not in the frame itself, but at the shelf points furthest from the frame.

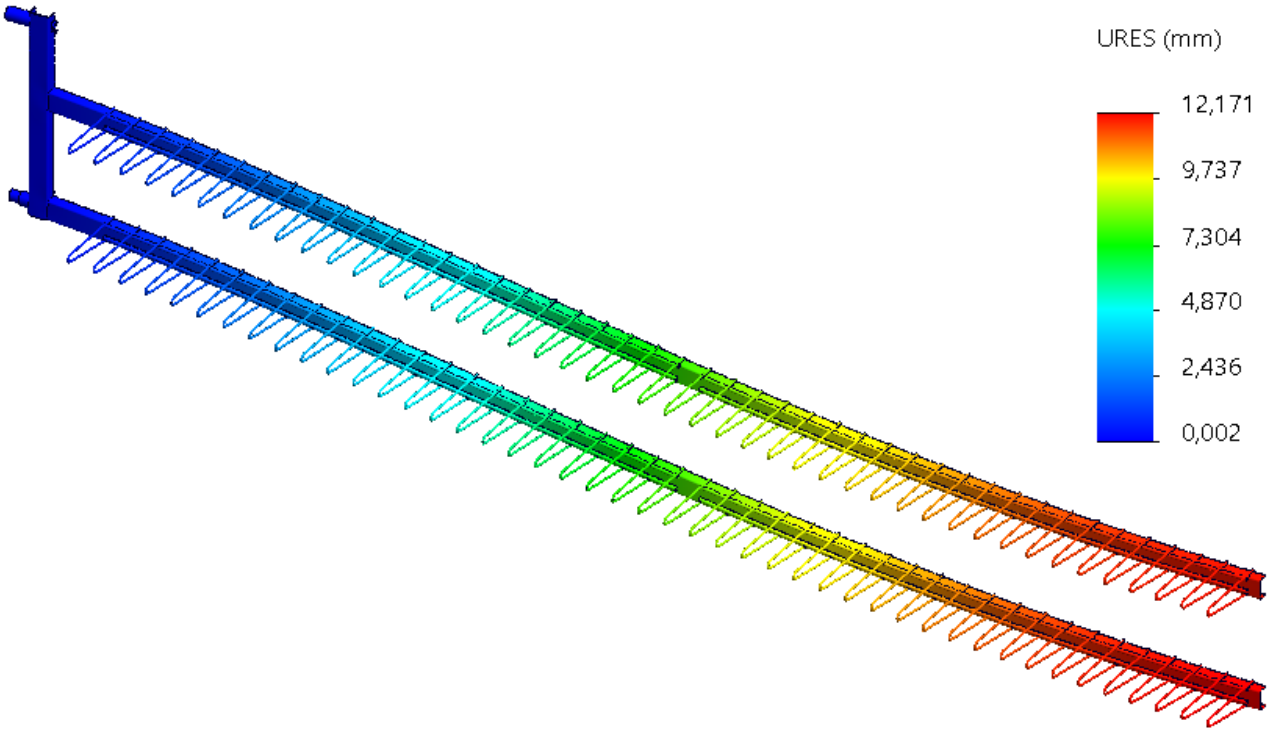



Figure 8. **Distribution of deflections of hanger No 1**

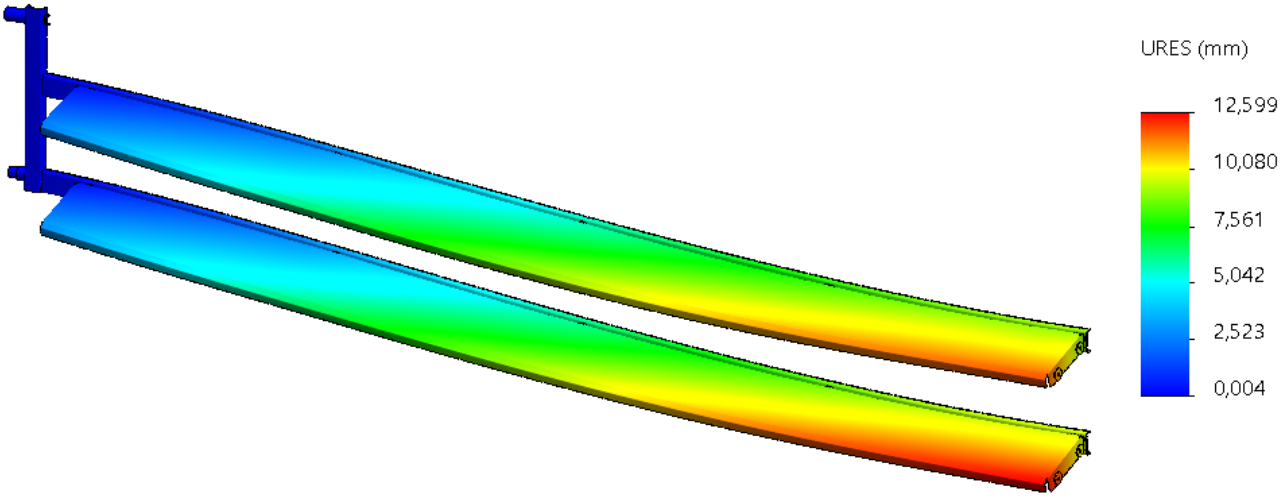



Figure 9. **Distribution of deflections of hanger No 2**

In order to determine the effect of temperature on the stiffness of the structure, additional calculations were carried out at 70 °C. The calculation of stresses and strains and the interpretation of the results must take into account that the mechanical properties of the material depend on temperature [5]. When temperature was not considered, the modulus of elasticity of AISI 304 stainless steel was used as defined in the Solidworks Simulation material database, i.e. 190 GPa. According to [5], at 100 °C the modulus of elasticity of AISI 304 should be 194 GPa. Since the data in Reference [5] shows only a 3 % difference in modulus at temperatures between 20 °C and 100 °C, the calculations assume that the mechanical properties of AISI 304 are independent of temperature.

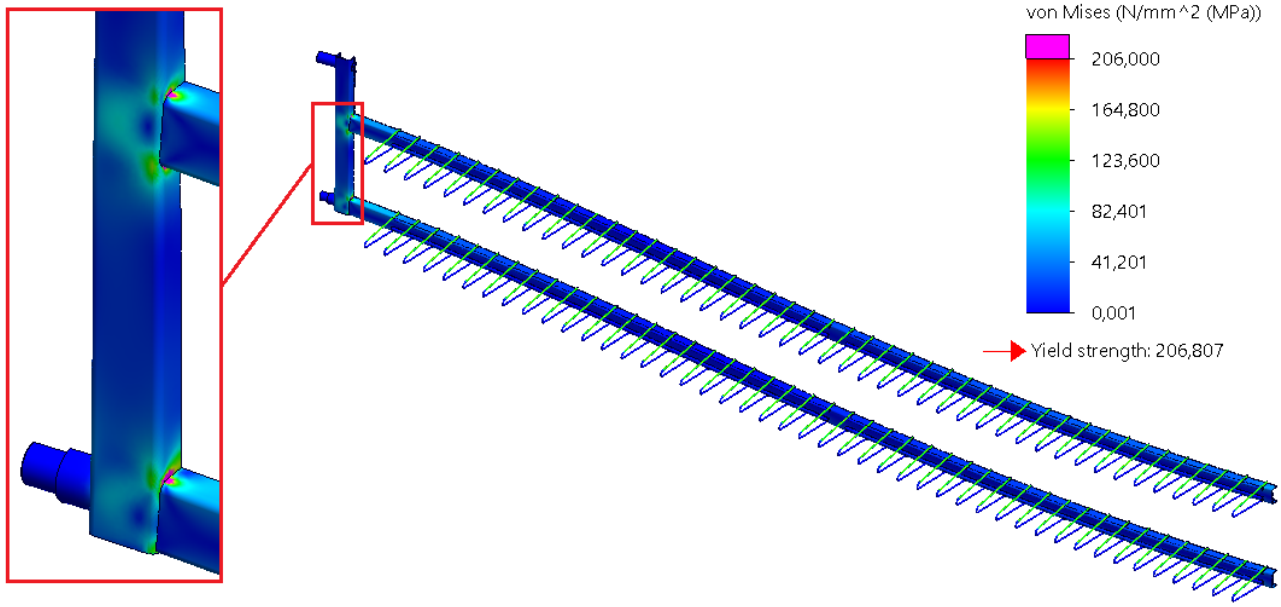



Figure 10. **Stress distribution of hanger No 1**

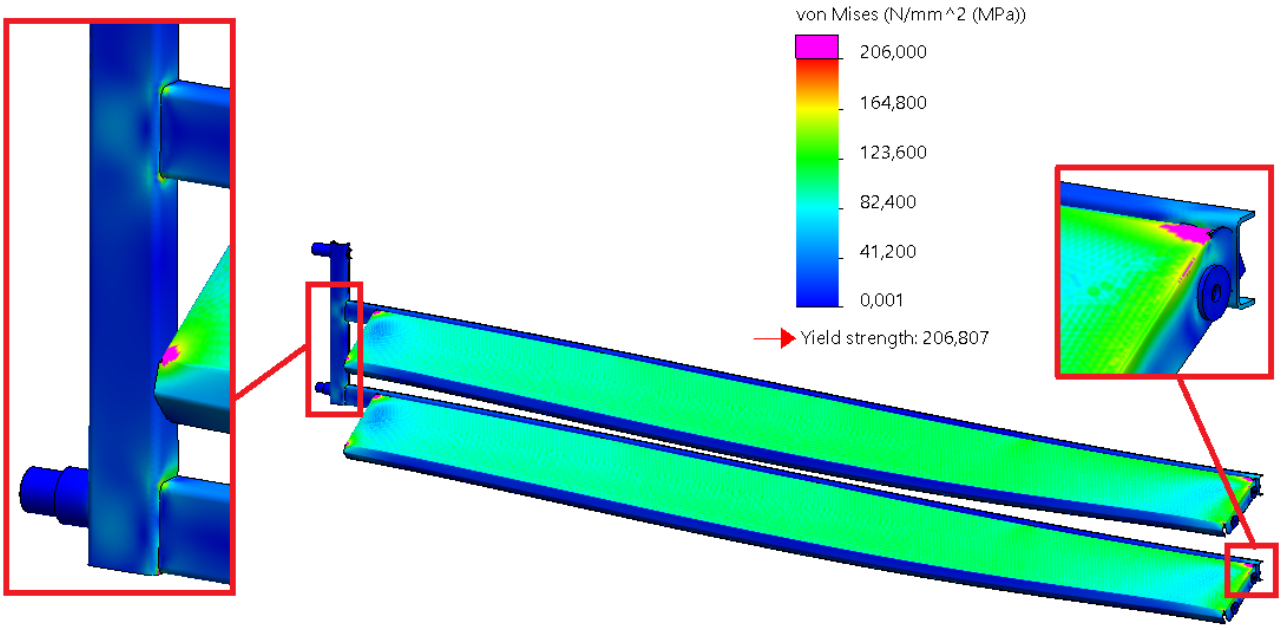



Figure 11. **Stress distribution of hanger No 2**

The analysis of the results of the stress calculations showed that the trend of the stress distributions for hanger No 1 remained the same (Fig. 6 and Fig. 10) as in the case where the temperature was not assessed. The maximum stresses occur in the same areas and the maximum stresses at the stress concentrations are about 20 per cent higher when temperature is considered.

Comparison of the results of the stress calculation for hanger No 2 showed that the maximum stresses were generated at a different location for the temperature assessment than for the no-temperature assessment (Fig. 7 and Fig. 11). In addition, their value more than doubled. This can be explained by the fact that the phenomena of thermal conduction and convection were not taken into account. As the total area of the surfaces to which the temperature load has been applied is considerably larger than that of hanger No 1, the calculation results for hanger No 2 have a significantly larger error than those for hanger No 1. The maximum stresses occur in areas of a very small area, which are also areas of stress concentration. In view of this, the interpretation of the results obtained from the stress calculations suggests that the strength of the hanger as a whole is sufficient. As mentioned above, this has been confirmed in practice by the operation of the hangers.

The results of the deformation calculations are shown in Figures 12 and 13. The deformations are shown here on a scale of 10:1.

Comparison of the deflections (total displacements) of hanger No 1 shows that temperature has a negligible effect. The maximum deflections of hanger No 1 when not subjected to temperature are 12,17 mm (Fig. 8), while when

subjected to temperature the deflections were obtained to be 12,15 mm (Fig. 12). The difference in deflections did not exceed 0,3 per cent.

The deflections of the second hanger were higher when temperature was considered and were 16.68 mm (Fig. 13) compared to 12.6 mm (Fig. 9) when temperature was not considered. The difference in this case was more than 30 per cent. This significant difference in deflections is due to the fact that thermal conduction and convection phenomena were not considered.

When assessing the distribution of deflections in hanger No 2, it is observed that, in the case of no temperature assessment, the area of the largest deflections is close to the plane of symmetry (at the centre of the hanger) (Fig. 9), and in the case of a temperature assessment, the area of the largest deflections is concentrated closer to the free edge of the shelf (Fig. 13).

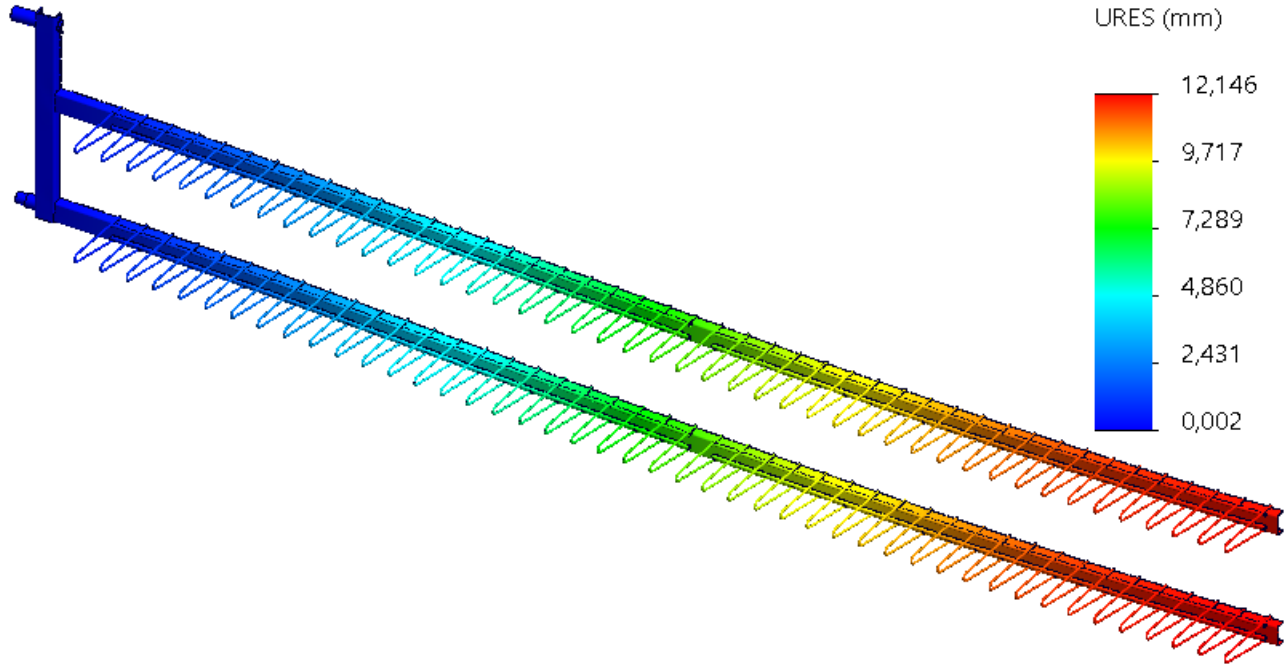



Figure 12. **Distribution of deflections of hanger No 1**

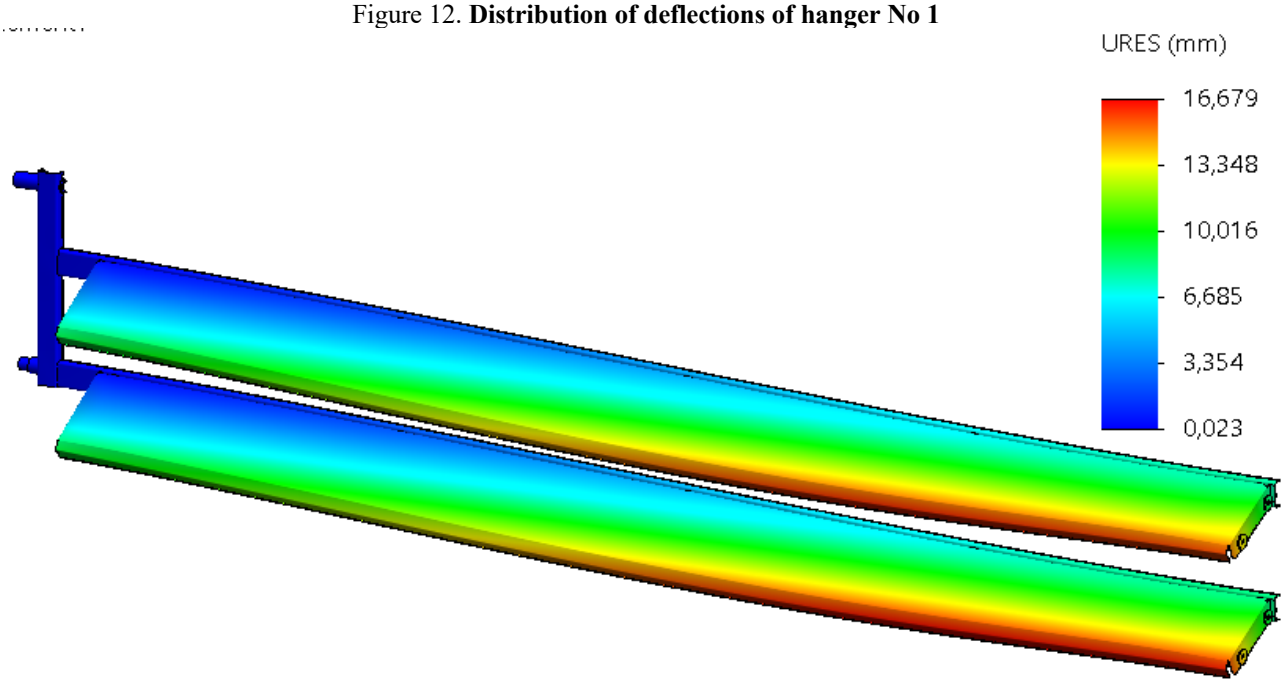



Figure 13. **Distribution of deflections of hanger No 2**

## CONCLUSIONS

1. In terms of strength, where temperature is not taken into account, hanger No 2 is the stronger hanger if the maximum stresses in the stress concentration zones are considered. If the stresses in the stress concentration zones are not taken into account, the strength of the two structures analysed is almost the same.
2. For the temperature effects, the higher strength, taking into account the maximum stresses occurring in the stress concentration zones, resulted in a hanger No 1. The reason for this is that Solidworks Simulation does not have the capability to take into account the phenomena of thermal conduction and convection.
3. Temperature had virtually no effect on the amount of deflection in hanger No 1. The difference in deflection between the temperature and non-temperature values was about 0.3 per cent.
4. For hanger No 2, the temperature (variation 70°C) had a significant effect on the magnitude of the deflections, with deflections around 30 % higher when temperature was considered than when no temperature was considered. This large difference is explained by the fact that in the second hanger model the temperature loads were added over a significantly larger area than in the first hanger model (area difference of more than 80 per cent).

## REFERENCES

1. Kumar Vardaan, Paras Kumar. Design, analysis and optimization of thresher machine flywheel using Solidworks simulation. Materials Today: Proceedings 2022, Vol. 56, 3651-3655.
2. Nitin Dagar, Rajneesh Sharma, Moti Lal Rinawa, Sumit Gulta, Vijay Chaudhary, Pallav Gulta. Design and analysis of piston using aluminum alloy and composites in Solidworks and Ansys. Materials Today: Proceedings 2022, Vol. 67, 784-791.
3. R.N.A. Kurniawan, D. Romahadi, M. Fitri, M.R. Karim. Implementation of the finite element method in Solidworks to optimize the front cast wheel design for motorcycles. International Journal of Innovation in Mechanical Engineering & Advanced Materials 2023, 4(3), 66-73.
4. Archad Hussain Jamali, Fida Hussain Jamali, Mujahid Ali, Waseem Akram Channa, Waseem Ahmed Shaikh, Qadir Bakhsh Jamali. Structural analysis of pelton bucket with AISI 1020 steel and structural steel material by using Solidworks and Ansys. Journal of Mechanics of Continua and Mathematical Sciences 2021, 16(5), 16-26.
5. Britisch Stainless Steel Association. Elevated temperature physical properties of stainless steels. https://bssa.org.uk/bssa_articles/elevated-temperature-physical-properties-of-stainless-steels/.

PANEVĖŽIO KOLEGIJA ISSN 2029-1280, eISSN 2669-0071. Taikomieji tyrimai studijose ir praktikoje – Applied Research in Studies and Practice, 2024, 20.

# MEASURES TO ENSURE THE PROFESSIONAL WELL-BEING OF SOCIAL WORKERS: MANAGERS' VIEWS

***Lina KAZOKIENĖ***

*Panevėžio kolegija/State Higher Education Institution, Lithuania*

**Abstract**. Leaders are aware that employees' work-related well-being has a direct impact on their productivity, job satisfaction, sickness absence and turnover rates. It is in an organisation's interest to invest in employee well-being as it also determines the intellectual capital of the organisation. Naturally, there is increasing demand for research on the factors that promote employee well-being in organisations. Understanding these factors allows leaders to develop solutions that enhance organisational competitiveness and contribute to the development of healthy organisational strategies. Empirically based welfare recommendations for social workers would contribute to the retention of social workers in the labour market. Many risk factors can be reduced or buffered, but this requires a renewed managerial knowledge and effective tools. The aim of this paper is to shed light on the occupational well-being of social workers and the measures to ensure it from a managerial perspective.

**Keywords**: well-being of social workers, work-related stressors, organisational measures

## INTRODUCTION

The last decade has seen an intensive change in the macro environment in the social services sector, characterised by economic pressures, restructuring and a shortage of qualified professionals, and a dynamic and unstable legal framework. The changes that have taken place and the complex context of social work undoubtedly have an impact on the professional well-being of social workers.

The physical and psychological well-being of workers is at risk if there is a mismatch between professional demands, resources and the challenges inherent in the specific nature of the work. This is manifested by occupational burnout, emotional exhaustion or various somatic symptoms such as headaches, sleep disturbance, chronic fatigue, etc. Over time, these symptoms can lead to heart disease, metabolic disorders, hormonal fluctuations or depression. Managers of organisations are aware that the occupational well-being of employees has a direct impact on their productivity, job satisfaction, sickness absence and employee turnover rates.

Ratcliff (2024), examining data from recent wellbeing research in the UK social work sector, reports that a large proportion of social workers (73% of respondents) experienced increased levels of emotional exhaustion during their careers. Straussner et al, (2018) noted mental health problems among social workers that emerged or were made more severe during social workers' careers. In addition, the complex nature of social work leads to an insufficient number of social work professionals on the labour market. According to the Employment Service, social worker is identified as one of the most in-demand professions on the labour market.

To retain staff, an organisation needs to systematically care for and invest in their professional well-being. This requires the integration of effective and optimal measures into management systems.

The analysis of academic papers in the field of professional well-being reveals that most of them are generic, focused on:

- identification of factors affecting well-being, (Lawn et al., (2020), Martin et al. (2020), Gerhardt et al., (2021), Lovejoy et al. (2021), Gerhardt et al. (2021)),
- the specificities of the Covid period and its impact on professional well-being (Luis et al. (2021),
- psychological aspects of well-being (research on the cause and consequences of stress, identification of stress-reducing measures, self-help techniques) (Lawn et al., (2020), Bubinaite and Bakanauskiene (2020)).

It is also important to note that most research on professional well-being is not focused on specific occupational or other groups (Lindeberg et al. (2024)), or focused on specific aspects (Rupert, and Dorociak, (2019), Gudžinskienė and Pozdniakovas, (2021)). As Pakhol (2020) found, the predictors of professional well-being are varied for different occupational groups. There is not much new research on well-being among social workers. There is a serious lack of up-to-date knowledge to make informed recommendations to social workers managers on how to enhance professional well-being, including the selection of effective measures.

*The aim* of this paper is to shed light on the occupational well-being of social workers and the measures to ensure it from a managerial perspective.

The updated managerial knowledge will contribute to increasing the productivity, resilience to stress and other negative factors of social workers and to retaining them in the social work market.

# OCCUPATIONAL WELL-BEING AND MEASURES TO PROMOTE IT

Workers' professional well-being relates to all aspects of their work: the quality and safety of the physical environment, as well as the well-being of workers at work in a given work climate and organisation. The descriptions of professional well-being identified by researchers reveal it to be a multidimensional, composite object, the structure of which is not agreed upon. In the context of professional well-being, job-related well-being (job demands), psychological well-being, physical well-being and economic well-being (see Table 1) are common.

Table 1

**Professional Wellbeing Complex**

(by Šorytė, Pajarskienė, (2014), Sherman and Axelrad (2020), Ansmann et al. (2020), Martin et al. (2020), Lovejoy et al. (2021), Gerhardt et al. (2021), Gudžinskienė and Pozdniakovas (2021), Hageman et al. (2021), Lindeberg et al. (2024), Daovisan and Intarakamhang (2024))

| Complex Element | Description | Sources |
|---|---|---|
| Work/Organizational Well-being | Characterized by employee job satisfaction, engagement at work, commitment to the organization, high productivity levels, and positive experiences of satisfaction (e.g., anticipated job continuity and performance). | Šorytė, Pajarskienė, 2014; Sherman and Axelrad (2020); Lovejoy et al. (2021) |
| Psychological Well-being | Combines indicators of mental well-being: employees' emotional and psychological state and mental health. | Šorytė, Pajarskienė, 2014; Ansmann et al. (2020); Gerhardt et al. (2021); Lindeberg et al. (2024) |
| Physical Well-being | Describes employees' physical condition, indicated by symptoms of physical health disturbances (e.g., headaches, back pain, heart rhythm disorders, sleep disturbances, fatigue, general somatic complaints) and mental health issues (e.g., depression, anxiety, tension, emotional exhaustion). | Šorytė, Pajarskienė, 2014; Lawn et al. (2020);. Martin et al. (2020); Gerhardt et al. (2021); Daovisan and Intarakamhang (2024) |
| Economic Well-being | Defined by current and future financial security, including individuals' ability to consistently meet basic needs and manage daily financial activities. | Hageman et al. (2021); Gudžinskienė and Pozdniakovas (2021) |

It should be noted that the occupational well-being complex is conditional. This is due to the lack of a clear distinction between the individual elements of well-being.

Different researchers do not attribute different elements of well-being in the same way. For example, mental health is classified as physical well-being in some sources and psychological well-being in others.

The social work literature has widely discussed solutions that promote the professional well-being of workers and reduce the consequences of risks associated with social work practice.

*When looking at effective measures to ensure well-being, the insight that emerges is that such measures have a positive impact on at least one part of the occupational well-being complex.*

According to Martin et al. (2020), Pakhol (2020), Gudžinskienė, Pozdniakovas (2021), Lovejoy (2021), occupational well-being can be influenced by organisational and self-care measures.

Self-care refers to a purposeful process of strategies to promote healthy living, including the physical, psychological and spiritual aspects of the person (Lawn et al., 2020). Importantly, self-care encompasses many different activities, even across multiple life domains, and is different for different individuals depending on their expectations, lifestyles and career situations (Rupert, and Dorociak, 2019). Martin et al. (2020) point out the importance of self-help measures but urge not to underestimate organisational solutions. Social work is seen as a stressful and time-consuming profession Ratcliff, (2024). Social workers work in stressful work environments where they are at risk of burnout, compassion fatigue, secondary traumatic stress and vicarious traumatization (Martin et al., 2020). Traumatic events involving clients (e.g. suicide) (Lawn et al., 2020, Martin et al., 2020), clients' demotivation and reluctance to accept help (Martin et al., 2020*),* and an increased risk of potential aggression and violence are all key factors in social work. In this context, work organisation decisions such as balancing working time/shifts, a clear and fair distribution of responsibilities

and duties, the duration of recuperation, the possibility of reconciling personal commitments and work (Lawn et al. (2020), Bubinaitė and Bakanauskienė, (2020) - are critically important. Lovejoy et al. (2021) describe an organisational support system with three components: work demands, work control and social support.

Work requirements include workload, work pace and intensity. Both very high and very low job demands are associated with lower perceived commitment to the organisation and lower job satisfaction. Employees need an optimal workload that is within their capabilities, but at the same time acts as a challenge and does not lead to boredom (Gudžinskienė and Pozdniakovas, (2021), Lovejoy et al (2021)).

Lovejoy et al. (2021), in describing job control as a tool to promote well-being, emphasise the decision-making power of workers and their freedom to decide on work-related issues. Research shows that giving employees more control over their work is associated with better psychological health and greater job satisfaction. Job control provides a sense of autonomy, promotes flexibility, and can therefore mobilise and protect against the negative consequences of job demands (Gudžinskienė and Pozdniakov, (2021)).

Social support measures (supervisory support, peer and management support, teamwork and social networking) are given greater emphasis throughout the support system (Finne et al. (2014), Lovejoy et al. (2021)). Lithuanian legislation even provides for minimum norms of supervision time that any social worker should take into account. There is a particular focus on supervisor-worker relationships and colleague relationships. The relationship between managers and employees is linked to the selection and implementation of measures to create well-being. Managers' ability to make decisions that allow employees to take sufficient rest and regain emotional balance and contributed to a difficult work-life balance, even in the face of fast-paced, demanding work (Lawn et al., 2020). The empathy and attention of managers, especially in critical incidents, helps employees maintain their self-confidence. Managers' trust in social workers, equal communication with employees, and support with constructive advice and guidance help to overcome professional burnout (Finne et al. (2014), Gerhardt et al., (2021)). Conversely, a lack of attention and incapacity on the part of supervisors can lead to social stressors such as workplace harassment, impatience, mobbing, workplace bullying, and lack of attention to incident reporting (Sherman and Axelrad (2020), (Martin et al., 2020), Lawn et al. (2020), Gerhardt et al. (2021), Šorytė, Pajarskienė, 2014, Ansmann et al. 2020). In the complex nature of work, a sense of belonging to a team and the camaraderie, routine, direction and meaning of routine help employees to remain stable or recover from critical incidents. Camaraderie and support networks are good tools to reduce isolation among workers by sharing stories and experiences, including experiences of managing one's own emotions, clarifying personal attitudes, and self-development (Sa´nchez-Moreno et al. (2014), Lawn et al. (2020).

More research work has found organisational measures that create and sustain well-being, which complement the recommendations of Lovejoy et al. (2021).

Additional examples include physical activities (exercise and other active sports), nutrition (Martin et al., 2020), Mindfulness practices, yoga (Ratcliff, (2024)), psychological support measures (individual counselling, group therapies) (Richards et al., 2010), physical environments and workplace spaces, and workplace tools (Palvalin, (2019)).

*The analysis of academic work suggests that there are many organisational tools for creating well-being, but employee well-being in the context of an organisation must also be linked to the specificity of that organisation. The specific context of the organisation may create different conditions for the realisation of the potential of the available well-being instruments and may trigger the need for different instruments*.

## STUDY METHODOLOGY

A qualitative research approach was chosen to uncover measures to ensure the professional well-being of social workers. According to Žydžiūnaitė et al (2008), the consequences of social phenomena are often determined by the subtle, intuition-based actions of managers, which are not always possible to describe clearly enough. As the analysis of scientific sources shows, measures to ensure the professional well-being of employees are divided into organisational and self-care measures. The latter are chosen and applied individually by employees according to their needs. In contrast, the manager is responsible for introducing, applying and integrating work organisation measures into the company's operational strategies. Given the importance of the manager's role in the development of professional well-being, the aim of the study was to identify the organisational measures used and preferred by social service institutions to promote well-being from the managers' point of view.

The aim of the study implies certain requirements for the informants: to work in a managerial role in budget social services companies. The latter requirement is based on the fact that social services in Lithuania are mainly provided by budgetary institutions. They have a longer history of service provision compared to the non-governmental sector. The selection of informants was carried out in cooperation with the Association of Managers of Social Service Institutions, in accordance with the eligibility requirements and the principle of voluntary participation. A total of 8 informants took part in the study. This is an optimal group size as each participant can express his/her point of view on the problematic issue. A focused group interview was conducted, during which the informants exchanged experiences, knowledge and attitudes in a dynamic interaction. The group discussion focused on three cognitive directions:

1) what are the tools used to create well-being in social services,

2) what are the desirable but for some reasons not applicable wellbeing building measures,

how the optimality of organisational wealth creation measures is based.

Group discussion was chosen as a separate data collection method to identify the problem. For example, Martin et al. (2020) point out that some organisations do not have any measures in place to enhance employee well-being. Meanwhile, Sa´nchez-Moreno et al. (2014) observe that over-involvement in service users' problems, due to the allocation of priorities or lack of time, implies a lack of attention to work well-being.

The transcribed data were analysed by creating categories, the names of which are linked to the groups of well-being measures identified in the theoretical analysis*, i.e.: job demands, job control and social support, physical activity and nutrition, psychological measures, physical environment.*

The study is based on the principles of respect for the voluntary decision to participate, confidentiality and anonymity. Participants are informed in advance about the study and its purpose, the study procedures, the ethical principles of the study and the guarantee of confidentiality. The study followed the principle of tolerance, respecting the views expressed by each participant and avoiding prejudices. The names of the participants were coded using a combination of the letter V and the numbers 1-8 (V1-V8).

## SURVEY RESULTS

The analysis of the participants' statements on measures to enhance the professional well-being of social workers led to a refined list of categories based on theoretical analysis (see Table 2).

Table 2

**Measures to promote the well-being of social workers**
(by Sherman and Axelrad (2020), Martin et al., 2020), Lawn et al. (2020), Gerhardt et al. (2021), Šorytė, Pajarskienė, 2014, Ansmann et al. (2020))

| **Job demands** |
|---|
| • Adequate resources in terms of staff and tools;<br>• Optimisation of travel time costs;<br>• Opportunities for continuous learning and skills development;<br>• Reducing administrative burden, digitization;<br>• Safety at work, reducing the risk of violence. |
| **Job control** |
| • Opportunities to combine work and personal life commitments (education, family, etc.);<br>• Ability to accept the ability to make decisions related to work tasks or to be involved in decision-making. |
| **Social support** |
| • Relationships with your manager, co-workers, founder;<br>• Supervision, interviews;<br>• Belonging to associated structures;<br>• Informal events. |
| **Physical environment** |
| • Spacious and comfortable workplaces;<br>• Recreation areas. |
| **Physical activities** |
| • Exercise, active sports;<br>• Trips, hikes. |
| **Psychological measures** |
| • Individual consultations;<br>• Psychotherapy. |
| **Economic measures** |
| • Physical activities;<br>• Decent salary. |

Informants mainly provided measures related to work organisation. Particular emphasis was placed on the provision of work tools "*so that employees are completely freed from the lack of work tools <...>, so that they have the best of everything and so that they feel very good at work*" (V3). Informants emphasised not only the provision of working tools themselves, but also their freedom of choice "I *don't decide which pen to buy. They know where to look, everything is digitised. They choose for themselves, they make their own basket <...> as far as their working tools are concerned <...> and the colours, and what calendars, and how they will open <...>. And then the procurement officers come in and order the goods*" (V8). Employee involvement in supply processes refers to the involvement of employees in certain decision-making processes that concern them. Several informants also mentioned company cars as a very important welfare tool. In contrast, free access to public transport was not identified as a welfare measure. Staff cars help to solve the problem of troublesome journeys in rural areas and save time.

Reducing administrative burdens by digitising processes also helps save time. This means that social workers can spend more time on direct work with clients, training or other activities. "*Reducing the administrative burden on staff by digitising and filling in travel sheets <...> all tasks, resolutions are not handwritten as before <...> everything is automated<...> tasks are done much faster <...> there is no need to be stressed about not getting something done all the time*" (V1). Digital technologies are stimulating the emergence of new ways of working, creating a new service delivery environment enriched by a variety of information sources and means of communication.

In the context of social work, job security measures have received particular attention. On the one hand, it reflects the complexity of work activities and the real threats. On the other hand, it should be noted that preventive measures are also in place ("*We prohibit all employees from working 24 hours a day 7 days a week <...> everybody is very satisfied*" (V3)), and reactive measures "*the telephone answering machines make a contribution to the work conversation, the effect is that when you hear "good afternoon, the conversation will be recorded" it changes really, <. ...> less stammering, there are not so many unreasonable demands from the employees*" (V2); "*we used to have <...> women who are scared and they are really scared - we have real cases of assaults <...>* now *we buy physical protection for the whole day*" (V5). As Sh. Lawn et al. (2020), the provision of services to people with inadequate behaviour, mental health problems, drunkenness and violence increases feelings of job insecurity. Naturally, safety measures help to ensure the basic needs of workers, without which the well-being of workers is not possible.

The analysis of academic papers shows a strong focus on balanced work schedules and flexibility. In this qualitative study, informants identified flexibility in work schedules as allowing employees to balance personal commitments. "*The schedules are balanced with studies, with family commitments, but when analysing each situation, because the institution is huge and too much flexibility leads to chaos*" (V7); "*we are always missing <...> signing off for personal reasons*" (V1). Flexible, individualised working schedules give staff the opportunity to control their work (start and end), to balance family commitments and to have a sense of autonomy. The value of flexible and individualised work schedules for well-being is emphasised by (Martin et al. (2020), Lovejoy et al. (2021). However, many scholars point out that organisational support should be expressed through a balanced, planned work organisation. In this case, it was observed that balanced workloads, the intensity of rest break tasks were not identified by the informants. This may be due to legislation that regulates and defines both work norms, intensity of service provision, and other work organisation factors. While legislation on work organisation issues helps to create a unified framework, the question arises as to what extent the limits set are in line with workers' expectations and their ability to remain productive and motivated.

According to Martin et al. (2020), time away from work-related stressors gives the worker the opportunity to take a break from the stress response, to heal and to avoid negative health effects. Informants noted that reducing working time for social workers would make a significant contribution to restoring workers' working capacity "*I would be in favour of reducing working time to 36 hours because we see how difficult the psychological conditions are, the emotional tensions <... > of course, when the 4 days are regulated, I expect it, naturally <..>*" (V6); "*we see a model for mothers and fathers who raise children up to the age of 3 years and are doing their best <..> I think that at least the 36-hour model would be a significant help for all workers <..> to improve their health, to stay longer on the social work market*" (V1). At present, the legislation stipulates a 40-hour working week for social workers and managers, while social pedagogues and health professionals working in the same institution work less. A level playing field would help to avoid the discrimination and perceived exclusion of workers that was mentioned by informants.

When talking about social support, the participants in the study grouped themselves into several groups of relationships, distinguishing:

worker-to-worker (*close colleague relationship <...> sometimes all you need to do is listen and that's enough to stabilise your emotions*" (V3); "*you can call your line manager crying to tell him what happened <...>* (V1),

supervisor-employee-supervisor "*managerial support for the employee* (V3); "*we defend our employees in pre-trial proceedings, represent them and they are not left alone <...> it helps people to stay in the workplace*" (V6); "of course psychological support managerial support for the employee immediately so that the employee is not left alone with the problem <..>" (V3)

the founder-manager *"a lot depends on the municipality (founder)*" (V3);

employee (or manager) - associated structures "*it's good that there is a trade union, it's good that there is such professional support <...> it really made it easier psychologically and physically when I felt that community*" (V4); "*it seems that in our field we are lonely and abandoned if there was no <...> trade union*" (V8);

It is in the category of social support that additional categories have emerged, i.e. the founder manager and the employee's or manager's membership of associated structures (associations, trade unions). The latter observation is found in the work of Bubinaitė and Bakanauskienė (2020), who write that trade union membership can mitigate the negative emotions of employees when they feel less secure about the nature of their jobs and their well-being. Employee affiliation could be an additional avenue for well-being research.

Physical environment, physical activity and psychological measures were mentioned in a general context, with the emphasis on expectations rather than on the measures used. "<...> 30% of our working day should be physical activity. We should find time for those 10,000 steps. I would like to see activity measures, even at national level, even if by force, that we have to take care of our physical activity in order not to disturb our psychosomatics" (V4). Economic measures were also mentioned as insufficient, not ensuring a decent living for the employee "*financial incentives for employees were also mentioned, what do we do, I don't know if this is a motivational measure at all, but I understand that for my employees it is very important*" (V8); "*the salary we receive should be a living wage, unfortunately it is not <...> we don't*

*feel valued*" (V2). Researchers point out that monetary remuneration for work is significant as long as it allows individuals to meet their needs and live comfortably. Once this threshold is reached, the income received no longer contributes to the well-being of workers. On the other hand, if income is insufficient to meet individuals' needs, it severely undermines their well-being and the quality of their life and work (Hageman et al., (2021) Šorytė, Pajarskienė, (2014), Gudžinskienė and Pozdniakovas (2021). Clearly, in the field of social work, wages are important and can act as a measure of well-being.

## CONCLUSIONS

The results of the study allowed for an expansion of the list of measures ensuring the professional well-being of social workers, grouping them into seven categories. In the Job demands category, job security measures received particular attention. Some of these measures are focused on preventive actions (knowledge) and real impact (acquiring safety services, recording phone calls, etc.). The increased risk of potential aggression and violence that employees face, particularly verbal threats, heightens the sense of job-related uncertainty and vulnerability, which explains the importance of these measures.

According to the informants, social support measures are also considered very important. Supervisions, peer reviews, and informal events were mentioned, as well as belonging to associated structures (which fosters a sense of community and security). Relationships with supervisors and colleagues traditionally remain crucial in building a trust-based, positive organizational microclimate. Additionally, the importance of relationships with the founder was highlighted. These relationships are based not only on moral support but also on empowerment, methodological assistance, and information sharing.

The study's results suggest that economic measures, such as fair wages, affect employees' well-being and their perception of recognition. Workplace measures and tools to perform tasks, including transportation, are more important in terms of work quality, as they allow employees to focus on their core functions while ensuring stable support processes.

## REFERENCES

Ansmann, L., Hower, K.I., Wirtz, M.A. (2020). Measuring social capital of healthcare organizations reported by employees for creating positive workplaces - validation of the SOCAPO-E instrument. BMC Health Serv Res 20, 272. https://doi.org/10.1186/s12913-020-05105-9

Bitinas, B., Rupšienė, L., Žydžiūnaitė, V. (2008). Kokybinių tyrimų metodologija: vadovėlis vadybos ir administravimo studentams. Klaipėda: S. Jokužio leidykla-spaustuvė, https://www.lituanistika.lt/content/25145

Bubinaitė, D. and Bakanauskienė, I. (2020). Darbuotojų gerovės tyrimas skirtingų kartų kontekste: universiteto padalinio atvejis. Lietuvos aukštųjų mokyklų vadybos ir ekonomikos jaunųjų mokslininkų konferencijų darbai, 23, 64-71. https://www.lituanistika.lt/content/103068

Daovisan H, Intarakamhang U. (2024). Measuring Occupational Well-Being Indicators: Scale Construction and Validation. Behavioral Sciences. 14(3):248. https://doi.org/10.3390/bs14030248

Finne, L. B., Christensen, J. O., and Knardahl, S. (2014). Psychological and social work factors as predictors of mental distress: a prospective study. PloS one, 9(7), e102514. DOI: https://doi.org/10.1371/journal.pone.0102514

Gerhardt, C., Semmer, N. K., Sauter, S., Walker, A., de Wijn, N., Kälin, W., Kottwitz, M. U., Kersten, B., Ulrich, B., and Elfering, A. (2021). How are social stressors at work related to well-being and health? A systematic review and meta-analysis. BMC public health, 21(1), 890. DOI: https://doi.org/10.1186/s12889-021-10894-7

Gudžinskienė, V. and Pozdniakovas, A. (2021). Socialinių darbuotojų profesinio perdegimo sindromą nulemiančios organizacinės priežastys. Social inquiry into well-being, 19, 1, 26-47. https://www.lituanistika.lt/content/96776

Hageman and et. (2021) Economic and Financial Well-Being in the Social Work Curriculum: Faculty Perspectives. Journal of social work education vol. 57, no. 2, 251–263 DOI: https://doi.org/10.1080/10437797.2019.1661919

Lawn, S., Roberts, L., Willis, E., Couzner, L., Mohammadi, L., & Goble, E. (2020). The effects of emergency medical service work on the psychological, physical, and social well-being of ambulance personnel: a systematic review of qualitative research. BMC psychiatry, 20(1), 348. DOI: https://doi.org/10.1186/s12888-020-02752-4

Lindeberg, P., Saunila, M., Lappalainen, P., Ukko, J. and Rantanen, H. (2024), The relationship between various social work environment elements and hybrid worker well-being, Facilities, Vol. 42 No. 15/16, pp. 1-16. DOI: https://doi.org/10.1108/F-03-2023-0019

Lovejoy, M., Kelly, E. L., Kubzansky, L. D., & Berkman, L. F. (2021). Work Redesign for the 21st Century: Promising Strategies for Enhancing Worker Well-Being. American journal of public health, 111(10), 1787–1795. DOI: https://doi.org/10.2105/AJPH.2021.306283

Luis, E., Bermejo-Martins E., Martinez M., Sarrionandia A., Cortes C., Oliveros E., Sol Garces M., Oron J.V., Fernịndez-Berrocal P. (2021). Relationship between self-care activities, stress and well-being during COVID-19 lockdown: a cross-cultural mediation model. BMJ Open 11. DOI:10.1136/ bmjopen-2020-048469

Martin, E., Myers, K., Brickman K. (2020). Self-Preservation in the Workplace: The Importance of Well-Being for Social Work Practitioners and Field Supervisors, Social Work, Volume 65, Issue 1, January 2020, Pages 74–81, https://doi.org/10.1093/sw/swz040

Pakhol, B. (2022). Features of professional well-being of representatives of different professional groups. Tiltai, 84(1), 1-18. DOI 10.15181/tbb.v84i2.2126

Palvalin, M. (2019). Knowledge Work Performance Measurement in the New Ways of Working Context. (Tampere University Dissertations; Vol. 47). Tampere University. http://urn.fi/URN:ISBN:978-952-03-1055-4

Ratcliff M. (2024). Social Workers, Burnout, and Self-Care: A Public Health Issue. Delaware journal of public health, 10(1), 26–29. DOI: https://doi.org/10.32481/djph.2024.03.0

Richards, K., Campenni, C.E., & Muse-Burke, J.L. (2010). Self-care and Well-being in Mental Health Professionals: The Mediating Effects of Self-awareness and Mindfulness. Journal of mental health counseling, 32, 247-264. DOI:10.17744/mehc.32.3.0n31v88304423806

Rupert, P.A., &Dorociak, K.E. (2019). Self-care, stress, and well-being among practicing psychologists. Professional Psychology: Research and Practice. DOI:10.1037/PRO0000251

Sánchez Moreno, E., de la Fuente Roldán, I. N. Barrón López de Roda, A. y Gallardo Peralta, L. P. (2015). Burnout, informal social support, and psychological distress among social workers. British Journal of Social Work, 45, 2368-2386. DOI: https://doi.org/10.1093/bjsw/bcu084

Sherman A &Axelrad H. (2020). A qualitative study on money, well-being and serial crowdfunding. Baltic Journal of Management. ahead-of-print. DOI:10.1108/BJM-06-2020-0190

Straussner, S. L. A., Senreich, E., &Steen, J. T. (2018). Wounded Healers: A Multistate Study of Licensed Social Workers' Behavioral Health Problems. Social work, 63(2), 125–133. DOI: https://doi.org/10.1093/sw/swy012

Šorytė D. and Pajarskienė B. (2014) Darbuotojų gerovė ir ją skatinantys psichosocialinės darbo aplinkos veiksniai. Visuomenės sveikata Vilnius: Lithuanian Institute of Hygiene, Occupational Health Centre https://www.scribd.com/document/660566159/VS-2014-2-65-LIT-Darbuotoju-gerove

PANEVĖŽIO KOLEGIJA ISSN 2029-1280, eISSN 2669-0071. Taikomieji tyrimai studijose ir praktikoje – Applied Research in Studies and Practice, 2024, 20.

# EMOTIONAL INTELLIGENCE IN RELATION TO DEPRESSIVE SYMPTOMS IN LITHUANIAN CLINICAL NURSES: A PILOT STUDY

***Marius BARANAUSKAS, Ingrida KUPČIŪNAITĖ, Jurgita LIEPONIENĖ***

*Panevėžio kolegija/ State Higher Education Institution, Lithuania*

**Abstract.** The World Health Organisation's European Work Programme 2020-2025 identifies mental health as a key element of personal and collective well-being. In Lithuania, the importance of emotional literacy education is not sufficiently focused on, so the aim of this study was to identify and assess the relationship between emotional intelligence and depression symptomatology in nurses working in personal health care institutions in the Republic of Lithuania.

The results of the study showed that almost one in five nurses in the healthcare sector has an insufficient level of emotional intelligence. The higher-risk group of nurses with low levels of emotional intelligence is exclusively represented by nurses working in primary health care settings. Higher depressive symptomatology among nurses working in Lithuanian healthcare institutions is associated with insufficiently developed emotional literacy, which is uniquely determined by the nursing staff's insufficient ability to manage individual emotions ($r = -0.3$, $p = 0.007$). Health care institutions in Lithuania need to protect and enhance the mental health of nurses and reduce depressive symptomatology, so the recommendations of this study should focus on the consistent rationalisation and optimisation of existing prevention programmes by integrating an emotional literacy component.

**Keywords:** clinical nurses, depressive symptoms, emotional intelligence

## INTRODUCTION

The World Health Organisation's European Work Programme for 2020-2025 identifies mental health as a key element of personal and collective well-being. Mental health disorders are very common and contribute to the growing burden of disability in the European region. People of all ages and social groups face challenges arising from mental health disorders. The most common mental health disorders are depressive and anxiety disorders and somatisation, which can lead to co-morbidities, including burnout syndrome, which is particularly common in health care workers. In order to reduce morbidity and mortality due to mental health disorders, a coalition has been formed at international level to reduce the stigma that leads society to perceive people with mental health disorders as problematic. One of the measures to promote mental health includes increasing mental health literacy among health workers (World Health Organization, 2023). The Action Plan on Occupational Safety and Health 2022-2027 (2022) notes that, according to the Procedures for the Promotion of Employee Competence in Mental Health, municipal public health offices are to organise training for employees on mental health competences in enterprises, thereby contributing to the promotion of the mental health of employees in enterprises. More specifically, in order to promote a safe and healthy environment conducive to the psychological/emotional well-being of medical staff, to reduce the incidence of psychological violence in personal health care institutions, and to strengthen the mental health of current and future personal health care professionals, an Action Plan for Ensuring the Mental Well-being of Employees in the Personal Health Care System for the period 2021-2024 has been developed, focusing on the promotion of employees' social, emotional, and other competencies, psychological resilience, and literacy in the area of mental health.

One of the components of resilience to psychological stress is a sufficient level of emotional intelligence (EQ). EQ refers to the general ability to understand and regulate one's own and others' emotions and to deal effectively with emotionally distressing situations. Notably, research has shown a correlation between employee performance and effectiveness and EQ (Moroń & Biolik-Moroń, 2021; Uraz & Arhan, 2020). A sufficient level of EQ can influence the quality of work performed. Specifically, employees with high EQ are able to recognise and attend to their feelings, stimulate themselves, sympathise and build relationships with other people. With EQ, a worker can do their job with more sincerity and a more goal-oriented approach in order to achieve better quality. Workers are able to do their daily tasks, focusing on the ability and efforts to properly supervise the EQ, in addition to others, are able to better implementation of the organization, in which the work of the work, the objectives and to facilitate the psychological stress.

While the importance of emotional intelligence education has been recognised worldwide for more than 20 years, in Lithuania the focus on the importance of emotional literacy education has been too low. On the other hand, while there are programmes in Lithuania to promote mental health coherence among employees, their impact is focused only on reducing psychological violence in the workplace and preventing alcohol consumption. At the same time, health workers, exclusively nurses (including midwives), are also subjected to constant psychological stress due to the relatively low level of funding for their work, the heavy workload and, as a consequence, the development of burnout syndrome. While nurses' emotional literacy development is consistently as important as the development of professional skills, there is currently no research in Lithuania on nurses' EQ and its association with depressive symptoms.

*The aim of the study* was to determine and evaluate the relationship between emotional intelligence and depressive symptomatology in nurses working in personal health care institutions in Lithuania.

## SURVEY ORGANISATION AND METHODOLOGY

A single-observer cross-sectional survey was carried out from 24 October to 28 November 2023. A representative sample volume (n = 96) was calculated and constructed using the official OpenEpi software (Open Source Epidemiologic Statistics for Public Heart, 2013) to organize the study, with a precision of 10% and a confidence level of 95%.

A non-random convenience sampling method using the official survey system "Apklausa.lt" via 4 official Facebook groups was used to survey 40.7 ± 12.9 year old respondents (n = 76). Given the exclusion criteria of having been diagnosed with a mental health disorder requiring inpatient treatment in the last 12 months, 74 nurses (n = 74) were finally included in the data analysis.

The study was carried out using a questionnaire survey. The 52-question questionnaire was developed using two standardised questionnaires: the Schutte Self-Report Inventory (SSRI) (Schutte et al., 1998) and the Patient Health Questionnaire-9 (PHQ-9) (Montvidas, 2018). In order to find out the socio-demographic characteristics of the respondents (biological sex, age, education), work characteristics (length of employment, place of work, duration of work per week, night work and shift work), and mental status, the questionnaire was supplemented with 9 questions.

A five-point Likert scale was used to assess nurses' EQ ('strongly disagree' - 1 point, 'disagree' - 2 points, 'not sure' - 3 points, 'agree' - 4 points, 'strongly agree' - 5 points). The SSRI consisted of 4 subscales: (1) Statements about perceiving emotions helped to clarify the ability to detect emotions in faces, pictures, voices, cultural artefacts, as well as in oneself; Statements about managing one's own emotions were intended to clarify the ability to use, modify or adapt one's emotions (positive and negative) in the given situation in order to achieve the set goals; (3) Statements about managing other people's emotions helped to clarify the ability to use or modify any type of other people's emotions, even negative ones, in order to achieve goals; (4) Statements about using emotions helped to clarify the ability to use emotions in order to facilitate various cognitive activities such as thinking or problem solving.

For EQ expression, the total SSRI scores could range from 33 to 165. The mean score for each EQ component was calculated as the sum of the statement scores divided by the number of statements reflecting the component. The higher the number, the more pronounced the EQ. Given that when studying the EQ of large groups of people, if the mean EQ score was 124 and the standard deviation was about 13, the current study set thresholds referring to low (scores < 111), moderate (scores 111 ≤ scores < 124), and high (scores ≥ 124) EQ (Schutte et al., 1998). In addition, previous studies conducted in Lithuania have examined the reliability and validity of the Lithuanian version of the SSRI questionnaire (Akelaitis & Malinauskas, 2014). The Cronbach alpha coefficient for the Lithuanian version of the SSRI questionnaire was 0.76.

The PHQ-9 was used to assess nurses' depressive symptom expression. The PHQ-9 is a part of the broader Patient Health Questionnaire (PHQ) that assesses depressive symptoms. The original PHQ was developed in 1999 and standardised in two studies involving approximately 6000 patients from different primary care and gynaecology-obstetrics clinics (Kroenke et al., 2001). The PHQ-9 consisted of 9 statements corresponding to the diagnostic criteria for depression. A four-point Likert scale was used to assess the statements. Specifically, for each statement, the respondent was asked to tick one of four responses describing how often the symptom had occurred in the last two weeks: 'not at all', 'a few days', 'more than half of all days', 'almost every day'. Each of these answers is scored from 0 to 3, depending on how often the symptom occurred. At the end of the PHQ-9, respondents were asked an additional question to assess the difficulty of daily personal and work activities due to depressive symptoms. The response options to the last statement of the PHQ-9 were consistent: "not at all difficult", "slightly difficult", "very difficult", "extremely difficult". The intensity of depressive symptoms was assessed on the basis of the sum of the scores and the answer to the additional question. A score of 0-4 identified low depressive symptoms, 5-9 low depressive symptoms, 10-14 moderate depressive symptoms, 15-19 severe depressive symptoms and 20-27 very severe depressive symptoms. It should be noted that despite the back-translation of the PHQ-9 into Lithuanian (Montvidas, 2018), the limitations of this instrument in its application in Lithuania are that there is no study that has yet standardised the Lithuanian version of the PHQ-9 in the Lithuanian population, and no Lithuanian-specific baseline threshold has been established for the assessment of a diagnosis of depressive disorder. In this study, in order to avoid overdiagnosis, clinically significant depressive symptoms, where additional psychiatric consultation is recommended to confirm the diagnosis of depression, were considered when the sum of the respondents' scores was greater than or equal to 15.

Statistical analysis of the data was performed using SPSS (Statistical Package for Social Sciences) v. 25.0 (Armonk, NY, USA). The Shapiro-Wilk test was used to test the normality of the data. The $\chi 2$ (Chi-squared) test was used for the analysis of categorical data. Arithmetic means and standard deviations (SD) were calculated for the analysis of some quantitative continuous and discrete variables. A difference in results was considered statistically significant when the resulting p-value was less than or equal to 0.05. Given the univariate cross-sectional study design, the dependent variable was depressive symptomatology and the independent variable was EQ level. To assess the relationship between the analysed traits, Pearson's linear correlation coefficient (r) was calculated. According to the calculated correlation coefficient, the strength of the association between the analysed traits was assessed on a scale from 0 to 1 or from 0 to -1. If r = 0, there was no relationship between the variables. The correlation coefficient ranged from - 1 to - 0,7, indicating a strong inverse relationship, from - 0,7 to - 0,5, a moderate inverse relationship, from - 0,5 to - 0,2, a weaker-than-average inverse relationship, and from - 0, 2 to 0 - weak inverse relationship, from 0 to 0.2 to 0.2 weak direct relationship, from 0.2 to 0.5 to 0.5 to 0.5 to 0.7 weak moderate direct relationship, from 0.7 to 1 - strong direct relationship. In order to make

sure that the resulting correlation is not a coincidence, and the relationship between the variables is significant, the p-value is estimated to be less than or equal to the relationship between the variables being analyzed is statistically reliable.

## RESULTS AND DISCUSSION

The cross-sectional study included 21 - 68 (mean: 40.1 ± 12.9) nurses, exclusively female (n = 74). According to Table 1, the estimated distribution of subjects by education was based on a large proportion of nurses with a higher non-university education (51.4%) and a slightly smaller proportion with a higher university education (23.0% and 25.7%). The distribution of nurses in terms of years of work experience, the highest proportion of junior nurses (52.7), with 1 - 5 years of work experience. At 16.2 per cent of the 11 - 20 years of seniority, and at 6 - 10 years and 21 - 30 years of seniority were only 6.8 and 8.1 per cent of the nurses respectively. The nurses' characteristic of the worker's activity revealed that most of the worker's activity (64.9). The number of nurses is 24.3 per week for 40 - 50 hours a week and 10.8 per week for 50 - 60 hours a week. The results show that nurses work 12 to 14 hours a week, but 89.2 percent of the 12-hour workweek, almost every ten nursing worker (10.8) - 14-hour workweek. Regarding the practice of night work weekly, 12 hours night work 16.2 percent, 12 hours night work - 18.9 percent, and 36 hours night work - 6.8 percent nursing.

Table 1

**Distribution of nurses (%) by socio-demographic characteristics and occupational characteristics**

| Variables | | % |
|---|---|---|
| Age | < 41 years old | 54,1 |
| | ≥ 41 years old | 45,9 |
| Education | Post-secondary education | 23,0 |
| | Higher non-university education | 51,4 |
| | Higher university education | 25,7 |
| Seniority | 1 – 5 years | 52,7 |
| | 6 –10 years | 6,8 |
| | 11 – 20 years | 16,2 |
| | 21 – 30 years | 8,1 |
| | > 30 years | 16,2 |
| Duration of work (hours per week) | 36 – 40 hours | 64,9 |
| | 40 – 50 hours | 24,3 |
| | 50 – 60 hours | 10,8 |
| Shift duration (hours) | 12 hours | 89,2 |
| | 14 hours | 10,8 |
| Duration of night work (hours per week) | 0 hours | 58,1 |
| | 12 hours | 16,2 |
| | 24 hours | 18,9 |
| | 36 hours | 6,8 |

According to the study, the average EQ expression intensity of the nurses was 121.2 ± 21.6 points. According to the level of EQ, the subjects were divided into low (20.3% (mean ± SN: 91.4 ± 20.8)), medium (63.5% (mean ± SN: 122.7 ± 6.9)), and high (16.2% (mean ± SN: 152.7 ± 7.8)) levels of EQ.

A more detailed analysis of the nurses' SSRIs revealed average subscale scores: the mean subscale score (± SN) for perceiving one's own emotions was 3.6 ± 0.7, the mean subscale score (± SN) for managing one's own emotions was 3.7 ± 0.7, the mean subscale score (± SN) for managing other people's emotions was 3.6 ± 0.7, and the mean subscale score (± SN) for using one's emotions was 3.9 ± 0.8. According to the data presented in Table 2, the nurses were distributed according to their low level of perception and management of their own emotions in 55.4% and 55.4%, respectively. When the distribution of nurses was assessed according to their ability to manage other people's emotions, it was found that 52.7% of the nurses had a low level of skills of managing other people's emotions. The results of the study related to the use of emotions, i.e. the ability to use emotions to facilitate various cognitive activities such as thinking or problem solving, showed that as many as 58.1% of the nurses had a low level of skills in using emotions.

Table 2

**Distribution of nurses (%) according to SSRI subscale results**

| SSRI subscales | Low level EQ | High level EQ |
|---|---|---|
| Perception of own emotions (%) | 55,4 | 44,6 |
| Managing own emotions (%) | 55,4 | 44,6 |
| Managing other people's emotions (%) | 52,7 | 47,3 |
| Use of emotions (%) | 58,1 | 41,9 |

The distribution of nurses according to EQ level, taking into account sociodemographic characteristics (age, education) and work characteristics (length of service, duration of weekly work, duration of night and shift work), did not reveal statistically significant differences between the variables analysed ($p > 0.05$). On the other hand, a statistically significant difference was found between the variables analysed with regard to the place of work of the nurses. Specifically, a significantly higher proportion of nurses working in primary care (47.8%) had low EQ levels compared with nurses working in emergency care (0%) and in hospital (9.1%) ($\chi 2 = 18.2$, $p = 0.006$).

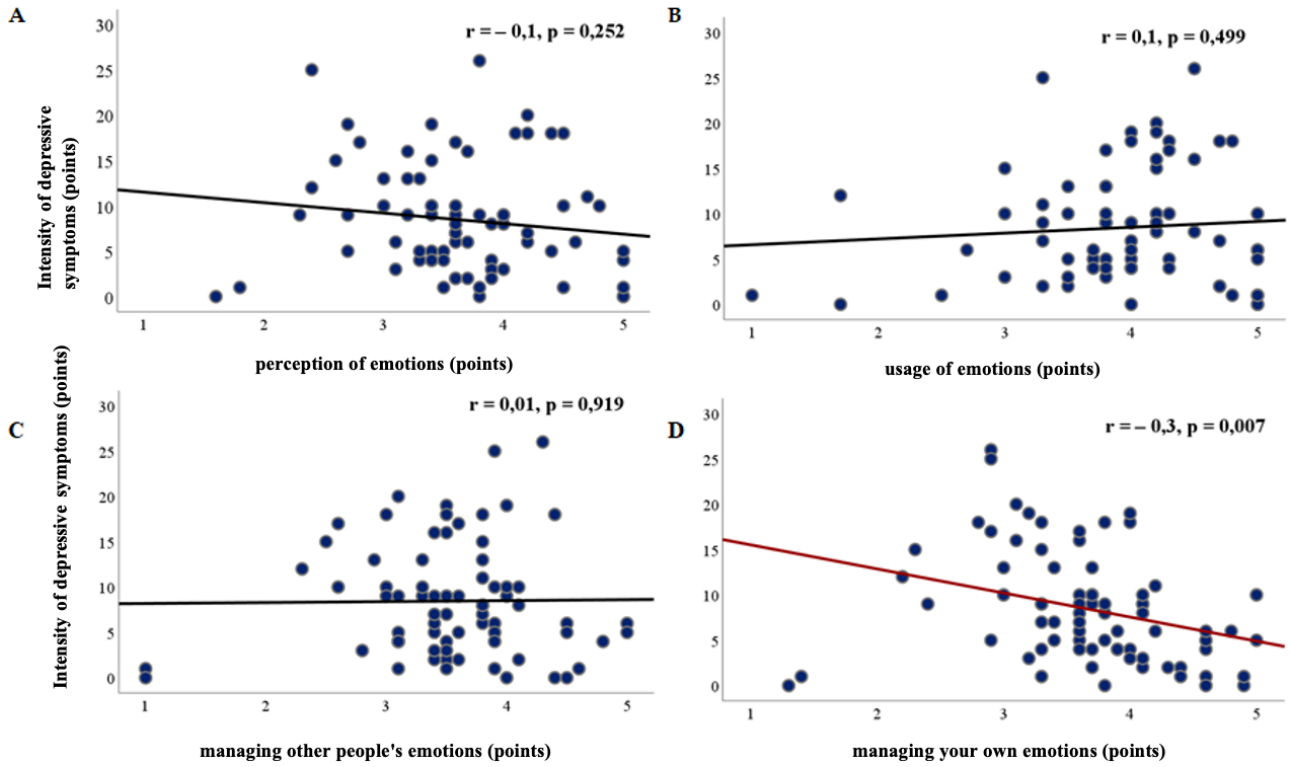



Figure 1. **Relationship between nurses' intensity of depressive symptom expression and EQ components**

Note: A - relationship of depressive symptomatology with level of emotion awareness ($r = -0.1$, $p = 0.252$); B - relationship of depressive symptomatology with level of emotion use ($r = 0.1$, $p = 0.499$); C - relationship of depressive symptomatology with level of emotion management in other people ($r = 0.01$, $p = 0.919$); and D - relationship of depressive symptomatology with level of self-management of emotion ($r = -0.3$, $p = 0.007$).

In the next steps of the data analysis, the nurses' depression symptomatology was almost evenly distributed between nurses with minimal (31%) and low (34%) depression symptoms. Moderate depressive symptoms were experienced by 15% of the subjects. One in five (20%) nurses had severe and very severe, clinically significant symptoms of depression.

Finally, the correlation analysis revealed no statistically significant relationship between the intensity of nurses' depressive symptom expression and the EQ components related to perception of emotions ($r = - 0.1$, $p = 0.252$) (Fig. 1, part A), use of emotions ($r = 0.1$, $p = 0.499$) (Fig. 1, part B) and management of others' emotions ($r = 0.01$, $p = 0.919$) (Fig. 1, part C). At the same time, there was only a statistically significant inverse relationship between depressive symptomatology and the level of self-management of emotions ($r = -0.3$, $p = 0.007$) (Figure 2(D)), suggesting a possible negative association of poor self-management of emotions with more intense depressive symptomatology.

In conclusion, when health care institutions in Lithuania need to implement programmes to prevent psychological violence and alcohol consumption, to protect and enhance the mental health of nurses and to reduce depressive symptomatology, the recommendations of this study should be focused on the consistent rationalisation and optimisation of the existing prevention programmes, integrating an emotional literacy component, which would include: (1) Targeted specialised counselling by psychologists in healthcare settings, with the aim or objective of developing

emotional literacy among nurses; (2) the use of mindfulness and acceptance psychology-based methodologies. (2) Introducing Mindfulness in health care settings and providing practical training and encouragement for nurses in key mindfulness exercises (cognitive behavioural therapy-based sessions, yoga, meditation).

Our study has limitations related to the relatively small sample size and the convenience sampling method. For these reasons, the results of the study should be interpreted and applied to a larger population of nurses with caution. In addition, a further longitudinal (cohort) prospective study in a larger cohort of Lithuanian nurses is needed to further validate the results of our pilot study.

## CONCLUSIONS

The majority (63%) of nurses have only a moderate level of emotional intelligence. Nearly one in five (20.3%) nurses working in Lithuanian personal health care institutions have an insufficient level of emotional intelligence. The riskier group of nurses with insufficient emotional intelligence is exclusively represented by nurses working in primary health care institutions.

Nurses working in Lithuanian healthcare institutions are at increased risk of depressive disorders: one in five (20%) nurses experience clinically significant depressive symptoms that are predictive of a diagnosis of a mental health problem.

The higher prevalence of depressive symptoms among nurses working in Lithuanian healthcare institutions is related to a lack of emotional literacy, which is uniquely determined by the nursing staff's lack of capacity to manage individual emotions.

## REFERENCES

1. 2022–2027 m. darbuotojų saugos ir sveikatos veiksmų planas: 2022 m. balandžio 5 d. Nr. A1-251/V-693. (2022). https://e-seimas.lrs.lt/portal/legalAct/lt/TAD/81574c22b51711ec9f0095b4d96fd400?jfwid=-.
2. Akelaitis, A., ir Malinauskas, R. (2014). Vyresniojo mokyklinio amžiaus mokinių emocinių gebėjimų raiška per kūno kultūros pamokas. Mokslas ir edukaciniai procesai, 2 (19), 5–9. https://www.wem.lt/moksliniai-zurnalai-publikacijos/mokslas-ir-edukaciniai-procesai/2014-nr-2-19/.
3. Kroenke K., Spitzer R. L., & Williams J. B. (2001) The PHQ-9: Validity of a brief depression severity measure. Journal of General Internal Medicine, 16 (9), 606–613. doi:10.1046/j.15251497.2001.016009606.x.
4. Montvidas, J. (2018). Paciento sveikatos klausimynas-9. Biologinė psichiatrija ir psichofarmakologija, 20 (2), 57–59. https://biological-psychiatry.eu/wp-content/uploads/2019/01/JBPP_2018_v20_No2_57-59.pdf.
5. Moroń, M., & Biolik-Moroń, M. (2021). Trait emotional intelligence and emotional experiences during the COVID-19 pandemic outbreak in Poland: A daily diary study. Personaly and Individual Differences, 1(168), 110348. doi:10.1016/j.paid.2020.110348.
6. Open Source Epidemiologic Statistics for Public Heart. (2013). https://www.openepi.com/SampleSize/-SSPropor.htm.
7. Schutte, N. S., Malouff, J. M., Hall, L. E., Haggerty, D. J., Cooper, J. T., Golden, C. J., & Dornheim, L. (1998). Development and validation of a measure of emotional intelligence. *Personality and Individual Differences*, *25* (2), 167–177. https://doi.org/10.1016/S0191-8869(98)00001-4.
8. Uraz, D., & Arhan, B. (2020). Improved Performance and Effectiveness through the development of Emotional Intelligence in the Workplace. Journal La Bisecoman, 1 (5), 20–26. https://doi.org/10.37899/journallabisecoman.v1i5.267.
9. World Health Organization (2023). Data and digital health in the WHO European Region in 2022. A year in review. Available online: https://iris.who.int/bitstream/handle/10665/371068/WHO-EURO-2023-7393-47159-69055-eng.pdf?sequence=1.

PANEVĖŽIO KOLEGIJA ISSN 2029-1280, eISSN 2669-0071. Taikomieji tyrimai studijose ir praktikoje – Applied Research in Studies and Practice, 2024, 20.

# THE CHALLENGES OF ART EDUCATION IN THE CONTEXT OF DISTANCE LEARNING FOR HIGHER AND GENERAL EDUCATION

***Reda JONUŠAUSKIENĖ, Sigitas LAURINAVIČIUS***

*Panevėžio kolegija/State Higher Education Institution, Lithuania*

**Abstract.** Globalisation and advancements in digital technologies have significantly influenced education, particularly in the shift to distance learning. While not new, the importance of distance education grew during the COVID-19 pandemic, simultaneously exposing numerous challenges.

This paper aims to reveal problematic aspects of arts education in the context of distance learning in higher and general education. It identifies differences between art studies and general art education, examines activity models and working methods, and discusses the learning environment's importance in distance education. The methods employed include analysis and systematisation of information.

The following conclusions were reached. The fundamental differences between art studies and general art education are most evident in purpose and content, distinguishing professional competencies from self-expression. Dependence on technology complicates some traditional methods but enables broader access to content through well-designed tools. A well-equipped learning environment enhances students' capacity and shapes school culture, influencing attitudes towards artistic expression and intercultural competence, evolving with cultural contexts.

**Keywords**: Distance education; distance learning; learning environment; art education

## INTRODUCTION

Globalisation, the rapid development of digital technologies and the penetration of digital technologies in education and studies are constantly introducing certain adjustments. The usual emphasis is on the impact on quality, flexibility and accessibility of the learning process. On the other hand, we are witnessing how quickly, despite constructive progress, the established system can be seriously challenged, for example by pandemic constraints, warfare, climate or economic problems, and so, when it comes to studies and education, the focus naturally turns more towards distance learning. And although distance education, as Lamanauskas & Makarskaitė-Petkevičienė (2021) points out, is not a new subject in university practice, nor is it a new area of research, due to the constant changes in the technological and educational environment, it is, according to Melnikovas (2017), cyclical, constantly evolving, and remains relevant.

Interest in distance education increased particularly during the COVID-19 pandemic, when the global quarantine restricted the activities of contact schools, making distance education the only form of education that could be used without interrupting the learning process. At the same time, a number of problems have emerged for which no adequate preparation had been made. As revealed by various studies conducted by Merfeldaitė et al. (2020), Mishra et al. (2020), Lamanauskas & Makarskaitė-Petkevičienė (2021), Bilyakovska (2023), Prima et al. (2023), the problems were related to both technical resources, such as lack of computers, software, network capacity, and human resources, such as teachers' and students' willingness to use the technical equipment, lack of time, lack of adequately prepared teaching and learning materials, gaps in managerial work, and motivation.

Meanwhile, according to the researchers, the main advantages of distance education are its flexibility, convenience, accessibility and attractiveness, especially through modern computer technologies and the digitisation of content.

It should be noted that when analysing the science-art interface, the most common models in the scientific literature identify art as an aid to create a clearer or more playful presentation of scientific content. According to Kalogiannakis et al. (2021), to address the problems of content interest and learning motivation, the methodology of playfulness of the educational process is used, where fun visualisation and playfulness of the game principles, or their individual elements, are transferred to scientific or work situations. However, it was not possible to find any scientific work directly addressing the issues of the visual arts situation in distance education. Therefore, it is reasonable to ask what is the situation with visual arts subjects, i.e. art studies in the general context of distance education? How do or should the methods of teacher-pupil, teacher-student, teacher-student activity change? What is the role of the learning environment and what special skills and conditions does such learning require?

According to Kalogiannakis et al. (2021), to address the problems of content interest and learning motivation, the methodology of playfulness of the educational process is used, where fun visualizations and the principles of the game, or their individual elements, are transferred to scientific or work situations. However, it was not possible to find any scientific work directly addressing the issues of the visual arts situation in distance education. Therefore, it is reasonable to ask what is the situation with visual arts subjects, i.e. art studies in the general context of distance education? How do or should the methods of teacher-pupil, teacher-student, teacher-student activity change? What is the role of the learning environment and what special skills and conditions does such learning require?

**The aim** of this paper **is** to highlight the challenges of art education in the context of distance learning for higher and general education. To achieve this aim, **the objectives are:** to identify the differences between art studies and general art education; to provide an overview of the activity models and working methods that enable the successful achievement of the objectives of the subject; and to discuss the importance of the learning environment in distance learning.

The article is based on **the methods** of selecting scientific publications, analysing their content and organising the information into logical, task-oriented semantic fragments, as well as personal experience of practical work in a higher education institution and a general education school.

## DIFFERENCES BETWEEN ART STUDIES AND GENERAL ART EDUCATION

In order to highlight the problematic aspects of art education arising from the application of distance learning in higher education and general secondary education, it is worth first of all highlighting the fundamental differences between art education in art studies and art education in general education schools. These are most evident in terms of content and purpose. To take the Lithuanian situation as an example: while the purpose of art education in general education, which, according to the updated visual arts curricula, consists of the elective subjects of Art, Media Arts and History of Art, is 'to enable pupils to acquire the skills of creative expression in the arts, aesthetic appreciation of the environment and cognitive skills of visual creation' (summarised by the *General Curriculum (Bendrosios programos)*, 2022), it is much more difficult to define the purpose of the subjects of study in tertiary education in a generalised way. Especially in the field of study, which are directly oriented towards very specific activities requiring a high level of professionalism, as opposed to general education, which focuses on general cognition and self-expression.

However, it is not only the content and purpose of learning that differ, but also the maturity, motivation, attitudes, behavioural patterns, etc. of learners. It is difficult to expect that all 20 to 30 students in a class will have the same or at least a similar interest in art, when peers in the same group are united from the outset by their choice of study programme.

As Jucevičienė & Lipinskienė (2001) note, the critical aspects relevant to a particular student may differ from the critical aspects identified by other students. Therefore, it is very important to show and emphasise to students that each of them may see and perceive the same phenomenon differently. This is essentially the principle of individualised education, which is particularly relevant in the overall process of art education or art studies. The authors point out that such an individualised approach enables all participants in the teaching/learning process, including teachers, to develop their own experience alongside their own perception, while also becoming familiar with other students' ways of perceiving, and the critical aspects they have identified accordingly, so that two forms of learning – knowledge acquired on both an individual and a collective level – are intertwined and complement each other.

However, in distance learning conditions, where, according to Laužackas (2008), distance and/or time separates the learner and the teacher, and ICT is used for the transfer of information, the possibility of adequately applying the same methods of teaching and learning that were common during contact work changes. Of course, the activity model and working methods of a particular session are the competence and responsibility of each teacher at the same time, and the choice of the appropriate methods is as important as the content itself, which is why special attention must be paid to it.

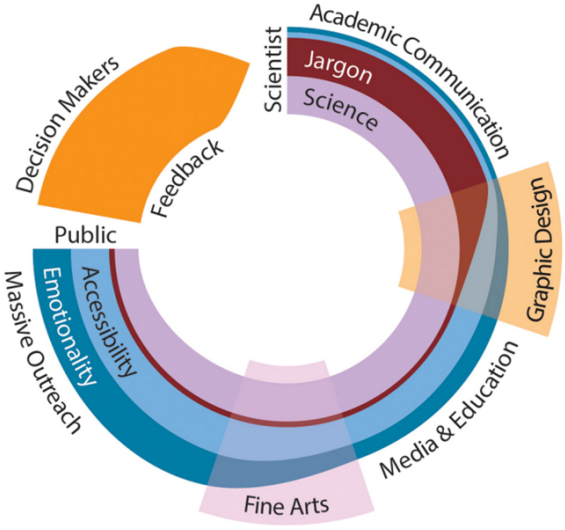



Figure 1. **Accessibility and emotionality in science education and communication**
Source: Zaelzer, C. (2020). The Value in Science-Art Partnerships for Science Education and Science Communication. *Eneuro*, *7*(4), p. 3.

As already mentioned in the introduction, the most common models in the scientific literature identify art as an aid to enliven or play with more complex scientific situations. Here, according to Braund & Reiss (2019) and Zaelzer (2020), the advantage of art is that it operates through emotions and experiences, and is therefore highly engaging and thus helps to delve deeper into even quite complex research questions. A visual example of this is illustrated in Figure 1, where a diagram drawn by the authors depicts the adaptation of scientific information for the general public through artistic solutions (see Figure 1).

## THE ROLE OF ACTIVITY MODELS AND THE LEARNING ENVIRONMENT

Traditionally, art studies and art education have been based on a wide range of individual practical-creative activities, accompanied by a wide range of oral and demonstrative methods, ensuring both the transfer of information to the learner and feedback, with real-time reactions to changes in the situation, and discussion of mistakes and solutions. In the case of distance education, this requires additional resources: filming or photographic equipment (in some cases tripods, additional lighting), software and the skills to use it all, replacing some of the spoken information with written information. Since, as mentioned above, distance and/or time separates the participants in distance education, each consultation, observation or evaluation comment leads to two extremes: in one case, lengthy descriptions, which are very time and energy consuming, in the other case, laconic and formal phrases.

Some traditional methods, such as working from life, creative collaboration in groups, collaborative project work, have to take on completely new forms, or become impossible in principle (e.g. drawing from life and drawing from a photograph, while similar on the surface, are very different methods). Individual masterclasses or seminars, case studies are hardly possible in distance education, unless they are carefully and technically prepared in advance. The realities and technical resources required for such a high quality preparation of teaching material can be seen in Figures 2 and 3.

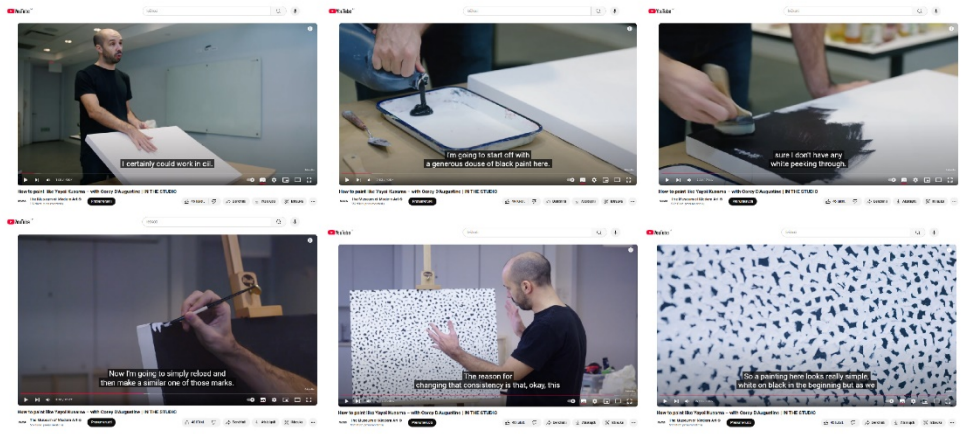



Figure 2. **Compilation of video snippets from MoMA's training sessions**
Source: The Museum of Modern Art. (March 23, 2017). *How to paint like Yayoi Kusama – with Corey D'Augustine* [Video]. YouTube. https://youtu.be/fZBC3nmvJb8?t=25

Figure 2 is a compilation of video excerpts from a training session organised by MoMA, the Museum of Modern Art. It shows at least 6 different filming angles and layouts, allowing to convey in detail the relevant visual information to the user (learner) according to the lesson plan, together with a professionally recorded soundtrack, without any noise or other distractions.

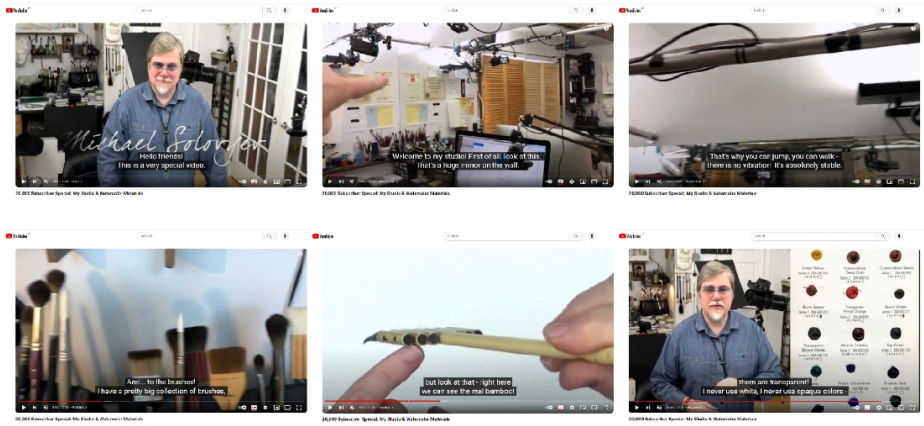



Figure 3. **Compilation of video parts on the studio of M. Solovyev**
Source: Watercolor. (Jul 21, 2020). *Michael Solovyev demo 1 Join* [Video]. YouTube. https://youtu.be/BsG8SGWYqOc

A similar situation is captured in Figure 3, a compilation of video fragments from the studio of M. Solovyev, a member of the Canadian and American Watercolour Association, where the author holds distance watercolour courses. This figure shows not only the different perspectives and viewpoints, but also the state-of-the-art studio equipment, which simultaneously captures the artist's movements, palette, the work in progress, and, when necessary, individual parts of the studio. There are also subtitles, although the original recording has a professionally produced soundtrack, a frame saver and different camera shots in one frame.

These are examples of technically excellent examples of distance learning, illustrating the multimedia and modern technology capabilities required by the distance learning environment for visual arts. However, as Neifachas et al. (2022) point out, the term "learning environment" encompasses two dimensions in parallel: the environment organised by the teacher and the environment in which the students learn. Various relevant sources link a well-equipped learning environment directly to the creation and enhancement of learners' learning power. For example, Jucevičienė & Lipinskienė (2001) explain learning power as the autonomy and responsibility given to the student by the learning environment to control his/her own learning process and to maintain the motivation for quality learning, while the *Lithuania's vision for the future "Lithuania 2050"* (*Lietuvos ateities vizija „Lietuva 2050",* 2023) emphasises the creative powers of the individual, stating that in order to develop these powers not only the quality of curricula is important, but also the physical environment of educational institutions, which is free from material resources that could in any way restrict learning (*Lietuvos ateities vizija „Lietuva 2050"*, 2023).

However, art education or art studies are not limited to technical facilities, theoretical knowledge and/or practical skills. Scholars are quite unanimous in their view that the cultural environment is an integral part of the learning process in order to develop the skills of aesthetic appreciation of the environment and the cognitive abilities of visual creativity. Burkė (2019) highlights the noticeable link between the creation of educational spaces as aesthetic environments and the formation of students' attitudes towards artistic expression.

Summarising the findings of various studies, Vilbikienė (2022) argues that the physical learning environment is a multifactorial holistic experience, which in turn shapes the culture of the school, manifested through the attitudes, behaviour, values, beliefs, habits, attitudes, and traditions of community members. Such a cultural context, according to Radzevičienė (2007), is understood as a specific culture, i.e. a worldview that is acquired and transmitted through teaching and social relationships. Through learning it, cultural competence is acquired, which may change with the changing cultural context.

The specificity of distance education in a globalised context clearly implies a growing multicultural context and the increasing importance of intercultural competence. However, this in part changes the relationship with the specific local cultural environment, some of the methods of operation and in some cases the set of value attitudes. And while there are sometimes doubts about the effectiveness of distance learning, it must be acknowledged that the evolution of information and communication technologies has made it inevitable that this field will evolve.

## CONCLUSIONS

The identified fundamental differences between art studies and art education in general education are most evident in terms of content and the purpose of the specific subjects, with a distinction between the competences necessary for professional performance and the development of individual self-expression and general aesthetic education. There may also be some differences due to the individual attitudes of the learners, personal needs or critical aspects relevant to a particular student. Meanwhile, research on the science-art interface treats the arts as a tool to enliven or gamify more complex learning situations.

In terms of operational models and working methods, distance learning itself becomes an important aspect, with distance and/or time separating the pupil or student and the teacher or lecturer. While it is understood that the choice of operational methods is the competence and responsibility of each teacher, the direct dependence on digital technologies implies the adaptation of methods to specific human resources and material environments. Distance and/or time differences and dependence on information technology make some traditional methods complicated or inapplicable, but the careful and high-quality development of teaching/learning tools opens up the possibility of creating wider and easier access to relevant content.

Researchers interpret the learning environment as a term that encompasses two dimensions in parallel: the one organised by the educator and the one in which the pupil or student learns; a well-equipped physical learning environment is linked to the creation and enhancement of the learner's power to learn and is seen as a multifactorial, holistic experience that, in turn, shapes the school culture. It shapes students' attitudes towards artistic expression and their overall cultural competence, which in turn changes as the cultural context changes.

## REFERENCES

Bendrosios programos: September 30, 2022, No. V-154. (2022). Valid edition from October 1, 2022. https://emokykla.lt/bendrosios-programos/visos-bendrosios-programos?KL_PROJ_5=3715

Braund, M., & Reiss, M. J. (2019). The 'Great Divide': How the arts contribute to science and science education. Canadian Journal of Science, Mathematics and Technology Education, 19(3), 219–236. https://doi.org/10.1007/s42330-019-00057-7

Burkė, A. (2019). Mokyklos estetinės ugdymo (si) aplinkos ir mokinių meninės saviraiškos sąsajos. Acta Paedagogica Vilnensia, 42, 99–128. https://doi.org/10.15388/ActPaed.42.7

Jucevičienė, P., & Lipinskienė, D. (2001). Edukacinė, studentą įgalinanti studijuoti, sistema mokymosi paradigmos kontekste. Socialiniai mokslai, (2(28)), 55–59. https://www.lvb.lt/permalink/f/1470m9t/LIT01LITLI000020719

Kalogiannakis, M., Papadakis, S., & Zourmpakis, A. I. (2021). Gamification in science education. A systematic review of the literature. Education sciences, 11(1), 22. https://doi.org/10.3390/educsci11010022

Lamanauskas, V., & Makarskaitė-Petkevičienė, R. (2021). Distance Lectures in University Studies: Advantages, Disadvantages, Improvement. Contemporary Educational Technology, 13(3), ep309. https://doi.org/10.30935/cedtech/10887

Laužackas, R. (2008). Kompetencijomis grindžiamų mokymo/studijų programų kūrimas ir vertinimas: monografija. Vytauto Didžiojo universitetas.

Lietuvos ateities vizija „Lietuva 2050“: December 23, 2023, No. XIV-2466. (2023). Valid edition from December 29, 2023. https://www.lrs.lt/sip/portal.show?p_r=35435&p_k=1&p_t=287183

Melnikovas, A. (2017). Nuotolinio mokymo funkcijų genezė technologinio ir edukacinio virsmo paradigmų kontekstuose. Bridges/Tiltai, 76(1). 113–126. https://doi.org/10.15181/tbb.v76i1.1517

Merfeldaitė, O., Prakapas, R., & Railienė, A. (2020). Nuotolinio mokymo organizavimas COVID-19 metu: bendrojo ugdymo mokyklų patirtis. Pedagogika, 140(4), 5–17. https://doi.org/10.15823/p.2020.140.1

Mishra, L., Tushar Gupta, T. & Shree, A. (2020). Online teaching-learning in higher education during lockdown period of COVID-19 pandemic. International Journal of Educational Research Open, 1, 100012. https://doi.org/10.1016/j.ijedro.2020.100012

Neifachas, S., Slušnienė, G., & Butvilas, T. (2022). Mokymo(si) aplinkos kaitos prasmių suvokimas: mokytojų veiklos pokyčiai kuriant pamokų turinį. Studijos–verslas–visuomenė: dabartis ir ateities įžvalgos: tarptautinės konferencijos mokslinių straipsnių rinkinys, 1(VII), 145–157. https://doi.org/10.52320/svv.v1iVII.243

Radzevičienė, A. (2007). Internationalisation of higher education institutions: human resource management [Doctoral Dissertation, Vilnius Gediminas Technical University]. Technika. https://vb.vgtu.lt/object/elaba:1966589/

Vilbikienė, G. (2022). Mokyklų architektūra kaip ugdymo (si) nuostatų erdvinė išraiška [daktaro disertacija, Vilniaus Gedimino technikos universitetas]. Vilniaus Gedimino technikos universitetas. https://www.lvb.lt/permalink/f/1470m9t/ELABAETD135751425

Zaelzer, C. (2020). The Value in Science-Art Partnerships for Science Education and Science Communication. Eneuro, 7(4), 1–6. https://doi.org/10.1523/ENEURO.0238-20.2020

Біляковська, О. О. (2023). Професійна підготовка майбутніх учителів в умовах цифровізації освіти. Наукові записки. Серія: Педагогічні науки, (210), 10–14. https://doi.org/10.36550/2415-7988-2023-1-210-10-14

Пріма, Р. М., Гончарук, О. В., & Пріма, Д. А. (2023). Формування цифрової компетентності майбутніх педагогів в інформаційно-освітньому середовищі закладу вищої освіти. Наукові записки. Серія: Педагогічні науки, (209), 81–86. https://doi.org/10.36550/2415-7988-2022-1-209-81-86

PANEVĖŽIO KOLEGIJA ISSN 2029-1280, eISSN 2669-0071. Taikomieji tyrimai studijose ir praktikoje – Applied Research in Studies and Practice, 2024, 20.

# SIDE EFFECTS EXPERIENCED BY PATIENTS AFTER TEETH WHITENING PROCEDURES

*Aušra RUDŽIANSKIENĖ, Justina STALIORAITYTĖ*

*Klaipėdos valstybinė kolegija /Higher Education*

**Abstract.** Nowadays, huge attention is paid to appearance, of which healthy teeth and a beautiful white smile have become an integral part. As teeth whitening procedures become more popular, newest teeth whitening products are emerging on the market, which, if used incorrectly, can damage the soft and hard tissues of the mouth. The aim of the study is to determine the side effects experienced by patients after teeth whitening procedures using different whitening methods. The study involved adult respondents who had undergone a teeth whitening procedure. A quantitative research method was applied. The results of the study showed that respondents undergo teeth whitening procedures either in dental offices or at home, and the main side effect they identify is tooth sensitivity, which occurs immediately or the next day.

**Keywords**: teeth whitening; side effects; tooth sensitivity

## INTRODUCTION

Relevance of the Study: Tooth discoloration is one of the most common complaints among patients seeking to improve the color of their front teeth. Over the past decades, aesthetic dentistry has become an important part of dental practice, and teeth whitening has become one of the most popular dental procedures. The market observes a variety of teeth whitening products, allowing the selection of major categories of professional teeth whitening products, whitening systems at home or in dental clinics. (Jin Y. at al, 2024; Awati A.S. at al 2024).

Objective: Reveal the side effects experienced by respondents after teeth whitening.

Tasks:

1. To find out which teeth whitening method respondents choose to improve the color of their teeth.
2. To determine the most common side effects after teeth whitening procedures.
3. Compare the tooth sensitivity experienced by respondents after teeth whitening procedures, whether they whitened their teeth in a dental office or at home.

## THE RESEARCH METHOD

A quantitative research method was chosen for the study. The study involved persons aged from 18 who had undergone teeth whitening. An anonymous questionnaire was used to obtain the results, and the data were not publicly published. 115 respondents participated in the study. The SPSS program version 24.0 was used to perform statistical analysis of the study data. MS Excel version 2010 was used to display the diagrams.

## RESULTS

Table 1

**Demographic Data of Respondents**

| **Demographic Factors** | | ***n*** | ***Percentage*** |
|---|---|---|---|
| Gender | Women | 93 | 80,9% |
| | Men | 22 | 19,1% |
| Place of Residence | City | 83 | 72,2% |
| | Village | 10 | 8,7% |
| | Town | 22 | 19,1% |
| Age | 18-29 years | 59 | 51,3% |
| | 30 years and older | 56 | 48,7% |

The study involved 115 respondents who used teeth whitening procedures. The majority of respondents were women, accounting for 80.9% (n=93). Most of the participants lived in the city 72.2% (n=83), 19.1% (n=22) lived in town, and 8.7% (n=10) lived in village. The age of the participants ranged from 18 to 65 years.

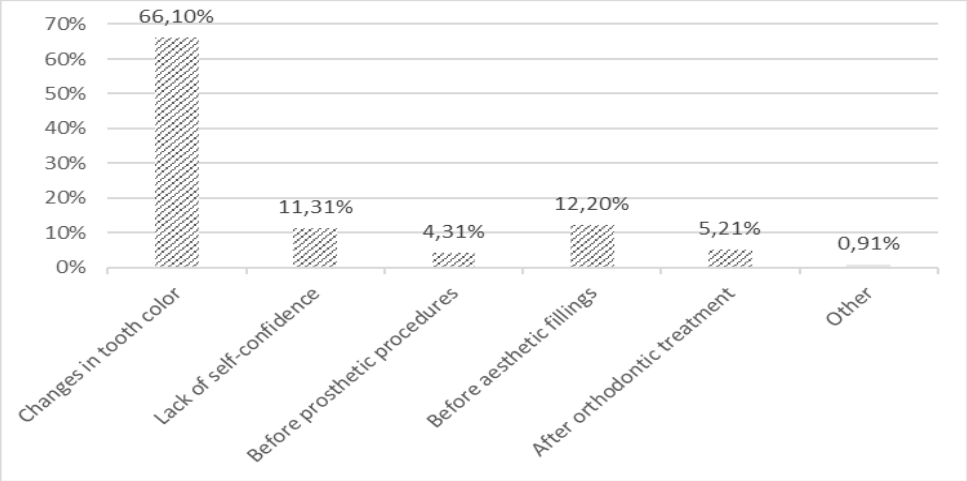



Figure 1. **Reasons Influencing Respondents' Choice to Whiten Their Teeth**

A conducted study showed (see Fig. 1) that the main reason respondents whiten their teeth is due to changes in tooth color (66.1%; n=76). The least chosen reasons for teeth whitening are before prosthetics and after orthodontic treatment, at 4.3% and 0.9%, respectively.

The aim was to determine the reasons for choosing to whiten teeth, comparing the distribution of respondents' answers between those living in the city and those living in the countryside/town.

Table 2

**Reasons Influencing Respondents' Choice to Whiten Their Teeth, Comparing Between City and Village/Town**

| Reasons | Place of residence | |
|---|---|---|
| | City (n=83) | Village/town (n=32) |
| Changes in tooth color | 75,9% (63) | 40,6 % (13) |
| Lack of self-confidence | 6 % (5) | 25 % (8) |
| Before prosthetic procedures | 2,4 % (2) | 9,4% (3) |
| Before aesthetic fillings | 10,8% (9) | 15,6% (5) |
| After orthodontic treatment | 4,8% (4) | 6,3% (2) |
| Other | - | 3,1% (1) |

The study found (see Table 2) that respondents living in the city and village/town most often choose teeth whitening procedures due to tooth color changes (75.9% and 40.6%, respectively). Those living in the city least often choose teeth whitening before prosthetic procedures (2.4%), while respondents living in the village/town least often choose teeth whitening after orthodontic treatment (6.3%). Joiner A, Luo W. (2017) in their article state that the main reason for an unattractive smile was the changed teeth color, i.e., stained or yellowed teeth.

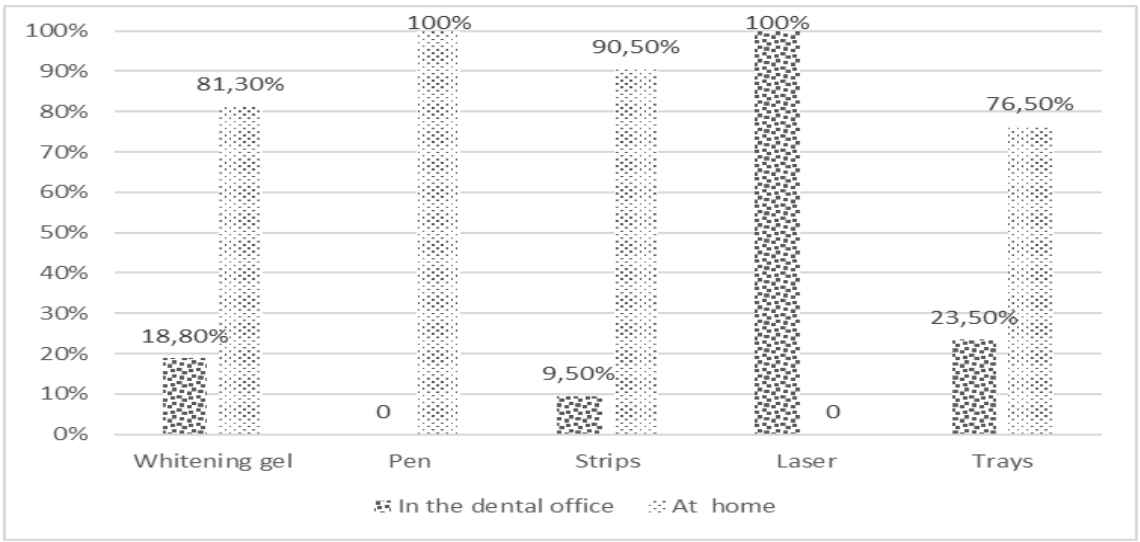



Figure 2. **Teeth Whitening Method Applied to Respondents**

Figure 2 shows that laser teeth whitening is most commonly used in dental offices (100%), while whitening strips are the least used (9.5%). At home, respondents chose whitening pens for teeth whitening (100%) and used whitening trays the least (76.5%). Naidu AS et al. (2020) in their study noted that whitening strips are the most effective home whitening products for changing tooth color. The conclusions of Zhao X et al. (2023) confirm that whitening systems are effective both at home and in dental clinics, and patients can decide which system to choose based on their personal preferences regarding treatment duration.

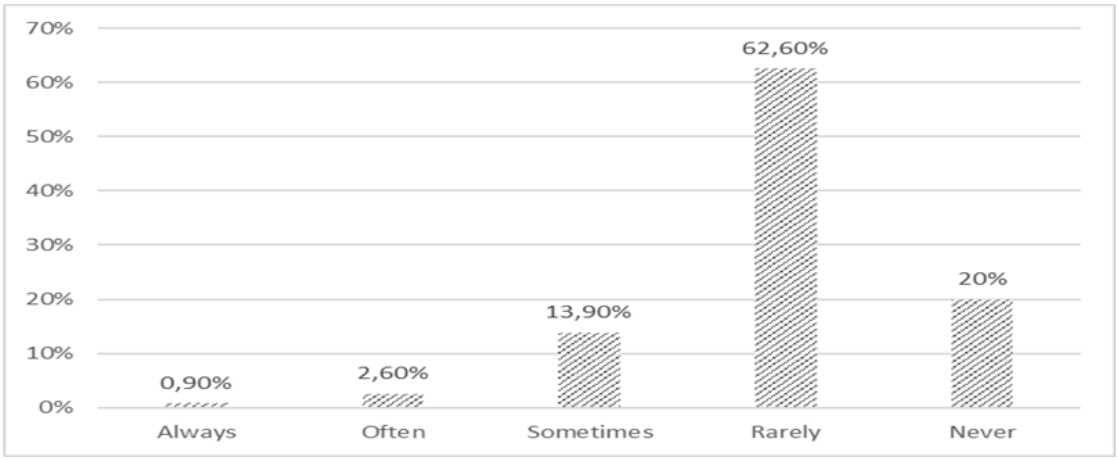



Figure 3. **Distribution of Tooth Sensitivity in Respondents Before Teeth Whitening Procedure**

The study results revealed (Figure 3) that 0.9% of respondents always felt tooth sensitivity before the teeth whitening procedure, while 62.6% of respondents rarely felt tooth sensitivity.

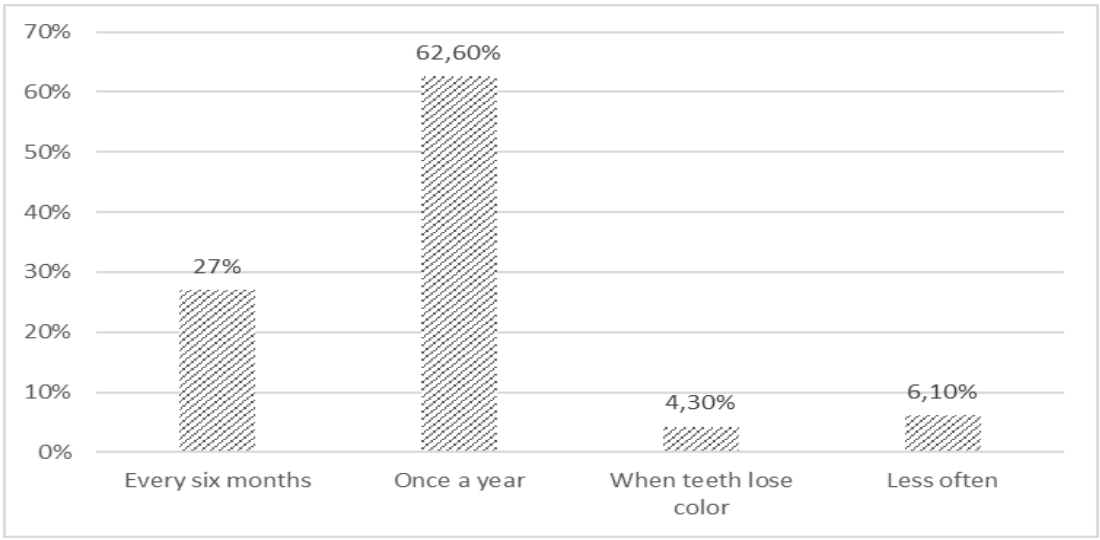



Figure 4. **Distribution of respondents' answers based on how often they whiten their teeth**

The study results showed (Figure 4) that the majority of respondents (62.6%) whiten their teeth once a year, while 4.3% of respondents stated that they whiten their teeth only when they lose color. Pan Q, Westland S. (2018) state that the teeth whitening procedure has become popular in order to improve the color and aesthetic appearance of teeth, and the respondents' choice was influenced by the desire to increase self-confidence and improve appearance. A study conducted by Awati AS et al. (2024) showed that 90% of patients choose whitening as a treatment method, which is considered minimally invasive.

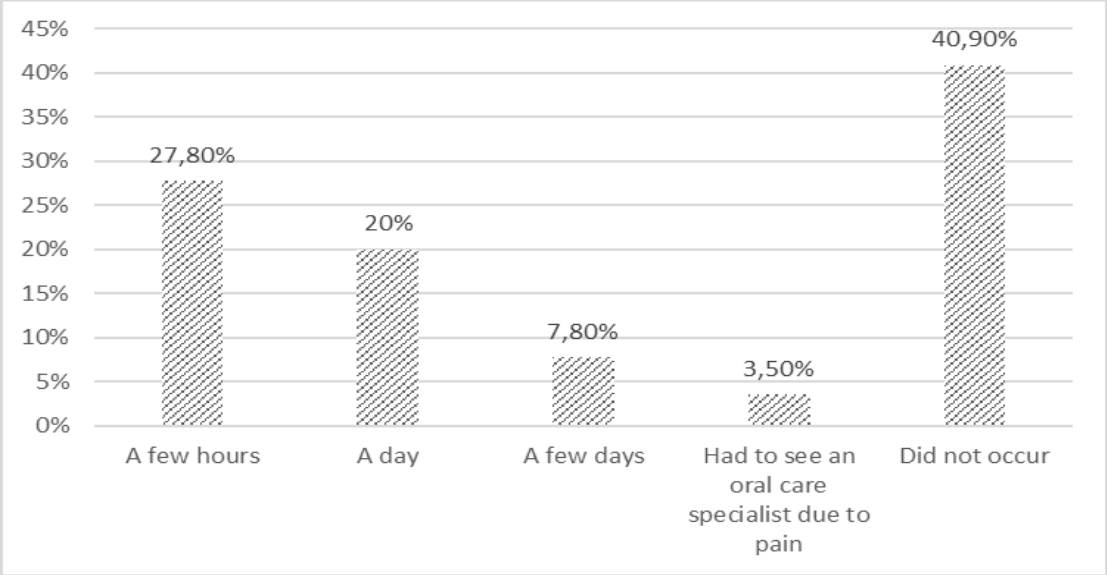



Figure 5. **Distribution of respondents' answers based on the duration of tooth sensitivity after the teeth whitening procedure**

The results of the study (Figure 5) showed that 40.9% of the subjects did not experience tooth sensitivity, while 3.5% had to consult an oral care specialist due to pain. Krishnakumar K. et al. (2022) in their article state that the most significant reduction in postoperative tooth sensitivity was observed immediately (within an hour) and 24 hours after in-office teeth whitening.

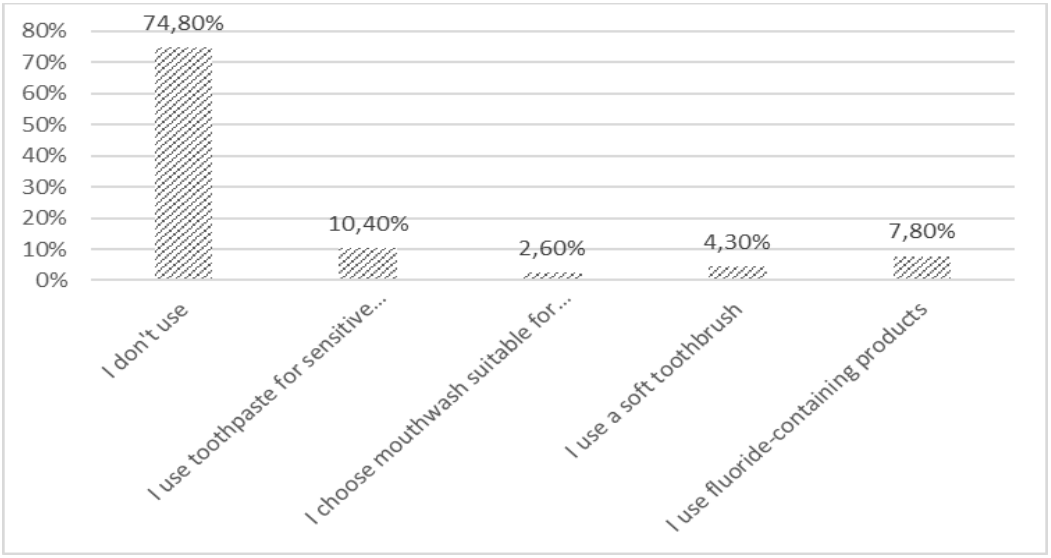



Figure 6**. Distribution of respondents' answers based on the measures they use to alleviate tooth sensitivity after the teeth whitening procedure**

The results of the study (Figure 6) showed that the majority of respondents, 74.8%, do not use additional measures to reduce tooth sensitivity after teeth whitening. Only 2.6% of the subjects use mouthwash for sensitive teeth. Cabral AEA et al. (2024) in their article state that toothpastes for sensitivity are effective when teeth are whitened at home with high-concentration carbamide peroxide or when teeth are whitened with highly concentrated hydrogen peroxide in the dental office.

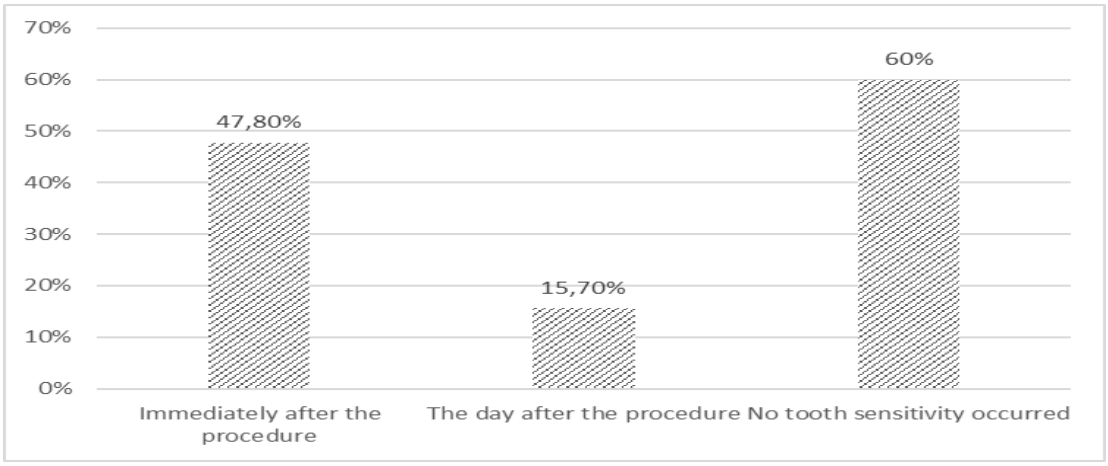



Figure 7. **Distribution of respondents' opinions on when tooth sensitivity occurred after the teeth whitening procedure**

The study found (Figure 7) that the majority of respondents, 60%, did not experience tooth sensitivity after teeth whitening procedures, while 15.7% of respondents experienced tooth sensitivity the following day. Teeth whitening causes increased tooth sensitivity and this is one of the side effects of teeth whitening (Rodríguez-Martínez, J.at al. 2019).

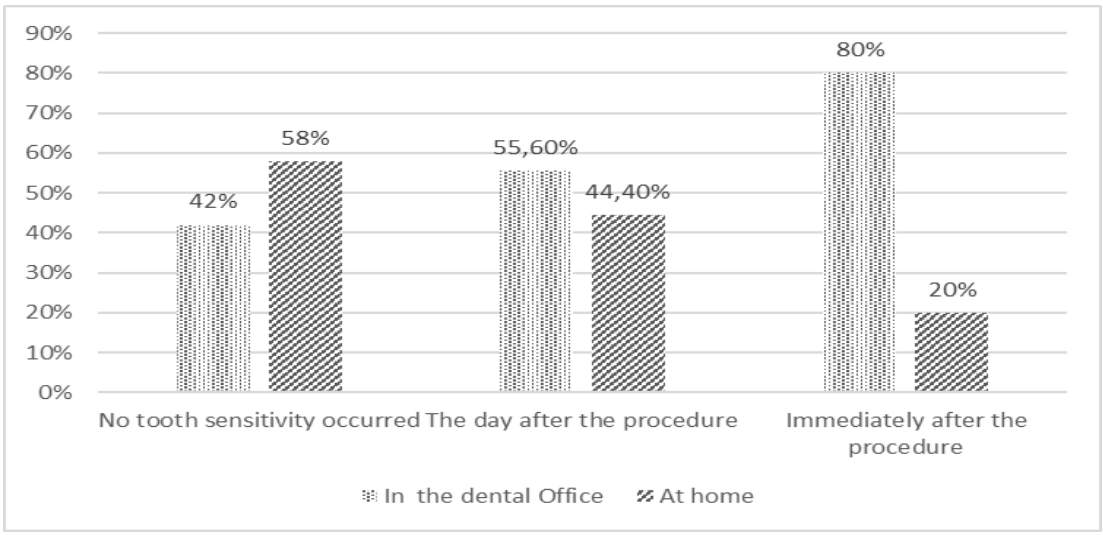



Figure 8. **Distribution of respondents' opinions on when tooth sensitivity occurred during in-office and at-home teeth whitening**

The study observed (see Fig. 8) that the majority of respondents (80%) who had their teeth whitened in the office experienced tooth sensitivity immediately after the procedure, while 42% did not experience any sensitivity. Among those who whitened their teeth at home, 58% did not feel any tooth sensitivity, and the least number of respondents (20%) experienced sensitivity immediately after the procedure.

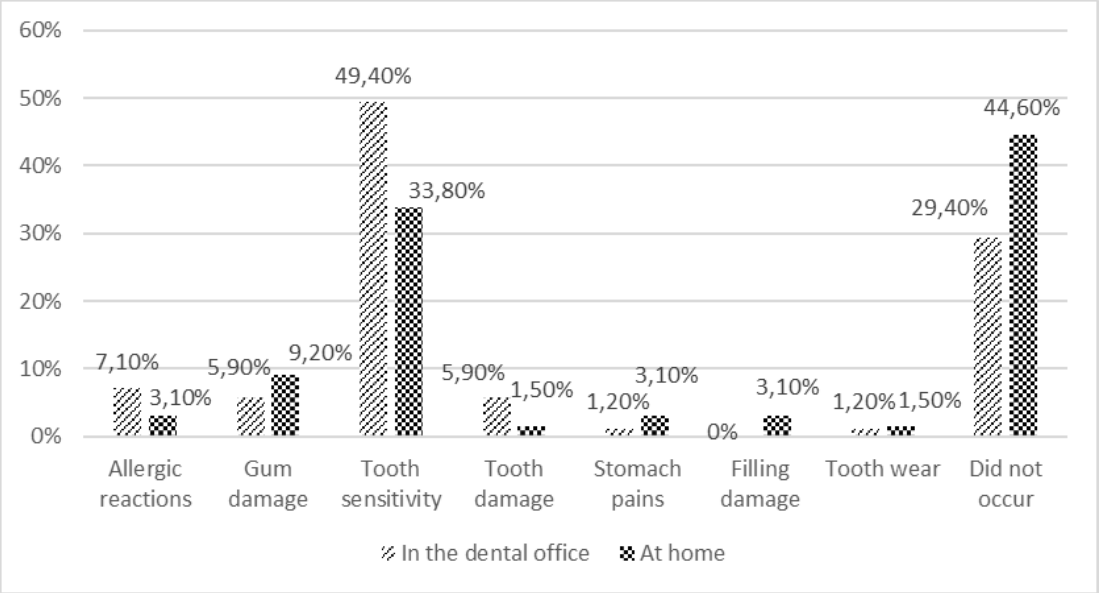



Figure 9. **Side effects experienced by respondents after teeth whitening procedures, both at home and in-office**

The results (Figure 9) showed that the most common side effect reported by patients whitening their teeth at home was tooth sensitivity, chosen by 33.8% of respondents. The least common side effects were tooth damage and wear, each reported by 1.5% of respondents. Additionally, 44.6% of respondents reported no side effects from home whitening. After in-office whitening, 49.4% of respondents reported tooth sensitivity as the most common side effect, while 29.4% reported no side effects. The least common side effects after in-office whitening were tooth wear and stomach pain, each reported by 1.2% of respondents. Barbosa et al. (2024) and Krishnakumar K (2022) state that the use of whitening agents can cause side effects such as tooth sensitivity, gum irritation, and changes to the enamel surface, including indentations and roughness. Aidos M. et al. (2024) mention in their study that there are no significant differences in tooth color changes between different whitening methods, as tooth sensitivity is present regardless of the chosen whitening technique.

## CONCLUSIONS

1. The results of the study showed that respondents prefer to whiten their teeth at home or in dental clinics to improve the color of their teeth. At home, they mostly use pencils, whitening strips and whitening gels for teeth whitening, while in dental offices, they most often used laser teeth whitening, and less often - whitening trays and whitening gel.
2. The most common side effects after teeth whitening procedures, as identified by the respondents, were teeth sensitivity, gum damage, allergic reactions, and teeth damage.
3. The results of the study showed that respondents who had their teeth whitened in a dental office experienced teeth sensitivity immediately after the procedure and the next day, while those who had whitened their teeth at home reported tooth sensitivity only the next day.

## REFERENCES

Aidos M, Marto CM, Amaro I, Cernera M, Francisco I, Vale F, Marques-Ferreira M, Oliveiros B, Spagnuolo G, Carrilho E, Coelho A, Baptista Paula A.(2024) Comparison of in-office and at-home bleaching techniques: An umbrella review of efficacy and post-operative sensitivity. Heliyon. 2024 Feb 3;10(3):e25833. doi: 10.1016/j.heliyon.2024.e25833. Erratum in: Heliyon. 2024 Nov 01;10(24):e39823. doi: 10.1016/j.heliyon.2024.e39823. PMID: 38371984; PMCID: PMC10873745

Awati AS, Paul A, Dhaded N, Joshi SB, Lagali-Jirge V.(2024) Effectiveness of KTP lasers in tooth bleaching, by comparing tooth color change after bleaching with KTP, Nd:YAG, Er:YAG, and diode laser system: A systematic review. J Conserv Dent Endod. 2024 Jul;27(7):685-694. doi: 10.4103/JCDE.JCDE_200_24. Epub 2024 Jul 8. PMID: 39262603; PMCID: PMC11385901.

Barbosa LMM, Amâncio Filha MBG, Leite JVC, Santos JVDN, De Medeiros JM, De Oliveira ILM, Pecho OE, Meireles SS, Lima RBW( 2024 ). Over-the-counter products in tooth bleaching: A scoping review. J Dent. 2024 Jun;145:104989. doi: 10.1016/j.jdent.2024.104989. Epub 2024 Apr 4. PMID: 38582435.

Cabral AEA, Lourenço MAG, de Medeiros Santos BS, Carvalho MG, Pazinatto RB, Leite FPP, de Melo LA.( 2024). Effectiveness of desensitizing toothpastes in reducing tooth sensitivity after tooth bleaching: a systematic review. Clin Oral Investig. 2024 Jul 30;28(8):457. doi: 10.1007/s00784-024-05857-2. PMID: 39078468.

Jin Y, Paranhos KS, Salamone A, Bongiorno W, Brizuela M.(2024). Internal Tooth Whitening. 2024 May 7. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2024 Jan–. PMID: 38753915

Joiner A, Luo W. (2017)Tooth colour and whiteness: A review. J Dent.;67:S3–10.

Krishnakumar K, Tandale A, Mehta V, Khade S, Talreja T, Aidasani G, Arya A.(2022) . Post-Operative Sensitivity and Color Change Due to In-Office Bleaching With the Prior Use of Different Desensitizing Agents: A Systematic Review. Cureus. 2022 Apr 11;14(4):e24028. doi: 10.7759/cureus.24028. PMID: 35547454; PMCID: PMC9090214.

Naidu, A. S., Bennani, V., Aarts, J. M., & Brunton, P. (2020, June). Over-the-Counter Tooth Whitening Agents: A Review of Literature. Brazilian Dental Journal, 31(3), 221-235.

Pan Q, Westland S. (2018 Jul). Tooth color and whitening – digital technologies. J Dent. 1;74:S42–6.

Rodríguez-Martínez, J., Valiente, M., & Sánchez-Martín, M.-J. (2019). Tooth whitening: From the established treatments to novel approaches to prevent side effects. Journal of Esthetic and Restorative Dentistry, 31(5), 431-440.

Zhao X, Pan J, Malmstrom H, Ren Y.(2023).Treatment Durations and Whitening Outcomes of Different Tooth Whitening Systems. Medicina (Kaunas). Jun 12;59(6):1130. doi: 10.3390/medicina59061130. PMID: 37374334; PMCID: PMC10302806.

PANEVĖŽIO KOLEGIJA ISSN 2029-1280, eISSN 2669-0071. Taikomieji tyrimai studijose ir praktikoje – Applied Research in Studies and Practice, 2024, 20.

# THE ROLE OF EDUCATORS IN SHAPING CARING MASCULINITY IN EARLY CHILDHOOD

***Rasa GLINSKIENĖ, Dalia URBONIENĖ***

*Panevėžio kolegija/ State Higher Education Institution, Lithuania*

**Abstract**. The article presents teachers' attitudes towards the development of caring masculinity in preschool and their role in this process. It is revealed that by fostering caring masculinity in preschool, children begin to become aware of gender stereotypes and norms, acquire important skills such as emotional awareness, the ability to care for themselves and others, maintaining friendships, and empathy. By promoting caring as a norm of masculinity, teachers can help reduce the negative impact of traditional masculinity norms on boys' development and promote gender equality.

**Keywords**: masculinity, gender norms, stereotypes, expectations, sexuality, caring

## INTRODUCTION

In recent years, the topic of caring masculinity has increasingly been addressed in European policy, academic studies and education. The first systematic survey of men and gender equality was carried out in all EU Member States in 2011-2012 (EIGE, 2012). For a long time, gender equality policies in Europe were focused on women, and men's role in this area indirectly reflected the general dominance of men in society. Gender equality was considered a concern for women and men – neutral. Gender mainstreaming and other policy measures helped to raise this topic. Men became visible and named in the context of gender equality: for example, in the conferences on men, masculinity and equality held during the Swedish (2001) and Finnish (2006) EU presidencies, or in EU programmes and strategies that encouraged men to take on care responsibilities and actively participate in gender equality policies. According to many authors (Hanlon, 2012; Scambor et al., 2014; Elliott, 2016), the focus is mainly on gender equality, a critical rethinking of traditional expectations for men and the already changing life practices of men. In order to change gender inequality, it is necessary to fundamentally change family and work policies, our patriarchal habits and discourses through various institutions that make up society: family, educational institutions, media, companies, etc. The results of research in countries participating in the international project ECARoM (2023) show that no country systematically implements gender equality-based pedagogy and attention to caring masculinity is rarely paid. Legal acts and policy documents discuss gender equality, diversity and caring issues to some extent, but they are often mentioned only in general terms, without providing any specific guidelines.

The Lithuanian research database contains few early childhood education studies and scientific articles that address the topic of gender and gender stereotypes. Although nurturing caring masculinity in preschool is an important factor in children's emotional and social development, teachers' attitudes and roles in this area may influence its effectiveness and implementation. Little is known about how teachers understand the concept of nurturing masculinity, what role they assign to nurturing caring masculinity in preschool, and how they integrate it into their educational practices.

## EARLY CHILDHOOD EDUCATION FROM A GENDER PERSPECTIVE

**The concept of caring masculinity.** Early childhood education in terms of gender is an important process aimed at shaping the concept of equal opportunities and equality from childhood, which has a significant impact on children's views of themselves and others and their opportunities in society. Successful education in this area can help reduce gender stereotypes, promote gender equality and create a more just and tolerant society in the future.

Caring masculinity is based on caring, not on fulfilling the role of breadwinner. According to Scambor et al. (2014), caring masculinity is increasingly implemented in men's everyday lives, but it is still an "alternative" masculinity that needs to be promoted by well-informed and knowledge-based policies.

Gracia, Garcia Roman (2015) emphasize that, having displaced the traditional family model, where the man was the breadwinner and focused on work, and the woman on care and family, today a new model prevails, where both family members work and take care of the family. However, this does not mean that the society in which these changes are taking place has achieved gender equality. Although women have increased their paid work hours and reduced their unpaid care time, and men have done the opposite, the differences still remain significant. The ageing of European society is leading to an increasing need for care, which is leading to a care crisis, which is manifested in the breakdown of the capacity to care. The social need is to achieve progress in equality, to reduce inequalities in the labour market and to increase and promote men's participation in care.

The concept of caring masculinity has emerged relatively recently. Nancy Fraser (1996) analysed the concept of care as a human norm, which responds to the concept of caring masculinity that obliges all areas. The concept of the

universal caregiver has been developed to highlight the value of care tasks and to encourage men to engage in these activities in order to achieve gender equality (Scambor et al. 2014).

Deevia Bhana et al. (2023) in her study of the gender distribution of caregiving roles found that hegemonic masculine ideals were based on the denial of childcare responsibilities, as the men in the study denied caregiving work, re-establishing gender hierarchies and placing the same responsibilities on women. She argues that calls for more men to work in European education and training institutions are sometimes based on the preservation of normative masculine ideals based on male role modeling. One aspect of the masculine role modeling discourse is the need for male teachers to restore boys' "failing" masculinity in school.

**Gender norms, stereotypes, expectations.** The term "gender" refers to the socially assigned roles, responsibilities, and opportunities associated with women and men, as well as the hidden power structures that regulate their relationships with each other. The study of gender norms, stereotypes, and expectations is closely related to the theoretical foundations of gender studies, sociology, psychology, and other disciplines. Within this theoretical background, several major theories can be distinguished:

- socialization theories – Emile Durkheim and Talcott Parsons examined the socialization processes in which people acquire gender roles and norms. They emphasize how society transmits gender roles from generation to generation;
- feminist theories – Simone de Beauvoir emphasized the importance of social equality for women and criticized traditional gender roles and stereotypes that encourage women to be only housewives and mothers, Judith Butler introduced the concept of "performance" equality, arguing that gender roles and identities are nothing more than social actions that an individual performs, taking into account expectations;
- cognitive psychology theories – Jean Piaget studied the cognitive processes by which children acquire adult gender norms and values. He explained how children learn about gender differences and how this influences their worldview;
- social constructionist theories – Peter Berger argues that social phenomena, such as gender roles, are socially constructed and depend on people's interpretations.

Despite recent progress, in most societies the rights and opportunities of women and men still differ significantly. Differences between men and women are related to opportunities for advancement at work, pay, and opportunities to participate in and influence decision-making processes. In reality, inequality between men and women is rooted in social norms and values throughout the world. According to Scambor, Holtermann (2023), gender norms and stereotypes are the basis of expectations that people have in their everyday lives related to gender, constraining and preventing the development of their interests and abilities. They develop the concept of caring masculinity as a counterpoint to dominant masculinity, because caregiving tasks require men to adopt values and caring traits that contradict dominant masculinity. They also emphasize that caring masculinities are a critical form of men's commitment to gender equality. These models of masculinity include values that stem from feminist care ethics, such as attention, interdependence, shared responsibility, support, and empathy**.**

**The role and influence of teachers in incorporating caring as a norm of masculinity in preschool education.** Teachers have an important and complex role in finding gender-sensitive educational strategies. When it comes to self-care, an important aspect includes learning empathy, recognizing and managing emotions, and understanding boundaries. Scambor, Holtermann (2023) argue that in order to change the hegemonic masculinity approach to relationships, it is necessary to develop self-care skills, promote self-reflection, teach not to be afraid to show joy, pain, and one's inner emotions. It is useful to promote activities that emphasize alternative masculinities and highlight the idea that boys are also sensitive to the environment and the world. Krišovà and Polankovà (2020) argue that gender-sensitive education is understood as education in which teachers are aware of gender inequality in society and the role of the educational process in gender socialization. This is an education in which teachers reflect on their own behavior patterns, teaching and communication methods with children, discuss the gender structure in society and create an environment in which everyone, regardless of their gender identity or gender expression, feels part of it. It is important that gender equality in the educational process is not only part of the educational content, but also an overarching principle that teachers follow when communicating with children. In preschool education institutions, children are encouraged to take care of themselves and others. Scambor and Holtermann (2022) argue that friendship is an important aspect of children's social, emotional and cognitive development. Children often prefer friendship with children of similar age, gender, ethnicity and social behavior. Friendships in young children are usually characterized by games. However, activities of caring and being close to each other also play an important role. Developmental psychologists Rose and Asher (2017) believe that at an early age, children play more with members of the same gender group and that children's friendships differ depending on gender.

Research focuses mainly on girls' friendships and their benefits, such as caring, helping, and conflict management. Boys' friendships are left aside and it is implicitly stated that they are less interested in friendships or are not good friends. However, boys' friendships can be just as valuable and stable as girls'. Active promotion and modeling of caring masculinity is important for both boys and girls, in order to ensure that friendships are not constrained by gender stereotypes. By establishing new friendships with members of the opposite sex, children learn to meet different needs and recognize them, expressing friendship through different activities and actions. It is important for the educator to support them in already familiar activities and show new ways of expressing friendship, caring, and emotions. The problem of violence and bullying, which manifests itself in aggression directed at another person, is increasingly common in preschool institutions. Legkauskas (2013) identifies one of the main reasons – lack of empathy. It is appropriate to start

developing empathy at an early age in order to reduce bullying in children in older age. According to Siegler et al. (2016), empathy describes the ability to empathize with another person's emotional state or situation. A prerequisite for the formation of this skill is the ability to recognize and understand other people's emotions. Already at an early age, children begin to worry about the negative emotions of other people, especially children. They do not necessarily suffer with others, but experience stress due to the suffering of others.

Empathy and emotions play a significant role in care work. They are also important when learning to understand the concept of caring masculinity. Understanding and empathizing with the situation of another strengthens the perception of the importance of caring masculinity and caring activities. Showing feelings, being empathetic, asking for help and providing it are gender-independent actions that everyone should cultivate.

By including caring as a masculine norm, teachers should be role models for children, demonstrating how men can be caring, responsible, and emotional and compassionate, because caring is not just a feminine trait, caring is an important, valuable quality for every human being. Teachers can create a safe and open environment in which children can freely express their feelings, regardless of their gender.

## RESEARCH RESULTS

**The aim of the study** is to analyze teachers' attitudes towards the development of caring masculinity in preschool age and their role in this process.

To achieve the research objective, a quantitative research method was chosen, using the questionnaire survey methodology. This method allowed collecting systematic and structured information about the research object, thus providing the opportunity to analyze the obtained data quantitatively. The questionnaire survey was conducted in March-April 2024, and its target group was preschool teachers currently working in preschool education institutions. 113 respondents participated in the study: 109 of them were women and 4 were men, which reflects the prevailing number of women in this sector. Although the study sample is not representative of the opinions of all Lithuanian educators, it provides valuable insights into the main trends and problems characteristic of this professional group. The results obtained allow us to assess the general moods, attitudes and challenges faced by preschool teachers, thus contributing to a deeper analysis of this area and the formation of possible solutions. The results of the study revealed that 43 percent of of the teachers who participated in the study have more than 10 years of work experience in the field of preschool education. This indicator allows us to state that the study was attended by educators who have accumulated significant practical experience and professional knowledge necessary for effective work with preschool children. It was also found that 35 percent of the respondents' work experience ranges from 1 to 5 years, which allows us to describe this group as educators who have already gained some experience, but are still developing their professional skills. A small part of the teachers who participated in the study, working in this field for less than one year, are most likely novice specialists who are just entering the field of preschool education.

When analyzing the work of educators with children of different ages, it was found that 21 percent of respondents work with children aged 3–4 years and 4–5 years. A significant proportion – 30 percent or 34 teachers – indicated that they work with children aged 5–6 years. Meanwhile, 27 percent of respondents work with mixed age groups, in which the age range of children is not strictly defined. These data reveal a great diversity of respondents' work experience and the age groups of children being educated, which provides a more complete picture of teachers' professional activities and the characteristics of their educational environment.

The results of the study reveal significant trends in teachers' experience with gender stereotypes in childhood, which may influence their attitudes and behavior in professional activities. Only one-fifth (20 percent) of respondents indicated that in childhood they were very often encouraged to choose certain behaviors, toys or clothes that correspond to their gender. This suggests that these teachers experienced a strong influence of gender stereotypes in shaping their understanding of gender roles. In addition, 35 percent of those surveyed said that they often encountered such encouragement in childhood, which suggests that almost half of the respondents experienced a strong influence of gender norms.

In contrast, 26 percent of the teachers participating in the study noted that these gender restrictions rarely occurred in their childhood. This suggests that this group was given more freedom to choose according to individual interests, with less restriction by traditional gender stereotypes. Even more interesting is the proportion of respondents who said that they were never encouraged to choose gender-specific behaviors, toys or clothing – this amounts to just over a fifth (21 percent) of all participants. These teachers may have grown up in an environment with fewer gender stereotypes and greater emphasis on individual self-expression (Figure 1).

These data reveal that teachers' childhood experiences with gender stereotypes vary. Some respondents grew up in environments where gender differences were strongly emphasized, while others experienced less or no pressure from gender stereotypes. This may have implications for their views on the formation of gender roles in educational institutions. Teachers who themselves encountered less stereotypical encouragement in childhood may be more inclined to apply inclusive, gender-stereotype-breaking educational practices. Meanwhile, those who experienced more stereotypical pressure may intuitively transmit these norms to their students. Thus, these results reveal not only individual experiences, but also possible links to pedagogical practice and the ways in which gender stereotypes are transmitted in educational environments.

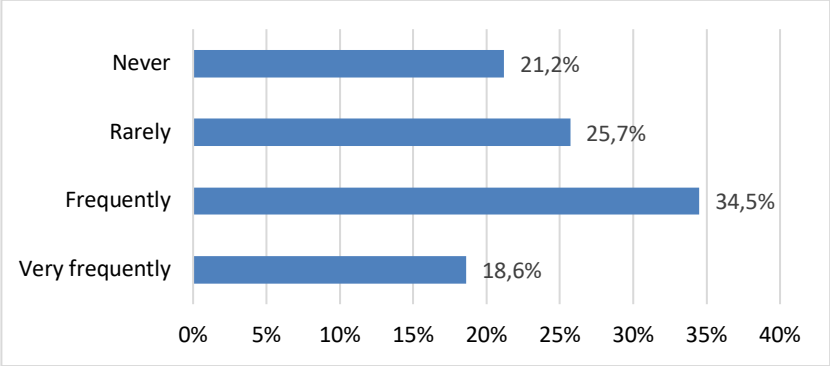



Figure 1. **Promoting gender choices in childhood**

The survey asked respondents whether they had encountered the term "caring masculinity". The results showed that less than half (47%) of respondents said they had heard the term, while 53% admitted that they were not familiar with the term. These data suggest that the awareness of almost half of respondents about this concept reflects a growing interest and awareness of gender role diversity and flexibility. However, the fact that more than half of teachers have not heard the term highlights the gaps in this area. This may be due to limited information availability, lower personal or professional interest, or the influence of dominant gender stereotypes.

These results highlight the need to promote awareness of gender role flexibility by including this topic in curricula and teacher professional development activities. This is particularly relevant in the field of pre-school education, where ideas of gender equality and diversity can be integrated into educational processes from an early age. The concept of "caring masculinity" in question refers to men's ability and willingness to care for their family and loved ones not only materially but also emotionally. It includes empathy, emotional availability, the ability to express love, understanding, and active participation in childrearing, family life, and community activities. This approach not only promotes gender equality, but also allows men to discover new ways of expressing themselves in various areas of life, contributing to the creation of an emotionally richer and healthier society.

Additionally, respondents were asked how they understood the concept of "caring masculinity". Slightly less than half of respondents expressed agreement, neutrality or at least partial agreement with the statement that caring masculinity is the opposite of hegemonic masculinity. They acknowledged that this term encompasses the transformation of men's roles from traditional breadwinner to active participation in family life and fatherhood. These responses indicate that most respondents tend to agree that masculinity can be understood as a dynamic relationship between traditional and modern values that emphasize emotional and social connection to family and community. This indicates that educators are becoming increasingly open to new approaches to gender roles, but also highlights the need to more actively disseminate these ideas in the educational context.

More than half of the respondents expressed a negative or partially negative attitude towards the statement that caring masculinity is associated with questioning traditional masculine values and norms that society applies to men's behavior. This result indicates that some respondents are not inclined to associate caring masculinity with a critical attitude towards the norms defining masculinity or are inclined to view them sceptically. This may be due to the fact that traditional masculine values are still strongly entrenched in society, or to the view that caring does not necessarily have to be interpreted as a revision of these norms. However, this attitude also reflects changes taking place in society, which encourage the inclusion of more diverse and flexible norms in the concept of masculinity.

Most respondents (more than half) agreed or strongly agreed with the statement that caring masculinity includes understanding how to be a good father. This shows that caring is often associated with active participation in raising children and caring for their well-being. The largest part of respondents also expressed agreement with the statement that caring masculinity includes the ability to care for and support family members and loved ones. This view reveals that the role of men in the family is perceived not only through the prism of material provision, but also through the provision of emotional, social and psychological support. The ability to care for family members includes such aspects as emotional availability, readiness to provide assistance to loved ones in solving problems and overcoming difficulties. Caring is manifested by active participation in everyday family activities, including household chores and childcare. The ability to support family members emotionally, contribute to conflict resolution and create a harmonious family atmosphere is also important. These results indicate that caring masculinity is increasingly perceived as an integral, multifaceted form of masculinity that emphasizes not only responsibility for the well-being of the family, but also emotional connection with its members (Figure 2).

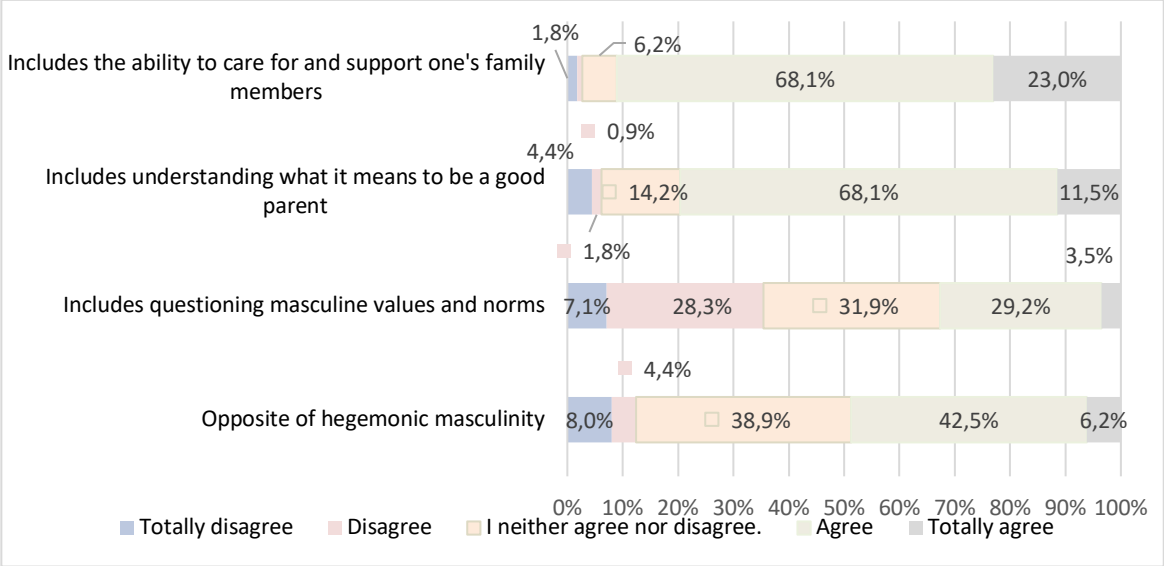



Figure 2. **Perceptions of caring masculinity**

Childcare can be seen as a first indicator of broader changes, gradually expanding forms of care and including them in various areas of life. As the study "Men's Role in Gender Equality" shows, changes in the division of care work between men and women are more likely to occur in the family environment than in the professional sphere. The level of male participation in the professional care sector has remained stable over the past decade, but low – in most European countries, men account for less than 15% of (paid) care workers (Scambor, Wojnicka and Bergmann, 2014).

Numerous studies confirm that quality early childhood education has long-term positive consequences. These consequences include better academic achievement, greater employment opportunities, as well as better social and emotional adjustment. Early childhood education, which is accessible and inclusive, is particularly important for promoting equality and reducing social exclusion and inequality. Given this context, the study asked whether preschools should be more actively involved in gender stereotype reduction programs (Figure 3). The results showed that the majority of respondents agreed with this idea: more than one in ten strongly agreed, and a significant proportion said they agreed.

However, there are also differences of opinion. Slightly less than half of the respondents (37%) chose a neutral position, stating that they do not have a clear opinion on the involvement of preschool institutions in gender stereotype reduction programs. This may indicate indecision or a lack of information about the effectiveness of such programs and their potential benefits. Meanwhile, a small part (8.8%) of the respondents expressed their disagreement with these initiatives, doubting their necessity, effectiveness or importance.

These results reveal that the question of why gender stereotype reduction programs are necessary and what methods could ensure their effective implementation requires more detailed scientific research. In-depth analysis could help formulate effective strategies and provide clear arguments that would strengthen support for these programs and the importance of their implementation. Such an approach could contribute to the promotion of gender equality and inclusion in the context of preschool education.

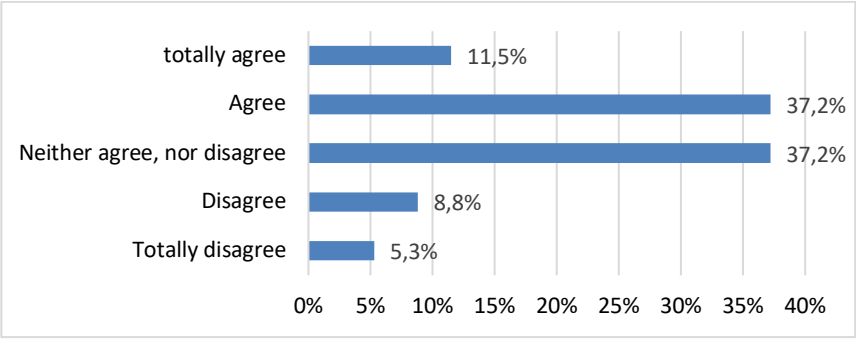



Figure 3. **The role of preschool institutions in reducing gender stereotypes**

The study aimed to identify three main aspects related to the development of caring masculinity in preschool age. Respondents were given the opportunity to choose several possible answers (Figure 4). More than half of the respondents indicated that it is extremely important to develop tolerance and understanding towards other people.

Early formation of tolerance and understanding provides children with essential social skills that help them communicate effectively with people from different cultures and backgrounds. Such qualities not only contribute to the creation of friendly and harmonious interpersonal relationships, but also reduce the risk of conflicts and misunderstandings in the future. This process is particularly important in order to promote social inclusion and develop a respectful attitude towards the differences of other people from early childhood.

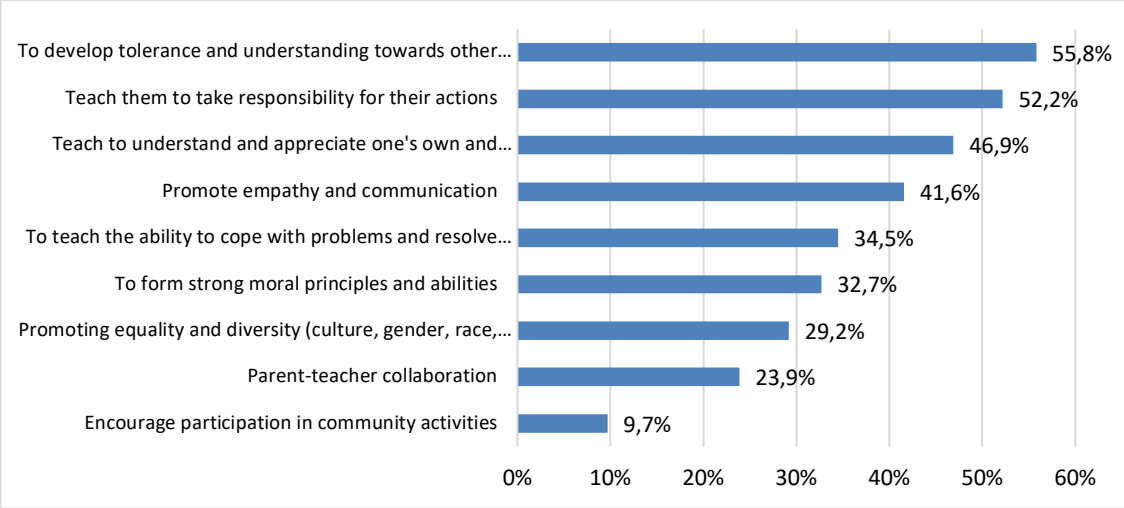



Figure 4. **Aspects of caring masculinity**

Tolerance, forbearance and mutual understanding are essential factors ensuring the well-being of both the individual and society. The results of the study showed that 52 percent of respondents agree with the statement that it is extremely important to develop the ability to take responsibility for one's actions at preschool age. This indicator reflects the general perception that children must not only act, but also understand the consequences of their behavior. Developing responsibility promotes such qualities as honesty, self-esteem, the ability to solve problems and independence. When analyzing the respondents' answers, it was noted that 42 percent of them emphasized the importance of developing empathy. Also, more than a third of respondents emphasized the need to teach children to constructively resolve conflicts and effectively cope with problems and challenges. Slightly less than half of those surveyed noted that it is necessary to form moral principles and skills. More than a quarter of the teachers participating in the study identified the promotion of equality and diversity (cultural, gender, racial differences) as an important element of education. The importance of parent-teacher cooperation was emphasized by 24 percent of respondents, while a small number of educators highlighted the need to encourage children to participate in community activities.

The study looked at specific strategies teachers use to reduce gender stereotypes in preschool education. The results of the study revealed that many educators choose gender-neutral strategies that promote cooperation and equality between boys and girls. More than half of the respondents use gender-neutral toys and books, create an environment suitable for all children, and encourage a variety of activities and interests that are not limited by gender stereotypes. 47 percent of respondents said that they always encourage children to participate in activities that are traditionally attributed to the other gender, but about 30 percent of educators never do this.

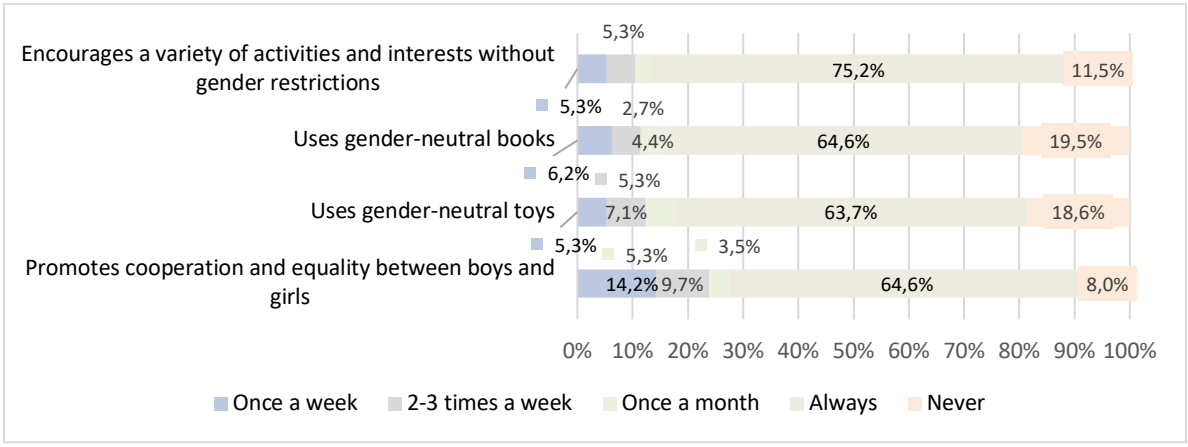



Figure 5. **Strategies for reducing gender stereotypes**

In addition, 58 percent of respondents indicated that they regularly include books, films and stories that promote the perception that any profession is achievable regardless of gender. About 54 percent of those surveyed regularly collaborate with parents to reduce gender stereotypes, but a third of educators (31 percent) do not undertake this activity. Parental involvement is particularly important because their role in raising children includes modeling gender equality, challenging rigid stereotypes, and promoting a diverse range of experiences and interests. This approach not only helps build respect and equality in relationships, but also contributes to the prevention of violence against women (Figure 5).During the study, educators were asked whether it is important to encourage children to play in groups other than one gender. The results showed that 24 percent of respondents said that it is very important, and 50 percent said it is important. Thus, the majority of respondents support this idea. Encouraging preschool children to play with friends of the opposite

sex is a significant factor in the development of social skills, as it helps children communicate and cooperate with different personalities, as well as reduce gender stereotypes, promote equality and understanding. The role of educators and parents in this area is extremely important, as the friendly and respectful behavior they encourage among children contributes to the creation of a positive social environment and reduces the likelihood of conflicts. However, 22 percent of respondents expressed doubt or neutrality on this issue, and only 4 percent indicated that it is completely unimportant.

The study also revealed that 59 percent of educators advocate that girls be offered to play with cars and boys with dolls, emphasizing that children should be given the freedom to choose toys according to their interests, regardless of their gender. Despite this, 41 percent of respondents said that they do not offer such activities.

Respondents were also asked about their methods of talking to children about care professions. 69 percent of educators said that they always use simple language that children understand, 22 percent said that they use such language less often (1-3 times a week or once a month), and 9 percent said that they never use simplified language. Many respondents noted that they include visual material, such as photos or illustrations depicting men and women working in care. This helps children understand and imagine these professions. In addition, educators often tell stories in which the main characters are male representatives of the caring professions, thus denying gender stereotypes about the distribution of professions and promoting awareness of the importance of caring.

Almost all respondents (98%) include interactive activities in the educational process that help children think actively, promote creativity and engagement. Only less than a tenth of educators indicated that they do not use such activities (Figure 6).

The results also revealed that the majority of educators organize creative activities during which children have the opportunity to express what they would like to be when they grow up. These activities are significant for the formation of children's personalities, as they help children to know their interests and aspirations and promote personal growth. Such involvement in the creative process not only develops children's self-expression, but also promotes their independence and confidence in their abilities.

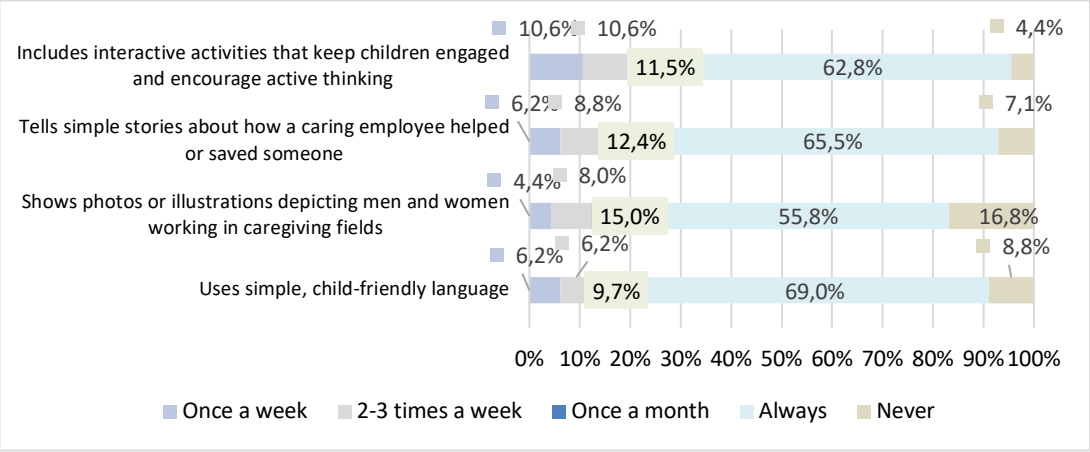



Figure 6. **Educational tools used by teachers**

The study participants were asked to indicate why it is important to develop caring masculinity skills in preschool age. They could choose to agree or disagree, maintain a neutral opinion, completely agree or completely disagree that developing caring masculinity skills at an early age increases children's self-confidence and confidence in others, children make new friends, reduce rude behavior among peers, better understand their own and others' emotions, and learn ways to resolve conflicts. From the answers provided, it can be assumed that the majority of respondents, about 85 percent. agree or completely agree that children's self-confidence increases, which can be associated with the opportunity to feel independent and confident in their abilities, trusting other people can help children communicate better and build relationships with others. More than half, 81 percent. of respondents, agree or completely agree that developing caring masculinity skills at an early age helps children integrate and make friends more easily, which indicates that these skills promote social interaction and integration into society. 84 percent. of respondents agree or strongly agree that nurturing caring masculinity contributes to less aggressive or rude behavior among peers. The vast majority (78 percent) agree that it helps children understand how to resolve conflicts and problems, and even 91 percent of respondents agree or strongly agree that it helps children better understand their own and others' emotions.

The study sought to find out whether nurturing caring masculinity in preschool has a long-term impact on children's development and life. Analyzing the results obtained, it can be seen that slightly more than half, 53 percent. of all respondents who participated in the study agree that nurturing caring masculinity in preschool has a long-term impact on children's development and life, and 14 percent. of teachers who participated in the study even completely agree with this conclusion. It is understandable that educators recognize the importance of this education and its long-term significance for children's lives. However, a significant proportion of respondents, 29 percent, who neither agree nor disagree with this statement, 4 percent. completely or strongly disagree with it. This shows that while many people agree with the importance of nurturing masculinity in preschool, there are still some doubts about this issue.

The question was asked what activities or methods teachers use to promote caring masculinity in preschool groups. Respondents could choose many possible options. The study shows that educators use various methods to promote caring masculinity in preschool groups. Less than a fifth of respondents say that they use group activities that promote cooperation and caring for others. Slightly more than a tenth, 12 percent. indicate that they use a method in which children participate in environmental care, promoting a sense of responsibility for the common space. Also, slightly more than a tenth of respondents chose reading fairy tales and discussions, during which the value of caring and empathy is emphasized. The practice of compliments and gratitude, which encourages expressing gratitude to each other, was chosen by slightly more than a tenth of the teachers participating in the study. In summary, it can be stated that these methods help children learn and understand the importance of caring and acquire skills that they can apply in their daily lives and relationships with other people.

The teachers who participated in the study were asked what comments or observations they would like to make about the development of caring masculinity in preschool. Respondents indicate the need for more methodological materials: "*maybe there should be methodological materials that would help organize such activities more easily, or recommendations for suitable fiction*". Several respondents emphasize the importance of emotional education for boys, stating: "*it is very important to teach and educate that a boy is not only the stronger sex, for whom crying is a sign of weakness*", "*the attitude that boys and girls have the same feelings*", which shows that teachers see the need to develop empathy and emotional intelligence. Many teachers believe that the role of the family is extremely important, stating that "*children should see a good example in families*", "*first of all, teachers themselves need to change their attitude towards different genders, then it will be easier and give up various phrases such as - you are a man, and men don't cry*", "*it is important when talking to children not to single out what only men do, but children must first see caring masculinity in their own family*". According to the respondents, teachers need special training: "*we need training for educators, more examples of activities*", "*but first the mindset of the older generation of educators should be changed*". It can be concluded that teachers feel the need for additional education and support in this area. Teachers support gender equality and freedom in games, stating that "*it is best when children can choose their own friends, without dividing them by gender*", "*children should grow up and enjoy childhood, but they should not be bombarded with too much information*". Some respondents who participated in the study believe that the development of caring masculinity should be included in educational programs. They state, "*in order for it to be included in the preschool education program*", "*stereotypes still prevail in society that girls only play with dolls, boys with cars, so it is necessary to educate not only educators, but also the public on this topic*". The respondents' answers show various opinions and approaches, because some believe that the existing measures are sufficient, "*I think it is enough that we adapt it and it is in your questionnaire*", others see a greater need for education and information, "*this is new education in preschool age, so more information is needed*". There are also opinions that the development of caring masculinity should not be artificially imposed, "*the development of caring masculinity in preschool age should not be artificially forced to ignore or deny the perception and assessment of traditional genders and roles*". The study participants understand that this is a new and important topic in preschool education, but it also poses challenges. They emphasize that "*it is a new and very necessary topic*", "*a very good choice of topic, especially relevant in modern society*".

In conclusion, it can be stated that the development of caring masculinity in preschool is an important and relevant topic, a crucial step in creating an empathetic and equal society. This education promotes empathy, self-awareness and emotional intelligence, which are essential for healthy personality development. Boys who are taught caring are better able to understand and express their feelings, establish equal relationships with others and contribute to the creation of a less violent and more just society. The success of this education largely depends on the ability of teachers to integrate caring values into everyday educational activities and their personal attitude and understanding of gender equality. Teachers should not only teach, set an example, but also create an appropriate environment in which children can freely express their emotions and needs. The role of teachers in this process is very important, but they need appropriate training and tools to be able to effectively integrate these values into the educational process.

Successfully cultivating caring masculinity will help boys grow into more understanding, responsible, and empathetic people, capable of building positive and equal relationships with those around them.

## CONCLUSIONS

• The concept of caring masculinity emphasizes that masculinity is not only traditionally understood as strength, independence or authority, but also includes empathy, emotional openness and responsibility for oneself and others, and these qualities are universal and necessary for the harmonious development of the personality and society. This concept invites us to abandon gender stereotypes and recognize that caring is an important dimension of masculinity, which can and should be developed from an early age. Traditional gender stereotypes that impose emotional coldness or masculine dominance through force on boys can be fundamentally changed through the conscious educational process of educators. Educators who inclusively teach that boys can be gentle, sensitive and caring help to develop healthy self-esteem and emotional maturity. They can do this through educational content and communication.

• Preschool children actively learn through observation and imitation, therefore the behavior of educators becomes the main tool in shaping children's attitudes towards emotions, empathy and caring. Educators who demonstrate these qualities in their daily work encourage boys to understand that caring is a valuable and gender-neutral quality. Caring for children, their emotions and physical well-being becomes a living example of how masculinity can include

tenderness and attentiveness. The results of educators' activities at this age have a long-term impact on boys' emotional and social lives. Preschool children are receptive to social habits and values, so the formation of caring masculinity at this stage helps to prevent the formation of toxic masculinity, promote harmonious relationships with peers and family members, and strengthen boys' ability to effectively resolve conflicts while maintaining respect and empathy.

• Educators' competencies and personal attitudes play a crucial role, as their approach to gender roles also shapes their educational practice. The development of caring masculinity requires educators to understand the modern concept of masculinity themselves, which includes empathy, cooperation and emotional openness. Workshops and training for educators focused on gender equality and emotional intelligence development can help them better fulfil this role. Educators, working together with parents, can reinforce the understanding that caring is a shared goal both within the family and in the educational setting.

## REFERENCES


Bhana, D., Moosa, E. (2023): Men who teach early childhood education: mediating masculinity, authority and sexuality. Teaching and teacher education, vol.122, Prieiga per internetą: https://www.sciencedirect.com/science/rticle/abs/pii/S0742051X22003341

ECaRoM.eu. Europos Sąjungos finansuojamas projektas, 2021-2023. Prieiga per internetą: : https://gap.lt/wp-content/uploads/2021/03/Vadovas.-Rupestingo-vyriskumo-puoselejimas-ankstyvajame-ir-pradiniame-ugdyme_web.pdf

EIGE (European Institute for Gender Equality) (2012): Gender Equality Index 2012. prieiga per internetą: https://eige.europa.eu/sites/default/files/documents/Gender-Equality-Index-Report.pdf

Elliot, K., (2016) Caring Masculinities: Theorizing an Emerging Concept: Men and Masculinities. Prieiga per internetą: https://uwethicsofcare.gws.wisc.edu/wp-content/uploads/2020/03/Elliot-Caring-Masculinities.pdf

Fraser, Nancy (1996): Gender equity and the welfare state: a post-industrial thought experiment. In S. Benhabib (Ed.), Democracy and difference. Contesting the Boundaries of the Political, Princeton, New Jersey: Princeton University Press: 218–242.

Gracia, P.; García Román, J. (January 12, 2015). Género y trabajo doméstico: ¿Tiende España a la igualdad? (Gender and domestic work: Does Spain tend to be equal?). *ElDiario.es.* Prieiga per internetą: https://www.eldiario.es/catalunya/catalunya-insolita/genero-trabajo-domestico-tiende-espana-igualdad_1_1863186.html

Hanlon, Niall (2012): Masculinities, Care and Equality: Identity and Nurture in Men's Lives. Hampshire: Palgrave Macmillan.

Krišovà D., Polankovà, L. (2020). Towards Gender-Sensitive Education. A Handbook for Teacher Trainers. Brno, Budapest, Vienna.

Legkauskas, K. (2013). Vaiko ir paauglio psichologija. Vilnius: Vaga.

Orechova, M., Frišmantaitė, A. (2021).Rūpintis yra vyriška: vyriškumo normų kaita ankstyvajame ugdyme. Tyrimo ataskaita, Lygių galimybių plėtros centras,Vilnius.

Prieiga per internetą: https://gap.lt/wp-content/uploads/2022/01/Ecarom-report_Lithuania_national-language.pdf

Rose, Amanda J. and Asher, Steven R. (2017): The Social Tasks of Friendship: Do Boys and Girls Excel in Different Tasks? Child Development Perspectives 11 (1): 3–8.

Scambor, E., Bergmann, N., Wojnicka, K., Belghiti-Mahut, S., Hearn, J., Holter, Ø. G., ... White (2014): Men and gender equality: European insights. Prieiga per internetą: https://journals.sagepub.com/doi/abs/10.1177/1097184X14558239

Scambor, E., Holtermann, D.(2022). Fostering caring masculinities in early childhood education and primary schools. prieiga per internetą: https://www.dissens.de/fileadmin/ECaRoM/Scambor_-_Holtermann__2022__Fostering_Caring_Masculinities_in_early_childhood_education_and_primary_schools_online_Version.pdf

Scambor, E., Holtermann, D.(2023): Ist Sorgearbeit nichts für Männer? Eine Erkundung von Elli Scambor und Daniel Holtermann. Berlin

Scambor, E., Wojnicka, K., ir Bergmann, N., (2014). Framing the involvement of men in gender equality in Europe: between institutionalised and non – institutionalised politics. Prieiga per internetą:https://www.researchgate.net/publication/275338538_Framing_the_Involvement_of_Men_inGender_Equality_in_Europe_Between_Institutionalised_and_Non-Institutionalised_Politics

Siegler, R.; Eisenberg, Nancy; DeLoache, Judy and Saffran, Jenny (2016): Entwicklungspsychologie im Kindes- und Jugendalter. Berlin Heidelberg: Springer-Verlag.

Tronto, Joan C. (2015): Who Cares? How to Reshape a Democratic Politics. Ithaca London: Cornell University Press.

PANEVĖŽIO KOLEGIJA ISSN 2029-1280, eISSN 2669-0071. Taikomieji tyrimai studijose ir praktikoje – Applied Research in Studies and Practice, 2024, 20.

# ANALYSIS TO IMPROVE THE PERFORMANCE OF A SIX-AXIS ROBOT

***Dmitrij CHARUNOV[a], Mantas JAUGELAVIČIUS[a], Daiva STANELYTĖ[ab]***

*[a] Klaipedos valstybine kolegija – Higher Education Institution, Lithuania*
*[b] Lithuanian Energy Institute, Lithuania*

**Abstract.** This works on maintenance and real-time diagnosis methods for six-axis robots to ensure their stable operation and production efficiency. Two main areas of maintenance are discussed – software and technical. Software failures can be caused by incorrectly written data, faulty code or poor interface management, which can directly affect the performance of the robot and the quality of production. The technical part analyses the maintenance of spare parts, the optimization of energy consumption and the monitoring of sensors to reduce mechanical and electrical failures. The analysis also highlights the use of real-time sensor data and artificial intelligence algorithms for quick fault detection and preventive maintenance, contributing to the reliability of the system and reducing the risk of major failures.

**Keywords**: six-axis robot, diagnostic, failure, recommendation

## INTRODUCTION

**Relevance**. As production volumes increase, industrial companies are automating their production system. By automating the production process, engineers aim to save labor, energy and materials and improve the quality of the final product. Automation of the production process includes activities such as: mechanics, hydraulics, pneumatics, electronics and computer-aided design. Automation is very much linked to the science of robotics, where all robots, both hardware and software, can work automatically, without any human assistance.

**Problem Statement.** Different types of robots are involved in the production process and one of the most popular robots is the six-axis robot, which is better than other multi-axis robots because of its characteristics. A six-axis robot is a type of manipulator that is used to manipulate materials without direct, physical contact with the operator. Because the robot arm is six-axial, it can manipulate six different parts of the robot, allowing it to avoid various obstacles and handle objects from almost any angle. The robot's permissible movement makes it versatile and allows it to be used for a wide range of production processes: assembly, welding, material handling (painting, sandblasting, etc.), packaging, quality control, etc.

With the emergence of automated processes, not only are there failures on the hardware side, but also on the software side. This analysis analyses the most common problems/faults that occur in the operation of a six-axis robot, both from the component and the software side. After analyzing these problems, recommendations are given on how to avoid them and improve the working principle of this robot in order to make the production process more stable.

To achieve the aim of the analysis, the following **objectives** were set:

1. To examine the principles of failures in six-axis robot software systems.
2. To identify failures during the operation of a six-axis robot.
3. To formulate recommendations for improving the performance of a six-axis robot.

## RESEARCH METHODOLOGY

A quantitative research method was used to look at data that was put together from different source studies. The topic in question was thoroughly examined as a result of the inclusion of works by foreign authors in the reviewed sources. Research data and theoretical evaluations published in *IEEE* and *Science Direct* were analysed. Titles, abstracts, and full articles of scientific articles were reviewed to determine their appropriateness for analysis. The most pertinent databases, where the findings of studies on the topic were published, were chosen for the systematic and comprehensive literature search.

A literature search was performed using every search word that may be utilised to describe the concept under investigation. 55,677 publications were found based on the keyword combinations used. The table that follows displays the outcomes.

Table 1

**Results of the literature search in scientific article databases**

| Key words | Science Direct | IEEE | Total |
|---|---|---|---|
| Six-axis robot | 36,608 | 341 | 36,949 |
| Diagnostic | 4,459 | 3 | 4,462 |
| Failure | 10,486 | 7 | 10,493 |
| Recommendation | 3,773 | 0 | 3,773 |
| **Total** | 55,326 | 351 | 55,677 |

Since the data needed for the investigation is available in scientific databases, the study complies with research ethical guidelines.

## PRINCIPLES OF FAILURE OF SOFTWARE SYSTEMS IN A SIX-AXIS ROBOT

When automating manufacturing processes with six-axis robots, mechanical engineers need to ensure that the robot is stable, efficient, and safe. Allowing robot movements makes the design complex and the robot itself prone to failure. Unnoticed failures can have serious consequences and can lead to catastrophic consequences (Sabry, Amirulddin, 2024). Unforeseen failures can lead to process stoppages and product damage. Therefore, (Figure 1) shows key motivations for improving efficiency. Failures depend on various aspects such as errors in sensor measurements, engine speedometers, etc., but everything is controlled and monitored by the software system.

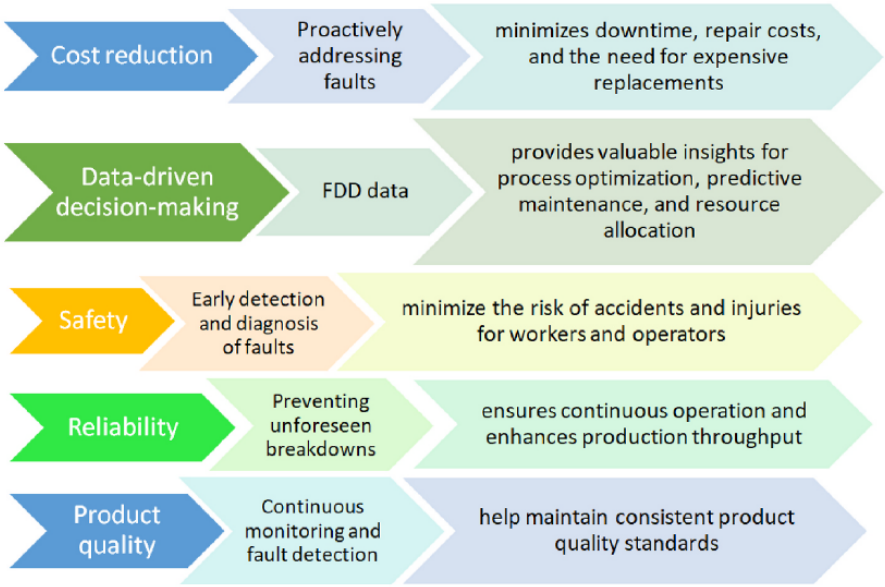



Figure 1. **Key motivations when developing effective FDI techniques**

The system first performs diagnostic operations to detect faults and then compares the properties of the test data with the diagnostic results. These features are fed into a classifier to diagnose robot faults. (Hsu, Ting, Huang et al., 2021). The diagnostic results allow maintenance to be carried out to avoid serious damage. The classifier is trained on historical standard features obtained from the initial diagnosis (Hsu, Ting, Huang et al., 2021). There are several ways to maintain the software system: online and autonomously (on-site maintenance). The principle of diagnostic analysis is dependent on this.

The remote structure consists of three subsystems, whose composition and order of operations are illustrated (Figure 2): fault detection subsystem; fault diagnosis subsystem; condition assessment subsystem.

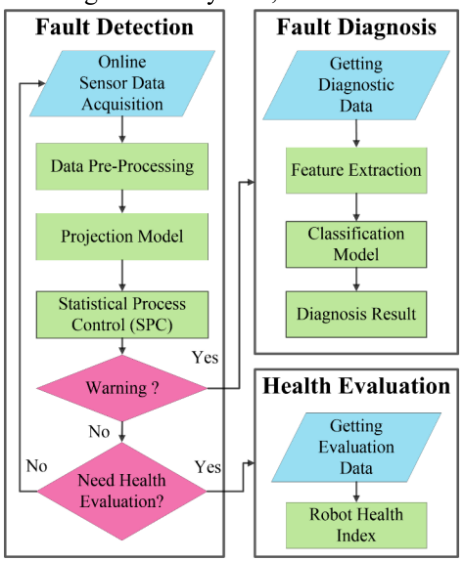



Figure 2. **Intelligent online fault detection, diagnosis and health evaluation system**

When the robot reaches a warning threshold, the fault diagnosis subsystem is triggered when the robot stops the current task. In addition, the data from the existing diagnostics, the projection model and the Statistical Process Control (SPC) control limits are first determined from the historical normal data of the current task. If the warning conditions are not satisfactory, the next step will be to apply the conditions of the evaluation process, which will be determined either by the duration of the job or by the user specification. If these conditions are met, the evaluation subsystem is started when the robot stops its current task. The fault-finding subsystem shall return to the starting point to continue the next cycle.

Before remote maintenance of the system, the subsystem forms the required pre-processing estimates, projection model and SPC bounds from the historical normal data of the current task, as illustrated in (Figure 3). The related parts of the autonomous development process and the remote fault detection process are described below (Hsu, Ting, Huang et al., 2021).

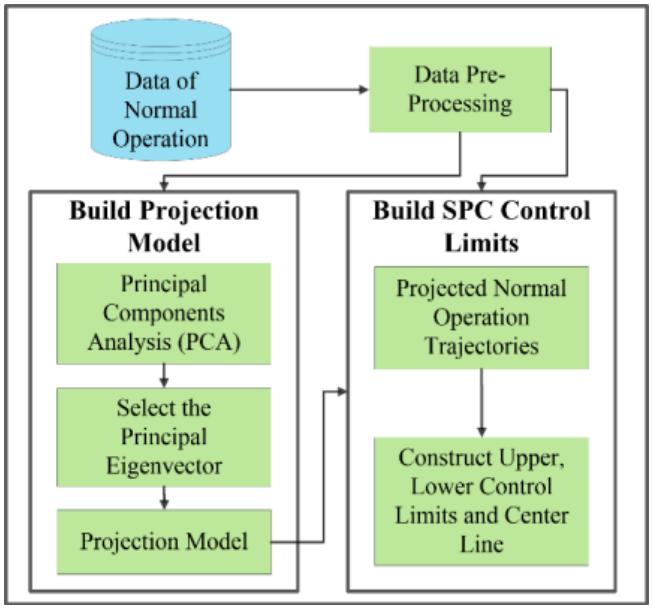



Figure 3. **The offline building process of the projection model and the control limits of the SPC**

Software failures result from a variety of causes, including human factors and equipment malfunctions, such as communication between other systems, sensor data errors or algorithmic errors (Sabry, Amirulddin, 2024), which can be seen in (Figure 4). The causes of software failures can be varied, one of the main errors is software bugs, which can arise from a misconfigured or programmatically corrupted system, which can cause incorrect robot movements. In addition, among the important problems, (Li, Wang, Wang, Duan, 2020) identified that sensor data errors, which arise from environmental disturbances such as moisture or dust, can affect the robot's response, which may cause the robot to perform the wrong motion or turn at the wrong angle.

Control system malfunctions are often caused by human errors in writing the system code, which can be due to algorithms that process motion sequences or real-time signals. Also, (Sabry, Amirulddin, 2024) state that if a six-axis robot uses different versions of software, problems can arise in the communication between components. Other faults can also occur, such as communication glitches, if the robot communicates with other systems, such as control centres or other robots, communication problems can cause synchronisation errors (Sabry, Amirulddin, 2024).

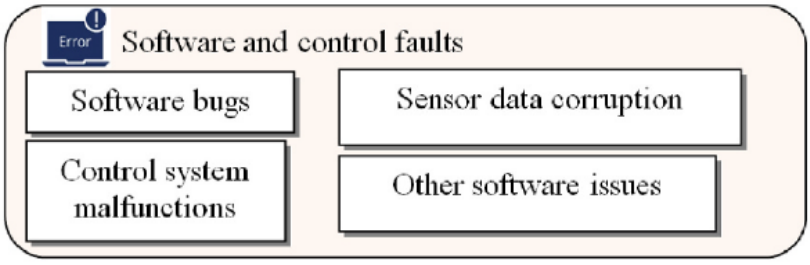



Figure 4. **Categorization of faults in industrial machines**

Improper control can damage the robot and the product (Sabry, Amirulddin, 2024). If the robot is given the wrong data, it may perform incompatible movements. The User Interface (UI) is essential, as a complex or unclear UI can lead to errors that adversely affect the robot's functions. In addition, a lack of maintenance of the software system can lead to errors in sensors, motors or communication. An effective error detection system is essential for robot safety. Human errors in programming and simulation have a significant impact (Figure 5). Incorrectly chosen algorithms or non-

optimised algorithms can lead to slow response times and higher energy consumption. Also, incorrect kinematics or dynamics models can lead to inaccurate movements, and inadequate testing can lead to loss of data.

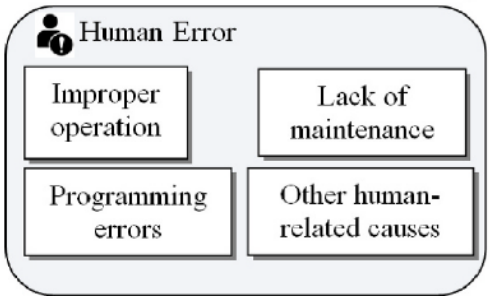



Figure 5. **Categorization of faults in industrial machines**

In general, the principle of a six-axis robot depends on the stability of the software and the efficiency of the sensors, as well as on human responsibility and other factors to keep the robot stable.

## SIX-AXIS ROBOT TECHNICAL FAILURE PRINCIPLES

Technical failures also have a significant impact on the performance of a six-axis robot (Sabry, Amirulddin, 2024). Technical failures are separated in different categories, processing related failures, electrical failures, human errors, these categories can be seen in (Figure 6).

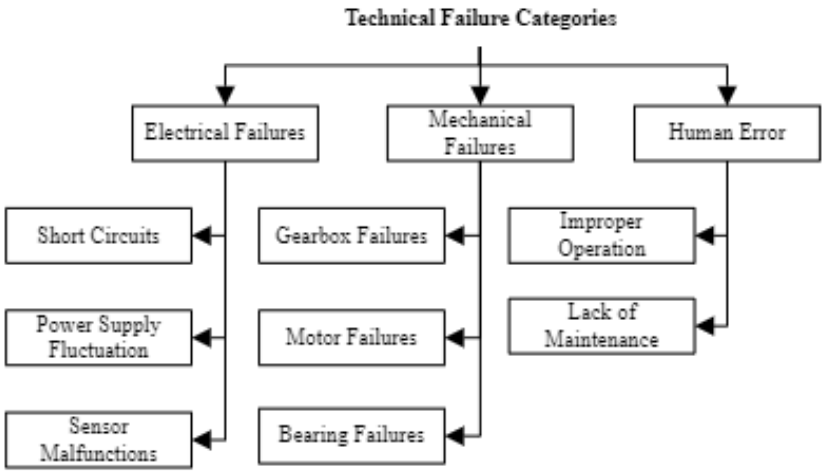



Figure 6. **Technical failure categories**

Gearbox failures are often mechanical problems caused by improper maintenance. Wear and tear and friction build-up cause vibration, noise and heat build-up. Replacement of bearings and seals is necessary and overheating of motors often occurs with incorrectly set loads, causing abnormal acceleration and deceleration (Sinha, Ahmed, Das, 2023). Motor overheating can also be affected by the temperature of the environment in which the robot is operating. At the same time, (Sabry, Amirulddin, 2024) emphasizes that regular maintenance is necessary to keep a six-axis robot at optimum performance and running smoothly for a long time. Such maintenance includes changing belts, monitoring and replenishing the oil level, as well as replacing all intermediate parts, (Morenas, Fernandez, Gomez, 2024). The robot is also a moving object, and the electrical wires that connect to the robot can wear out from the robot's movements, which can cause short circuits, power fluctuations, sensor malfunctions, or no current at all.

Therefore, each of the features discussed in this section has a significant impact on the stability of the robot and directly determines the quality of the product.

## RECOMMENDATIONS TO IMPROVE THE PERFORMANCE OF THE SIX-AXIS ROBOT

As factories become more complicated and interconnected, the impact of a single machine failure can bring the production chain to a standstill (Sabry, Amirulddin, 2024). Optimizing settings, software and controls, and preventive maintenance are important to improve their performance. In addition, the increasing complexity of modern machines makes manual fault detection and diagnosis increasingly difficult and time consuming, (Sabry, Amirulddin, 2024). To ensure the safety, reliability and productivity of automated systems, comprehensive fault detection and isolation (FDI) strategies are required, which will be discussed in this section.

## SOFTWARE IMPROVEMENTS

One of the means of stable operation of a six-axis robot is continuous monitoring. Continuous monitoring is a real-time monitoring system that collects data from sensors, such as sensors monitoring vibration level, temperature, motor current and other parameters (Sabry, Amirulddin, 2024). Another system that can be applied in robotics is fault diagnosis. This is a set of algorithms and models that can accurately diagnose the root cause of detected faults. Also, to detect faults faster, artificial intelligence can be applied that can learn from previous readings and thus increase the accuracy of the operation. Advance maintenance is also recommended to improve the performance and stability of the six-axis robot. Using sensor data, maintenance or minor repairs can be carried out in a timely manner to avoid major failures that could halt the production process for a long time.

## TECHNICAL RECOMMENDATIONS

To keep a six-axis robot stable, the technical part also needs to be improved, so the following criteria must be followed to improve performance. Timely maintenance is essential, which includes replacing spare parts such as bearings, seals, belts, oil, etc. The energy efficiency of six-axis robots is also important, both in terms of reducing operating costs and improving system stability. Improving energy efficiency requires designing an optimal robot trajectory and inputting the right data to the motors to prevent them from consuming too much energy and overheating, which can also cause the robot to stop working. It is also necessary to monitor the technical condition of the sensors, as they can wear out and fail and need to be replaced in time, as well as to ensure that the parameters of these sensors are correctly set so that the system analyses the robot's behavior correctly.

## CONCLUSIONS

1. Analysing the failure principles of a six-axis robot from the software side, it can be said that human inattention/error, poorly written code, incorrectly written initial data, improperly updated software, and improper use of the interface program can all lead to robot failures. This depends on how the robot will work, what movements it will use and can affect the output, damage it, cause losses during production or even cause human injury.
2. The six-axis failure principles can technically arise from mechanical failures, processing-related failures, electrical failures and human error. The main components that require more maintenance are the motor, bearings, seals, gearbox and electrical wiring. Failure to carry out regular maintenance can lead to vibrations, overheating, short circuits, etc., which can affect the stability of the robot's operation and directly affect the quality of the product.
3. With the increasing complexity and interdependence of production equipment, the maintenance and fault management of efficient systems is becoming increasingly important to ensure uninterrupted production. The failure of a single component can bring the entire production chain to a standstill, making it essential to invest in optimisation and preventive maintenance. Continuous data monitoring and advanced fault diagnosis systems allow real-time anomaly detection and rapid problem identification, which not only increases system reliability but also efficiency. Strategies such as AI-based diagnostics and early maintenance can reduce the risk of major failures. Finally, technical improvements, including energy efficiency improvements and sensor health monitoring, contribute to the long-term stability and productivity of six-axis robots and other automated systems.

## REFERENCES

Adam H. E. A., Kimotho J. K., Njiri J. G. Results in Engineering(17), (2023). Multiple faults diagnosis for an industrial robot fuse quality test bench using deep-learning. 101007. Retrieved from: https://doi.org/10.1016/j.rineng.2023.101007

Alian H., Konforty S., Ben-Simon U., Klein R., Tur M., Bortman J. Mechanical Systems and Signal Processing, (2019). Bearing fault detection and fault size estimation using fiber-optic sensors. 392-407. Retrieved from: https://doi.org/10.1016/j.ymssp.2018.10.035

Aparnathi R., Dwivedi V. V. International Journal of Robotics and Automation (IJRA), (2014). The Novel of Six axes Robotic Arm for Industrial Applications. 161-167. Retrieved from: https://doi.org/10.11591/ijra.v3i3.4892

Daoliang Li , Ying Wanga, Jinxing Wang , Cong Wanga, Yanqing Duan. Sensors and Actuators A 309 , (2020). Recent advances in sensor fault diagnosis: A review. 111990. Retrieved from: https://doi.org/10.1016/j.sna.2020.111990

Findeisen M., Todtermuschke M., Schaffrath R., Putz M. Procedia Manufacturing, (2018). A method for energetic comparison of 6-axis industrial robots and its further scope for resource-efficient plant design p251-258. Retrieved from: https://doi.org/10.1016/j.promfg.2018.02.118

Hiroshima: Alam M. M., Ibaraki S., Fukuda K. Automation Technol, (2021). Kinematic Modeling of Six-Axis Industrial Robot and its Parameter Identification: A Tutorial. 599-610. Retrieved from: https://doi.org/10.20965/ijat.2021.p0599

Hsu H. K., Ting H. Y., Huang M. B., Huang H. P. Mechanika, (2021). Intelligent Fault Detection, Diagnosis and Health Evaluation for Industrial Robots. 70–79. Retrieved from: https://doi.org/10.5755/j02.mech.24401

Kiranmai V. P., Bysani S. S., Kumar V., Kusuma S. M. International Journal of Innovative Technology and Exploring Engineering (IJITEE), (2019). Design and Development of Techniques for Equipment Health Monitoring System. 277-282. Retrieved from: https://doi.org/10.35940/ijitee.b1012.1292s19

Lee H., Raouf I., Song J., Kim H. S., Lee S. Mathematics, (2023). Prognostics and Health Management of the Robotic Servo-Motor under Variable Operating Conditions. 11, 398. Retrieved from: https://doi.org/10.3390/math11020398

Master of Science Thesis in Electrical Engineering, (2020). Modeling and Control of 6-axis Robot Arm. Linköping: Shuman A. M. Linköping: Linköping University, 2020. SE-581 83.

Morenas J. D. L., Fernandez F. M., Gomez J. A. L. Sensors, (2023). The Edge Application of Machine Learning Techniques forFault Diagnosis in Electrical Machines. 23, 2649. Retrieved from: https://doi.org/10.3390/s23052649

Sabry A. H., Amirulddin U. A. B. U. Mechanical Engineering(23), (2024). A review on fault detection and diagnosis of industrial robots and multi-axis machines. 102397. Retrieved from: https://doi.org/10.1016/j.rineng.2024.102397

Shuai Y. Scientific Programming, (2022). Research on Fault Diagnosis Technology of Industrial Robot Operation Based on Deep Belief Network. 260992. Retrieved from: https://doi.org/10.1155/2022/9260992

Sinha A., Ahmed S. F., Das D. 2023 IEEE Guwahati Subsection Conference (GCON), (2023). Explainable AI for Bearing Fault Detection Systems: Gaining Human Trust. Retrieved from: https://doi.org/10.1109/GCON58516.2023.10183502

Talli A., Meti V. K. V. Materials Science and Engineering, (2020). Design, simulation, and analysis of a 6-axis robot using robot visualization software. 67-72 Retrieved from: https://doi.org/10.1088/1757-899X/872/1/012040

Wang X., Li Y., Zhang Q., Chai H. 2017 Chinese Automation Congress (CAC), (2018). Closed-loop parity-space based fault detection: Application to simplified quadruped robot model. Retrieved from: https://doi.org/10.1109/CAC.2017.8243292

PANEVĖŽIO KOLEGIJA ISSN 2029-1280, eISSN 2669-0071. Taikomieji tyrimai studijose ir praktikoje – Applied Research in Studies and Practice, 2024, 20.

# PUBLIC CONSUMPTION OF MICROPLASTICS AND AWARENESS ABOUT POTENTIAL HEALTH EFFECTS AND PREVENTION

***Asta BUTKUVIENĖ***

*Panevėžio kolegija/ State Higher Education Institution, Lithuania*

**Abstract**. Worryingly widespread and extremely durable, microplastics are harmful because they release toxins and contaminants all over the world. Microplastics are also thought to be vectors for transmitting diseases and toxic substances, posing potentially serious health risks when inhaled and ingested by humans. The aim of the study was to investigate public consumption habits of microplastics and awareness about potential health effects and prevention. The tasks of the study were to investigate awareness of microplastics forms and possible routes of entry into the human body, to detect the knowledge of the presence of microplastics in human's different tissues and organs and potential harmful health effects, to reveal plastics and microplastics consuming habits and awareness about prevention measures. Conclusions: Half of respondents were familiar with polyethylene, polyester, polyethylene terephthalate, one third-of styrene, nylon and polypropylene to be microplastics.Two third of participants reported that microplastics are found in human excretions and all human's body. The majority of respondents were aware about the main routes of microplastics' entry into human's body, but there were gaps in their knowledge. More than half of respondents indicated hormonal disruption, cancerogenicity, allergies or asthma, weakening immunity and causing chronic inflammation as microplastics harmful health effects. The majority of respondents are using plastic bags and packages for foodstuffs, water and drinks in plastic bottles. Prevention measures, offered by the majority of respondents, were to sort plastic waste, to avoid plastic packages and bottles of foodstuffs and water, heating food in plastic dishes, though only half of respondents are sorting plastic waste, heating food in plastic-free dishes and wearing clothes made of natural fibers. Despite increased awareness, behaviors reflecting preventive actions remained inconsistent. The findings highlight the urgent need for better public education and regulatory action to mitigate microplastic exposure and its associated health risks.

The TOPSIS multi-criteria approach allows for a comprehensive and integrated assessment of the financial autonomy of municipalities by providing a single summary indicator composed of several revenues ratios.

The empirical research analyses the situation of the revenue potential of Panevėžys region municipalities, assessing the financial autonomy of municipalities in the period 2009-2022. The research shows that all municipalities in the region are very homogeneous in terms of revenue indicators and have a moderately low level of financial autonomy. The empirical results also show that municipalities' financial autonomy is changing slowly compared to the results of previous research. This confirms the dependence of municipalities on centralised financial management, which is governed by the legal acts that have a strong impact on the development of municipalities' financial autonomy and financial capability. Hence, the results in a way also show a lack of capacity on the part of municipalities themselves to seek opportunities to create sustainable, stable perspectives from an economic and social perspective.

**Keywords:** microplastics; public awareness; health effects; prevention; environmental pollution

## INTRODUCTION

Currently, accurate statistics are unavailable regarding the sources of microplastics and the total amount of microplastics deposited in the land and sea. Various human activities and products, such as washing, worn tires, city dust, road paint, ships, and cleaning products, have been reported as sources of microplastics (Lee et al., 2023). Currently, four major routes of exposure have been identified including entanglement, contact, ingestion and inhalation. Humans may be the most exposed organism because they are at the peak of the food chain. Humans can be exposed to microplastics through direct ingestion, direct contact, and inhalation (Enyoh et al., 2020). These micro-nanoplastics (MNPs) in the gut can change the composition of gut microbiota populations and impact the production of gut microbiota metabolites. MNPs can damage intestinal structure, induce intestinal inflammation, and alter the expression of intestinal tight junction proteins and mucosal proteins. Ultimately, MNPs in the gut can lead to an increase in intestinal permeability and a disruption of the intestinal barrier function (Zhang et al., 2023). Polypropylene microplastics were found in human placentas (Ragusa et al., 2020). The synthetic fiber industry is a representative example of potential workplace exposure to microplastics through inhalation. The results of many studies have demonstrated that microplastic inhalation can lead to respiratory and lung diseases among workers in factories using synthetic fibers (Lee et al., 2023). In addition, studies have indicated that workers in plastic-related industries develop many kinds of cancer because of chronic exposure to high levels of airborne microplastics (Wang, Lee, Chiu, Lin, & Chiu, 2020). It was suggested that plastic particles can easily cross all biological barriers and reach different organs, especially the cardiovascular system, with the potential to modulate several molecular pathways. It is postulated that the direct interaction of PPs with cellular and subcellular components induces genotoxicity and cytotoxicity within the cardiovascular system (Yalameha et al., 2024). Patients with carotid artery plaque in which MNPs were detected had 4,5 times higher risk of a composite of myocardial infarction, stroke, or death from any cause (Marfella et al., 2024). Microplastics disrupt hypothalamic-pituitary axes, including the

hypothalamic-pituitary-thyroid/adrenal/testicular/ovarian axis leading to oxidative stress, reproductive toxicity, neurotoxicity, cytotoxicity, developmental abnormalities, decreased sperm quality, and immunotoxicity (Ullah et al., 2023).

**The object of the study:** public consumption of microplastics and awareness about potential health effects and prevention

**Objective of the study:** to investigate public consumption habits of plastics and microplastics and awareness about potential health effects and prevention

**Tasks of the study:**

1. To investigate awareness of microplastics forms and possible routes of entry into the human body.
2. To detect the knowledge of the presence of microplastics in human's different tissues and organs and potential harmful health effects.
3. To reveal respondent's plastics and microplastics consuming habits and awareness about prevention measures.

## THE RESEARCH METHOD

The research employs a quantitative survey conducted in August-September 2024, involving 108 respondents. Respondents were randomly selected. 106 questionnaires were collected. The data were obtained and analyzed from 102 questionnaires. The respondents were interviewed using social media and by direct contact. The majority of respondents were females (68% / 32%). The data were evaluated and processed using the Microsoft Office Excel program.

## THE RESULTS AND DISCUSSION

The survey enrolled people of different ages between 18 and 89 years, including young and elderly adults. The results show that the majority of respondents were between the ages of 18-39 years. The results revealed that one third of the respondents had obtained secondary, one fourth-master, one fifth-bachelor educational degree. The minority had obtained a vocational bachelor or associate professor educational degree. The education of the respondents also can influence the knowledge about microplastics.

It was estimated that more than half of respondents reported being employees, one fourth were students. The lesser part were retired or unemployed people (see Figure 1).

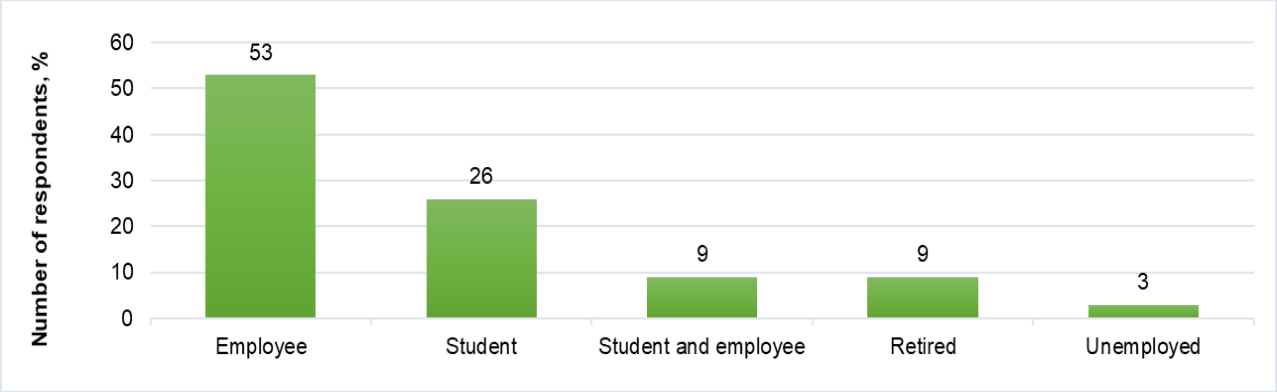



Figure 1. **The occupation**

Primary microplastics is directly released in the environment as small particles and are estimated to represent between 15-31% of microplastics in the oceans. The main sources: laundering of synthetic clothes (35% of primary microplastics); abrasion of tyres through driving (28%); intentionally added microplastics in personal care products, for example microbeads in facial scrubs (2%). Secondary microplastics originate from degradation of larger plastic objects, such as plastic bags, bottles or fishing nets. Account for 69-81% of microplastics found in the oceans (European Parliament, 2018). Microplastics are easily ingested due to their micro-level sizes and move easily through the food chain and persist in the environment since they are refractory to biodegradation. Due to these characteristics, microplastics pose potential hazards to humans and the environment (Lee et al., 2023). The results indicate that more than half of the respondents are familiar with polyethylene, polyester, less than half-polyethylene terephthalate and styrene to be the source of microplastics, but significantly lesser part of the respondents were aware that polyvinyl chloride, polypropylene, nylon, acrylic and polyurethane also are the source of the microplastic particles (see Table 1).

The microplastics can physically block the digestive system, stimulate the mucous membrane, and injure it. When the size of microplastics becomes smaller than 1 micrometer to form nanoplastics, they can pass through the primary tissue barrier in the body and penetrate the capillary blood vessel through the bloodstream, which can be dispersed throughout the body (Lee, et al., 2023).

Table 1

**The microplastics sources**

| The substance | Agree, % | Don't know, % | Disagree, % |
|---|---|---|---|
| Macroplastics | 47 | 24 | 29 |
| Polyethylene terephthalate ( phthalates) | 44 | 56 | - |
| Bisphenol (BPA) | 18 | 82 | - |
| Polyvinyl Chloride (PVC) | 20 | 71 | 9 |
| Stirene, polystyrene | 38 | 62 | - |
| Polyethylene (PET) | 56 | 44 | - |
| Polypropylene (PP) | 32 | 68 | - |
| Polyester | 53 | 46 | 1 |
| Nylon | 32 | 62 | 6 |
| Acryl | 15 | 83 | 2 |
| Polyurethane | 11 | 85 | 4 |

The majority of respondents stated that micro- or nanoplastics is found in feces, urine, and the entire human body, more than half were aware about micro- or nanoplastics presence in breastmilk, brain and atherosclerotic plaques, less than half of the respondents stated that microplastics particles can be found in humanembryo's tissues. The results indicate that the awareness of the presence of the micro- and nanoplastics in human's bodies and excretions is insufficient (see Table 2).

Table 2

**The micro- and nanoplastics in human's body and excretions**

| The tissues or secretions/ excretions | Agree, % | Don't know, % | Disagree, % |
|---|---|---|---|
| Breastmilk | 56 | 35 | 9 |
| Urine | 65 | 32 | 3 |
| Feces | 78 | 21 | 1 |
| Human fetus (embryo) | 41 | 50 | 9 |
| Brain | 56 | 31 | 13 |
| Blood | 47 | 50 | 3 |
| Atherosclerotic plaques in blood vessel walls | 51 | 44 | 5 |
| Entire body | 65 | 26 | 9 |

Humans are exposed to between tens of thousands and millions of microplastics each year, or several milligrams per day. The main exposure route could be the inhalation of indoor air and drinking water in plastic bottles. Exposure to microplastics through food intake is likely the main exposure source ( Wright, & Kelly, 2017). The majority of respondents agree that microplastics enter the human's body with drinking water, especially drinking water from plastic bottles, from takeaway food plastic packages, especially when heated, or heating baby formula in plastic bottles and other foodstuff packages. Half of respondents were aware that fish, seafood, body care products also contain microplastics which enter the body. The lesser part were aware that inhaling air, eating fruits and vegetables, meat or other agricultural products, which are polluted with micro- and nanoplastics particles from the soil also can serve as the routes of

microplastics entry into human's body. The results revealed that the majority of respondents were partially aware about the main routes of microplastics' entry into the human body, but there were significant gaps in their knowledge (see Table 3):

Table 3

**The routes of microplastics entry into human's body**

| The route of entry | Agree, % | Don't know, % | Disagree, % |
|---|---|---|---|
| Inhaling air | 38 | 36 | 26 |
| Drinking water | 70 | 12 | 18 |
| Drinking water from plastic bottles | 74 | 23 | 3 |
| From foodstuffs packages (meat, fish, etc.) | 62 | 29 | 9 |
| From takeaway food packages | 68 | 27 | 5 |
| Heating food in microwave owen in takeaway package | 74 | 20 | 6 |
| Eating fruits, vegetables | 26 | 48 | 26 |
| Eating meat and other agricultural products | 35 | 44 | 21 |
| Eating fish and seafood | 56 | 26 | 18 |
| Through body care products | 50 | 38 | 12 |
| Heating baby formula in plastic bottles | 65 | 29 | 6 |

Microplastics may cause oxidative stress in the airways and lungs when inhaled, leading to respiratory symptoms such as coughing, sneezing, and shortness of breath due to inflammation and damage, as well as fatigue and dizziness due to a low blood oxygen concentration (Wright, & Kelly, 2017). According to Ali et al., (2024), it is suggested that exposure to micro- and nanoplastis can lead to health effects through oxidative stress, inflammation, immune dysfunction, altered biochemical and energy metabolism, impaired cell proliferation, disrupted microbial metabolic pathways, abnormal organ development, and cancerogenicity. The research results indicate that more than half of respondents were aware about negative impacts on the endocrine and immune systems, development of cancer, asthma or other allergies, and oxidative stress and inflammation. It is important to state that only half of respondents indicated microplastics' negative impact on gut microbiota, development of cardiovascular diseases, one fourth were aware that microplastics binds to and transfers to organism pesticides, fungicides and other toxins, the lesser part knew that microplastics can be the cause of the premature birth, the increased resistance to antibiotics, high levels of low density lipoprotein (bad cholesterol). According to these findings it can be stated that the knowledge about the potential negative health effects was limited and society needs more information and education (see Table 4).

Table 4

**The potential negative health effects**

| The health effects | Agree,% | Don't know, % | Disagree, % |
|---|---|---|---|
| Asthma and other allergies | 56 | 44 | - |
| Premature birth | 15 | 79 | 6 |
| Increases resistance to antibiotics | 17 | 68 | 15 |
| Due to cancerogenicity promotes oncological diseases | 59 | 38 | 3 |
| Increases low density lipoprotein (bad cholesterol) levels | 15 | 76 | 9 |
| Increases risk of cardiovascular diseases | 47 | 53 | - |
| Causes oxidative stress and chronic inflammation | 53 | 44 | 3 |

| | | | |
|---|---|---|---|
| Has negative impact on gut microbiota | 50 | 47 | 3 |
| Has negative impact on the endocrine system, disrupts hormone secretion | 62 | 38 | - |
| Has negative effect on the immune system | 53 | 46 | 1 |
| Binds to and transfers to organism pesticides, fungicides, other toxins | 26 | 73 | 1 |

Participants' plastic consumption patterns were also evaluated. The majority of respondents reported using plastic bags, bottles, and containers for food storage, despite knowing the associated risks. The results reveal a significant gap between public awareness and behavioral changes concerning plastic consumption. The majority of participants were not aware that polystyrene takeaway food packages and plastic tea and coffee cups had been replaced by other sort plastic packages since 2021 in Lithuania, like in other European Union countries. While most respondents are aware of the major routes of microplastic entry into the human body and some health risks, many continue to use plastic products that exacerbate microplastic pollution of the environment and human's body (see Table 5).

Table 5

**The consumption of plastics**

| **The plastic products** | **Agree, %** | **Don't know, %** | **Disagree, %** |
|---|---|---|---|
| Plastic bags for food stuffs | 91 | - | 9 |
| Plastic packages for food stuffs | 97 | - | 3 |
| Takeaway food in polystyrene packages | 76 | 6 | 18 |
| Plastic bottles ( drinking water, other beverages) | 82 | - | 18 |
| Disposable plastic coffee, tea cups | 71 | - | 29 |
| Plastic baby bottles, spoons, dishes | 29 | 3 | 68 |

Where sustainable alternatives are easily available and affordable, single-use plastic products cannot be placed on the markets of EU Member States. Cotton bud sticks, cutlery, plates, straws, stirrers, and sticks for balloons, cups, food and beverage containers made of expanded polystyrene, and all products made of oxo-degradable plastic are banned since 2021. For other single-use plastic products, the targets are: reducing consumption through awareness-raising measures; introducing design requirements, such as a requirements to connect caps to bottles; introducing labeling requirements, to inform consumers about the plastic content of products, disposal options that are to be avoided, and harm done to nature if the products are littered in the environment; introducing waste management and clean-up obligations for producers, including Extended Producer Responsibility schemes (Directive on SUP, 2021). The measures suggested by the majority of the respondents were to sort plastic waste, to prevent nature from pollution, to avoid plastic food stuff bags, to avoid heating food in plastic packages, to avoid drinking water in plastic bottles, and use their own metallic cup for the takeaway coffee (see Table 6).

Table 6

**The measures suggested to avoid microplastics**

| **The measures** | **Agree,%** | **Don't know,%** | **Disagree,%** |
|---|---|---|---|
| Avoid heating food in plastic packages | 88 | 6 | 6 |
| Consume reusable baby pampers | 53 | 21 | 26 |
| Consume reusable feminine hygiene pads | 38 | 36 | 26 |
| Avoid drinking water in plastic bottles | 88 | 6 | 6 |
| Refuse from plastic food stuff bags | 91 | 6 | 3 |

| | | | |
|---|---|---|---|
| Takeaway coffee in own metallic cup | 88 | 12 | - |
| Don't use plastic water filters | 73 | 26 | 1 |
| Wear clothes made of natural fibers | 68 | 29 | 3 |
| Refuse from plastic baby bottles, spoons, dishes | 56 | 29 | 15 |
| Choose laminate or natural floor covering instead of PVC | 50 | 38 | 12 |
| Clean frequently dust from all surfaces | 62 | 23 | 15 |
| Avoid seafood | 21 | 58 | 21 |
| Avoid body care/cosmetic products containing microplastics | 65 | 29 | 6 |
| Sort plastic waste, prevent nature from pollution | 98 | 2 | - |
| Prefer ecologic journeys | 68 | 31 | 1 |

Countries around the world are strengthening related laws on primary microplastics. The European Union is taking various measures to recycle plastics, develop biodegradable plastics, distinguish harmful substances in plastics, and prevent marine waste generation (Directive on SUP, 2021).The results of the study revealed that more than one fourth of the respondents agree with the fact that that it is impossible to remove microplastics from nature, food chains and human body, the minority stated that microplastics can be removed totally. The optimism about removing plastics from the nature, food chains and human's body was reserved, as the majority of respondents stated that it can be achieved only partially (see Figure 2):

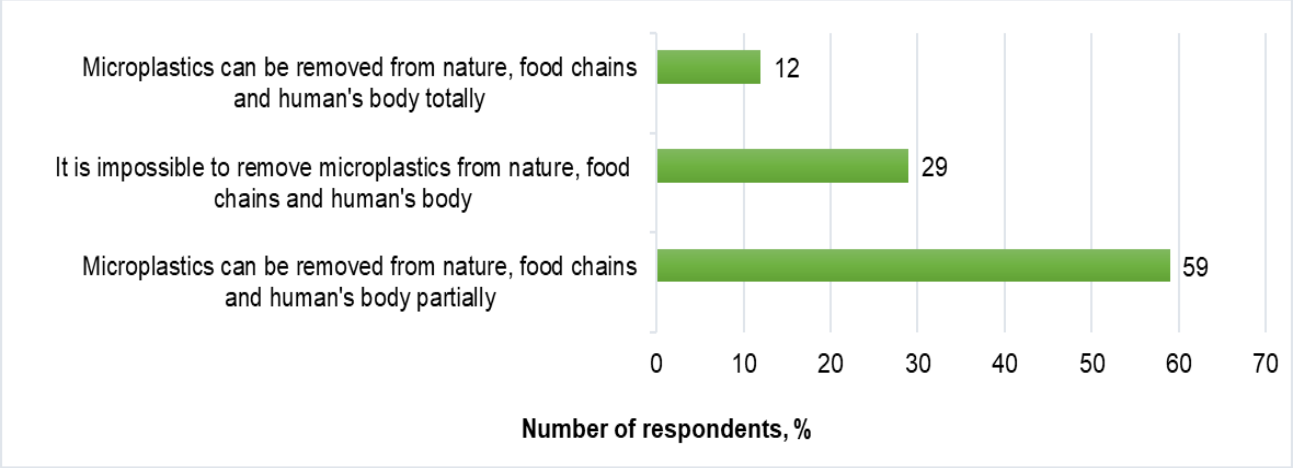



Figure 2. **The positivity**

The respondents reported the measures for diminishing plastics and microplastics pollution they already implemented. The majority are sorting plastic waste, not polluting nature, and heating food in non-plastic packages. Choosing natural fiber clothing was practiced by a smaller portion of the participants. Despite increased awareness, behaviors reflecting preventive actions remained inconsistent (see Figure 3):

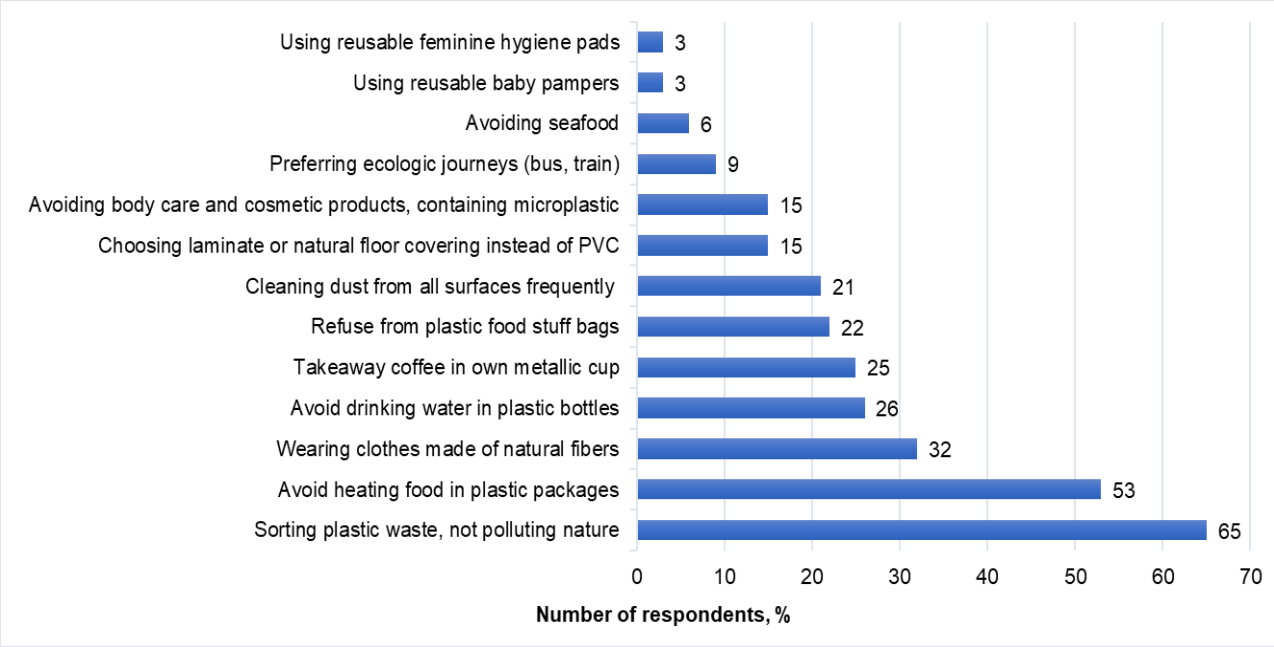



Figure 3. **The implemented measures**

The results reveal that half of the respondents recognize polyethylene, polyester, and polypropylene as microplastic sources. A significant portion is aware of microplastics' entry routes into the human body and their presence in various tissues. Notably, over half of the participants identify health risks such as hormonal disruptions and cancerogenic effects. Consumption habits indicate reliance on plastic packaging, but many respondents advocate for prevention measures like sorting plastic waste. These findings underscore the urgent need for increased public awareness and targeted interventions to mitigate health risks associated with microplastics. Governments and regulatory bodies, particularly in the European Union, have started implementing measures such as banning single-use plastic, promoting plastic waste recycling, and promoting fully biodegradable plastics. However, more comprehensive global action is needed, including public education to reduce plastic pollution and mitigate its health impacts.

## CONCLUSIONS

1. Half of respondents were familiar with polyethylene, polyester, polyethylene terephthalate, one third-of styrene, nylon and polypropylene to be the source of microplastics. The majority of respondents were aware about the main routes of microplastics' entry into the human body, but there were gaps in their knowledge.
2. Two third of participants reported that microplastics are found in human excretions and all human's bodies. More than half of respondents indicated hormonal disruption, cancerogenicity, allergies or asthma, weakening immunity and causing chronic inflammation as microplastics harmful health effects.
3. The majority of respondents are using plastic bags and packages for foodstuffs and takeaway food, water and drinks in plastic bottles. Prevention measures, offered by the majority of respondents, were sorting of plastic waste, avoiding plastic packages and bottles of foodstuffs and water and heating food in non-plastic dishes. Two third of respondents are sorting plastic waste, more than half are heating food in plastic-free dishes and one third are wearing clothes made of natural fibers. Despite increased awareness, behaviors reflecting preventive actions remained inconsistent.

## REFERENCES

Ali, N., Katsouli, J., Marczylo, E. L., Gant, T. W., Wright, S., & Bernardino de la Serna, J. (2024). The potential impacts of micro-and-nano plastics on various organ systems in humans. EBioMedicine, 99, 104901. https://doi.org/10.1016/j.ebiom.2023.104901

European Parliament. (2018). https://www.europarl.europa.eu/topics/en/article/20181116STO19217/microplastics-sources-effects-and-solutions

European Union. (2021). Directive on single-use plastics (SUP). European Commission. Retrieved from https://environment.ec.europa.eu/topics/plastics/single-use-plastics/sups-marking-specifications_en

Enyoh, C. E., Shafea, L., Verla, A. W., Verla, E. N., Qingyue, W., Chowdhury, T., & Paredes, M. (2020). Microplastics Exposure Routes and Toxicity Studies to Ecosystems: An Overview. Environmental analysis, health and toxicology, 35(1), e2020004. https://doi.org/10.5620/eaht.e2020004

Zhang, Z., Xu, M., Wang, L., Gu, W., Li, X., Han, Z., Fu, X., Wang, X., Li, X., & Su, Z. (2023). Continuous oral exposure to micro- and nanoplastics induced gut microbiota dysbiosis, intestinal barrier and immune dysfunction in adult mice. Environment international, 182, 108353. https://doi.org/10.1016/j.envint.2023.108353.

Lee, Y., Cho, J., Sohn, J., & Kim, C. (2023). Health Effects of Microplastic Exposures: Current Issues and Perspectives in South Korea. Yonsei medical journal, 64(5), 301–308. https://doi.org/10.3349/ymj.2023.0048

Marfella, R., Prattichizzo, F., Sardu, C., Fulgenzi, G., Graciotti, L., Spadoni, T., D'Onofrio, N., Scisciola, L., La Grotta, R., Frigé, C., Pellegrini, V., Municinò, M., Siniscalchi, M., Spinetti, F., Vigliotti, G., Vecchione, C., Carrizzo, A., Accarino, G., Squillante, A., Spaziano, G., … Paolisso, G. (2024). Microplastics and Nanoplastics in Atheromas and Cardiovascular Events. The New England journal of medicine, 390(10), 900–910. https://doi.org/10.1056/NEJMoa2309822

Ragusa, A., Matta, M., Cristiano, L., Matassa, R., Battaglione, E., Svelato, A., De Luca, C., D'Avino, S., Gulotta, A., Rongioletti, M. C. A., Catalano, P., Santacroce, C., Notarstefano, V., Carnevali, O., Giorgini, E., Vizza, E., Familiari, G., & Nottola, S. A. (2022). Deeply in plasticenta: Presence of microplastics in the intracellular compartment of human placentas. International Journal of Environmental Research and Public Health, 19(18), 11593. https://doi.org/10.3390/ijerph191811593

Ullah, S., Ahmad, S., Guo, X., Ullah, S., Ullah, S., Nabi, G., & Wanghe, K. (2023). A review of the endocrine disrupting effects of micro and nano plastic and their associated chemicals in mammals. Frontiers in endocrinology, 13, 1084236. https://doi.org/10.3389/fendo.2022.1084236

Wang, Y. L., Lee, Y. H., Chiu, I. J., Lin, Y. F., & Chiu, H. W. (2020). Potent Impact of Plastic Nanomaterials and Micromaterials on the Food Chain and Human Health. International journal of molecular sciences, 21(5), 1727. https://doi.org/10.3390/ijms21051727

Wright, S. L., & Kelly, F. J. (2017). Plastic and human health: A micro issue? Environmental Science & Technology, 51(12), 6634–6647. https://doi.org/10.1021/acs.est.7b00423

Yalameha, B., Rezabakhsh, A., Rahbarghazi, R., Khaki-Khatibi, F., & Nourazarian, A. (2024). Plastic particle impacts on the cardiovascular system and angiogenesis potential. Molecular and cellular biochemistry, 10.1007/s11010-024-05081-2. Advance online publication. https://doi.org/10.1007/s11010-024-05081-2

PANEVĖŽIO KOLEGIJA ISSN 2029-1280, eISSN 2669-0071. Taikomieji tyrimai studijose ir praktikoje – Applied Research in Studies and Practice, 2024, 20.

# THE EFFECT OF SUSTAINABILITY CONSCIOUSNESS ON TOURISTS' GREEN PRODUCT PURCHASE INTENTION

***Oğuzhan DALMAZ[a], Pınar ÇELİK ÇAYLAK[b]***

*[a] Kumluca Chamber of Commerce and Industry, Turkiye*
*[b] Akdeniz University, Serik Faculty of Business Administration, Turkiye*

**Abstract**. Although sustainable tourism is a frequently discussed topic in academia and politics, the development of sustainable tourism is still a difficult issue for developing economies. Sustainable tourism development can promote development by using the social capital of the society. Sustainability awareness, which is the most important of social issues, is the process of learning how to make decisions that take into account the long-term future of the economy, ecology and inequality in all communities. In other words, individuals with high sustainability consciousness are more sensitive about environmental issues when making decisions. Tourists with high sustainability consciousness have a higher potential to contribute to a sustainable future with the environmentally friendly products they demand. The aim of this study is to examine the relationship between tourists' sustainability consciousness and green purchase intentions. For this purpose, a survey was conducted on 419 tourists who visited Antalya, an important tourism destination in Turkey, and were selected by random sampling method, and the effect of tourists' sustainability consciousness on green purchase intentions was tried to be determined. SPSS computer package program was used in the analysis of the data. According to the data obtained as a result of the study; supports that tourists with high sustainability consciousness tend to buy more green.

**Keywords**: Sustainable Tourism, Sustainability Consciousness, Green Purchase Intention

## LITERATURE REVIEW

Tourism development leads to the management of all resources in a way that meets economic, social and aesthetic needs while preserving cultural integrity, basic ecological processes, biodiversity and life support systems (Speier, 2005; 71-72). In addition, as a result of the developments in tourism in the 1990s and the increase in demand for tourism, a close relationship has emerged between sustainability and tourism (Çalan, 2014; 17). The World Tourism Organization defined sustainable tourism in 2005 as tourism that takes into account current and future socio-cultural, environmental and economic impacts while responding to the needs of tourists, the sector, the environment and local people.

Sustainable tourism and sustainability consciousness share a symbiotic relationship that influences and strengthens each other in the tourism industry. Sustainable tourism essentially refers to practices that prioritize environmental protection, respect for local cultures, and fair distribution of benefits among target communities (Boley and Green, 2016; 38). On the other hand, sustainability consciousness is related to individuals' understanding of environmental, social, and economic sustainability issues and their determination to adopt responsible behaviors to address these concerns. An important aspect of their relationship lies in the promotion of responsible behavior (Gulzar et al., 2023; 5).

Tourists' sustainability consciousness is shaped by a number of factors, including their level of education, exposure to sustainability initiatives, socio-economic background and cultural upbringing (Miller et al., 2014; 28). Education plays an important role in raising awareness about environmental issues, social inequalities and the importance of sustainable development in tourism. Exposure to sustainability initiatives through media, educational programs or personal experiences significantly influences tourists' attitudes and behaviours (Gericke et al., 2019; 38).

Green purchase intention is defined as an individual's awareness of the concept of environmental sustainability and their greater preference for green companies, products or services (Mas'od and Chin, 2014; 479-480). The concept of green includes the ecological dimension of sustainable development, which consists of socio-cultural, ecological and economic sub-dimensions. Similarly, such behaviours also integrate environmental concern and belief in environmental protection or consumption of green products or services (Lee et al., 2012; 69). The increase in interest in green products and services has led consumers to develop positive purchase intentions and participate in green campaigns (Mas'od and Chin, 2014; 480). This is consistent with the results of many previous studies showing that consumers with increased environmental concern or environmental awareness have positively affected environmentally friendly purchasing behaviours (Albayrak et al., 2013; 28).

The relationship between green purchase intention and sustainability is complex and multifaceted, representing a dynamic interaction between individual consumer behaviour, market dynamics, industry practices, and broader sustainability goals (Xiao and Li, 2011; 323). Green purchase intention essentially refers to consumers' tendency and motivation to choose products or services that are consistent with their environmental values and desires for a more sustainable future (Chen and Chang, 2012; 502).

The relationship between sustainability consciousness and green purchasing intentions is becoming increasingly important in understanding consumer behaviour in the tourism industry. Sustainability consciousness refers to tourists' awareness and concerns about the environmental, social and economic impacts of their travel choices (Gericke et al., 2019; 35). This awareness is often reflected in behaviours such as choosing environmentally friendly accommodations, participating in conservation efforts and supporting local businesses that prioritize sustainability. These behaviours are crucial in developing a sustainable tourism ecosystem. Moreover, there is a remarkable relationship between these practices and green purchasing intentions. Because these practices not only contribute to a sustainable tourism infrastructure but also affect tourists' purchasing decisions (Miller et al., 2014; 27). This relationship emphasizes the role of environmental consciousness in shaping purchasing decisions and suggests that increasing tourists' sustainability consciousness can effectively promote more sustainable consumption patterns in the tourism sector. In this context, increasing tourists' sustainability consciousness may be an important strategy to encourage more environmentally responsible consumption in the tourism industry (Miller et al., 2014; 28).

## METHODOLOGY

In the research, a survey technique from quantitative data methods was used. The sustainability consciousness scale prepared by Gericke et al. (2019) was used to measure the sustainability consciousness of tourists, and the green purchase intention scale prepared by Nekmahmud and Fekete-Farkas (2020) was used to measure green purchase intentions. The research was conducted on tourists visiting Antalya, one of Turkiye's important tourist destinations. In this context, a face-to-face survey was conducted with 419 tourists.

The sustainability consciousness scale prepared by Gericke et al. (2019) used in the research consists of knowledge, attitude and behavior dimensions.

Table 1

**Dimensions and Statement Numbers of the Sustainability Consciousness Scale**

| No | Dimensions | Statement Number |
|---|---|---|
| 1 | Knowledge | 1,2,3,4,5,6,7,8,9 |
| 2 | Attitude | 10,11,12,13,14,15,16,17,18 |
| 3 | Behaviour | 19,20,21,22,23,24,25,26,27 |

The green product purchase intention scale prepared by Nekmahmud and Fekete-Farkas (2020) consists of 5 items in a single dimension.

Table 2

**Statement Numbers of the Green Product Purchase Intention Scale**

| No | Statement Number |
|---|---|
| 1 | 28,29,30,31,32 |

### *2.1. Reliability Analysis*

Scales with a Cronbach Alpha value above 0.7 are reliable scales (Hair et al., 2011). The reliability of the scales used in the study was revealed to be at a high level as a result of the analysis.

Table 3

**Cronbach Alpha Value of Scales**

| | *Cronbach Alpha (a)* |
|---|---|
| Sustainability Consciousness Scale | 0,963 |
| Green Product Purchase Intention Scale | 0,933 |

### *1.2. Demographic Information*

Frequency analysis was performed to reveal the demographic characteristics of the participants. The results of the analysis are given in the table below.

Table 4

**Demographic Information**

| Features | Category | Frequency | Percent |
|---|---|---|---|
| Gender | Female | 221 | 52,7 |
| | Male | 198 | 47,3 |
| Date of Birth | 1996 and later | 220 | 52,5 |
| | 1981-1995 | 150 | 35,8 |
| | 1961-1980 | 47 | 11,2 |

| | | | |
|---|---|---|---|
| | 1960 and before | 2 | 0,5 |
| Marital Status | Married | 136 | 32,5 |
| | Single | 283 | 67,5 |
| Educational Status | Primary | 3 | 0,7 |
| | High School | 65 | 15,5 |
| | Bachelor | 266 | 63,5 |
| | Master/Doctorate | 85 | 20,3 |
| Occupation | Student | 100 | 23,9 |
| | Retired | 11 | 2,6 |
| | Housewife | 11 | 2,6 |
| | Freelance | 131 | 31,3 |
| | Officer | 88 | 21,0 |
| | Unemployed | 23 | 5,5 |
| | Others | 55 | 13,1 |
| Income | 11.500 TL and less | 117 | 27,9 |
| | 11.501 – 22.000 | 99 | 23,6 |
| | 22.001 – 30.000 | 77 | 18,4 |
| | 30.000 TL and above | 126 | 30,1 |

As a result of the frequency analysis conducted to determine the demographic characteristics of the participants, it was found that 52,7% of the participants we female and 47,3% were male. It was seen that 52,5% of the participants were born in 1996 and later. It represents more than half of the participants. The analysis revealed that 67,5% of the participants were single and 32,5% were married. In terms of educational status, it was concluded that 63,5% of the participants had a bachelor's degree, 20,3% had a master's or doctorate degree, 15,5% had completed high school and 0,2% were primary school graduates. The rate of freelance participants is 31,3%, unemployed are 5,5% and retired and housewife participants are 2,6%.

While 30,1% of the participants have an income of 30.000 Turkish Liras and above, 27,9% have an income of 11.500 TL and below, 23,6% have an income of 11.501-22.000 TL and 18,4% have an income of 22.001-30.000 TL.

### *1.3. Frequency Analysis*

Table 5

**Frequency Analysis of the Sustainability Consciousness Dimension of Knowledge**

| | **Sustainability Consciousness Dimension of Knowledge** | **Strongly Disagree** | **Disagree** | **Undecided** | **Agree** | **Strongly Agree** | **Mean** | **Std. Deviation** |
|---|---|---|---|---|---|---|---|---|
| | | **%** | **%** | **%** | **%** | **%** | | |
| 1 | Reducing water consumption is essential for sustainable development. | 2,86 | 1,91 | 5,01 | 26,01 | 64,20 | 4,4678 | 0,965 |
| 2 | Preserving species diversity in nature is essential for sustainable development. | 2,15 | 3,10 | 1,91 | 20,05 | 72,79 | 4,5823 | |
| 3 | For sustainable development, people need to be educated on how to protect themselves against natural disasters. | 3,10 | 2,86 | 5,01 | 23,39 | 65,63 | 4,4558 | |
| 4 | The peaceful resolution of conflicts in societies is essential for sustainable development. | 2,63 | 3,58 | 7,64 | 30,31 | 55,85 | 4,3317 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 5 | Respect for human rights is essential for sustainable development. | 2,86 | 3,82 | 5,97 | 27,45 | 59,90 | 4,3771 | |
| 6 | To ensure sustainable development, all people in the world must have access to good and quality education. | 2,39 | 3,82 | 8,11 | 27,92 | 57,76 | 4,3484 | |
| 7 | To ensure sustainable development, companies must treat their employees, customers and suppliers fairly. | 2,86 | 2,63 | 7,16 | 30,07 | 57,28 | 4,3628 | |
| 8 | Sustainable development requires the equitable distribution of basic human rights, such as food and health care, among all people in the world. | 2,86 | 3,34 | 6,92 | 26,01 | 60,86 | 4,3866 | |
| 9 | Ending world poverty is essential for sustainable development. | 4,06 | 5,73 | 14,08 | 30,55 | 45,58 | 4,0788 | |

When the responses to the statements in the knowledge dimension of sustainability consciousness are examined, it is seen that all of the statements, except for one statement, are strongly agreed by over 50 percent. According to this result, we can say that the sustainability consciousness of the tourists participating in the survey is strong in terms of knowledge.

Table 6

**Frequency Analysis of the Sustainability Consciousness Dimension of Attitude**

| **Sustainability Consciousness Dimension of Attitude** | | **Strongly Disagree** | **Disagree** | **Undecided** | **Agree** | **Strongly Agree** | **Mean** | **Std. Deviation** |
|---|---|---|---|---|---|---|---|---|
| | | *%* | *%* | *%* | *%* | *%* | | |
| 10 | Using natural resources in excess of our needs does not threaten human health or our future well-being. | 1,91 | 3,82 | 4,06 | 26,01 | 66,83 | 4,4940 | 0,965 |
| 11 | I think stricter laws and regulations are needed to protect the environment. | 2,15 | 3,34 | 4,77 | 20,05 | 53,46 | 4,3556 | |
| 12 | I think it is important to do something about the problems related to climate change. | 2,63 | 4,53 | 5,49 | 23,39 | 58,23 | 4,3580 | |
| 13 | I think everyone should be educated on how to live sustainably. | 2,63 | 4,06 | 6,68 | 30,31 | 52,51 | 4,2983 | |
| 14 | We must ensure that those who come after us have the same abundance of resources that we have today. | 2,39 | 3,34 | 7,16 | 27,45 | 60,14 | 4,3914 | |
| 15 | I believe that women and men should have equal opportunities for education and employment everywhere in the world. | 2,86 | 5,01 | 7,64 | 27,92 | 60,86 | 4,3461 | |
| 16 | I think companies have a responsibility to reduce the use of packaging and disposable items. | 3,10 | 3,10 | 12,41 | 30,07 | 54,89 | 4,2697 | |
| 17 | I think it is important to reduce poverty. | 2,15 | 3,58 | 9,07 | 26,01 | 53,94 | 4,3126 | |
| 18 | I think that big companies should provide the same conditions for their employees in poor countries as in rich countries. | 3,58 | 4,53 | 12,17 | 30,55 | 50,36 | 4,1838 | |

When we look at the responses of tourists to the statements regarding the attitude dimension of sustainability consciousness, it is seen that more than half of the participants responded “strongly agree” to all statements. This clearly tells us that more than half of the tourists who participated in the survey have adopted sustainability consciousness as an attitude.

Table 7

**Frequency Analysis of the Sustainability Consciousness Dimension of Behavior**

| **Sustainability Consciousness Dimension of Behaviour** | | **Strongly Disagree** | **Disagree** | **Undecided** | **Agree** | **Strongly Agree** | **Mean** | **Std. Deviation** |
|---|---|---|---|---|---|---|---|---|
| | | *%* | *%* | *%* | *%* | *%* | | |
| 19 | I recycle as much as I can. | 3,58 | 6,68 | 19,09 | 37,23 | 33,41 | 3,9021 | 0,965 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 20 | Whenever possible, I separate household waste as separate waste. | 4,30 | 9,55 | 19,33 | 35,80 | 31,03 | 3,7971 | |
| 21 | I try to produce less waste (such as throwing away less food and not wasting paper). | 3,58 | 6,21 | 16,47 | 33,89 | 39,86 | 4,0024 | |
| 22 | When I chat, text and play games on the computer and phone, I treat people with the same respect as I do in real life. | 4,30 | 5,49 | 7,40 | 29,36 | 53,46 | 4,2220 | |
| 23 | I support a charity organisation and an environmental group. | 3,34 | 7,16 | 21,00 | 39,14 | 29,36 | 3,8401 | |
| 24 | I respect men and women equally. | 2,63 | 5,97 | 6,21 | 26,49 | 58,71 | 4,3270 | |
| 25 | I do things to help poor people. | 4,06 | 4,06 | 15,99 | 34,84 | 41,05 | 4,0477 | |
| 26 | I buy second-hand goods online or in shops. | 13,84 | 21,48 | 20,05 | 26,25 | 18,38 | 3,1384 | |
| 27 | I avoid buying products from companies that have a bad reputation towards their employees and the environment. | 5,01 | 5,25 | 15,27 | 29,83 | 44,63 | 4,0382 | |

The frequency analysis of the responses of tourists to the statements on the behavioral dimension of sustainability consciousness shows us that, although not strongly, the sustainability consciousness of tourists is reflected in their behavior.

Table 8

**Frequency Analysis of the Green Product Purchase Intention**

| **Green Product Purchase Intention** | | **Strongly Disagree** | **Disagree** | **Undecided** | **Agree** | **Strongly Agree** | **Mean** | **Std. Deviation** |
|---|---|---|---|---|---|---|---|---|
| | | **%** | **%** | **%** | **%** | **%** | | |
| 28 | I am willing to choose environmentally friendly tourism products/services when travelling to Antalya. | 5,0 | 3,1 | 13,8 | 32,7 | 45,3 | 4,10 | 0,932 |
| 29 | I plan to choose environmentally friendly products/services when travelling to Antalya. | 3,8 | 4,1 | 16,0 | 34,8 | 41,3 | 4,06 | |
| 30 | I make an effort to purchase environmentally friendly products and services when travelling to Antalya. | 4,5 | 5,0 | 15,3 | 33,9 | 41,3 | 4,02 | |
| 31 | I buy products/services that are considered to be less harmful to the environment in Antalya. | 4,1 | 4,1 | 15,3 | 33,7 | 43,0 | 4,07 | |
| 32 | I avoid purchasing products and services that could potentially damage Antalya's tourist attractions. | 3,3 | 2,4 | 11,9 | 29,8 | 52,5 | 4,26 | |

In the frequency analysis of the responses to the statements about tourists' intention to purchase green products, it is seen in the table that the majority marked the answers "I agree" and "I strongly agree". This means that tourists' intention to purchase green products is high.

### *1.4. Correlation Analysis*

Table 9

**Correlation Analysis**

| | | **Gender** | **Date of Birth** | **Marital Status** | **Education** | **Income** |
|---|---|---|---|---|---|---|
| **Gender** | r | 1,000 | 0,033 | -0,028 | -0,036 | **0,184** |
| | p | | 0,500 | 0,569 | 0,468 | 0,000 |
| **Date of Birth** | r | 0,033 | 1,000 | **-0,543** | 0,009 | 0,416 |
| | p | 0,500 | | 0,000 | 0,854 | 0,000 |
| **Marital Status** | r | -0,028 | **-0,543** | 1,000 | 0,004 | **-0,323** |
| | p | 0,569 | 0,000 | | 0,927 | 0,000 |
| **Education** | r | -0,036 | 0,009 | 0,004 | 1,000 | **0,272** |
| | p | 0,468 | 0,854 | 0,927 | | 0,000 |
| **Income** | r | **0,184** | **0,416** | **-0,323** | **0,272** | 1,000 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | p | 0,000 | 0,000 | 0,000 | 0,000 | |
| **Sustainability Consciousness** | r | **-0,214** | **0,106** | -0,074 | 0,076 | 0,034 |
| | p | 0,000 | 0,030 | 0,132 | 0,118 | 0,494 |
| **Green Product Purchase Intention** | r | **-0,177** | 0,095 | -0,091 | **0,117** | 0,016 |
| | p | 0,000 | 0,052 | 0,063 | 0,016 | 0,746 |

There is a significant relationship between sustainability consciousness and gender (r=-0.214; p<0.01), it can be said that female tourists have higher sustainability consciousness. There is a positive and significant relationship between sustainability consciousness and age (r=0.106; p<0.01), it can be said that as tourists get older, their sustainability consciousness becomes higher.

There is a significant relationship between green purchase intention and gender (r=-0.177; p<0.01), it can be said that female tourists have higher green purchase intention. There is a positive and significant relationship between green purchase intention and education (r=0.117; p<0.01), it can be said that as tourists' educational status increases, their green purchase intention increases.

## CONCLUSIONS

The study was conducted to reveal the effect of sustainability consciousness of tourists visiting Antalya on their green purchasing intentions. In broader terms, the relationships between the sub-dimensions of sustainability consciousness, namely sustainability knowledge, attitude and behaviour, and green product purchasing intentions were examined.

As a result of the comparative analyses, it was revealed that tourists' sustainability consciousness and green purchasing intention differed according to gender. As a result, the study revealed that sustainability consciousness has a significant effect on green purchasing intention. No study was found in the literature examining the effect of sustainability consciousness on green purchasing intention in the field of tourism.

The relationships supported in the study show how great the effect of sustainability consciousness of tourists on green purchasing intentions while on holiday is. In this respect, it is concluded that individuals with high sustainability consciousness have high green purchasing intentions in this direction. As a result of this positive and significant relationship between green purchasing intention and sustainability consciousness, it is concluded that tourists tend more towards environmentally friendly tourism products and services in holiday destinations. In addition, it has been concluded that tourists are willing to buy environmentally friendly products and services if their sustainability consciousness is high, not only during the time they spend in the destination but also during their travel to the destination. With this relationship, it can be suggested that studies can be carried out to make tourists gain sustainability consciousness in order to minimize the damage given to the environment in tourism.

With all this, it is a remarkable result that the gender of the tourists differs in terms of sustainability consciousness and green purchase intention as a result of the study. The fact that female tourists have more sustainability consciousness and green purchase intention than males can be interpreted as women thinking more about the future, the motivation to survive and protect their children or family, and perhaps due to their maternal characteristics. This result supports the results of the studies conducted by Akdoğan (2021), D'Souza and Taghian (2005), Anvar and Venter (2014), Jain and Kaur (2006), Aydoğan and Dinar (2019) that women have a higher green purchase intention than men. In addition to gender, it was concluded that tourists' sustainability consciousness increases with the increase in education level, but it was observed that it did not significantly affect green purchase intention. This situation can be interpreted as arising from compulsory consumption. For example, in order for a tourist's consumption and meeting their needs during their trip to be sustainable, sustainability tools must be widespread throughout the country. If an individual cannot easily access these sustainable vehicles or if accessing these vehicles is costly for them, their prefer ability may remain low. As a result, differences may be observed in individuals' green purchasing intentions.

After the concept of sustainability has gained importance in recent years, the impact of changing holiday habits and tourist behaviours on the tourism sector is inevitable. According to the results of this study, the differences in the attitudes and behaviours of tourists with sustainability consciousness have been revealed. In this sense, it will be effective for businesses operating in the sector to benefit from these results and add green services and products to their services or products. In particular, the emergence of the intention of tourists with sustainability consciousness to purchase green products has had effects on the sector such as the increase in the consumption of products and services that have the least impact on the environment, the emergence of a tendency towards local people, and the importance of local and typical markets. In this respect, it can be recommended within the scope of this study that the tourism sector focuses on environmentally friendly products and services. In addition, it would be appropriate for local people to conduct studies aimed at tourists with sustainability consciousness in order to have a positive economic impact on tourism.

In this research, the effect of tourists' sustainability consciousness on green purchasing intention was revealed as a result of a survey conducted on tourists visiting Antalya.

## REFERENCES


Akdoğan, L. (2021). Yeşil Reklamlara Yönelik Tutumun Yeşil Ürün Satın Alma Niyetine Etkisinde Çevresel Sorumluluğun Aracılık Rolü: Y Kuşağı Üzerine Bir Araştırma. *Unpublished Master Thesis*, Hasan Kalyoncu University Institute of Postgraduate Education, Gaziantep.

Albayrak, T., Aksoy, Ş. and Caber, M. (2013). The Effect of Environmental Concern and Scepticism on Green Purchase Behaviour. *Marketing Intelligence and Planning*, 31(1), 27-39.

Anvar, M. and Venter, M. (2014). Attitudes and Purchase Behaviour of Green Products among Generation Y Consumers in South Africa. *Mediterranean Journal of Social Sciences*, 5(21), 183-194.

Aydoğan, S. ve Dinar, N. (2019). Yeşil Ürün Satın Almada Yeşil Reklam ve Çevre Bilincinin Etkisi. *Akademik Sosyal Araştırmalar Dergisi,* 7(90), 229-252.

Boley, B.B. and Green, G.T. (2016). Ecotourism and Natural Resource Conservation: The 'Potential' for a Sustainable Symbiotic Relationship. *Journal of Ecotourism,* 15(1), 36-50.

Chen, Y.S. and Chang, C.H. (2012). Enhance Green Purchase Intentions: The Roles of Green Perceived Value, Green Perceived Risk, and Green Trust. *Management Decision,* 50(3), 502-520.

Çalan, M. (2014). The Difference between Turkish and European Sustainable Tourism and Recommendations to Improve the Turkish Sustainable Tourism. *Unpublished Master Thesis*. Akdeniz University Institute of Social Science, Antalya.

D'Souza, C. and Taghian, M. (2005). Green Advertising Effects on Attitude and Choice of Advertising Themes. *Asia Pacific Journal of Marketing and Logistics*, 17(3), 51-66.

Gericke, N., Pauw, J.B., Berglund, T. and Olsson, D. (2019). The Sustainability Consciousness Questionnaire: The Theoretical Development and Empirical Validation of an Evaluation Instrument for Stakeholders Working with Sustainable Development. *Sustainable Development,* 27(1), 35-49.

Gulzar, Y., Eksili, N., Celik Caylak, P. ve Mir, M.S. (2023). Sustainability Consciousness Research Trends: A Bibliometric Analysis. *Sustainability*, 15, 16773.

Hair, J., Ringle, C.M. and Sarstedt, M. (2011). PLS-SEM: Indeed a Silver Bullet. *Journal of Marketing Theory and Practice*, 19(2), 139-152.

Jain, S.K. and Kaur, G. (2006). Role of Socio-Demographics in Segmenting and Profiling Green Consumers: An Exploratory Study of in India. *International Consumer Marketing*, 18(3), 107-117.

Lee, N., Choi, Y.J., Youn, C. and Lee, Y. (2012). Does Green Fashion Retailing Make Consumers More Eco-friendly?: The Influence of Green Fashion Products and Campaigns on Green Consciousness and Behavior. *Clothing and Textiles Research Journal*, 30(1), 67-82.

Mas'od, A. and Chin, T.A. (2014). Determining Socio-Demographic, Psychographic and Religiosity of Green Hotel Consumer in Malaysia. *Procedia-Social and Behavioral Sciences*, 130, 479-489.

Miller, D., Merrilees, B. and Coghlan, A. (2014). Sustainable Urban Tourism: Understanding and Developing Visitor Pro-Environmental Behaviours. *Journal of Sustainable Tourism,* 23(1), 26-46.

Nekmahmud, M. and Fekete-Farkas, M. (2020). Why Not Green Marketing? Determinates of Consumers' Intention to Green Purchase Decision in a New Developing Nation. *Sustainability,* 12(19): 1-31.

Speier, J.V. (2005). Sustainable Development and Tourism. *Unpublished PhD Thesis*. Faculty of the School of Policy, Planning and Development University of Southern California, California.

Xiao, J.J. and Li, H. (2011). Sustainable Consumption and Life Satisfaction. *Social Indicators Research*, 104, 323-329.

PANEVĖŽIO KOLEGIJA ISSN 2029-1280, eISSN 2669-0071. Taikomieji tyrimai studijose ir praktikoje – Applied Research in Studies and Practice, 2024, 20.

# MAINTENANCE IN INDUSTRY 4.0

***Donatas BALČIŪNAS***

*Panevėžio kolegija/ State Higher Education Institution, Lithuania*

**Abstract.** The Industry 4.0 industrial revolution is moving at high speed and covers more and more segments. Technologies are constantly improving and help to do work faster, safer, cheaper and simpler. Advanced technologies require more intensive and better maintenance, with requirements to minimize service costs, reduce downtime, and protect the environment by reducing unnecessary waste of materials. Therefore, Maintenance 4.0 is being developed - "Predictive maintenance" and “Prescriptive maintenance” are being applied and developed, where unnecessary maintenance is not performed, but data is analyzed and diagnostic and prognostic models are created based on it. This paper reviews the interaction of the Industrial Revolution with Maintenance models, identifies their main advantages and disadvantages, and delve into their creation methods.

**Keywords**: predictive maintenance, prescriptive maintenance optimization, Industry 4.0, Maintenance 4.0

## INTRODUCTION

The use of computers and other digital devices in manufacturing began in the second half of the 20th century, thus signalling the emergence and development of Industry 3.0. In contrast to Industry 3.0, today's industry has reached a level where all nearby equipment is connected, data is transmitted from one mechanism to another, from one controller to another, systematized and often analyzed by artificial intelligence, which makes decisions without intervention.

Sensor technologies, data analytics, cloud technologies, mobile end devices, and real-time location systems are being deployed to improve the production process (Firoz Khan Fasuludeen at al., 2021). All of this brings us to the Industry 4.0 revolution, it focuses on connecting data, operations and resources through digital connectivity. This requires continuous improvement and implementation of new technologies that would increase production productivity. To implement all advanced manufacturing technologies, it is necessary to combine all the latest achievements: Internet of Things (IoT), big data, artificial intelligence, machine learning and cyber-physical systems (Achouch et al., 2022).

All companies aim to maximize equipment performance and minimize downtime as much as possible. At the peak of the Industry 4.0 revolution, simple maintenance methods such as “Reactive maintenance” or “Proactive maintenance” are not so effective, therefore "Predictive maintenance" and “Prescriptive maintenance” are being applied and developed, where unnecessary maintenance is not performed, but data is analyzed and diagnostic and prognostic models are created based on it.

**The objective of the research** is to review the current situation and assess and assess the data needed to implement Industry 4.0 maintenance in factories, to conduct an analysis of various maintenance methods and strategies, and to present conclusions.

**Research methods:** analysis of scientific literature and data analysis.

## REVIEW OF MAINTENANCE STRATEGIES

Industry 4.0 is a major breakthrough in the industrial field, which requires simultaneous processing of huge amounts of data, management of different systems, provision of analyses and support of predictive actions. The main components are connected by the Internet: computing, Automation, IoT, Cybersecurity, Smart factory, Big data, digitalization and manufacturing. Considering all the advantages of this industrial leap, it is necessary not to forget about the emerging problems that require active solutions. Various sources indicate that the maintenance strategies can be divided into five branches:

- **Reactive maintenance** – the strategy where maintenance is only performed when a device or mechanical machine breaks down.
- **Preventive maintenance** – proactive actions are taken to prevent problems, and maintenance is performed according to the established schedule and identified faults.
- **Condition-based maintenance** - the condition of the equipment is monitored by sensors and maintenance is performed only when a fault is registered.
- **Predictive maintenance** – is based on long-term equipment monitoring to optimize equipment performance and service life, data is constantly updated and condition status is known in real time.
- **Prescriptive maintenance** – analyses data in real time and provides data on how to delay or completely eliminate equipment failure.

A graphical interpretation of maintenance strategies has been created based on the works of M. Jasiulewicz-Kaczmarek (2020) (see Figure 1).

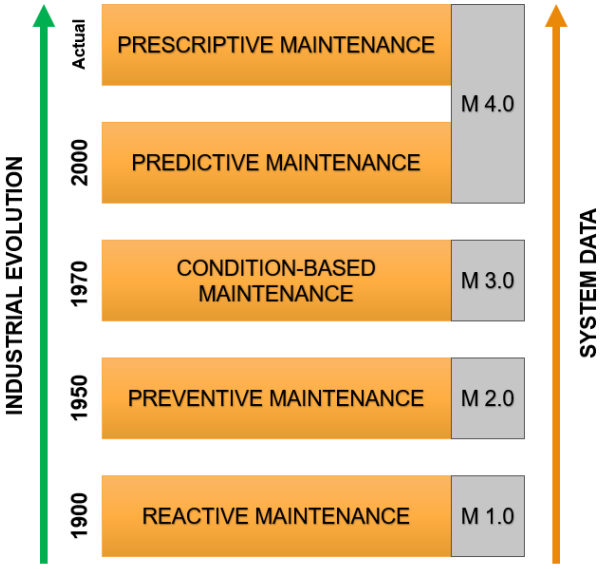



Figure 1 Development of industrial maintenance

According M. Jasiulewicz-Kaczmarek (2020) smart and sustainable maintenance must ensure benefits for this three dimensions:

Social dimension: implements new educational model, improves working safety, improves working condition and improves workers satisfaction.

Environmental dimension: decreases spare parts and lubricant utilization, improves environmental safety, minimizes end of life waste and optimize energy consumption.

Economic dimension: improves economic efficiency, reduces maintenance time, improves machine performance and decreases spare parts inventories. ).

## USAGE AND PERSPECTIVE OF MAINTENANCE 4.0

All benefits can be achieved by applying Maintenance 4.0, which is the interaction of artificial intelligence (AI) and machine learning (ML), which ensures smooth failure prediction and effectively reduces factory downtime. This technology has gained great importance and the global market is growing every year (see Figure 2). These technologies are expensive, but given the benefits they provide, more and more companies are implementing them. This is well reflected in the exponential growing market.

More and more companies are moving to Industry 4.0 solutions, which require a changing maintenance need that must keep up with the capabilities of the installed equipment. According B. W. Shaheen (2022) Maintenance 4.0 uses advanced analysis methods not only to predict failures, but also to prevent such failures and optimize maintenance schedules and resources. Currently, it can be found in many modern industries, such as the automotive, aerospace, chemical and machining industries.

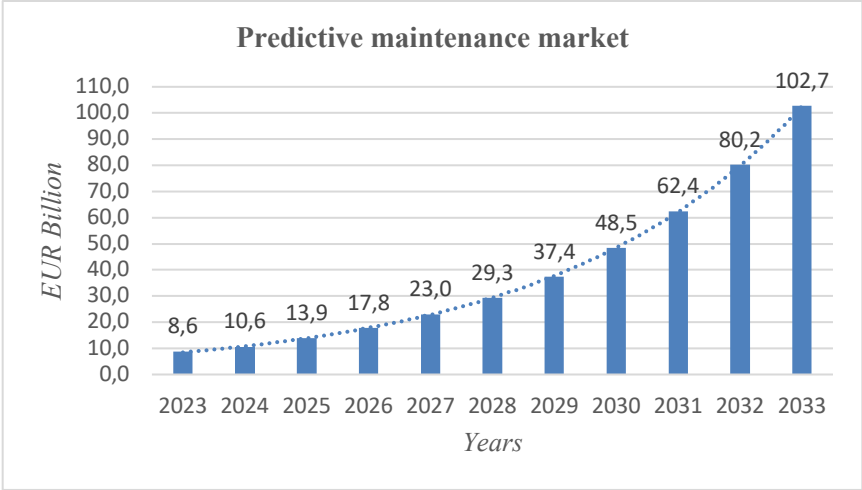



Figure 2 Global market for predictive maintenance components 2023-2033

The failure prediction curve (see Figure 3) is well depicted in the work of M. Achouch (2022). This graph clearly reflects the point at which the installation is working perfectly (Point P) and the point at which a failure sequence of part or all of the installation begins (Point P to Point F). If the development of the failure is detected before a complete functional stop (Point F), then it is possible to eliminate the failure in time, avoid downtime and save repair costs for company.

In the Maintenance 4.0 predictive process the most important work is done by the Big Data sources. It is defined as a large collection of diverse data that is used for machine learning, predictive modelling, and other advanced analytical functions. Industrial Big Data is accumulates from the following sources (Y. Yan et al., 2017):

- Design data
- Machine operation data
- Staff behaviour data
- Cost information
- Logistics information
- Environmental conditions
- Fault detection and system status monitoring data
- Product quality data
- Product usage data
- Customer information

By correctly managing, structuring and processing this collected data, it is possible to accurately predict the onset of failures and inform the operator or other responsible element in the factory about this. Data processing can detect and determine: equipment manufacturing defects, the current condition of the equipment, personnel work habits, product defects, manufacturing defects, and other information important to the company (Y. Yan et al., 2017). And this way, equipment is protected, costs are saved, and the sustainability is preserved.

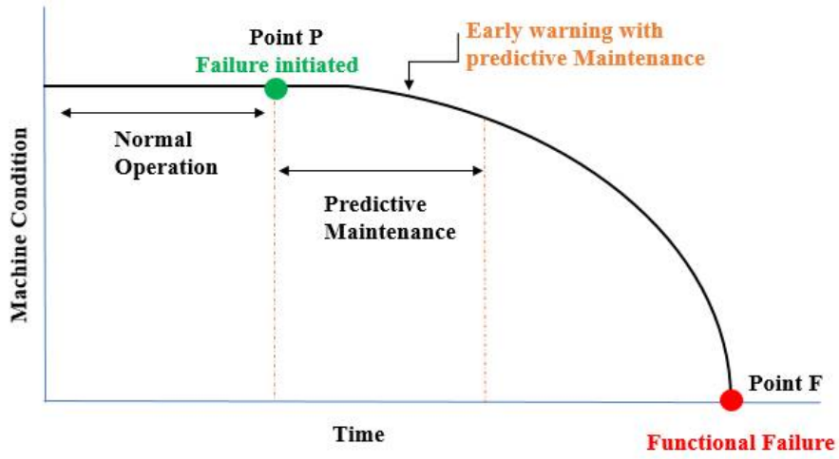



Figure 3 Potential failure diagram (Achouch et al., 2022)

Looking to the future a new industrial revolution, new human-centric era of Industry 5.0, is currently taking shape, in which employees will work with advanced technologies and robots and mechanisms controlled by artificial intelligence, aiming to improve workplace processes and further optimize production. It will create higher-value jobs, giving customers more freedom to meet their needs, and employers more freedom to empower their ideas. But it will also be an industrial revolution that will eliminate the need for unskilled labour, and companies will face human challenges. Along with Industry 5.0 comes Maintenance 5.0, which will be a type of advanced predictive maintenance. It is the interaction of software, robots, and humans.

## CONCLUSIONS

Summarizing all the collected and analyzed information, it can be seen that maintenance solutions are constantly evolving and advancing in parallel with the industrial revolution, his requires more and more data and investment for it.

These include:

1. The financial results of a manufacturing company directly depend on the maintenance method used, because service affects downtime, product quality, and sustainability.
2. Properly collected and analyzed data can predict failures and help prevent them. This type of prediction is called “Prescriptive maintenance”.
3. The most important role in “Prescriptive maintenance” is played by data collection and analysis, which is what Big Data describes.

4. The Maintenance 4.0 market is growing exponentially. However, regardless of this, the Maintenance 5.0 system, which will be even more advanced, is being implemented in parallel.

## REFERENCES

Jasiulewicz-Kaczmarek, M., Kluk, P., Legutko, S. (2020). Maintenance 4.0 technologies – new opportunities for sustainability driven maintenance. Management and Production Engineering Review, 12:2, 74-87.

Yan, Y., Meng, Y., Lu, L., Li, L. (2017). Industrial big data in an Industry 4.0 environment: challenges, schemes, and applications for predictive maintenance. IEEE Access, vol. 5, pp. 23484-23491.

Psarommatis, F., May, G., Azamfirei, V. (2023). Envisioning maintenance 5.0: Insights from a systematic literature review of Industry 4.0 and proposed framework, Journal of Manufacturing Systems, 68, 376-399.

Cortes-Leaf, A., Cardenas, C., Del-Walle-Soto, C. (2022). Maintenance 5.0: Towards a worker-in-the-loop Framework for resilient smart manufacturing. Appl. Sci., 12, 11330.

Jasiulewicz-Kaczmarek, M., Gols, A. (2019). Maintenance 4.0 technologies for sustainable manufacturing – an overview. SienceDirect, IFAC PapersOnLine, 52-10, 91-96.

Shaheen, B., W., Nemeth, I. (2022). Integration of maintenance management system functions with industry 4.0 technologies and features – a review. Proccesses 2022, 10, 2173.

Firoz Khan Fasuludeen, K., Nida, N., Naveed, A., Mir Irfan, U., H. (2021). Production and maintenance in industries: Impact of Industry 4.0. Impact of Industry 4.0, Industrial Robot, 49 (3), 461-475.

Pinciroli, L., Baraldi, P., Zio, E. (2023).Maintenance optimization in Industry 4.0. Reliability engineering and system safety, 234, 109204.

Achouch, M., Dimitrova, M., Ziane, K., Sattarpanah Karganroudi, S., Dhouib, R., Ibrahim, H., Adda, M. (2022). On predictive maintenance in Industry 4.0: overview, models, and challenges. Appl. Sci., 12, 8081.

Stodola, P., Stodola, J. (2019). Model of predictive maintenance of machines and equipment. Management and Production Engineering Review, Appl. Sci., 10, 213.

Global Predictive Maintenance Market By Component. Internet access: https://market.us/report/predictive-maintenance-market/

PANEVĖŽIO KOLEGIJA ISSN 2029-1280, eISSN 2669-0071. Taikomieji tyrimai studijose ir praktikoje – Applied Research in Studies and Practice, 2024, 20.

# THE POSSIBILITIES OF APPLYING ARTIFICIAL INTELLIGENCE IN THE ACTIVITIES OF EMPLOYEES OF EDUCATIONAL INSTITUTIONS

***Gintarė MILČĖ***

*Kolping Higher Education Institution*

**Abstract.** The sudden emergence and rapid advances in Artificial Intelligence (hereinafter – AI) have impacted the entire education sector, opening up new educational opportunities for every educator. Research shows that ChatGPT's AI model already have the highest number of monthly active daily users by 2023, surpassing even the most popular social networks such as TikTok and Instagram. Tools such as ChatGPT, Gemini, Microsoft Copilot can not only generate text responses, create virtual images, but also artworks, create music from text. This provides employees of educational institutions with a wider range of options for creating more engaging and interesting learning content and faster information retrieval. The aim of this study is to reveal the possibilities of application of artificial intelligence in the activities of employees of educational institutions. The study found that AI includes the following opportunities for staff in educational institutions: ideas generation, translation, text paraphrasing, lesson planning. It was also found that AI enriches the learning process, encourages creative solutions, speeds up preparation time and reduces routine work. However, difficulties in using AI were also noted, such as: lack of information, lack of knowledge of what queries to make in the AI system, and lack of training in the use of AI.

**Keywords.** Artificial Intelligence, ChatGPT, employees of educational institutions

## INTRODUCTION

The sudden emergence of AI and its rapidly developing progress have influenced the entire education sector, opening up new educational opportunities for every educational worker. Research shows that ChatGPT's AI model has become the page with the highest number of monthly active daily users in 2023 (Trust, Whalen, 2023). To ensure the responsible and effective use of AI in education, educators must stay up-to-date with the latest developments in AI. This is especially important as technological advancements continuously reshape the educational landscape. While AI systems can improve learning opportunities, simplify tasks and provide feedback, in the same time AI applications in education can also help personalize needs, allowing educators to create more engaging and effective learning environments, content that takes into account the strengths, weaknesses and learning styles of each individual learner. AI-based tools can also improve assessments by providing immediate feedback and allowing for more accurate assessment of student performance (Gillani et al., 2023).

However, without proper knowledge and understanding, there is a risk that these opportunities will not be fully utilized. It is therefore relevant to explore how these technologies can contribute to improving work efficiency, fostering creativity, modernizing teaching and learning. Also, it is important to talk about the challenges that need to be overcome to make AI an integral part of everyday practice in the activities of employees of educational institutions.

**Problematic questions:**

1. What application possibilities does AI provide in the activities of educational workers?
2. What impact does AI work have on work processes?
3. What are the challenges of working with AI?

**Research object** – the possibilities of applying AI in the activities of employees of educational institutions.

**The purpose of the research** – to reveal the possibilities of application of artificial intelligence in the activities of employees of educational institutions.

**Tasks:**

1. Describe the concept of artificial intelligence.
2. To determine the possibilities of application of artificial intelligence in the activities of educational workers.
3. Identify the impact of artificial intelligence on work processes.

To reveal the challenges faced by education workers when working with artificial intelligence.

## CONCEPT OF ARTIFICIAL INTELLIGENCE

Artificial Intelligence (hereinafter – AI) is a man-made system of computer algorithms and programs that can perform tasks that normally require human intelligence. AI frameworks found in the most popular platforms used in everyday life, such as Youtube, Amazon, Meta, Google Translate, Google Maps, etc. These “intelligences” are integrated into systems that have functions such as image processing, speech recognition, decision-making, language translation or even artificial creation (Chan, Colloton, 2024). According to Indroes et al. (2023), AI refers to the ability of a digital machine to carry out tasks usually involving intelligent beings, and the technologies associated with it can be divided into

different branches, such as: machine learning, computer vision, computer-aided speech and communication, and natural language, image, and record processing. One of the most remarkable achievements of the AI is the emergence of advanced language models such as ChatGPT. These models are designed to understand and generate human-like content in conversations, to answer questions, engage in dialogue and provide useful information to users. Another emergent AI is DALL-E, which is designed to create image models, to generate images – the images generated correspond to realistic images based on textual descriptions. In addition, the AI has also made very significant advances in sound processing, using models such as Whisper. These models have been trained to analyze and generate human-like speech, enabling applications such as voice assimilators and text-to-speech systems (Indroes et al., 2023).

Chen (2020), pointed out that not only is AI focused on language processing, but it is also capable of adapting to new situations, solving problems, answering questions perfectly and performing other tasks that normally require a certain level of intelligence in humans. According to the author, the AI is a complete computer innovation, or as the author puts it, a "computational culmination", which enables it to function in a human-like way. Kamalov et al. (2023), argue that the most important characteristics of AI are: learning, reasoning, problem solving, language comprehension and the ability to perform tasks normally performed by a human; Kothari (2024) refers to characteristics such as – learning and adaptation, language recognition and processing, problem solving; automated tasks and modelling of human behavior and emotions; Charles (2022) notes the following – adaptability, automation involving every day and work tasks, problem solving based on the data provided, adapting to the user's needs, and simulated human interaction. It can be noted that all authors emphasize these emergent characteristics, such as: communication, problem solving, automated tasks, etc. (Figure 1).

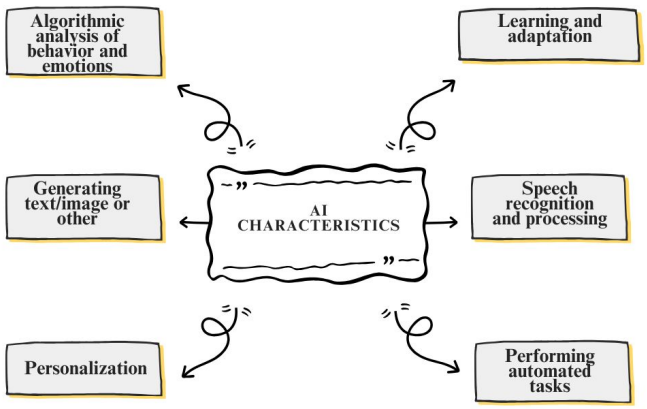



Figure 1. **Compiled by the author (2024), based on Kamalov (2023), Kothari (2023), Charles (2022).**

Thus, the rapid development and growth of AI is increasingly changing the way people communicate, collaborate, work, teach, and learn, and that changes the processes of work. The unexpectedly rapid progress and emerging capabilities of AI have had a particular impact on the entire education sector, opening up new educational opportunities for every education worker.

## AI IN EDUCATION

Digital learning tools, information communication tools and other digitalization have long entered the education sector, but AI is a sudden factor in the development of education. According to Limna (2022), AI is increasingly used as a digital assistant, helping educational staff (and students) to use teaching (learning) material in various ways, integrate it into the teaching content, individualize it, taking into account teaching (learning) needs and different teaching (learning) experiences. The author indicates that the application of AI in education has provided new opportunities to create more inclusive learning activities, technologically improve teaching programs and personalize environments, improve feedback, speed up work and task preparation or even submission. Zeide (2019) talked about AI before it was fully developed and had not reached its highest potential; the author revealed that there are three main categories of AI applications in education: institutional, learner support and educational. Institutional is intended for the development and improvement of the curriculum, the improvement of the educational subject; learner support – for consultations, information search, familiarization with the most important information; educational – for the development of individual content, self-development, pedagogical development. Thus, such opportunities for the application of AI in education not only contribute to the improvement of the quality of teaching (learning), but also promote the development of new teaching methods and the modernization of the educational process. The rapid advancement of AI has made it a ubiquitous and transformative force integrated into the field of education, which means that teaching and learning can be improved and fundamentally changed. It is believed that the potential of AI will continue to grow in the future and will fundamentally change the education sector. According to Zadorina (2024), AI tools will provide the opportunity to create content and focus on learning choices that will adapt to the progress of each learner. Tobler (2024) points out, that AI facilitates the creation of tasks, automates assessment by answering questions with immediately provided answer options,

and improves feedback. It is emphasized that natural language recognition, imitation of human emotions – not only facilitate work employees of educational institutions, but also enrich educational content. The author found that educational institution employees who are interested in and use AI tools transform the traditional learning process into an interactive and engaging experience, as their content includes quizzes, simulations, and gamified elements that are particularly attractive to learners. Thus, such opportunities for applying AI in education not only contribute to improving the quality of teaching, but also encourage the development of new teaching methods and the modernization of the educational process.

## RESEARCH METHODOLOGY

In order to reveal the possibilities of applying AI in the activities of educational institution employees, a qualitative study was chosen, which allows a better understanding of the experiences and opinions of the research participants. According to Merriam and Tisdell (2016), qualitative research helps the researcher to focus on subjective aspects that cannot be observed in quantitative research: focusing on the motivations, experiences, feelings of the research participants. Qualitative research is particularly useful for answering 'how' and 'why' questions related to people's experiences. Thus, in order to uncover the applicability of AI in the work of education staff – the aim was not only to find out whether the AI tool itself is easy to use, but also, from a human factors point of view, to understand the opinions, experiences and challenges of education staff in their work with these tools. This approach has provided deeper insights into the integration of the AI into educational processes and has helped to understand the factors that lead to a more effective use of these technologies in daily activities.

The data collection method is a semi-structured interview. The survey was attended by 10 research participants (hereinafter – RP) – employees of educational institutions (9 teachers and 1 social pedagogue). The data were analyzed using qualitative content analysis. The ethical principles of anonymity, confidentiality, personal freedom to answer the interview questions, and privacy protection were observed during the study.

## RESEARCH FINDINGS. THE POSSIBILITIES OF APPLICATION OF ARTIFICIAL INTELLIGENCE IN THE ACTIVITIES OF EDUCATIONAL WORKERS

The results of the study revealed that the possibilities of applying AI in the activities of employees of educational institutions are very wide. The research participants revealed that AI can be widely applied in the education sector, and the possibilities of application are very wide, including idea generation, lesson planning, creation of visual content and tasks (Table 1).

Table 1

**Possibilities of application of AI in the activities of educational workers**

| Subcategory | Confirmatory Statements |
|---|---|
| Generating ideas | *Save time generating ideas<...>(RP2)*<br>*First of all – for generating ideas and planning lessons. (RP2)*<br>*DI makes the work easier, because the material is written quickly, the information helps to structure the work. (RP4)*<br>*It is mostly used for creating tasks and generating ideas. (RP5)*<br>*Helps save time generating new ideas. (RP7)* |
| Translation from/into Foreign Languages | *Save time in idea generation, translation from English. (RP2)*<br>*I use ChatGPT for translations, which quickly solves translation issues. (RP8)*<br>*For search, text editing, and translation, it works very well.(RP3)*<br>*AI tools are most useful in translations... (RP5)*<br>*Most commonly used tools in the work environment are Google Translate and ChatGPT. (RP7)*<br>*Translate a necessary scientific paper written in an incomprehensible foreign language. (RP9)* |
| Text Paraphrasing | *I use Quillbot to rewrite and paraphrase texts. (RP1)*<br>*ChatGPT for information search, text structuring. (RP2)* |
| Lesson Planning | *Speeds up lesson preparation. (RP1)*<br>*Made it easier to prepare for lessons, find ideas for organizing various activities. (RP4)*<br>*Lesson planning, test preparation, but the tests should not be administered through the computer, but written by hand. (RP2)*<br>*I now spend half the time on lesson preparation compared to before. (RP6)* |

| | |
|---|---|
| Task Creation | *For quizzes and tests. (RP1)*<br>*For test preparation. (RP2)*<br>*For task preparation. (RP3)*<br>*Mostly used for task creation, idea generation. The tool has been used more intensively only since this September, so it's still the beginning and a learning stage. (RP6)* |
| Visual Content Creation | *I create visuals, plan lessons, and have tried creating an electronic book. (RP2)*<br>*For students' practical work (illustration with GDI images). (RP3)*<br>*GDI – generative AI computer-generated visuals. Created visuals help better illustrate teaching materials. (RP6)*<br>*Canva allows creating representative announcements. (RP7)*<br>*Creation of slides, pictures, etc. (RP9)* |
| Machine Translation | *For conversations, images, videos, for example, I have tried turning on automatic translation in MS Teams. (RP3)* |
| Presentation/Slide Creation | *I use Quillbot to rewrite and paraphrase texts, and I create slides based on the presented results. (RP1)*<br>*ChatGPT helps generate material for slides. (RP2)*<br>*It could greatly help other teachers prepare for lessons and create assessment tasks, but I haven't tried much yet. (RP10)* |
| Individual Plan Preparation for Students with Special Educational Needs | *Facilitates preparation for lessons and the development of individual plans for SEN students. (RP2)* |
| Communication with Administration and Parents | *I think it could also be useful in communication with the administration or parents to reach compromises in certain situations. (RP6)*<br>*Communication in a foreign language. (RP8)*<br>*"Sometimes I need advice on how to 'nicely' inform parents about their children's issues (e.g., developmental), or to find out if certain behaviors are normal. (RP9)* |
| Information Structuring | *Materials are quickly written, and information helps me structure tasks, lesson plans. (RP7)* |
| Activity Reflection | *Evaluation, self-assessment, reflection." (RP4)*<br>*Helps focus on problem areas and provide more effective feedback. (RP7)* |

Thus, as can be seen from the presented research results, the possibilities of applying AI in the activities of employees of educational institutions are extremely wide and cover various areas of activity. The main areas in which AI is used among educational employees are idea generation, translation from/to a foreign language, text creation and paraphrasing. AI is also widely used for lesson planning, task creation and helps in preparing individual plans for students with special needs. Moreover, the study showed that AI tools are not limited to pedagogical activities. They are also used to facilitate communication and collaboration with the administration and parents, ensuring a smoother flow of information and more effective communication. For example, automated tools help to produce and distribute newsletters, manage timetables and respond quickly to parent/administration queries and to create beautiful and appropriate text. Such applications underline the versatility of AI in both pedagogical and administrative processes, highlighting its role as a source of efficiency and innovation in educational institutions. Also, it is noted that AI tools make an important contribution to processes of reflection, and feedback for improvement. AI tools make it easier for educational staff in to identify problem areas and enable more accurate and effective feedback. Automated AI functions help to quickly summarize the strengths and weaknesses of work, while suggesting personalized ways to improve. In addition to encouraging reflection, AI help to analyze the effectiveness of teaching and encourage learners to review their own learning process and identify areas that need more attention.

Further research results revealed the impact of AI on work processes. The study highlighted that AI not only speeds up routine tasks, but also improves the efficiency of lesson preparation and diversifies teaching methods (Table 2).

Table 2

**The impact of AI on work processes**

| Subcategory | Confirmatory statements |
|---|---|
| Speeding up preparation for lesson | *Speeds up lesson preparation. I look up information on Google, but very often I also open ChatGPT and ask for advice on lesson planning." (RP1)*<br>*Saves time in idea generation. (RP1)*<br>*Speeds up and saves time. (RP3)*<br>*Helps me structure tasks and lesson plan, helps create several tasks faster than I used to. (RP4)*<br>*I now spend half the time on lesson preparation compared to before." (RP6)*<br>*Helps create several tasks faster than I used to. (RP7)* |
| Diversifying the teaching process | *Speeds up, saves time, and diversifies the teaching process. For example, I cannot always come up with or find enough ideas to present to students, but I ask AI, and it gives me many ideas that I improve and adapt to my needs, then give them to students. (RP3)*<br>*Facilitates creative decisions. (RP7)* |
| Facilitating creative decisions | *AI helps generate creative decisions, create tasks faster than usual. (RP7)*<br>*Reduces errors and facilitates creative decisions. (RP8)* |
| Reduction of routine tasks | *Routine tasks should be reduced. (RP3)*<br>*Speeds up routine tasks. (RP4)*<br>*Daily tasks become more efficient and less stressful. (RP5)* |
| Facilitating the search for information | *Facilitates information search and data analysis. (RP7)* |

The results of the research revealed that AI reduces the volume of routine work, simplifies information search, thereby providing more time and opportunities to focus on other work processes. Also, AI reduces the volume of routine work, simplifies information search, thus providing more time and opportunities to focus on other work processes. In addition, AI tools help to structure information more effectively, prepare educational materials and tasks, thus contributing to improving the overall quality of education. It can be noted that one of the most important features that emerged is that the AI significantly speeds up preparation for lessons. Participants in the study reported that the process of searching for information is much faster, often using not only the traditional Google search engine but also ChatGPT, which provides additional ideas for lesson planning ("*Speeds up lesson preparation. I look up information on Google, but very often I also open ChatGPT and ask for advice on lesson planning.*" (RP1)). AI tools not only save time in generating ideas, but also help to structure tasks and lesson plans efficiently, allowing for faster preparation of several tasks at once. In addition, participants in the study highlighted that they now spend half as much time on lesson preparation as they used to ("*I now spend half the time on lesson preparation compared to before.*" (RP6)), which leads to greater productivity and less stress. AI also encourages new creative solutions and makes it easier to adapt learning content to the individual needs of students. As mentioned by the research participants "*AI helps generate creative decisions*" (RP7), AI tools reduce the likelihood of errors, ensure more efficient and creative task creation, so employees of educational institutions can better meet individual educational goals. Making creative decisions with AI becomes easier and smoother, allowing teaching to become a more interesting and interactive process. It helps to improve interactivity in the classroom, promotes active learning and enhances the learning experience for both teachers and learners.

Further research results revealed that employees of educational institutions seeking to apply AI tools in their activities face various challenges (Table 3).

Table 3

**Challenges of working with AI**

| Subcategory | Confirmatory statements |
|---|---|
| Choosing the right tools | *How to find the most suitable tool(s)... I mainly use one, but it's hard to choose because you need time to learn." (RP3)* |
| Reliability of information | *I think the hardest part is distinguishing whether the information is appropriate and well-presented. (RP1)*<br>*The challenge is to carefully monitor the language of the information provided. (RP6)*<br>*Sometimes there are doubts about the accuracy of the information. (RP7)* |
| Formulating the right query | *The relevance of search terms for formulating questions. (RP5)*<br>*Properly selecting the necessary commands to ensure the AI-generated result meets the need. (RP8)* |

| | |
|---|---|
| Paid versions | *If I find some more advanced feature, or something interesting, they usually only give a free trial version, and after that, you have to pay. (RP2)*<br>*It would be nice if it were free because many tools are paid. (RP4)*<br>*There aren't any versions or licenses purchased. (RP5)* |
| Lack of knowledge about AI | *I face difficulties in understanding how to make the most of AI's capabilities. (TD7)*<br>*Honestly, I lack knowledge about AI and how it could simplify the teaching process. (RP9)*<br>*At first, when this novelty appeared, some teachers, especially older ones, found it harder to adapt. I'm used to traditional teaching methods, so it's difficult for me to adjust, but if someone showed me how to use it, I would. (TD10)* |
| Lack of AI training | *So far, no training has been organized at the institution. (TD6)*<br>*No [training], but it is planned for the future. (TD9)*<br>*No [training]. But if needed, various organized training opportunities will be used. (TD10)* |

The results of the research revealed that, first of all, it is difficult to choose the right tools for their activities that would meet their needs and ensure the reliability of information. It was also noted that there are difficulties in formulating appropriate AI queries, and for others, paid versions of AI limit their accessibility. In addition, some educational workers face a lack of knowledge about AI and are not trained to work with it, and their institutions do not provide sufficient training on the applicability and use of AI.

Participants stressed that ensuring the reliability of AI-generated information is a complex process, requiring careful monitoring of the results. One participant shared the experience: "*I think the hardest part is distinguishing whether the information is appropriate and well-presented.*" (RP1), another added: "*Sometimes there are doubts about the accuracy of the information."* (RP7). It can be seen that not all employees of educational institutions trust and use AI, so they need to carefully select the information, check it and then use it to develop educational content. In addition, many participants mentioned difficulties in formulating appropriate AI queries, and incorrectly formulated queries can produce not only irrelevant but also erroneous results. For example, one respondent said: "*Properly selecting the necessary commands to ensure the AI-generated result meets the need." (RP8).* Another issue is the availability of AI tools only in paid versions. Research participants noted that if they want to use more advanced features, they are usually only offered a free trial version and then have to pay when free version expires. One participant mentioned, *"It would be nice if it were free because many tools are paid."* (RP4). This creates an additional financial burden for employees who want to fully exploit the potential of AI tools, while using an undeveloped version of the AI can lead to a higher incidence of misinformation or incomplete assignments. In addition, many of the participants in the study cited a lack of knowledge about AI and the fact that their institutions do not yet provide enough specialized training to extend their knowledge. Participants noted, that "*I face difficulties in understanding how to make the most of AI's capabilities."* (TD7). This means that AI is not fully integrated into the daily work of staff in educational institutions, which limits the progress of both individual educators and the educational institution as a whole.

## CONCLUSIONS

1. AI – machine's ability to perform the cognitive functions we associate with human minds: perceiving, reasoning, learning, interacting with the environment, problem-solving and etc.
2. It has been determined that the possibilities of applying AI in the activities of an educational worker include: generating ideas, translating from/into a foreign language, paraphrasing text, planning lessons, creating tasks, creating visual content, creating presentations, preparing individual plans, creating communicative messages, structuring information.
3. It has been identified that in the work process, AI diversifies the teaching process, facilitates creative solutions for employees of educational institutions, speeds up the time of preparation for activities, reduces routine activities, and facilitates the search for information.
4. It was revealed that employees of educational institutions seeking to apply AI in their work find it difficult to choose suitable AI tools, lack of information reliability, difficulty in properly formulating AI requests, lack of AI training.

## REFERENCES

Chan, C. K. Y., & Colloton, T. (2024). Generative AI in Higher Education: The ChatGPT Effect (p. 287). Taylor & Francis.

Charles, V. J. (2022). Characteristics, assurances, and requirements of artificial intelligence using in higher education institutions. ResearchGate. Retrieved from https://www.researchgate.net/publication/369022105

Chen, L., Chen, P., & Lin, Z. (2020). Artificial intelligence in education: A review. Ieee Access, 8, 75264-75278.

Gillani, N., Eynon, R., Chiabaut, C., & Finkel, K. (2023). Unpacking the "Black Box" of AI in education. Educational Technology & Society, 26(1), 99-111.

Indroes, G. M., Noviandy, T. R., Maulana, A., Irvanizam, I., Jalil, Z., Lensoni, L., ... & Idroes, R. (2023). Student perspectives on the role of artificial intelligence in education: A survey-based analysis. Journal of Educational Management and Learning, 1(1), 8-15.

Kamalov, F., Santandreu Calonge, D., & Gurrib, I. (2023). New Era of Artificial Intelligence in Education: Towards a Sustainable Multifaceted Revolution. Sustainability, 15(16), 12451. https://doi.org/10.3390/su151612451

Kothari, S. (2024). Major goals of AI. Simplilearn. Retrieved from https://www.simplilearn.com/tutorials/artificial-intelligence-tutorial/major-goals-of-ai

Limna, P., Jakwatanatham, S., Siripipattanakul, S., Kaewpuang, P., & Sriboonruang, P. (2022). A review of artificial intelligence (AI) in education during the digital era. Advance Knowledge for Executives, 1(1), 1-9.

Merriam, Sharan B., and Tisdell, E. J. (2016) Qualitative research: A guide to design and implementation. John Wiley & Sons.

Tobler, S. (2024). Smart grading: A generative AI-based tool for knowledge-grounded answer evaluation in educational assessments. MethodsX, 12, 102531.

Trust, T., Whalen, J., & Mouza, C. (2023). Editorial: ChatGPT: challenges, opportunities, and implications for teacher education. Contemp. Issues Technol. Teacher Educ. 23(1), 1–23.: Society for Information Technology & Teacher Education, Waynesville, NC USA.

Zadorina, O., Hurskaya, V., Sobolyeva, S., Grekova, L., & Vasylyuk-Zaitseva, S. (2024). The Role of Artificial Intelligence in Creation of Future Education: Possibilities and Challenges. Futurity Education, 4(2). 163-185.https://doi.org/10.57125/FED.2024.06.25.09

Zeide, E. (2019). Artificial intelligence in higher education: Applications, promise and perils, and ethical questions. Educause Review, 54(3).

PANEVĖŽIO KOLEGIJA ISSN 2029-1280, eISSN 2669-0071. Taikomieji tyrimai studijose ir praktikoje – Applied Research in Studies and Practice, 2024, 20.

# PATTERNS OF DIETARY SUPPLEMENT CONSUMPTION AMONG THE STUDENTS OF BIOMEDICAL SCIENCES

***Asta BUTKUVIENĖ***

*Panevėžio kolegija/State Higher Education Institution, Lithuania*

**Abstract**. Dietary supplement term includes everything from individual nutrients — vitamins A, B, C, D, E, and K and minerals like calcium — to multivitamins and specialized "senior" formulas that contain various combinations of vitamins, minerals, phytonutrients, and other compounds. Dietary supplements can be beneficial to the health, but they can also involve health risks. Side effects from dietary supplements happen most often if people take high doses or use them instead of medicines prescribed by their health care provider. Taking many different supplements can increase the risk of side effects and drug interactions. The aim of the study was to analyze the patterns of dietary supplement consumption among the students of biomedical sciences. The tasks: to reveal the motivations for taking dietary supplements, to detect the most popular dietary supplements, to estimate the duration of supplement consumption and perceptions of safety, to assess the beneficial and harmful effects. Conclusions: The dietary supplements were taken for maintaining good physical and academic performance, for better sports results, for faster recuperation after disease or due to disease or health condition and for weight loss or control. The most frequently used vitamins included D, C, and B, while minerals like magnesium, calcium, and potassium were also popular. Caffeine, protein supplements, probiotics, complex supplements for sports, and weight management products were most frequently cited by the respondents. The most common duration of taking dietary supplements was one-six months. Over half of the respondents reported using multiple supplements simultaneously, with a majority adhering to recommended doses. However, fewer than half regularly checked for the compatibility or had the recommendations from health professionals. The majority of respondents purchase dietary supplements at pharmacies or online from certified suppliers. There is a significant lack of awareness regarding the potential health risks associated with consumption of dietary supplements among the students. The most common beneficial effects reported were enhanced immunity, gaining more energy and stamina, better academic performance. The main harmful health effects were sleep impairments, headache and obstipation.

**Keywords**: dietary supplements; biomedical students; supplement consumption patterns; health risks; motivation for supplement use

## INTRODUCTION

The global dietary supplement market is forecast to reach a market value of 185.1 billion U.S. dollars in 2025. In 2021, it was estimated to be worth around 137 billion U.S. dollars. The market has been growing since 2018 and is expected to continue to grow up to 300 billion USD till 2028 (STATISTA, 2023). The European Food Safety Authority (EFSA) defines food supplements as concentrated sources of nutrients aimed at supplementing normal diets (EFSA, 2017). While multivitamins are generally safe at recommended doses, high doses of single vitamins may lead to adverse effects, such as gastrointestinal disturbances and more severe health complications (Biesalski & Tinz, 2017). Motivations for supplement use include disease prevention, enhanced physical performance, and compensation for dietary deficiencies (Frey, Hoffmann, & Heuer, 2017). Although consumers often assume these supplements are safe, excessive consumption of supplements may have deleterious effects. Such vitamin supplements include vitamin A, niacin, biotin, vitamin D, and vitamin E, and specific mineral supplements include zinc, copper, and iron. These supplements may have a number of potential adverse effects (Anselmo, & Driscoll, 2021). It should be stated that dietary supplements are not recommended for everyone to be used to generally support health and reduce the risk of diseases, but rather to be used by those people with a prolonged nutrient deficiency in their diet or a previously diagnosed deficiency in the body (Wierzejska, 2021). Only 50% of food supplement users were advised by a medical doctor, while others were often influenced by sport coaches, friends, or the internet and other media (Sirico et al., 2018). Despite the increase in supplement use, research indicates that many individuals, particularly in the general population, are often influenced by non-medical sources rather than healthcare professionals (Bailey, Gahche, Miller, Thomas, & Dwyer, 2013). There is an urgent need for better regulations regarding food supplement labeling and a more robust understanding of nutrition among healthcare providers (Sirico et al., 2018).

**Object of the Study:** The patterns of dietary supplement consumption among the students of biomedical sciences

**Objective of the Study:** to analyze the dietary supplement consumption patterns among the students of biomedical sciences.

**The specific tasks include:**

To identify the reasons for using dietary supplements.

To determine the most commonly consumed supplements.

To estimate the duration of supplement consumption and perceptions of safety.

To assess the awareness of the health effects, both beneficial and harmful.

## THE RESEARCH METHOD

The study employed a quantitative approach, surveying the second-year students of biomedical sciences from September to October 2024. It was decided to select this particular group of respondents, as first year students only start studying biomedical sciences and lack specific knowledge. A total of 93 respondents were randomly selected, and data from 92 questionnaires were analyzed. Only those students who are consuming or had consumed at least one dietary supplement were recruited. The majority of respondents (74%) were females. The biggest part of participant's ages were ranging from 18 to 39 years. Data were collected through social media and direct contact, and analyzed using Microsoft Office Excel.

## THE RESULTS AND DISCUSSION

The survey results indicated that 68 respondents were female (74 %) and 24 (26 %) were male. Most respondents fell within the 18-39 age group (87%), see Figure 1:

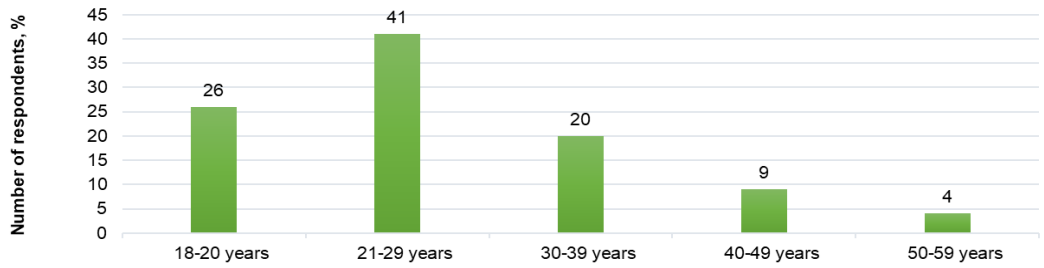



Figure 1. **The age**

Discussing the occupation of the respondents, the results revealed that half were both students and employees, less than half were only students. The minority reported being on maternity or paternity leave (see Figure 2).

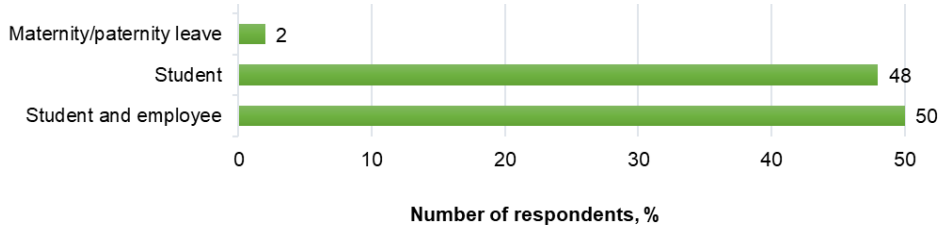



Figure 2. **The occupation**

People consuming dietary supplements are mainly divided into two groups; The first group wants to insure themselves against future illnesses, and the second are those who seek treatment for their current state of health (Lam et al., 2022). In physiological conditions, the supply of the required amount of nutrients is usually met by a normal diet (i.e. a regular diet that includes all foods and meets the energy and nutrient needs of healthy people). Based on the definition of food supplements and considering their physiological effects on different metabolic processes, the decision regarding their use should be taken carefully and be justified by the increased physiological demands or insufficient intake of nutrients from dietary sources (Sirico et al., 2017). The results of the study revealed that the majority of respondents were healthy and active physically, doing sports. One fourth of the participants reported having disease or specific health conditions, one fifth are losing weight. The respondents reported various motivations for supplement use, including maintaining good physical and academic performance, for better sports results, for faster recuperation after disease or due to existing disease or health condition, and for weight management ( see Figure 3).

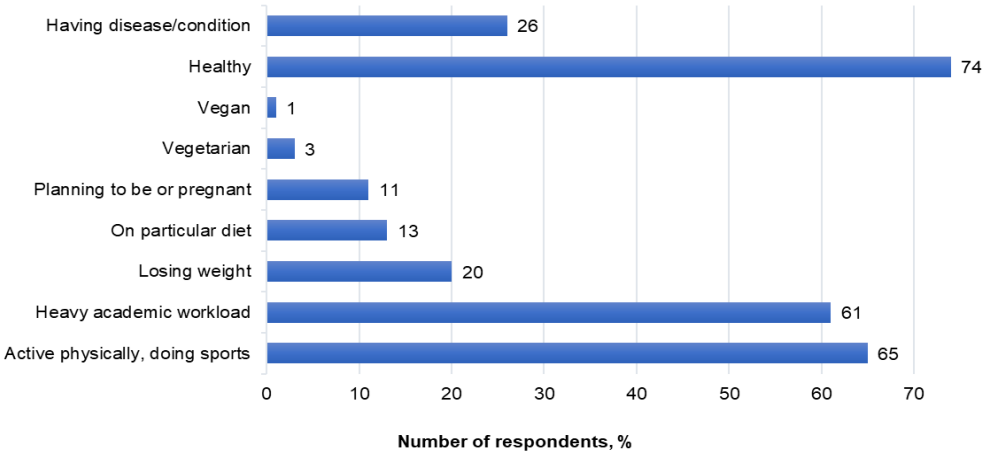



Figure 3. **The motivation due to the lifestyle and health condition**

The most popular supplements were divided into two groups ( group 1 and group 2). The results revealed that in group 1 the most popular were vitamins D, C, and B, along with minerals such as magnesium, calcium, and potassium (see Figure 4).

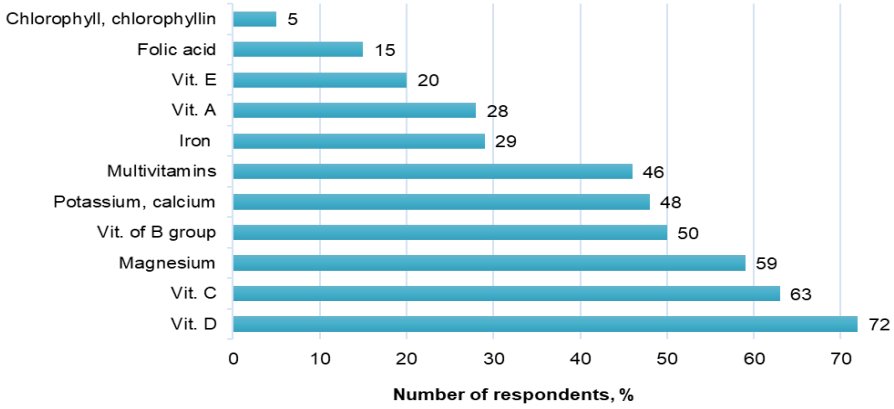



Figure 4. **The dietary supplements group 1**

According to Sirico et al., (2017), food supplement use was more common among university students (in particular, those in health professional graduate courses) than high school students. Individual sport practice, rather than team sport, was associated with higher likelihood of food supplement use. Multivitamins were most commonly used, while weight-loss formulations were the least popular. Strikingly, filling nutrient gaps was statistically not considered the main reason for taking food supplements. Instead, they were used to enhance mental performance or enhance well-being. The survey answers indicate that the participants had consumed or are consuming caffeine, protein supplements, complex supplements for sports, weight management, amino acid, ginkgo biloba supplements, and supplements for eye health. It can be stated, that caffeine, protein supplements, probiotics, complex supplements for sports, and weight management products were most frequently cited from the supplement group 2 (see Figure 5):

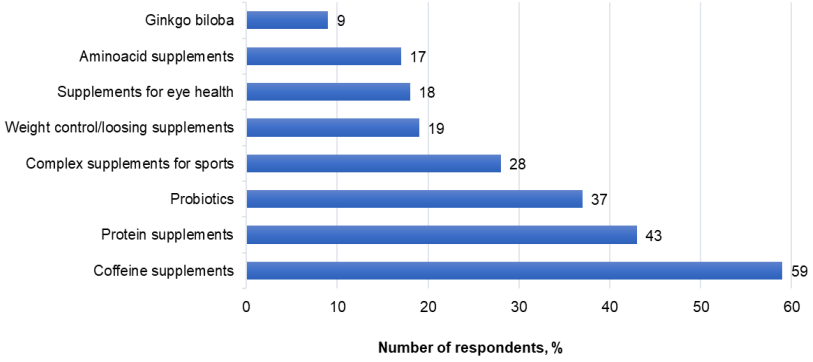



Figure 5. **The dietary supplements group 2**

The results revealed that the majority of students consumed only the recommended dose, more than half reported having consumed two or more dietary supplements at time, due to health conditions or the disease. Less than

half of the participants are always checking the compatibility between the supplements and other medications or had recommendations from the health care professional ( see Figure 6).

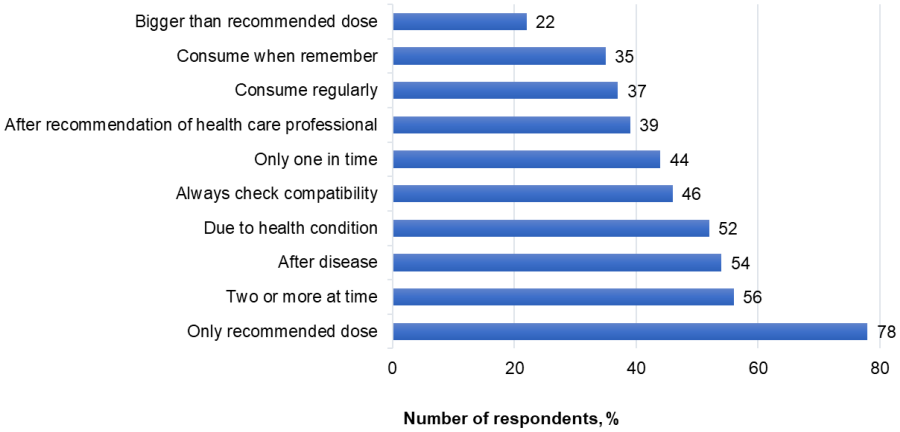



Figure 6. **The consuming regimen**

Discussing the duration of the supplement consumption, more than one third of the respondents stated that they are consuming or had consumed no longer than for one month, more than one third reported consuming or had consumed for 1-6 months, and more than one fourth stated consuming or had consumed for 6-12 months. The results indicate that the most common duration of dietary supplement's consumption was from one to six months ( see Figure 7):

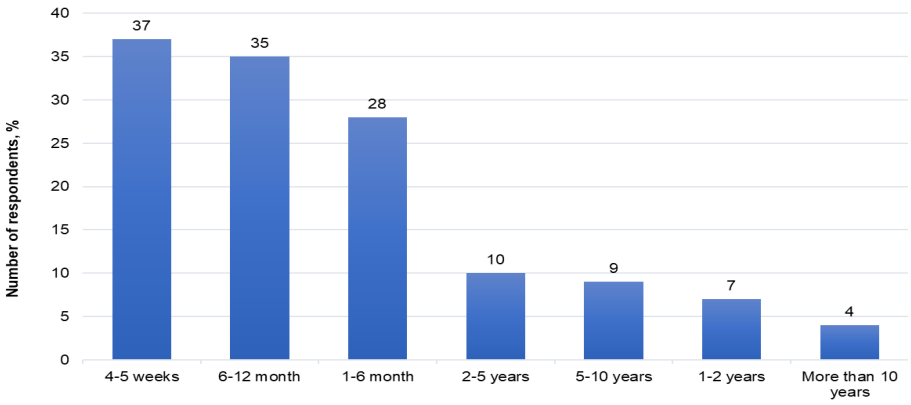



Figure 7. **The duration of consumption**

Ang, Ooi, Abd Aziz, & Tong, (2023) highlighted consumers' considerations when making online purchases of health supplements and natural products in both product-related and process-related domains: (1) product effectiveness, (2) product safety, (3) purchase convenience, (4) fair purchase and (5) online security, suggesting that consumers ultimately take an acceptable level of risk to make the decision to purchase health supplements and natural products online. As the results of the survey indicate, the majority of participants purchase the dietary supplements at pharmacies or online, but from the certified suppliers (see Figure 8):

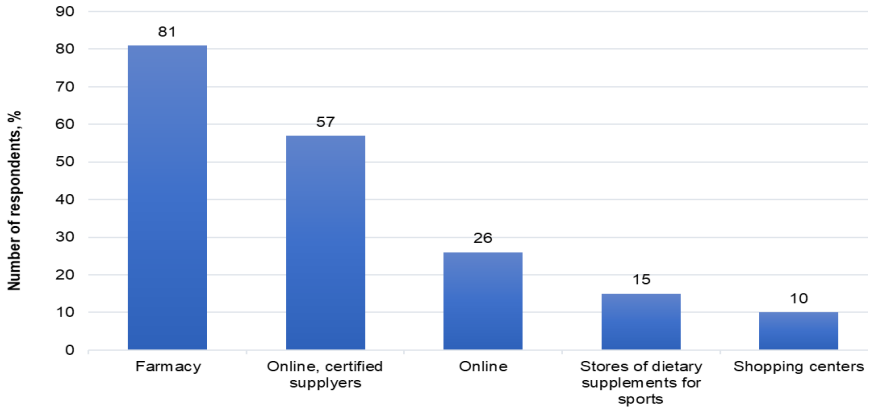



Figure 8. **The places of purchase**

However, dietary supplements and nutraceuticals are not necessarily safe for everybody. Like regular drugs, supplements with active ingredients that provide a physiological or pharmacological effect are likely to also cause adverse effects in susceptible individuals. More attention to adverse effects and potential interactions is needed to avoid serious

medical outcomes. Users and physicians alike should consult updated literature before beginning or advising a regimen involving these substances. Medical providers should be aware that a large fraction of the general population takes dietary supplements. They should therefore request information from patients about their supplement intake to provide optimal medical care (Ronis, Pedersen, & Watt, 2018). Adverse effects related to dietary supplement use were found to be associated with having respiratory disorders (asthma) and digestive disorders (AlTarrah, ElSamra, Daher, AlKhas, & Alzafiri, 2024). High doses of magnesium often result in diarrhea, nausea and abdominal cramping due to the osmotic effect. Calcium carbonate salt can cause gastric reflux and constipation (Moses, 2021). Iron deficiency anemia is a worldwide healthcare problem affecting approximately 25% of the global population. The most common iron deficiency anemia treatment is oral iron supplementation, which has been associated with gastrointestinal side effects such as constipation and bloating (Bloor, Schutte, & Hobson, 2021). Typical adverse effects of therapeutic iron doses, such as 100–200 mg/day include abdominal pain, nausea, vomiting, constipation, diarrhea and black discoloration of feces (Moses, 2021). Vitamin and mineral supplements do not lower the risk of cardiovascular diseases and cancer, while the role of omega-3 fatty acids in the prevention of cardiological diseases is not conclusively agreed. The use of weight loss supplements is either of marginal benefit or is completely ineffective, while the side effects and the risk of adulteration with illegal substances constitute serious grounds for caution to be advised (Wierzejska, 2021). Discussing the beneficial health effects, supplementation is warranted in the setting of established deficiency as well as prevention in individuals at risk; however, fortification (adding vitamins and minerals to common foods) is also an effective strategy for prevention that has been shown to decrease the burden of micronutrient deficiencies at the population level (Bailey, West, & Black, 2015). The most common beneficial health effects reported by the respondents were higher immunity, having more energy and stamina, better academic performance, normalized Hb and ferritin levels, and improved digestion. The most common adverse effects were sleep impairments (drowsiness or insomnia), headache, obstipation or diarrhea, and allergic reactions ( see Figure 9).

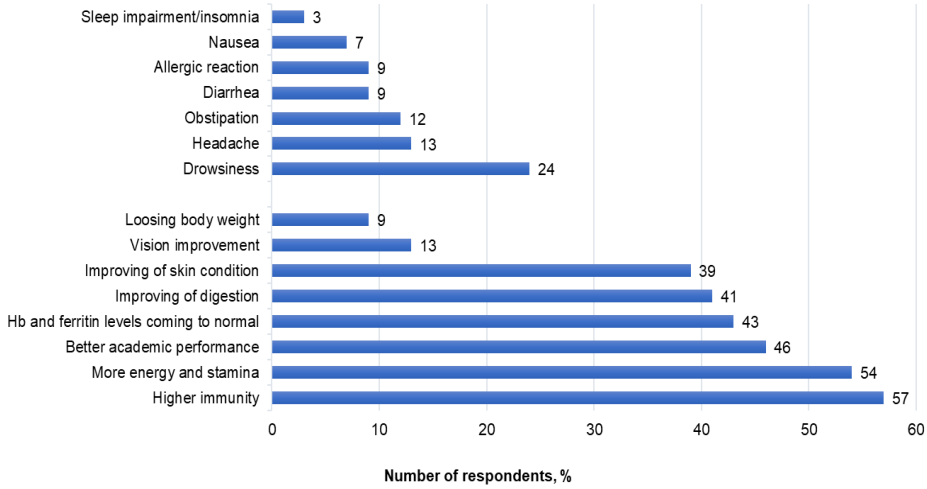



Figure 9. **The harmful and beneficial health effects**

The results of the survey suggest that attitudes of interviewed students of medical and health professional programs are not always based on medical evidence. These future health care professionals should be able to make recommendations supported by scientific data and food safety authority regulations. It is advisable to include specific courses or lectures covering the indications, interactions, and potential adverse effects of common food supplements in health care studies programs. As scientific knowledge about this topic is expected to increase in the future, medical education courses for clinicians and therapists should be organized.

## CONCLUSIONS

1. **The Reasons for use:** students predominantly used dietary supplements for physical and academic performance enhancement, disease or health condition management, and weight management.The dietary supplements were taken for maintaining good physical and academic performance, for better sports results, for faster recuperation after disease or due to existing disease or health condition, and for weight management.
2. **The most common supplements:** the most frequently used vitamins included D, C, and B, while minerals like magnesium, calcium, and potassium were also popular. Caffeine, protein supplements, probiotics, complex supplements for sports, and weight management products were most frequently cited by the respondents.
3. **Usage practices:** over half of the respondents reported using multiple supplements simultaneously, with a majority adhering to recommended doses. However, fewer than half regularly checked for the compatibility or had the recommendations from health professionals. The majority of respondents purchase dietary supplements at pharmacies or online from certified suppliers. There is a significant lack of awareness regarding the potential health risks associated with consumption of dietary supplements among the students.

4. **Awareness:** the most common beneficial effects reported were enhanced immunity, gaining more energy and stamina, better academic performance. The main harmful health effects were sleep impairments, headache and obstipation.

**Recommendations**

To address these gaps, it is recommended that health care education programs include specific courses on dietary supplements, their indications, interactions, and potential adverse effects. Additionally, continuous medical education for clinicians on the risks associated with drug and food supplement compatibility, interactions and side effects should be prioritized.

## REFERENCES

Ang, J. Y., Ooi, G. S., Abd Aziz, F., & Tong, S. F. (2023). Risk-taking in consumers' online purchases of health supplements and natural products: a grounded theory approach. Journal of pharmaceutical policy and practice, 16(1), 134. https://doi.org/10.1186/s40545-023-00645-x

Anselmo, F., & Driscoll, M. S. (2021). Deleterious side effects of nutritional supplements. Clinics in dermatology, 39(5), 745–756. https://doi.org/10.1016/j.clindermatol.2021.05.002

Bailey, R. L., Gahche, J. J., Miller, P. E., Thomas, P. R., & Dwyer, J. T. (2013). Why US adults use dietary supplements. JAMA Internal Medicine, 173(5), 355-361. https://doi:10.1001/jamainternmed.2013.2299

Bailey, R. L., West, K. P., Jr, & Black, R. E. (2015). The epidemiology of global micronutrient deficiencies. Annals of nutrition & metabolism, 66 Suppl 2, 22–33. https://doi.org/10.1159/000371618

Biesalski, H. K., & Tinz, J. (2017). Multivitamin/mineral supplements: Rationale and safety - A systematic review. Nutrition (Burbank, Los Angeles County, Calif.), 33, 76–82. https://doi.org/10.1016/j.nut.2016.02.013

Bloor S.R., Schutte R, & Hobson A. R. (2021). Oral Iron Supplementation—Gastrointestinal Side Effects and the Impact on the Gut Microbiota. Microbiology Research, 12(2):491-502. https://doi.org/10.3390/microbiolres12020033

EFSA (2017). Scientific Opinion on dietary reference values for vitamins and minerals. European Food Safety Authority. https://www.efsa.europa.eu/sites/default/files/2017_09_DRVs_summary_report.pdf

Frey, A., Hoffmann, I., & Heuer, T. (2017). Characterisation of vitamin and mineral supplement users differentiated according to their motives for using supplements: results of the German National Nutrition Monitoring (NEMONIT). Public health nutrition, 20(12), 2173–2182. https://doi.org/10.1017/S1368980017001021

Lam, M., Khoshkhat, P., Chamani, M., Shahsavari, S., Dorkoosh, F. A., Rajabi, A., Maniruzzaman, M., & Nokhodchi, A. (2022). In-depth multidisciplinary review of the usage, manufacturing, regulations & market of dietary supplements. Journal of Drug Delivery Science and Technology, 67, 102985. https://doi.org/10.1016/j.jddst.2021.102985

Moses, G. (2021). The safety of commonly used vitamins and minerals. Australian prescriber, 44(4), 119–123. https://doi.org/10.18773/austprescr.2021.029

Ronis, M. J. J., Pedersen, K. B., & Watt, J. (2018). Adverse effects of nutraceuticals and dietary supplements. Annual Review of Pharmacology and Toxicology, 58, 583–601. https://doi.org/10.1146/annurev-pharmtox-010617-052844

Sirico, F., Miressi, S., Castaldo, C., Spera, R., Montagnani, S., Di Meglio, F., & Nurzynska, D. (2018). Habits and beliefs related to food supplements: Results of a survey among Italian students of different education fields and levels. PLOS ONE, 13(1), e0191424. https://doi.org/10.1371/journal.pone.0191424

STATISTA. (2023). Global dietary supplements market forecast. Retrieved from https://www.statista.com/statistics/1264459/region-global-dietary-supplement-market/

AlTarrah, D., ElSamra, Z., Daher, W., AlKhas, A., & Alzafiri, L. (2024). A cross-sectional study of self-reported dietary supplement use, associated factors, and adverse events among young adults in Kuwait. Journal of Health, Population and Nutrition, 43(1), 117. https://doi.org/10.1186/s41043-024-00611-6

Wierzejska R. E. (2021). Dietary Supplements-For Whom? The Current State of Knowledge about the Health Effects of Selected Supplement Use. International journal of environmental research and public health, 18(17), 8897. https://doi.org/10.3390/ijerph18178897

PANEVĖŽIO KOLEGIJA ISSN 2029-1280, eISSN 2669-0071. Taikomieji tyrimai studijose ir praktikoje – Applied Research in Studies and Practice, 2024, 20.

# ANALYSIS OF CARBON FIBER USAGE IN THE AUTOMOTIVE INDUSTRY

*Gerda NOREIKAITĖ [a], Ramunė BENAITYTĖ[a], Daiva STANELYTĖ[ab]*

[a] *Klaipedos valstybine kolegija – Higher Education Institution, Lithuania*
[b] *Lithuanian Energy Institute, Lithuania*

**Abstract**. The increasing competition in markets encourages the search for innovative solutions that help stand out and attract customers. Carbon fiber, which is gaining popularity due to its excellent properties, holds great potential for this purpose. This article outlines the physical and technical properties of carbon fiber that can be applied in the automotive industry. It compares the properties of composite materials and alloys and explains why using carbon fiber in automotive parts manufacturing results in components with superior qualities compared to those made from steel or aluminum. Examples of automotive parts suitable for carbon fiber manufacturing are provided, along with descriptions of how carbon fiber components achieve better characteristics than those made from other materials. The article also analyzes the drawbacks of carbon fiber, including why it may be challenging and costly for the automotive industry to integrate carbon fiber manufacturing, and discusses the factors that drive up the cost of carbon fiber and make its recycling difficult.

**Keywords**: carbon fiber; automobiles; automotive industry

## INTRODUCTION

The developing automotive industry, aiming to design and produce reliable products, is seeking alternative materials with improved properties. In automotive manufacturing, priority is given to vehicle safety, creating a demand for strong materials. Carbon fiber has become popular in the aviation, automotive, and electrical sectors due to its excellent tensile properties, bending strength, strength-to-weight ratio, lightness, low density, thermal conductivity, electrical conductivity, chemical resistance, and resistance to creep (Azad et al., 2024). With the growing demand for cars and rising competition, there is a continuous search for ways to create higher-quality products that can stand out in the market.

In vehicles, metal is replaced by carbon fiber and various composites of carbon and other materials wherever possible. Composite materials are used to manufacture car body elements, brake and clutch discs, and trim parts, as they are durable, lightweight, and more resistant to abrasion and corrosion (Valiulis, 2010). For example, a sports car's body must be lighter to offset the weight of the engine and other components, while maintaining safety—a requirement well met by carbon fiber.

## THE RESEARCH METHOD

The aim of the study is to analyze the use of carbon fiber in the automotive industry.

Objectives of the study:

1. To identify the physical and technical properties of carbon fiber.
2. To present the applications of carbon fiber in automobiles.
3. To evaluate the drawbacks of carbon fiber.

Methodology of the study: The main research methods used include analysis of scientific sources, comparative analysis, systematization, and summarization. To ensure a thorough literature review, research data published in the Science Direct and Taylor & Francis databases were analyzed. Information was searched using keywords such as 'carbon fiber' and 'carbon fiber in the automotive industry.' Articles were selected from 2018 onward to ensure the information was current and relevant. These databases were chosen due to their reliable and relevant information aligned with the selected topic.

## PHYSICAL AND TECHNICAL PROPERTIES OF CARBON FIBER

The automotive industry is one of the most competitive industries worldwide (Vasco, 2021). With the rapid development of the automotive sector, reducing fuel consumption and emissions has become a critical issue that requires urgent solutions (Azad et al., 2024). Carbon fiber composites offer low weight, high strength, high stiffness, good resistance to vibration, fatigue, corrosion, and many other advantages (Ahmad et al., 2020). Composite materials, including carbon fiber, glass fiber, and fast-curing resins, possess properties that resist corrosion from oxygen, moisture, corrosive substances, saltwater, and humid environments (Khan et al., 2024). A comparison of the properties of traditional metals and composites is shown in Table 1.

Table 1

**Comparison of the Strength of Various Types of Composites and Alloy Materials**

| Material Name | Material Type | Tensile Strength Σu (MPa) | Density ρ (kg/m3) | Elastic Modulus E (GPa) | Material Name |
|---|---|---|---|---|---|
| **Steel (S355)** | Alloy | 500 | 7850 | 210 | **Steel (S355)** |
| **Carbon Fiber (High Strength)** | Composite | 7060 | 1820 | 294 | **Carbon Fiber (High Strength)** |
| **Aluminum (AA6082)** | Alloy | 150 | 2710 | 71 | **Aluminum (AA6082)** |
| **Laminated Glass Fiber (FR4)** | Composite | 317 | 2000 | 24 | **Laminated Glass Fiber (FR4)** |

According to Table 1, carbon fiber and laminated glass fiber have higher tensile strength than steel and aluminum. The elastic modulus of metals is also higher. Although their density is lower, steel and aluminum can be replaced by carbon fiber and laminated glass fiber, respectively (Khan et al., 2024).

Carbon fiber materials are used as electrodes and as reinforcement for other materials due to their unique physical and chemical properties (Qiao et al., 2023). Therefore, they can be used in the production of electrically insulating components where this property is required. Composite materials have low thermal and electrical conductivity, making them good insulators for components that require insulation (Khan et al., 2024).The best way to improve fuel efficiency is to reduce the weight of vehicle parts (Ahmad et al., 2020). While carbon fiber is stronger and stiffer than steel and aluminum, it weighs about a quarter of the weight of steel and 70% of the weight of aluminum (Khan et al., 2024). Comparison of Composite and Pure Materials in Figure 1.

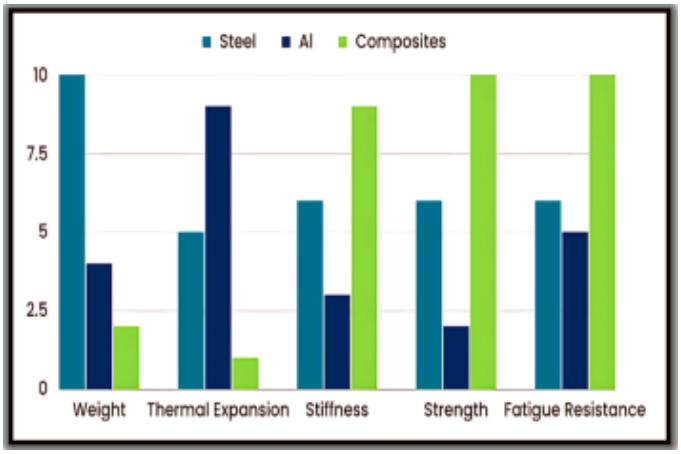



Figure 1. **Comparison between composite and pure materials**

When comparing carbon fiber to steel, aluminum, and laminated glass fiber, carbon fiber is lighter, which reduces fuel consumption as the vehicle becomes lighter. It is also stronger and stiffer, so the components do not break as easily, and in the event of a traffic accident, carbon fiber components can better perform their protective function for passengers. Carbon fiber is resistant to corrosion, fatigue, vibration, and moisture. These properties ensure a longer lifespan for the components as the impact of environmental factors is reduced. Therefore, carbon fiber has more suitable properties for the production of automotive components. Additionally, lighter vehicles can reduce road wear.

## APPLICATION OF CARBON FIBER IN AUTOMOBILES

Carbon fibers can be used in various parts of a vehicle (Ahmad et al., 2020). Typically, composite materials used in automotive structures are limited to secondary external components such as body panels, wheel housings, or bumpers (Othman et al., 2018).

**Chassis Frame**: The use of composite materials in the chassis helps reduce the overall weight of the vehicle, improves handling, and increases fuel efficiency (Khan et al., 2024). The chassis, as the frame of the vehicle, must be rigid or strong enough to absorb and stop the movements and vibrations of the engine, suspension, and axles (Ahmad et al., 2020). Composites can offer excellent fatigue resistance, ensuring that the chassis maintains its performance and structural integrity over time (Khan et al., 2024). Carbon fiber-reinforced plastics are suitable because they are about twice as strong but much lighter than steel or aluminum. The carbon fiber frame is inflexible; for example, metals can be melted or welded, whereas a carbon fiber chassis will not bend and will break under sufficient force, unable to be joined again (Ahmad et al., 2020).

**Hood**: Composite hoods can help improve vehicle handling and accelerate faster due to reduced weight and an improved power-to-weight ratio (Khan et al., 2024). Composite hoods can provide greater impact resistance, enhancing passenger safety in the event of a collision. Composite materials offer more design freedom, enabling manufacturers to produce hoods with complex curves and shapes (Ngo, 2020). Natural flax fiber, glass fiber composites, and carbon fiber composites show significant research impact. Studies recognize that composite materials for the hood reduce weight by almost 30%, while strength remains nearly the same under torsion and bending stresses (Khan et al., 2024).

**Bumper**: Composite bumpers can be designed to efficiently absorb and distribute impact energy, reducing structural damage to the vehicle and minimizing injury severity at low speeds (Rangabashiam et al., 2020). In case of minor damage, composite bumpers can be repaired more simply and cost-effectively compared to traditional steel bumpers. Composites simplify the integration of various features, such as sensors, parking aids, and lighting components. This simplifies the bumper's design and improves overall design efficiency (Khan et al., 2024).

**Doors**: Composite materials are known for their high stiffness and strength, which improves the structural integrity and impact resistance of vehicle doors. Composites can withstand corrosion, wear, and fatigue more effectively than metals (Rajak et al., 2019). Engineering composites can create quieter cabins due to specific acoustic properties that help reduce noise transmission through the doors. Car manufacturers can produce lighter and stronger doors, which, by utilizing the advantages of composite materials, contribute to increased safety and aesthetics (Salifu et al., 2022). Epoxy resin-reinforced carbon fiber absorbs more deformational energy than steel, reducing weight by 65% (Khan et al., 2024).

**Sunroof**: Composite materials with unique properties are used in the construction of car sunroofs. Weight reduction is one of the main reasons for using composites in sunroofs. Due to the reduction in weight, the overall efficiency of the vehicle can be improved. Composites have a high strength-to-weight ratio, making them desirable for reducing overall weight while maintaining structural integrity (Mansor et al., 2019). Some sunroof glazing or exterior surfaces can be made from composite materials.

**Engine cradle**: Another application of composite materials in automobiles is in the engine frame, a structural element that holds the engine and other related components. One of the key subcomponents of the engine subsystem, the engine frame performs four main functions: holding the engine, transmission, and suspension, distributing large chassis loads, reducing vibrations and shocks, and helping manage rigidity and collisions (Fonseca et al., 2019). Due to their natural thermal insulating properties, composite materials can improve heat management by reducing heat transfer from the engine to other parts of the vehicle (Huang et al., 2022). Vehicle safety and impact resistance can be enhanced by designing composite engine frames that absorb and dissipate impact energy (Khan et al., 2024). Composite engine mounts can reduce collision forces and protect other critical vehicle parts during a crash (Mohammadi et al., 2022). Using composites in the engine frame can simplify the integration of other elements, such as suspension systems and mounting points, making the vehicle’s design more unified and efficient (Sharma et al., 2022).

Therefore, by replacing certain materials used in the production of components with carbon fiber, we can achieve automotive parts with better properties. Due to its lightness and strength, carbon fiber is ideal for manufacturing chassis, sunroofs, hoods, and bumpers, and its thermal insulating properties make it suitable for engine frame (engine cradle) production. Carbon fiber-made car doors will be resistant to corrosion and reduce external noise.

## DISADVANTAGES OF CARBON FIBER

Material Cost: One of the barriers contributing to the limited use of carbon fiber in the automotive industry is the cost of materials (Othman et al., 2019). However, it should also be understood that replacing cheaper metals, currently used for functional automotive parts, with more expensive carbon composite materials will be very difficult (Ahmad et al., 2018). Currently, a large portion of CFRP (carbon fiber reinforced polymer) parts are used in high-end sports vehicles, with approximately 500 units produced annually (Othman et al., 2018).

Recycling: Recycling multiple different resins increases the disassembly costs, thus reducing the car's residual value. These resins are generally not recyclable and are disposed of in landfills as shredded automotive waste. Disposal in landfills and incineration have been the dominant recycling methods for a long time. However, these are not sustainable methods as they fail to address issues related to waste accumulation (landfilling) or require intensive energy consumption (incineration) (Butenegro et al., 2021). A survey conducted by the University of Michigan's Transportation Research Institute states that one of the main barriers to using composite materials in vehicle components is their recycling (Othman et al., 2019).Although carbon fiber has many suitable properties for the automotive industry, its production requires newer technologies to reduce the cost of carbon fiber so that the automotive industry can create affordable products for consumers. Also, due to the complexity of its production, industries may face challenges in obtaining larger quantities, which limits its use to sports and luxury cars. Possibly, due to the complex recycling of carbon fiber, its repair is also complicated. This requires specialized skills and equipment, which increases the cost. Since carbon fiber has different properties in different directions, due to its fiber orientation (anisotropic properties), challenges may arise in designing components. The load direction must be carefully considered, which can complicate manufacturing and repairs.

## CONCLUSIONS

1. After identifying the physical and technical properties of carbon fiber, we can conclude that carbon fiber has more suitable properties for automotive component manufacturing than commonly used materials such as steel, aluminum, or fiberglass. Carbon fiber is lightweight, yet strong and rigid.

2.Presenting the possibilities of carbon fiber usage, it was observed that many vehicle components can be made from carbon fiber to produce stronger, lighter, and higher-performance parts. Typically, carbon fiber is used to manufacture external automotive structures, as these parts are most exposed to external factors that shorten their lifespan. The produced components are resistant to corrosion, fatigue, vibration, and moisture.

3.Considering the drawbacks of carbon fiber, it is clear that the automotive industry could benefit from using carbon fiber, but the specifics of its production must be taken into account. In order to provide affordable products to consumers, the automotive industry must also consider the cost of the materials used. Additionally, the waste generated during production is difficult to remove because carbon fiber is hard to recycle. As a result, there is no circular economy, and environmental pollution occurs.

## REFERENCES

Ahmad H., Markina A. A., Porotnikov M. V., Ahmad F. (2020). A review of carbon fiber materials in automotive industry. IOP Conference Series: Materials Science and Engineering. (971), 032011.

Azad, H. K. M., Rahman, M. Z., Zhu D. (2024). Carbon fiber: composites and applications. Synthetic and Mineral Fibers, Their Composites and Applications, (10), 291-319. https://doi.org/10.1016/B978-0-443-13623-8.00010-1

Butenegro J. A., Bahrami M., Abenojar J., Martínez M. Á. (2021). Recent Progress in Carbon Fiber Reinforced Polymers Recycling: A Review of Recycling Methods and Reuse of Carbon Fibers. Materials, (14), 6401. https://doi.org/10.3390/ma14216401

Fonseca J.H., Han G., Quagliato L., Kim Y., Choi J., Keum T., Kim S., Han D.S., Kim N., Lee H. (2019). Design and numerical evaluation of recycled-carbon-fibrereinforced polymer/metal hybrid engine cradle concepts. International Journal of Mechanical Sciences, (163), 105115. https://doi.org/10.1016/j.ijmecsci.2019.105115

Huang Y., Xiao X., Kang H., Lv J., Zeng R., Shen J. (2022). Thermal management of polymer electrolyte membrane fuel cells: a critical review of heat transfer mechanisms, cooling approaches, and advanced cooling techniques analysis. Energy Conversion and Management, (254), 115221. https://doi.org/10.1016/j.enconman.2022.115221

Khan F., Hossain N., Mim J. J., Rahman SM M., Iqbal Md. J., Billah M., Chowdhury M. A. (2024). Advances of composite materials in automobile applications – A review. Journal of Engineering Research. https://doi.org/10.1016/j.jer.2024.02.017

Mansor M.R., Nurfaizey A., Tamaldin N., Nordin M. (2019). Natural fiber polymer composites: Utilization in aerospace engineering. Biomass, Biopolymer-Based Materials, and Bioenergy, (11). https://doi.org/10.1016/B978-0-08-102426-3.00011-4

Mohammadi H., Ahmad Z., Mazlan S.A, Johari M.H., Siebert G., Petrů M., Koloor S.S. R. (2022). Lightweight Glass Fibre-Reinforced Polymer Composite for automotive bumper applications: A review. Polymers (15). https://doi.org/10.3390/polym15010193

Ngo T., (2020) Composite and Nanocomposite Materials - From Knowledge to Industrial Applications. London: IntechOpen.

Othman R., Ismail N. I., Pahmi M. A. A. H., Basri M. H. M., Sharudin H., Hemdi A. R. (2018). Application of carbon fiber reinforced plastics in automotive industry: a review. Journal of Mechanical Manufacturing. 1 (144-154).

Qiao X., Zhang Y., Yang W., Liu J., Luo Y., Yuan Y. (2023). Carbon fibre-reinforced polydicyclopentadiene composites for automobile applications. Materials Letters. (337), 133848. https://doi.org/10.1016/j.matlet.2023.133848

Rajak D.K., Pagar D.D., Menezes P.L., Linul E. (2019). Fibre-reinforced polymer composites: manufacturing, properties, and applications. Polymers (10). https://doi.org/10.3390/polym11101667

Rangabashiam D., Tonner A. M., Prabakaran M., Rishekesh S., Janarthanam H. (2020). Design and analysis of impact damper to reduce direct impact on automobiles. AIP Conf. Proc. 2311, (1), 040001. https://doi.org/10.1063/5.0034294

Salifu S., Desai D., Ogunbiyi O.F., Mwale K. (2022). Recent development in the additive manufacturing of polymer-based composites for automotive structures—a review. The International Journal of Advanced Manufacturing Technology, (119), 6877–6891, https://doi.org/10.1007/s00170-021-08569-z

Sharma A.K., Bhandari R., Sharma C., Dhakad S.K., Pinca-Bretotean C. (2022). Polymer matrix composites: A state of art review. Materials Today: Proceedings, (57), 2330–2333. https://doi.org/10.1016/j.matpr.2021.12.592

Valiulis, A. V., (2010). Šiuolaikiškos inžinerinės medžiagos. Kūrimas ir taikymas: Vadovėlis. Vilnius: Technika.

Vasco J. C., (2021). Additive manufacturing for the automotive industry. Additive Manufacturing, (16), 505-530. https://doi.org/10.1016/B978-0-12-818411-0.00010-0

WHO, Stress. 2023.

PANEVĖŽIO KOLEGIJA ISSN 2029-1280, eISSN 2669-0071. Taikomieji tyrimai studijose ir praktikoje – Applied Research in Studies and Practice, 2024, 20.

# TOPSIS-BASED PERFORMANCE ASSESSMENT OF EXTERNAL WALL MASONRY BLOCKS FOR A NET-ZERO ENERGY RESIDENTIAL BUILDING

***Donatas AVIŽA*[a,b]**

[a]*Panevėžio kolegija/ State Higher Educational institution, Lithuania*
[b] *Kaunas University of Technology, Lithuania*

**Abstract**. This article investigates the use of the *Technique for Order Preference by Similarity to Ideal Solution* (TOPSIS) method for evaluating the performance of external wall masonry blocks in a net-zero energy residential building. Four alternative masonry blocks (autoclaved aerated concrete block *"Bauroc 200 mm Classic'* (B1)*;* silicate block *"ARKO 180 mm M-18"* (B2)*;* ceramsite block *"5 MPa FIBO 200 mm"* (B3) and ceramic block *"Porotherm" 188 mm 18,8 P+W"*(B4)) were assessed based on six criteria: the design value of the thermal conductivity coefficient (W/(m·K)); the price of the blocks and insulation EPS70N (€/m²); the resistance to freezing/heating (cycles); the compressive strength (MPa); the weight of the wall blocks (kg/m²) and the sound reduction index (dB). The results of the empirical research indicate that the ceramic block "*Porotherm 188 mm 18.8 P+W"* is the most effective wall masonry block for a net-zero energy residential building. This block achieved the highest relative performance score (0.8529). In contrast, the ceramsite block "*5 MPa FIBO 200 mm"* (0.4326 points) and the silicate block "*ARKO 180 mm M-18"* (0.4331 points) were the least effective alternatives among the four tested block types.

**Keywords:** external wall; masonry block; net-zero energy residential building; TOPSIS method

## INTRODUCTION

Buildings account for 40% of final energy consumption in the European Union (EU) and 36% of its energy-related greenhouse gas emissions, while 75% of EU buildings remain energy-inefficient. Regulation (EU) 2021/1119 of the European Parliament enshrines the target of economy-wide climate neutrality by 2050 into EU law and establishes a binding EU domestic reduction commitment to lower net greenhouse gas emissions by at least 55% below 1990 levels by 2030 (Regulation (EU) 2024/1275).

The new Directive (EU) 2024/1275 defines two concepts of buildings: "nearly zero-energy" and "zero-emission" buildings. In Lithuania, net-zero energy (or "nearly zero-energy") buildings are required to meet the standards of A++ class buildings, as specified in the technical construction regulation STR 2.01.02:2016 (Aviža, 2023).

Extensive scientific research on nearly zero-energy buildings is available in the literature (Lu, et al. 2024; Bliūdžius, et al. 2024; Makhloufi, et al. 2024; Wu, et al. 2021 and others). Despite the availability of data on various aspects of nearly zero-energy buildings, there is a lack of information regarding their external wall masonry blocks performance assessment across multiple criteria for residential buildings. As a result, this paper will examine typical exterior wall blocks for a net-zero energy (A++ class) residential building in more detail. After conducting a TOPSIS empirical analysis, the most effective external wall masonry block alternative will be determined.

*The goal of this paper is:* to assess the TOPSIS-based performance of external wall masonry blocks for net-zero energy residential buildings in Lithuania.

*The objectives of this study are*:

1. to investigate the application of the TOPSIS method in Multi-Criteria Decision-Making context.
2. to construct a research model based on a typical exterior wall detail (*Rendered Façade*) for a net-zero energy (A++ class) residential building in Lithuania.
3. to conduct a multi-criteria assessment of the effectiveness of four different external wall masonry blocks based on six criteria.

*Research methods:* review of technical and scientific literature; empirical analysis; TOPSIS application.

## THE TOPSIS METHOD

The Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), created by Yoon and Hwang in 1981, operates by determining the relative proximity of each alternative option to the optimal solution using Euclidean distance. TOPSIS is a popular method for multi-criteria decision-making (MCDM) applications due to its simplicity and computational efficiency (Jong et al. 2024). Other researchers (Kraujalienė, 2019, A. Podviezko & V. Podvezko, 2014) have examined the advantages and disadvantages of the TOPSIS application (Table 1).

Table 1

**Advantages and disadvantages of the TOPSIS method (Kraujalienė, 2019)**

| No | Advantages | Disadvantages |
|---|---|---|
| 1 | This absolute evaluation tool, which is not requiring transformation to minimize the variables; the data transformation is not perverted. | The application of Euclidean Distance does not look to the correlation of the attributes. |
| 2 | The TOPSIS method is allowing to interpret the absolute evaluation of certain alternative, its deviation magnitude assessing the results starting from the best and the worst average alternatives. | In this tool is quite difficult to weight and also keep the consistency of judgment, particularly with additional attributes. |
| 3 | This tool is providing the possibility of the most stable performance results in case the input data is varying. | |
| 4 | The research of developing hypothetical worst and best objects is suitable for certain tasks are worth to be started in many areas, where quantitative evaluation is needed. | |
| 5 | The TOPSIS is based on the simple process; it is programmable and easy to apply. | |
| 6 | The TOPSIS method is easy in terms of maintaining the same number of steps in regard to the size of the problem. | |
| 7 | The TOPSIS tool is widely in use for areas like logistics, manufacturing systems and engineering, environmental management, marketing management, design, business, water and human resources management. | |

The seven-step process of TOPSIS is well-defined and easy to comprehend, making it a widely used tool in decision-making (Jong et al. 2024). The core concept of this technique is that the chosen alternative should have the smallest geometrical distance from the positive solution (PIS) and the largest geometrical distance from the negative ideal solution (NIS). Nowadays this technique used in different fields of life such as energy, medicine engineering and manufacturing systems, safety and environmental fields, chemical engineering and water resources studies (Zulqarnain et al. 2020).

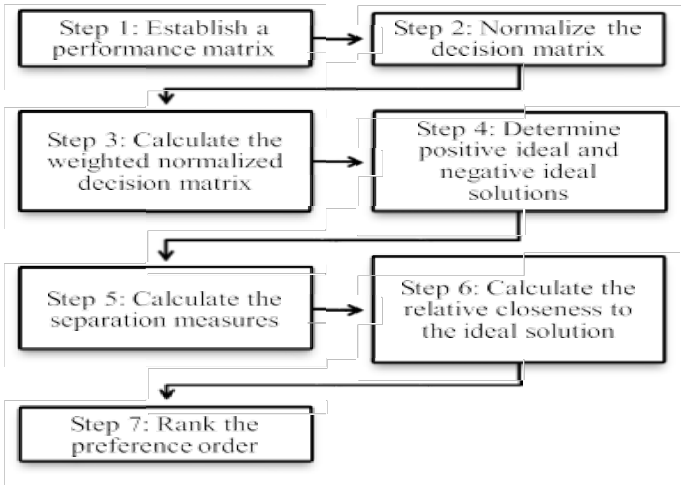



Figure 1. **The TOPSIS algorithm (Jong et al. 2024)**

The TOPSIS algorithm follows the seven steps illustrated in Fig. 1 (Jong et al. 2024).

## THE RESEARCH MODEL

The research model was created by using a typical external wall (*Rendered Facade* (ETICs)) detail of an A++ class residential building in Lithuania. The tested layer – no 1 (Figure 2).

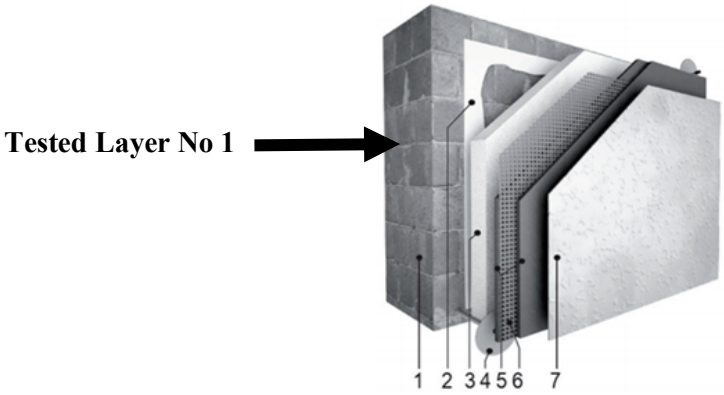



Figure 2. **The research model – external wall detail of an A++ class residential building (for the explanation of layers, see Table 2). Source: ST 2124555837.01:2021**

Following the Technical Regulations of Construction STR 2.01.02:2016, were calculated: a) the required heat transfer coefficient of an A++ class residential wall, U=0.11 W/m²K and b) the thickness of EPS70N thermal insulation material.

Table 2

**The External Wall Layers**

| No | Name of the layer | Thickness, mm |
|---|---|---|
| 1-2 | Wall Masonry Blocks + Adhesive mortar (5 mm) | 180-200 |
| 3 | Expanded polystyrene (EPS70N) foam $\lambda_{dec}$=0,032; 64,89 €/m³ | 270-300 |
| 4 | Anchor with plastic nail | - |
| 5 | Adhesive mortar coated with masonry sealer | 5 |
| 6 | Reinforcing mesh | |
| 7 | Decorative coat | |

In this study, four different wall masonry blocks were tested: autoclaved aerated concrete block "*Bauroc 200 mm Classic*" (B1), silicate block "*ARKO 180 mm M-18*" (B2), ceramsite block "*5 MPa FIBO 200 mm*" (B3), and ceramic block "*Porotherm 188 mm 18.8 P+W*" (B4).

The TOPSIS (*Technique for Order Preference by Similarity to Ideal Solution*) method was selected for the multi-criteria assessment of the effectiveness of these four masonry blocks based on six criteria.

## THE RESEARCH METHODOLOGY AND OUTCOMES

In the first TOPSIS-based performance evaluation step, a primary decision-making matrix (Table 3) is compiled, and four different wall masonry blocks – autoclaved aerated concrete block (B1), silicate block (B2), ceramsite block (B3), and ceramic block (B4) – are evaluated against six criteria extracted from the technical specifications: resistance to freezing/heating (cycles), compressive strength (MPa), weight of wall blocks (kg/m²), sound reduction index (dB), the price of the blocks and EPS70N insulation (€/m²) (Q4 2024). The design value of thermal conductivity coefficient (W/(m·K)) has been taken from the technical construction regulation (STR 2.01.02:2016), as some manufacturers declare inappropriate coefficient values for the energy performance assessment. The significance of all attributes is assumed to be equal (0.17).

Table 3

**Primary Decision-making Matrix**

| Tested alternatives/ Significances | Attributes | | | | | |
|---|---|---|---|---|---|---|
| | ***The design value of thermal conductivity coefficient (A1), W/(m·K)*** | ***The price (Q4 2024) of the blocks and insulation EPS70N (A2), €/m²*** | ***The resistance to freezing/ heating (A3), cycles*** | ***The compressive strength (A4), MPa*** | ***The weight of wall blocks (A5), kg/m²*** | ***The sound reduction index (A6), Db*** |
| Autoclaved aerated concrete block (B1) | 0.23 | 27.23 | 35 | 3 | 93.50 | 43 |
| Silicate block (B2) | 0.90 | 27.14 | 50 | 15 | 252.84 | 53 |
| Ceramsite block (B3) | 0.60 | 25.89 | 50 | 5 | 150.00 | 49 |

| Tested alternatives/ Significances | Attributes | | | | | |
|---|---|---|---|---|---|---|
| | ***The design value of thermal conductivity coefficient (A1), W/(m·K)*** | ***The price (Q4 2024) of the blocks and insulation EPS70N (A2), €/m²*** | ***The resistance to freezing/ heating (A3), cycles*** | ***The compressive strength (A4), MPa*** | ***The weight of wall blocks (A5), kg/m²*** | ***The sound reduction index (A6), Db*** |
| Ceramic block (B4) | 0.25 | 24.14 | 50 | 15 | 144.00 | 51 |
| Significance | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 |

In the next step, the primary decision-making matrix is normalized (Table 4).

Table 4

**Normalized decision-making matrix**

| Tested alternatives | Attributes | | | | | |
|---|---|---|---|---|---|---|
| | ***A1*** | ***A2*** | ***A3*** | ***A4*** | ***A5*** | ***A6*** |
| Autoclaved aerated concrete block (B1) | 0.203 | 0.521 | 0.375 | 0.136 | 0.275 | 0.438 |
| Silicate block (B2) | 0.794 | 0.519 | 0.535 | 0.682 | 0.743 | 0.539 |
| Ceramsite block (B3) | 0.529 | 0.495 | 0.535 | 0.227 | 0.441 | 0.499 |
| Ceramic block (B4) | 0.221 | 0.462 | 0.535 | 0.682 | 0.423 | 0.519 |

The weighted normalized decision matrix is computed in the next step (Table 5).

Table 5

**Weighted normalized decision matrix**

| Tested alternatives | Attributes | | | | | |
|---|---|---|---|---|---|---|
| | ***A1*** | ***A2*** | ***A3*** | ***A4*** | ***A5*** | ***A6*** |
| Autoclaved aerated concrete block (B1) | 0.084 | 0.147 | 0.149 | 0.167 | 0.162 | 0.023 |
| Silicate block (B2) | 0.084 | 0.167 | 0.167 | 0.124 | 0.167 | 0.039 |
| Ceramsite block (B3) | 0.167 | 0.158 | 0.158 | 0.086 | 0.139 | 0.167 |
| Ceramic block (B4) | 0.017 | 0.134 | 0.135 | 0.099 | 0.083 | 0.039 |
| Min./Max. | Min. | Min. | Max. | Max. | Min. | Max. |

In the final steps, the PIS and NIS were determined and calculated: Separation Distance from PIS and NIS for each alternative, Relative Closeness to the Ideal Solution, and Ranking of Preference Order (Table 6).

Table 6

**Ranking alternatives**

| Tested alternatives | Relative Closeness to the Ideal Solution, in scores | Ranking of Preference Order |
|---|---|---|
| Autoclaved aerated concrete block (B1) | 0.5649 | 2 |
| Silicate block (B2) | 0.4331 | 3 |
| Ceramsite block (B3) | 0.4326 | 4 |
| Ceramic block (B4) | 0.8529 | 1 |

After completing the multi-criteria TOPSIS-based evaluation, the efficiency scores were calculated for each wall masonry block (Figure 2).

The empirical analysis unveils that, for a net-zero energy (A++ class) residential building, the most effective external wall masonry block is the Ceramic block (B4), while the least effective is the Ceramsite block (B3), with a relative efficiency score of 0.4326 points.

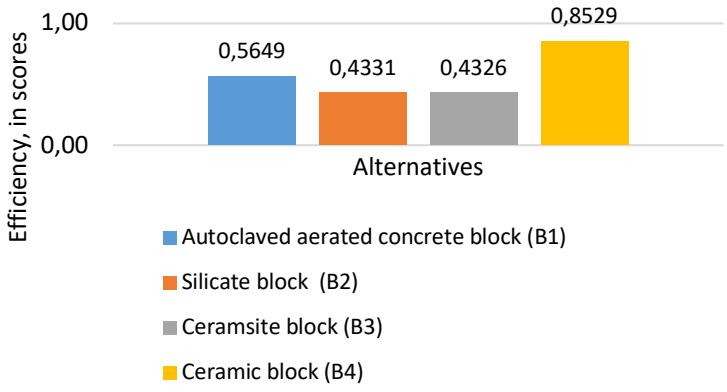



Figure 2. **The assessment of the efficiency of the wall masonry blocks**

## CONCLUSIONS

1. It was revealed by using the TOPSIS method that the most effective external wall masonry block for a net-zero energy (A++ class) residential building (considering four block alternatives and six criteria) is the Ceramic block "*Porotherm 188 18.8 P+W*" (B4). This alternative achieved the highest relative efficiency score of 0.8529 points.
2. The second most effective option is the autoclaved aerated concrete block "*Bauroc 200 Classic*" (B2), which scored 0.5649 relative efficiency points.
3. The least effective alternatives (out of the four tested) are the Ceramsite block "*5 MPa FIBO 200*" (0.4326 points) and the Silicate block "*ARKO 180 M-18*" (0.4331 points). The relative difference in efficiency between the best and worst alternatives is 49.28%.
4. If ceramic blocks are selected for future projects (A++ class), a total savings of 11.35% could be achieved on the cost of the blocks and their insulating materials.

## REFERENCES

Aviža, D. (2023). Evaluation of the thermal insulation performance of the ground floor of an A++ class public building using the SAW method. Taikomieji tyrimai studijose ir praktikoje - Applied Research in Studies and Practice, 19(1), 39-44. https://ojs.panko.lt/index.php/ARSP/article/view/202.

Bliūdžius, R. et al. (2024). Analysis of Improvement in the Energy Efficiency of Office Buildings Based on Energy Performance Certificates. Buildings, 14, 2791. DOI: https://doi.org/10.3390/buildings14092791.

Directive (EU) 2024/1275 of the European Parliament and of the Council of 24 April 2024 on the energy performance of buildings. European Parliament, 2024.

Jong, F. C. et al. (2024). Multi-Criteria Decision-Making Solutions for Optimal Solar Energy Sites Identification: A Systematic Review and Analysis. IEEE Access, 12(99). DIO: https:// 10.1109/ACCESS.2024.3461948.

Kraujalienė, L. (2019). Comparative analysis of multicriteria decision-making methods evaluating the efficiency of technology transfer. Business, Management and Education, 17, 72-93. DOI: https://doi.org/10.3846/bme.2019.11014.

Lu, M. et al. (2024). Multi-objective design optimization of multiple energy systems in net/ nearly zero energy buildings under uncertainty correlations. Applied Energy, 370, 123620. DOI: https://doi.org/10.1016/j.apenergy.2024.123620.

Makhloufi, A. W. et al. (2024). Optimising building performance for a resilient Future: A Multi-Objective approach to Net Zero energy strategies. Energy & Buildings, 324, 114869. DOI: https://doi.org/10.1016/j.enbuild.2024.114869.

Podviezko, A., & Podvezko, V. (2014). Absolute and relative evaluation of socio-economic objects based on multiple criteria decision making methods. Engineering Economics, 25(5), 522-529. https://doi.org/10.5755/j01.ee.25.5.6624.

ST 2124555837.01:2021 – Insulation of buildings with EPS. Construction regulation. Vilnius, 2021.

Technical construction regulation STR 2.01.02:2016. Design and certification of energy performance of buildings. Vilnius: Ministry of Environment of the Republic of Lithuania, 2024.

Wu, W. et al. (2021). Residential net-zero energy buildings: Review and perspective. Renewable and Sustainable Energy Reviews, 142, 110859. DOI: https://doi.org/10.1016/j.rser.2021.110859.

Zulqarnain, R. M. et al. (2020). Application of TOPSIS Method for Decision Making. International Journal of Scientific Research in Mathematical and Statistical Sciences, 7(2), 76–81. https://www.researchgate.net/publication/342347772.

PANEVĖŽIO KOLEGIJA ISSN 2029-1280, eISSN 2669-0071. Taikomieji tyrimai studijose ir praktikoje – Applied Research in Studies and Practice, 2024, 20.

# THE INFLUENCE OF ROTATION SPEED AND LUBRICANT TYPE ON THE FRICTION PROCESS PARAMETERS OF TAPERED BEARINGS

*Danas GARUCKAS*[a,b] *, Aurimas ČESNULEVIČIUS*[a,b]

[a]*Panevėžio kolegija/ State Higher Educational institution, Lithuania*
[b] *Kaunas university of technology Panevėžys Faculty of Technologies and Business, Lithuania*

**Abstract.** The service life of bearings depends on their operating conditions. This paper presents the results of experiments, during which the influence of rotation speed and lubricant type on the indicators of the friction process of tapered bearings was analysed. During the experiments, three different types of lubricants were used and the rotation speed was changed, simulating the speed of the car at 30, 50, 70, 90 and 130 km/h.

**Keywords**: tapered bearings, friction, wear, surface roughness

## INTRODUCTION

The technical performance and service life of car parts depend on the operating conditions. Wheel bearings are no exception. Wear and lubrication issues must be addressed in order to prolong their service life and conserve natural resources. A wide range of experimental studies on bearings are needed to find out how to extend their lifetime [1, 2].

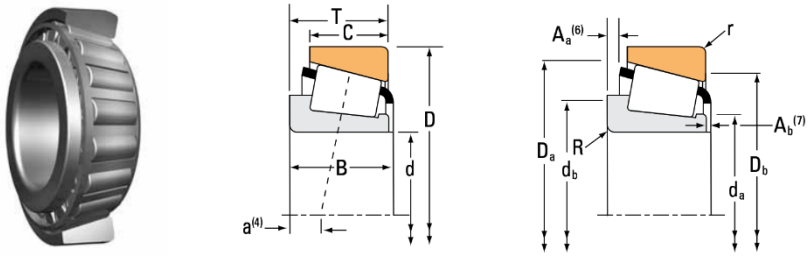



Figure 1. **TIMKEN tapered bearing [3]**

The bearings analysed in this study were TIMKEN JL69349-JL69310 bearings (Fig. 1). The dimensions of the bearing to be investigated are as follows: outer ring diameter D = 63,00 mm, inner ring diameter d = 38,00 mm, bearing height T (or H) = 17,00 mm [3].

The parameters of the bearing friction process measured in the study were the roughness of the bearing working surfaces (Ra, Rz, Rmax) and, to assess the bearing wear, the bearing height H. To assess the roughness of the bearing's working surfaces, it was limited to measuring the roughness of the working surface of the outer ring of the bearing, on which the rollers are rolling in the transversal direction of the rollers' roll trajectory. To record the bearing wear, the change in bearing height ΔH from its original reference height was measured.

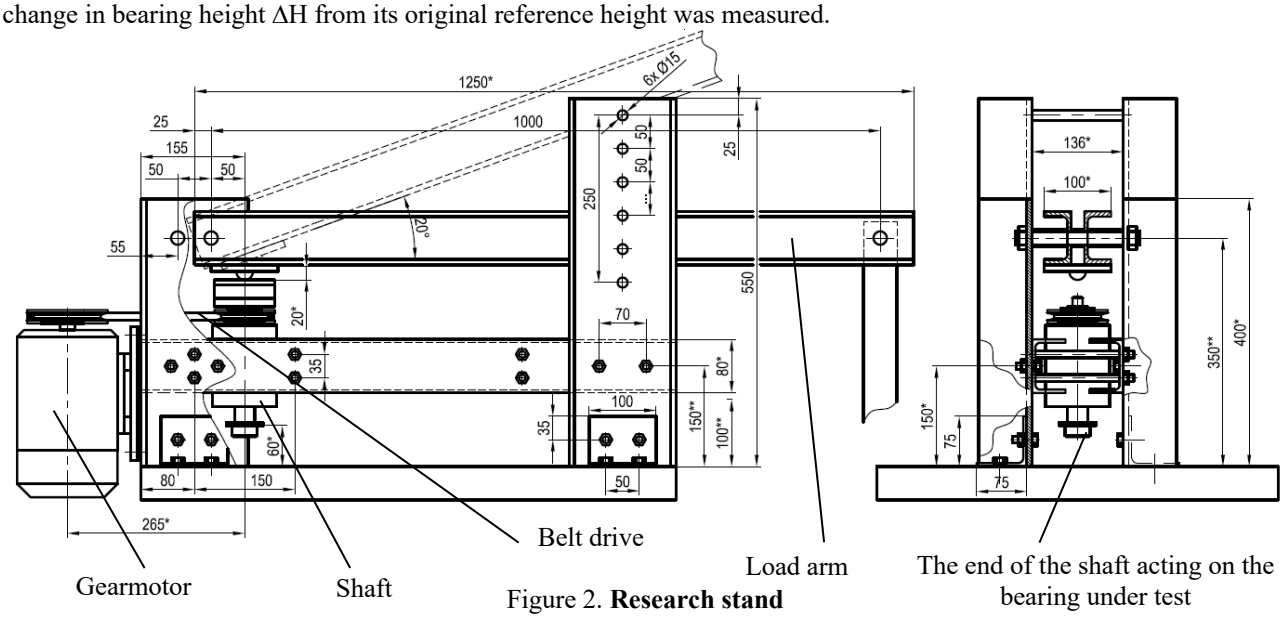



Figure 2. **Research stand**

During the experiment, the bearing temperature was monitored to ensure that it did not exceed the recommended limiting temperature for the bearing's normal operating temperature regime. The bearing was also visually inspected. The visual inspection included the assessment and recording of the occurrence, evolution and nature of defects on the working surfaces.

The bearing tests were carried out using a tribological stand, the design of which is shown in Figure 2. The weights were suspended at the end of the load arm during the test. The load transfer ratio is 1:20. When the load is applied, the spherical support of the load arm acts on the non-rotating plate of the support bearing. The rotating bearing bearing of the thrust bearing, which is fixed on the upper end of the shaft, transmits the axial force through the shaft to the inner ring of the tapered bearing. The bearing itself is mounted in a rectangular bearing house with lubrication channels and the bearing is set in a metal grease bath. As the bearing rotates, lubricant is drawn from the bath through the channels (due to the rotation of the bearing), passes through the bearing under test and returns from the bearing to the bath. The shaft receives the rotational motion through pressed-in wedges which are inserted into the longitudinal grooves of the rotating bush, through which the sleeve transmits the rotational motion to the shaft through the wedges. The bush rotates within the body of the sponge in radial bearings which accept the loads of the belt drive. The long grooves in the bush allow the shaft to move up and down. The rotary motion is transmitted to the sleeve by the electric motor via a belt drive. The speed of rotation is controlled by a frequency converter.

## RESULTS OF THE STUDY

Taking into account the in-service loads of the vehicles using JL69349-JL69310 tapered roller bearings when fully loaded, an average radial bearing load of Fr = 2550 N was assumed. The load remained constant throughout the test.

In order to investigate the variation of the bearing friction process characteristics, the experiment was carried out under different cases of the following conditions:

1. bearing speeds: 250 rpm, 500 rpm, 700 rpm and 1000 rpm;
2. different lubricats/oils: lubricant Autol Top 2000, transmission oil Pemco 80w90 and engine oil Pemco 10w40;
3. use of the revitalizant Xado in the case of Pemco 80w90 oil for bearings already tested with this oil (the results of these tests are not presented in this article).

Bearing surface roughness was measured with a Garant ST1 profilometer and bearing height change was measured with two Holex indicators. The changes in the working surface were recorded using an Olympus BX41M metallographic microscope with digital camera. Temperature measurements were carried out using a multimeter with thermocouple.

The bearings were tested for at least 2 million cycles. Measurements of the bearing parameters are taken every 300 000 cycles. For the measurements, the tribological stand was stopped, the bearing was removed from the bearing bed and washed. The lubricant in the bearing was not changed. After the measurements, the bearing was reinstalled in the bearing seat and the experiment continued. Up to 10 control operations were carried out on each bearing under test.

The research design is shown in Table 1. It shows which lubricants were used for the individual bearings tested and at which speeds they were tested. A total of 9 bearings were used for the experiments.

Table 1

Bearing experimental test conditions matrix

| Lubricant type / Bearing ID | *n*, rpm | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Autol Top 2000 | | | | Pemco 80w90 | | | | Pemco 10w40 | | | | 80w90 Xado |
| | 250 | 500 | 750 | 1000 | 250 | 500 | 750 | 1000 | 250 | 500 | 750 | 1000 | 1000 |
| KG01 | ● | | | | | | | | | | | | |
| KG02 | | | | | | ● | | | | | | | |
| KG03 | | | | | | | | | | ● | | | |
| KG04 | | | ● | | | | | | | | | | ● |
| KG05 | | | | | | | ● | | | | | | |
| KG06 | | | | | | | | | | | ● | | |
| KG07 | | | | | | | | | | | | ● | |
| KG08 | | | | | | | | ● | | | | | ● |
| KG09 | | | | ● | | | | | | | | | |

The study determined the dependence of the variation of the roughness parameters Ra, Rz and Rmax and the bearing height ΔH on the bearing test time. The time scale is represented in the graphs by the numbering sequence of the measurement steps, which are consecutively marked with an ID. The bearing test time between the two phases is 300 000 cycles.

The data from more than 5000 measurements have been statistically processed and the resulting averages are shown in the graphs below. The graphs also show polynomial curves to assess the regularity of the measured values. The paper presents only the dependencies between the bearing height ΔH and the variation of the roughness parameter Ra of the bearing outer ring working surface (Figures 3 to 8).

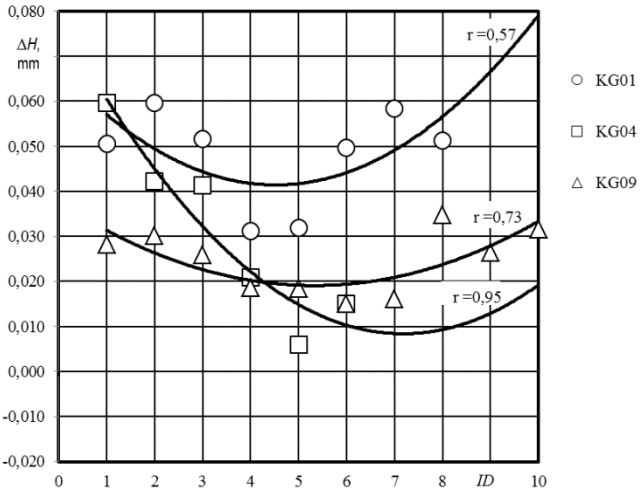



Figure 3. **Bearing height variation over time with Autol Top 2000 thick grease: bearing KG01 (n = 250 rpm), bearing KG04 (n = 750 rpm) and bearing KG09 (n = 1000 rpm)**

The lowest variation in the height of sample KG01 (Figure 3), from a value of 0.06 mm to a low of 0.032 mm, was obtained in ID measurement cycles 4 and 5. At the end of the test, the change in height of bearing KG01 decreases and is identical to the values at the beginning of the test. The largest change in ΔH is observed for sample KG04. The initial height value of 0,06 decreases to 0,005 mm. The change in height is observed to be several times faster than for sample KG01. At the end of the test, bearing KG01 ΔH is identical to the values at the beginning of the test.

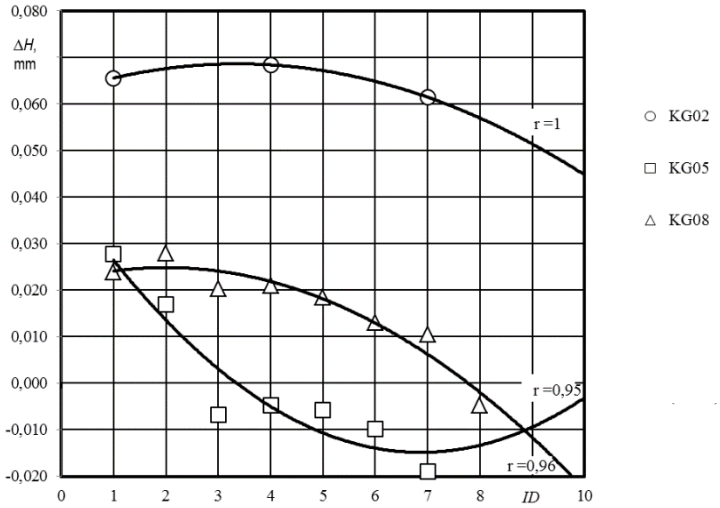



Figure 4. **Bearing height variation with time using Pemco 80w-90 gear oil: bearing KG02 (n = 500 rpm), bearing KG05 (n = 750 rpm) and bearing KG08 (n = 1000 rpm)**

The smallest variation for sample KG02 (Figure 4) ΔH. The bearing ΔH values varied from 0.068 mm to 0.062 mm and remained stable during the test. The highest change in ΔH is observed for sample KG05. The initial height value of 0,028 decreased to 0,02 mm.

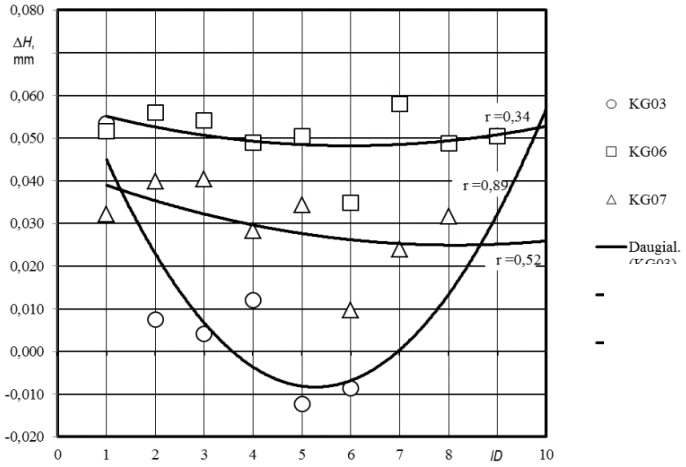



Figure 5. **Bearing height variation with time using Pemco 10w-40 engine oil: bearing KG03 (n = 500 rpm), bearing KG06 (n = 750 rpm) and bearing KG07 (n = 1000 rpm)**

The smallest variation in ΔH for sample KG06 (Figure 5) is from a value of 0.05 mm to a low of 0.048 mm in ID cycles 4 and 8. The highest ΔH is observed for sample KG03. The initial height value of 0,053 decreased to 0,012 mm.

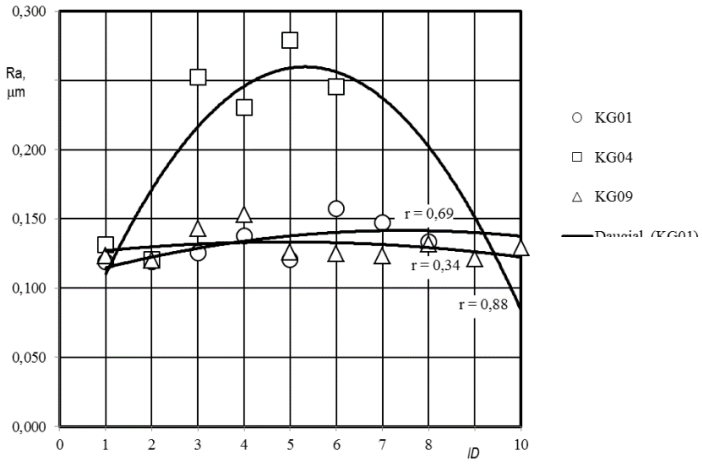



Figure 6. **Variation with time of the roughness parameter Ra of the bearing outer ring working surface using Autol Top 2000 thick lubricant: bearing KG01 (n = 250 rpm), bearing KG04 (n = 750 rpm) and bearing KG09 (n = 1000 rpm)**

The highest variation in roughness Ra from 0.13 µm to 0.25 µm is recorded for sample KG04 (Figure 6), which has several times higher roughness than samples KG01 and KG09. The curves for the changes in roughness of the latter samples are practically identical.

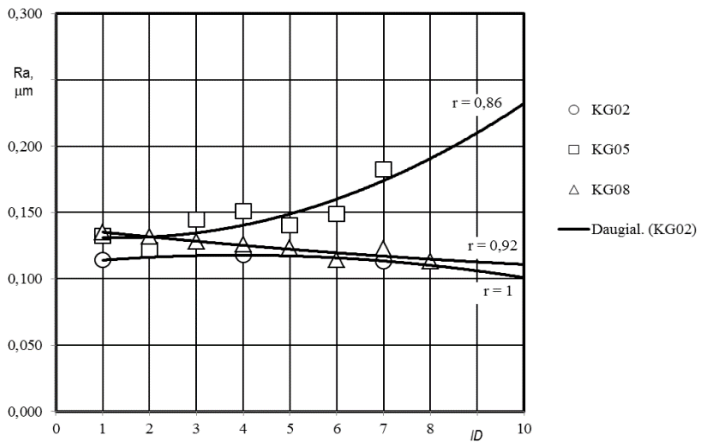



Figure 7. **Variation with time of the roughness parameter Ra of the working surface of the outer ring of the bearing for lubrication with Pemco 80w-90 gear oil: bearing KG02 (n = 500 rpm), bearing KG05 (n = 750 rpm) and bearing KG08 (n = 1000 rpm)**

The highest variation in roughness Ra (Figure 7) from 0.13 µm to 0.18 µm is recorded for sample KG05, which is several times higher than for samples KG02 and KG08. The curves for the changes in roughness of the latter samples are practically identical.

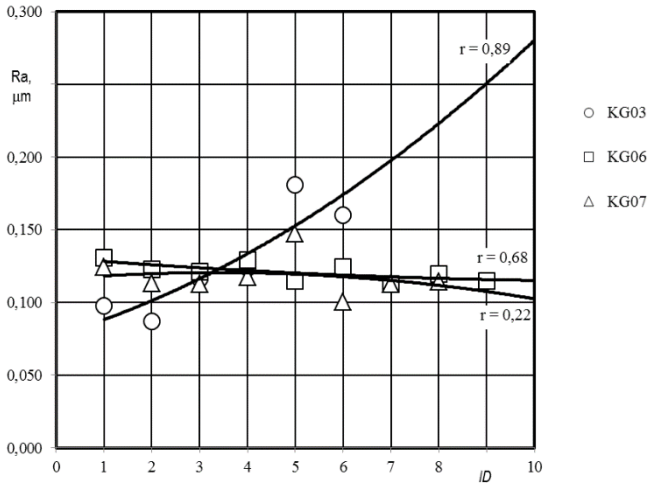



Figure 8. **Variation with time of the bearing outer ring roughness parameter Ra using Pemco 10w40 engine oil for lubrication: bearing KG03 (n = 500 rpm), bearing KG06 (n = 750 rpm) and bearing KG07 (n = 1000 rpm)**

The largest variation in roughness Ra (Figure 8), from 0,08 µm to 0,18 µm, is recorded for sample KG03, with several times higher roughness values than for samples KG06 and KG07. The curves for the changes in roughness for the latter samples (Figure 8) are practically identical.

## CONCLUSIONS

1. The greatest change in tapered bearing height was found for samples KG03, KG04 and KG05, which were tested at average revolutions.
2. The highest change in outer ring roughness of tapered roller bearings was found for KG03, KG04 and KG05 bearings, which also had the highest ΔH.
3. The results of the study show a direct correlation between the change in bearing height and the roughness index Ra.

## REFERENCES

1. Kriščiūnas A. Įvairių faktorių įtakos kūginių guolių trinties proceso rodikliams tyrimas. Magistro baigiamasis darbas. KTU, Panevėžio technologijų ir verslo fakultetas, TK, 2015 – 91 p.
2. Taper Roller Bearings Lubricated With Bio Greases. < http://www-ext.lnec.pt/APAET/pdf/Rev_17_A13.pdf > [viewed at 2024-09-10].
3. Tapered Roller Bearings | The Timken Company. < http://www.timken.com/en-us/products/Documents/Timken-Tapered-Roller-Bearing-Catalog.pdf > [viewed at 2024-04-05].

PANEVĖŽIO KOLEGIJA ISSN 2029-1280, eISSN 2669-0071. Taikomieji tyrimai studijose ir praktikoje – Applied Research in Studies and Practice, 2024, 20.

# FACTORS DETERMINING ORGANISATIONAL CYNICISM: THEORETICAL INSIGHTS

***Diana LIPINSKIENĖ***

*Panevėžio kolegija/Panevėžys University of Applied Sciences, Lithuania*

**Abstract**. Organisational cynicism has been a topic of discussion and debate among employees and top management. The article analyses the factors that determine the organisational cynicism of employees and seeks to reveal ways to reduce it. Reducing organisational cynicism leads to effective employee management, optimal management of the organisation's results and performance efficiency, therefore, in today's organisations, which are characterized by the fact that they employ employees of different generations who have different attitudes towards the work environment created in the organisation, which determines the emergence of organisational cynicism, the analysis of the factors that determine it becomes relevant. The article consists of two parts: first, the concept of organisational cynicism is revealed, and the second part of the article analyses the factors that determine organisational cynicism. Organisational cynicism in the article is understood as a negative attitude of employees towards the organisation in which they work, manifested in a sceptical and critical assessment of the organisation's behaviour, values, motives and actions, which is often associated with distrust of managers, contempt, suffering, anger and shame. An organisation seeking to reduce organisational cynicism must create conditions that ensure the harmony of employees' personal values and organisational culture, as well as the harmony of employees' needs and motivation system, while striving for a leadership style oriented towards leadership, rather than strict management.

**Keywords**: cynicism, organisational cynicism, factors for organisational cynicism

## INTRODUCTION

Organisational cynicism has been a topic of discussion and debate among employees and top management. In the modern labour market, organisational cynicism is becoming an increasingly serious problem, causing a negative impact not only on the psychological health of employees but also on workplace productivity and organisational success (Ucar & Ipek, 2019). Organisational cynicism can have a detrimental effect not only on organisational performance but also on employee well-being. This can manifest itself through fatigue, stress (Besse, Poremski, Lliberte & Latimer, 2018), lost motivation (Kang, 2020), etc. Organisational cynicism can arise due to complex employee-organisation relationships. However, an equally important reason for the manifestation of organisational cynicism is the demographic indicators of employees: previous work experience (Aslam, Ilyas & Imran, 2016), age, gender, education (Christian, 2023; Polatcan & Titrek, 2014), marital status, length of service, income, profession (Terzi & Derin, 2016). Therefore, organisational leaders need to understand the causes of organisational cynicism and ways to reduce or even avoid it.

In managing an organisation with employees of different generations, the attitude of employees towards the organisation itself, other members of the organisation, and commitment to the organisation are important, as this helps to achieve management effectiveness (Peng, Li, Wang, & Lin, 2020) and helps to avoid the expression of organisational cynicism (Kalkan, Aksal, Gazi, Atasoy, & Dagli, 2020). The authors' research results show that the expression of organisational cynicism is determined by organisational culture (Durrah, Chaudhary, & Gharib, 2019; Kangas et al., 2018; Ucar & Ipek, 2019; Uriesi, 2019;), management, and leadership (Farahnak, Ehrhart, Torres, & Aarons, 2020; Islam, Furuoka, & Idris, 2020; Oreg & Berson, 2019; Rahman & Hadi, 2019), which are factors that determine the efficiency and competitiveness of the organisation's activities. When innovations are developed or ideas are generated in an organisation with employees of different generations, the generation of creativity and innovation becomes a conceptual tool for reducing the expression of organisational cynicism (Aljawarneh and Atan, 2018; Christian, 2023; Kismono, 2023; Sameer, 2018). Therefore, the factors determining the expression of organisational cynicism must be constantly assessed and controlled to ensure optimal management of employees.

This paper aims to provide theoretical insights into the factors determining organisational cynicism.

The aim implied the following structure of the article: first, the concept of organisational cynicism is revealed, and in the second part of the article the factors determining organisational cynicism are analysed.

The article was prepared using the method of scientific literature analysis.

## CONCEPTUALISATION OF THE CONCEPT OF ORGANISATIONAL CYNICISM

To better understand the concept of organisational cynicism, the article will first review the concept of cynicism.

First, it is important to mention that cynicism can manifest in various areas: personal, professional and social life. When analysing the scientific literature (Durah et al., 2019; Nemr and Liu, 2021) it became clear that cynicism is an individual's detachment from societal norms, ethics, principles and customs, which is expressed in suspicion, distrust, anger, contempt, disappointment, emotional detachment and the belief that people are dishonest and selfish. Christian

(2023) defines cynicism as an attitude in which a person critically evaluates the world and its phenomena, often manifested in distrust and criticism. Cynicism, according to Caylak and Altuntas (2017), is understood as a specific reaction to a specific environment, for example, an organisation, or a negative attitude towards it, which arises from the belief that the organisation does not pay enough attention to employees. The approaches proposed by these authors allow us to state that when talking about individual cynicism, it can describe this individual's distrust and critical and negative attitude towards events, situations, people and phenomena occurring in his personal, professional and social environment, their negative assessment, manifested in negative emotions.

Regarding a more specific form of cynicism, i.e. organisational cynicism, it can be assumed that organisational cynicism is a negative attitude, the formation of which is promoted by employees' dissatisfaction with the organisation in which they work. This assumption is confirmed by the works of the authors which were analysed in the scientific literature (Ayik, 2022; Kokalan, 2019; Lutz et al., 2020; McCrindle, 2021; Yang et al., 2020; van Twist and Newcombe, 2021, etc.). For example, according to Ayik (2022), organisational cynicism is defined as a negative attitude of employees towards the manager, the organisation and the functioning of the organisation; as well as a condition in which many employees do not trust the organisation in which they work and, as a result, become isolated from the community, which causes professional stress and leads to a bad microclimate or a mismatch between personal and organisational values. According to McCrindle (2021), organisational cynicism is a reaction or negative emotions that are caused by employees' experiences in an organisation. According to Lutz et al. (2020), it is an employee's negative attitude toward the organisation, that usually arises when they believe that fair decision-making is not ensured in the organisation. Kokalan (2019) notes that a negative attitude arising from distrust in the organisation or its activities can manifest itself through suspicion, emotional detachment and disappointment, as well as through resentment or criticism of the organisation's decisions, activities or culture. A slightly different definition is provided by Tuna et al. (2018), who state that organisational cynicism is an attitude that includes a sense of insecurity, unfair beliefs, and cognitive, emotional and behavioural situations in the organisation. Cinar et al. (2014), defining the concept of organisational cynicism, note that it is a negative reaction of employees to the organisational culture and that it is the belief of employees that managers pursue personal interests without adhering to the principles of honesty and sincerity.

In summary, it can be stated that organisational cynicism is an employee's negative attitude towards his or her organisation, manifested in a sceptical and critical assessment of the organisation's behaviour, values, motives and actions, which reflects the employee's belief that the organisation lacks moral integrity. Organisational cynicism describes an employee's negative attitude not only towards the organisation in which he or she works but towards his or her colleagues as well. The definitions of organisational cynicism found in the scientific literature allow us to state that the expression of an employee's organisational cynicism is revealed in his or her distrust of managers, contempt, suffering, anger and shame, dissatisfaction and disappointment, failure to meet expectations, disrespectful behaviour, strong criticism of the organisation, sarcasm, and denial of various processes taking place in the organisation.

Having described the concept of organisational cynicism, the article further analyses its determining factors.

## ANALYSIS OF FACTORS THAT DETERMINE ORGANISATIONAL CYNICISM

Analysing the scientific literature, it became clear that various researchers who analyse the factors determining the emergence of organisational cynicism analyse them in different contexts, which leads to the fact that they emphasize different aspects of these factors. In this article, we have chosen to present three factors that determine the expression of organisational cynicism that are most often analysed in the works of scientists. These are the following: with employee values incompatible organisational culture, an inappropriate management style, and a motivation system that does not meet employee needs.

**1. The fit between employee values and organisational culture.**

Organisational culture can be generally defined as the values that dominate an organisation, on which the organisation relies in its activities, and which are reflected in the physical environment and the deeper, less noticeable layers of the organisation, as well as manifested through stories, memories, legends, and myths. Organisational values, principles, and norms of behaviour strongly influence the nature and success of people's work. In the scientific literature, one can find various statements about how with employees' values incompatible organisational culture can lead to employee disappointment and dissatisfaction with the organisation, i.e. organisational cynicism. Here, according to Besse et al., (2018), it can be stated that the expression of organisational cynicism can be caused by organisational culture due to an imbalance between the values and principles of the organisation and the values and principles of the employee, conflicts arise due to pressure to perform work or unclear work requirements, and according to Uriesi (2019) and Wisse & Sleebos (2016), this leads to an inappropriate communication style, which also causes employee dissatisfaction with the organisation. According to Smollan and Morrison (2019), a suitable organisational culture makes it easier for organisational members to overcome problems, such as organisational cynicism and helps to form a unique system of values and beliefs that exists within the organisation and has a positive or negative influence on the behaviour of its members.

It is also worth noting that the impact of organisational culture on the emergence or non-emergence of organisational cynicism can be revealed by studying the functions organisational culture performs. Ince (2018) distinguished the following functions of organisational culture:

- contributes to the organisation's most important goals,

- determines what the organisation and its different members can expect from each other,
- determines which methods of controlling the behaviour of organisational members, considering their age, are acceptable and which are not,
- shapes and defines the behaviour of organisational members among themselves,
- establishes norms of behaviour for members of different ages and positions
- determines the methods of punishing and rewarding organisational members.

Looking at the functions listed above, it becomes clear that the fit between the values of the organisation and employees, to effectively and smoothly perform these functions, becomes particularly important so as not to cause employee dissatisfaction, disappointment, conflicts, negative attitudes towards the organisation itself, in other words, so as not to cause organisational cynicism among employees.

In summary, it can be stated that organisational culture is an environment consciously or artificially created by management, which, due to the values that dominate in that environment, is often unique and stands out from other similar organisations. When talking about organisational culture as a factor of organisational cynicism, it is important to mention that a culture that reduces organisational cynicism must unite the efforts of the organisation's employees to achieve common goals, based on dominant values and principles. To do this, the fit between the values declared by the employees and the organisation must be ensured. Each employee of the organisation must be constantly encouraged to communicate openly, be part of the organisation, receive clear and timely information on various issues, and actively participate in the organisation's activities. An employee who knows the organisation's values and principles and supports them realises that he is part of the organisation, therefore helps the organisation achieve better results, feels responsible and recognized as a full member of the organisation, can communicate smoothly with other employees, which means that at the same time his negative attitude towards the organisation, in other words, organisational cynicism, decreases.

**2. Management style as a factor of organisational cynicism.**

An analysis of the scientific literature (Bakari, Hunjra, Jaros, & Khos, 2018; Farahnak et al., 2020; Gunduz, 2017; Ince, 2018; Oreg & Berson, 2019; Rahman & Hadi, 2019; Smollan & Morrison, 2019, etc.) suggests that the expression of organisational cynicism is also determined by management style. When analysing the works of scientists to answer the question of how management style can contribute to the emergence of organisational cynicism, it became clear that employees are less likely to distrust their organisation and be cynical towards it when their manager demonstrates leadership qualities and applies appropriate leadership instead of management styles. For example, Ince (2018) states that leaders rely on cooperation to mobilize people of different ages to achieve common goals; they are future-oriented and strive to change it because they are focused on the continuous culture of organisational improvement and progress; in addition, leaders rely on their charisma, influence, and ability to inspire everyone regardless of their age. According to Bakari, Hunjra, Jaros, and Khoso (2018), leaders view people as valuable resources that can be included in the organisation's activities and contribute to its success; they usually use a horizontal communication system, where information is shared at all levels of the organisation; they are interested in focusing people of different generations on the vision so that employees can be motivated to work towards overall organisational success.

Looking at the work of these researchers, it becomes obvious that employees of managers who apply this leadership style will be less likely to be dissatisfied with their organisation, will not criticize it, will not experience negative emotions, will not behave disrespectfully and will not be disappointed with either their organisation or their colleagues, in other words, organisational cynicism will be less common in such an organisation. Conversely, if the manager views employees as means to achieve the organisation's goals, if he or she communicates only vertically, if only the implementation of their plan, monitoring achievements and identifying problems is important and relevant to him, and if he or she focuses on the current situation and tries to manage it, and relies on his position and authority to control and manage employees, then he is likely to face more frequent organisational cynicism since employees will be angry, dissatisfied and disappointed with the organisation, they will criticize it and will be convinced that the manager makes decisions unfairly. As Farahnak et al. (2020) assume, a strong leader, seeking to maintain common values that unite employees of different generations, inspires and encourages them by his example to smoothly solve emerging problems, communicate constantly, and avoid reaching a stage where organisational cynicism becomes uncontrollable.

**3. The fit between employee needs and the motivation system**

Increasing employee motivation and creating a motivating reward or motivation system are constantly recurring themes in both scientific works and practitioner reports. The topic of the correlation between the motivation system and organisational cynicism is also inevitable. There is no point in creating a universal motivation system that is suitable for most employees since the needs, values, and life situations of each employee are different. This means that creating a universal motivation system would not satisfy the needs of all employees, which would lead to employee dissatisfaction, disappointment, criticism, anger, and other aspects of employee reaction to the organisation related to the expression of organisational cynicism. Such a system, according to Helvaci and Kilicoglu (2018), can only be created for a short period and to achieve short-term organisational goals. Therefore, when achieving long-term strategic goals, such motivation would be ineffective, and organisational cynicism would quickly arise.

What is needed to create a fit between employee needs and the motivation system? What motivation system would ensure a high level of employee motivation and not cause organisational cynicism? Hewett et al. (2019) note that to ensure successful employee motivation in an organisation, it is necessary to constantly improve and develop the psychological and social environment. Lee (2020) claims that employees will actively pursue organisational goals only when they, regardless of their generation, are unanimously convinced that their personal needs and interests are met, and

a favourable social environment is ensured. When analysing the scientific literature (Akar and Celik, 2019; Hewett et al., 2019; Lee, 2020; Nerstad, Wong, and Richardsen, 2019; Walsh and Magley, 2018; Zigarmi, Galloway, and Roberts, 2016) it was revealed that the following factors are important to create a favourable psychological and social environment:

- relationships based on mutual trust and understanding must be created between managers and employees in the organisation,
- the social environment must be based on the realization of material, security, social, and respect needs,
- employees need to be given more freedom, responsibility, and opportunities to combine personal life and work,
- a complex of both material and non-material motivational measures must be used,
- conditions must be created to satisfy physiological, communication, and self-realization needs, to combine personal life and work,
- methods of involving employees in decision-making and transferring responsibility must be created.

It should be noted that the needs and life situation of employees are not stable, it is dynamic. Therefore, in order to achieve the fit between the needs of employees and the motivation system, the motivation system must also constantly change.

In summary, it can be stated that organisational cynicism, manifested in employees' negative attitude towards the organisation and emotional detachment and the belief that managers pursue personal interests, without adhering to the principles of honesty and sincerity, occurs when the fit between the personal values of employees and the values of the organisation is not ensured, the applied management style is not focused on leadership and when the fit between the needs of employees and the motivation system is not ensured.

## CONCLUSIONS

1. Organisational cynicism is defined in the scientific literature as a negative attitude of employees towards their colleagues, professions and the organisation in which they work, manifested in a sceptical and critical assessment of the organisation's behaviour, values, motives and actions, which reflects the belief that the organisation lacks moral integrity, and which is often associated with distrust of leaders, contempt, suffering, anger and shame. Analysis of the scientific literature allowed us to distinguish such features indicating the expression of organisational cynicism as employee frustration, constant fatigue, pessimism, constant dissatisfaction, disrespectful behaviour, lack of commitment to the organisation, and distrust of the organisation.

2. The analysis of scientific literature has allowed us to highlight three factors that determine organisational cynicism: related to organisational culture, leadership style and motivation system. Therefore, an organisation that seeks to reduce organisational cynicism must create conditions that ensure the fit between employees' personal values and organisational culture, as well as the fit between employees' needs and motivation system, and strive for a leadership style oriented towards leadership, rather than strict management. If these conditions are not created, employees will likely be dissatisfied, disappointed, and angry, they will not trust the organisation, they will be convinced that decisions are made unfairly, they will criticize the organisation, their behaviour will change negatively, and tension, stress, conflicts will arise. Ultimately, this will affect the results of the entire company.

## REFERENCES

Ayik, A. (2022). Examining the Relationship Between Mobbing and Organisational Cynicism. International Journal of Education and Literacy Studies, 2(10), 102-109.

Akar, H. (2019). A Meta-Analytic Review on the Causes and Consequences of Organisational Cynicism. International Online Journal of Educational Sciences, 11(2).

Aljawarneh, N. M. S. & Atan, T. (2018). Linking Tolerance to Workplace Incivility, Service Innovative, Knowledge Hiding, and Job Search Behavior: the Mediating Role of Employee Cynicism. Negotiation and Conflict Management Research, 3, 1-23.

Aslam, U., Ilyas, M., & Imran, M. K. (2016). Detrimental effects of cynicism on organisational change: an interactive model of organisational cynicism (a study of employees in public sector organisations). Journal of Organisational Change Management, 29(4), 580-598.

Bakari, H., Hunjra, A. I., Jaros, S. & Khoso, I. (2018). Moderating role of cynicism about organisational change between authentic leadership and commitment to change in Pakistani public sector hospitals. Leadership in Health Services, 2, 51-79.

Besse, C., Poremski, D., Laliberté, V., & Latimer, E. (2018). The meaning and experience of stress among supported employment clients with mental health problems. Health & social care in the community, 26(3), 383-392.

Caylak, E. & Altuntas, S. (2017). Organisational Silence Among Nurses: the Impact on Organisational Cynicism and Intention to Leave Work. The Journal of Nursing Research, 2(25), 90-98.

Christian, B. (2023). Working for World Peace: Between Idealism and Cynicism in International Organisations. Swiss Journal of Sociology, 49(1), 21-39.

Cinar, O., Karcıoğlu, F., & Aslan, İ. (2014). The relationships among organisational cynicism, job insecurity and turnover intention: A survey study in Erzurum/Turkey. Procedia-Social and Behavioral Sciences, 150, 429-437.

Durrah, O., Chaudhary, M., & Gharib, M. (2019). Organisational cynicism and its impact on organisational pride in industrial organisations. International journal of environmental research and public health, 16(7), 1203.

Farahnak, L. R., Ehrhart, M. G., Torres, E. M. & Aarons, G. A. (2020). Leadership and Leader Attitudes on Subordinate Attitudes and Implementation Success. Journal of Leadership and Organisational Studies, 1(27), 98-111.

Gunduz, S. (2017). The Relationship between Spiritual Leadership and Organisational cynicism: The Moderating Effect of Emotional Intelligence. Dogus University Dergisi, 2(18), 117-132.

Helvaci, M. A. & Kilicoglu, A. (2018). The Relationship Between the Organisational Change Cynicism and Organisational Commitment of Teachers. Journal of Education and Training Studies, 11(6), 1-5-110.

Hewett, R., Shantz, A. & Mundy, J. (2019). Information, beliefs and motivation: The antecedents to human resource attributions. Journal of Organisational Behavior, 40, 570-586.

Ince, F. (2018). The Effect of Democratic Leadership on Organisational Cynicism: A study on Public Employees. Journal of Business Research, 2(10), 245-253.

Islam, M. N., Furuoka, F. & Idris, A. (2020). The impact of trust in leadership on organisational transformation. Global Business and Organisational Excellence, 4(39), 1-10.

Yang, J., Yu, C. S., & Wu, J. (2020). Work values across generations in China. Chinese Management Studies, 12(3), 486-505.

Kalkan, U., Aksal, F. A., Gazi, Z. A., Atasoy, R. & Dagli, G. (2020). The Relationship Between School Administrators' Leadership Styles, School Culture and Organisational Change. Sage Open, 2, 1-15.

Kang, E. (2020). The Relationship between Reinforcement of Employee's Customer-Centric Behavior and Employee Motivation Factors. Advances in Social Sciences Research Journal, 7(7), 338-347.

Kangas, M., Kaptein, M., Huhtala, M., Lamsa, A.-M., Pihlajasaari, P., & Feldt, T. (2018). Why Do Managers Leave Their Organisation? Investigating the Role of Ethical Organisational Culture in Managerial Turnover. Journal of Business Ethics, 153(3), 707-723.

Kismono, G. (2023). The moderating effect of generations on the relationship between work values and affective commitment. Jurnal Siasat Bisnis, 1-16.

Kökalan, Ö. (2019). The effect of organisational cynicism on job satisfaction: Testing the mediational role of perceived organisational spirituality. Management Research Review.

Lee, H. W. (2020). Motivational Effect of Performance Management does Leadership Matter? Transylvanian review of Administrative Sciences, 59, 59-76.

Lutz, Ch., Hoffmann, Ch. P. & Ranzini, G. (2020). Data capitalism and the user. An exploration of privacy cynicism in Germany. New media and Society, 22(7), 1168-1187.

McCrindle, M. (2021). Generation Alpha. Hachette UK.

Nemr, M. A. A., & Liu, Y. (2021). The impact of ethical leadership on organisational citizenship behaviors: Moderating role of organisational cynicism. Cogent Business & Management, 8(1), 186-196.

Nerstad, Ch. G. L., Wong, S. & Richardsen, A. M. Can Engagement Go Awry and Lead to Burnout? The Moderating Role of the Perceived Motivational Climate. International Journal of Environmental Research and Public Health, 16, 1-21

Oreg, S. & Berson, Y. Leaders' Impact on Organisational Change: bridging theoretical and methodological chasms. Academy of Management Annals, 1(13), 272-307.

Peng, J., Li, M., Wang, Z. & Lin, Y. (2020). Transformational Leadership and Employees' Reactions to Organisational Change: Evidence from a Meta-analysis. The Journal of Applied Behavioral Science, 3, 1-43.

Polatcan, M., & Titrek, O. (2014). The relationship between leadership behaviors of school principals and their organisational cynicism attitudes. Procedia-Social and Behavioral Sciences, 141, 1291-1303.

Rahman, Z. & Hadi, H. K. (2019). Does Organisational Culture Matters in Organisational Change? Transformational Leadership and Cynicism About Organisational Change. International Conference on Economics, Education, Business and Accounting, 2, 353-362.

Sameer, Y. M. (2018). Innovative behavior and psychological capital: Does positivity make any difference? Journal of Economics and Management, 2(23), 75-101.

Smollan, R. K. & Morrison, R. L. (2019). Office design and organisational change. Journal of Organisational Change Management, 4(32), 426-440.

Terzi, A. R., & Derin, R. (2016). Relation between Democratic Leadership and Organisational Cynicism. Journal of Education and Learning, 5(3), 193-204.

Tuna, R., Bacaksiz, F. E. & Seren, A. K. H. (2018). The Effects of Organisational Identification and Organisational Cynicism on Employee Performance Among Nurses. International Journal of Caring Sciences, 3(11), 17-29.

van Twist, A. V. E. D., & Newcombe, S. (2021). Strauss-Howe Generational Theory. Critical Dictionary of Apocalyptic and Millenarian Movements, (January), 1-10.

Ucar, R. & Ipek, C. (2019). The Relationship between High School Teachers' Perceptions of Organisational Culture and Motivation. Journal of Education and Training Studies, 7(7), p.102-116.

Urieşi, S. (2019). Organisational justice and trust in managers as factors of organisational commitment. Annals of AII Cuza University. Psychology Series, 28, 57-66.

Zigarmi, D., Galloway, F. J. & Roberts, T. P. (2018). Work Locus of Control, Motivational Regulation, Employee Work Passion and Work Intentions: An Empirical Investigation of an Appraisal Model. Journal of Happiness Study, 10, 1-27.

Walsch, B. M. & Magley, V. J. (2018). Workplace civility training: understanding drivers of motivation to learn. The International Journal of Human Resource Management, 2, 1-21

Wisse, B., & Sleebos, E. (2016). When change causes stress: Effects of self-construal and change consequences. Journal of business and psychology, 31, 249-264.

PANEVĖŽIO KOLEGIJA ISSN 2029-1280, eISSN 2669-0071. Taikomieji tyrimai studijose ir praktikoje – Applied Research in Studies and Practice, 2024, 20.

# RESEARCH OF BEARING CAPACITY OF PILE PRESSED FOUNDATIONS DEPENDING ON SOIL TYPE AND PILE DIAMETER

***Jovita KAUPIENĖ*[a,b] , *Aurimas ČESNULEVIČIUS*[a,b]**

[a]*Panevėžio kolegija / State Higher Education Institution, Lithuania*
[b]*Kaunas university of technology Panevėžys Faculty of Technologies and Business, Lithuania*

**Abstract**. Pile foundations are widely used to transfer structural loads to hard soil layers with high bearing capacity. During the design work, it is often necessary to combine the structural solutions of the foundations with the properties of the subsiding soils at the construction site. This article deals with pile foundations and their bearing capacity dependences on embedment depth, soil properties and pile diameter.

**Keywords**: piles, soils, foundations, bearing capacity

## INTRODUCTION

This paper presents a study of the dependences of the load-bearing capacity of squeezed piles on soil properties and embedment depth. Compared to other types of piles, squeezed piles compact the soil around them during embedment [1, 2, 3].

Pole foundations are calculated using the limit state method. This method evaluates the bearing capacity and deformation limit states. The bearing capacity of foundations is determined by two conditions - the strength of the foundation soil and the strength of the pile material. It is designed according to the lower carrying capacity of one of them [4].

The article presents the dependences of the bearing capacity of piles of different diameters embedded in one-layer soil on the depth of pile insertion. The embedment depth for pole foundations is recommended to be at least three diameters of the pile base or at least the side of a rectangle covering a smaller group of piles (at the depth of the pile base), but in all cases at least 5 m below the pile base. In this study, the penetration depth of the piles was chosen to be 9 meters.

## METHODOLOGY FOR CALCULATING THE BEARING CAPACITY OF THE PILE BASE

During the study, the limit bearing capacity of the pile foundation was calculated using the empirical method based on the data of static soil probing. During static probing, the limit bearing capacity $R_{c;m}$ is determined, to which the partial coefficients $\gamma_R$ ($\gamma_b$, $\gamma_s$, $\gamma_t$) are applied, and the design bearing capacity $R_d$ is found using equation (1) [4]. According to LST EN 1997 – 1:2003 [5], these coefficients depend on the number of tests performed.

$$R_d = [R_{c;m}]/\gamma_t; \quad (1)$$

Here $\gamma_t$ is a partial coefficient, which depends on the pile installation method.

When carrying out calculations of the load-bearing capacity of the pile base, first the load-bearing capacity of the pile $R_{c;cal}$ is calculated. Then the characteristic value of the load-bearing capacity $R_{c;k}$ is determined and the design value of the load-bearing capacity $R_{c;d}$ is calculated.

The load-bearing capacity $R_c$ of one pile is calculated as the sum of the load-bearing capacity $R_b$ of the foundation under the base of the pile and the load-bearing capacity $R_s$ of the sides of the pile:

$$R_c = R_b + R_s \quad (2)$$

The bearing capacity of the base under the pile is calculated using equation

$$R_b = \alpha_b \cdot q_c \cdot A_b \quad (3)$$

Here $q_c$ is the cone strength of the soil, MPa; $\alpha_b$ – empirical correlation coefficient between $q_c$ and base strength; $A_b$ is the area of pile sole in m$^2$. Cylindrical piles were investigated in this work.

The bearing capacity of the pile sides is calculated using equation

$$R_s = \sum (A_{si} \cdot q_{ci} \cdot \alpha_{si}) \quad (4)$$

Here $A_{si}$ is the surface area of the pile sides of the $i^{th}$ soil layer, m$^2$; $q_{ci}$ is conical strength of the $i^{th}$ soil layer, MPa; $\alpha_{si}$ is empirical coefficient of correlation between $q_c$ and soil friction strength, depending on soil type.

The bearing capacity of the pile is calculated using equation

$$R_{c,cal} = R_b / \gamma_{Rb} + R_s / \gamma_{Rs}; \quad (5)$$

Here $\gamma_{Rb}$ and $\gamma_{Rs}$ are modeling coefficients that depends on the method of pile installation. In this work, clamped bored piles were investigated, so $\gamma_{Rb} = 1.1$ and $\gamma_{Rs} = 1.35$ [4].

The characteristic value of the bearing capacity of the pile base is calculated using equation [6]

$$R_{c;k} = min\{(R_{c;m})mean / \varsigma_1; (R_{c;m})min / \varsigma_2\}; \quad (6)$$

Here $(R_{c;m})mean$ is the average value of the bearing capacity of the pile base, N; $(R_{c;m})min$ is the minimum value of the bearing capacity, N; $\varsigma_1$ and $\varsigma_2$ are correlation coefficients, the values of which depend on the number of poles tested under static loads.

It was assumed that $\varsigma_1 = 1$ and $\varsigma_2 = 1$ (numerical values selected according to [4]) in this work.

The design bearing capacity of the pile is calculated using equation

$$R_{c;d} = R_{c;k} / \gamma_t; \quad (7)$$

Here $\gamma_t = 1$ is a factor depending on the pile installation method [4].

In order for the pole foundation to safely withstand the calculated compressive loads (in all cases of safety limit state loads and their combinations), the following inequality must be satisfied [7]:

$$F_{c;d} \leq R_{c;d}; \quad (8)$$

Here $F_{c;d}$ is the calculated value of the representative axial compressive force of the load of the pile or their group, including the weight force of the pile itself or their group (N); $R_{c;d}$ is calculated value of $R_c$ (N); $R_c$ is bearing capacity (N) of the compressive pile foundation.

## DEPENDENCES OF PILE BEARING CAPACITY ON HOMOGENEOUS SOIL

The following conditions were adopted during the study:

- The cross section of the pile is round;
- The soil into which the pile is pressed is homogeneous;
- The entire pole is fully (100%) pressed into the ground;
- The weight of the pile is not evaluated;
- The influence of groundwater on the compressive strength of the soil is not evaluated.

Seven different diameter piles (from 0.3 m to 0.4 m) were analyzed during the research.

The test is performed by driving a round pile into different types of soil with different compressive strengths. Formulas (1) - (8) were used for calculations. The piles are driven deep until a maximum depth of 9 m is reached and their ultimate bearing capacity is calculated every 1 m. Homogeneous soils are studied in order to highlight the specific properties of the soil.

Calculations were made after choosing four different soil types: sand, sandy loam, loam and clay. The compressive strength of each soil was also varied. The characteristics of the soil are presented in Table 1.

Table 1

**Mechanical characteristics of soils**

| | | **Compressive strength $q_c$, MPa** |
|---|---|---|
| Sand | Sand (1) | 4,1 |
| | Sand (2) | 11,3 |
| | Sand (3) | 25,0 |
| Sandy loam | Sandy loam (1) | 1,9 |
| | Sandy loam (2) | 8,59 |
| | Sandy loam (3) | 13,29 |
| Loam | Loam (1) | 1,5 |
| | Loam (2) | 4,9 |
| | Loam (3) | 12,7 |
| Clay | Clay (1) | 1,1 |
| | Clay (2) | 3,6 |
| | Clay (3) | 6,27 |

The dependences of pile bearing capacity on soils of different strength are presented in Figure 1. The graphs show the results of pile bearing capacity calculations for piles of three different diameters: 0.3 m, 0.35 m and 0.4 m.

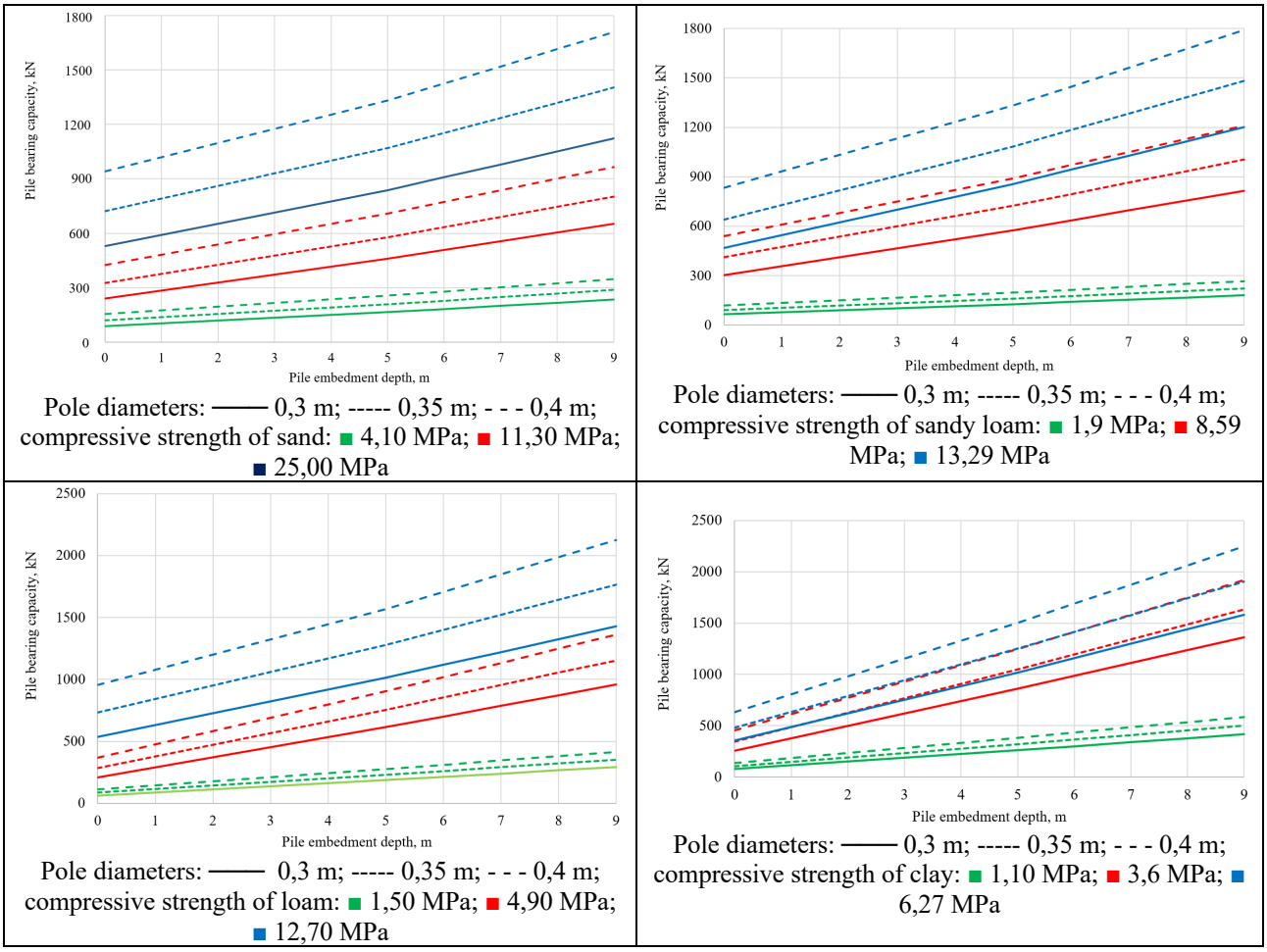



Figure 1. **Dependences of pile bearing capacity on pile embedment depth in soils of different strength**

The obtained results show that the higher the compressive strength of any of the four analyzed soils, the higher the gradient of the pile bearing capacity variation. Meanwhile, the diameter of the pile has a smaller influence on the gradient of the variation of the bearing capacity of the pile.

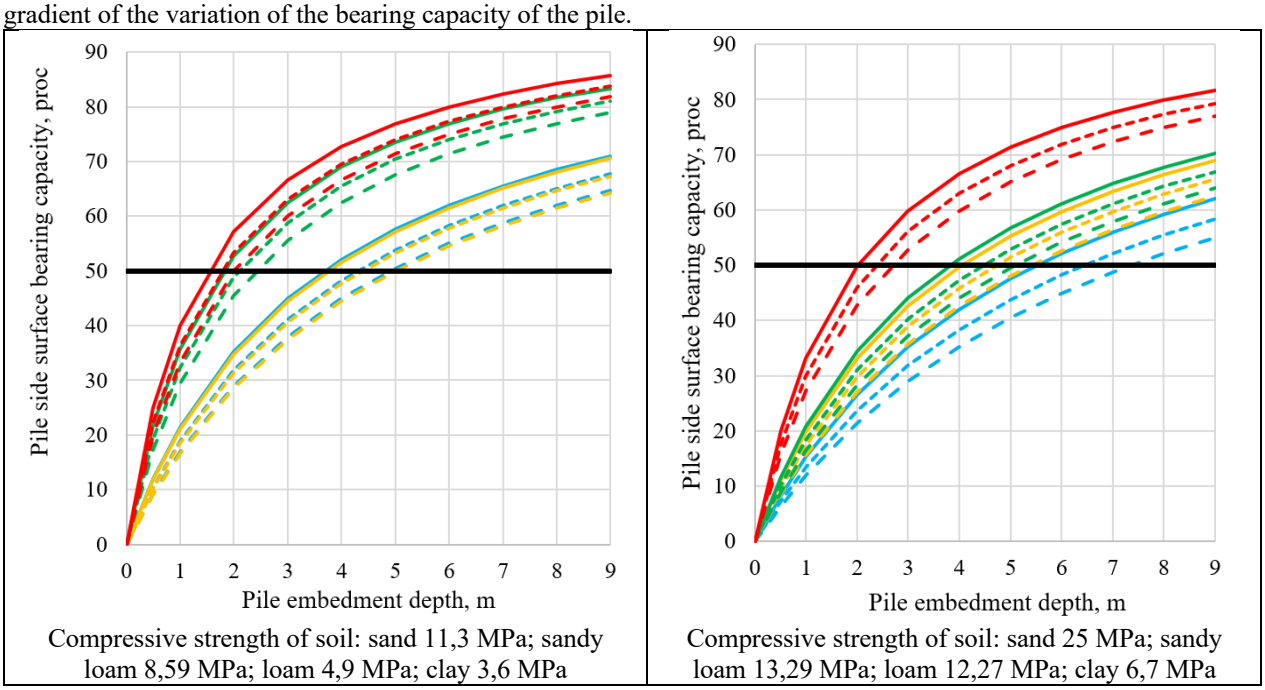



Figure 2. **Dependence of the bearing capacity ratio of the side surface of the pile to the bearing capacity of the pile base on the depth of pile insertion** (pile diameter: —— 0,30 m; ----- 0,35 m; - - - 0,40 m; soil: ■ sand; ■ sandy loam; ■ loam; ■ clay**)**

The study also analyzed how the bearing capacity of the pile is distributed between the pile base and the pile side face. Figure 2 shows the results of the pile bearing capacity distribution.

From the presented graphs, it can be seen that at the initial stage of pile insertion into the soil, more than 50% of the load-bearing capacity falls on the base of the pile. The bearing capacity of the side surface of the pile, at the same embedment depth, begins to dominate (exceeds 50%) in the soil with previously lower compressive strength.

nds on the pile installation method.

When carrying out calculations of the load-bearing capacity of the pile base, first the load-bearing capacity of the pile $R_{c;cal}$ is calculated. Then the characteristic value of the load-bearing capacity $R_{c;k}$ is determined and the design value of the load-bearing capacity $R_{c;d}$ is calculated.

The load-bearing capacity $R_c$ of one pile is calculated as the sum of the load-bearing capacity $R_b$ of the foundation under the base of the pile and the load-bearing capacity $R_s$ of the sides of the pile:

$$R_c = R_b + R_s \tag{2}$$

The bearing capacity of the base under the pile is calculated using equation

$$R_b = \alpha_b \cdot q_c \cdot A_b \tag{3}$$

Here $q_c$ is the cone strength of the soil, MPa; $\alpha_b$ – empirical correlation coefficient between $q_c$ and base strength; $A_b$ is the area of pile sole in m$^2$. Cylindrical piles were investigated in this work.

The bearing capacity of the pile sides is calculated using equation

$$R_s = \sum (A_{si} \cdot q_{ci} \cdot \alpha_{si}) \tag{4}$$

Here $A_{si}$ is the surface area of the pile sides of the $i^{th}$ soil layer, m$^2$; $q_{ci}$ is conical strength of the $i^{th}$ soil layer, MPa; $\alpha_{si}$ is empirical coefficient of correlation between $q_c$ and soil friction strength, depending on soil type.

The bearing capacity of the pile is calculated using equation

$$R_{c,cal} = R_b / \gamma_{Rb} + R_s / \gamma_{Rs}; \tag{5}$$

Here $\gamma_{Rb}$ and $\gamma_{Rs}$ are modeling coefficients that depends on the method of pile installation. In this work, clamped bored piles were investigated, so $\gamma_{Rb} = 1.1$ and $\gamma_{Rs} = 1.35$ [4].

The characteristic value of the bearing capacity of the pile base is calculated using equation [6]

$$R_{c;k} = min\{(R_{c;m})mean / \varsigma_1; (R_{c;m})min / \varsigma_2\}; \tag{6}$$

Here $(R_{c;m})mean$ is the average value of the bearing capacity of the pile base, N; $(R_{c;m})min$ is the minimum value of the bearing capacity, N; $\varsigma_1$ and $\varsigma_2$ are correlation coefficients, the values of which depend on the number of poles tested under static loads.

It was assumed that $\varsigma_1 = 1$ and $\varsigma_2 = 1$ (numerical values selected according to [4]) in this work.

The design bearing capacity of the pile is calculated using equation

$$R_{c;d} = R_{c;k} / \gamma_t; \tag{7}$$

Here $\gamma_t = 1$ is a factor depending on the pile installation method [4].

In order for the pole foundation to safely withstand the calculated compressive loads (in all cases of safety limit state loads and their combinations), the following inequality must be satisfied [7]:

$$F_{c;d} \leq R_{c;d}; \tag{8}$$

Here $F_{c;d}$ is the calculated value of the representative axial compressive force of the load of the pile or their group, including the weight force of the pile itself or their group (N); $R_{c;d}$ is calculated value of $R_c$ (N); $R_c$ is bearing capacity (N) of the compressive pile foundation.

## Dependences of pile bearing capacity on homogeneous soil

The following conditions were adopted during the study:

- The cross section of the pile is round;
- The soil into which the pile is pressed is homogeneous;
- The entire pole is fully (100%) pressed into the ground;
- The weight of the pile is not evaluated;
- The influence of groundwater on the compressive strength of the soil is not evaluated.

Seven different diameter piles (from 0.3 m to 0.4 m) were analyzed during the research.

The test is performed by driving a round pile into different types of soil with different compressive strengths. Formulas (1) - (8) were used for calculations. The piles are driven deep until a maximum depth of 9 m is reached and their ultimate bearing capacity is calculated every 1 m. Homogeneous soils are studied in order to highlight the specific properties of the soil.

Calculations were made after choosing four different soil types: sand, sandy loam, loam and clay. The compressive strength of each soil was also varied. The characteristics of the soil are presented in Table 1.

Table 1

**Mechanical characteristics of soils**

| | | **Compressive strength $q_c$, MPa** |
|---|---|---|
| Sand | Sand (1) | 4,1 |
| | Sand (2) | 11,3 |
| | Sand (3) | 25,0 |
| Sandy loam | Sandy loam (1) | 1,9 |
| | Sandy loam (2) | 8,59 |
| | Sandy loam (3) | 13,29 |
| Loam | Loam (1) | 1,5 |
| | Loam (2) | 4,9 |
| | Loam (3) | 12,7 |
| Clay | Clay (1) | 1,1 |
| | Clay (2) | 3,6 |
| | Clay (3) | 6,27 |

The dependences of pile bearing capacity on soils of different strength are presented in Figure 1. The graphs show the results of pile bearing capacity calculations for piles of three different diameters: 0.3 m, 0.35 m and 0.4 m.

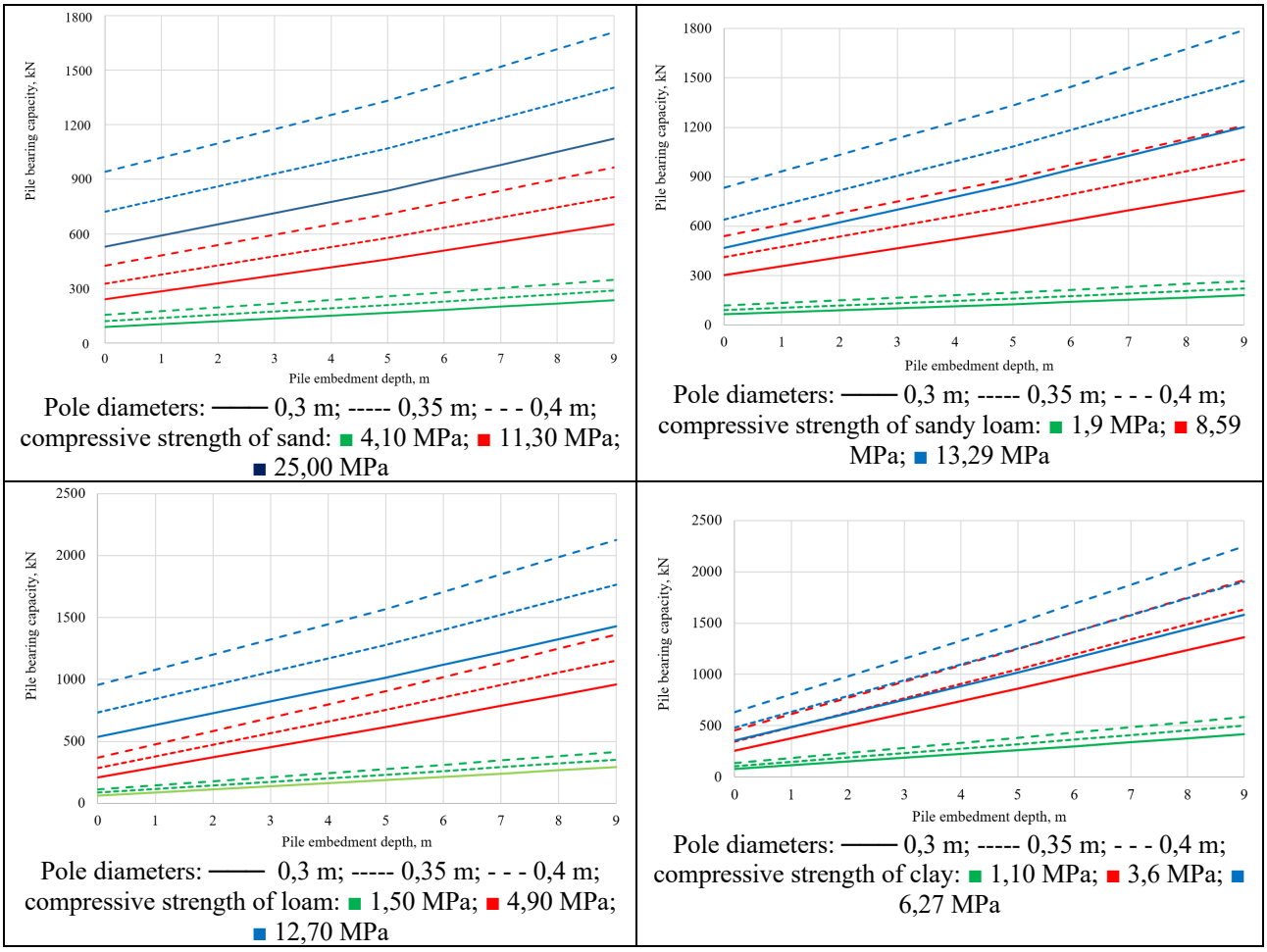



Figure 1. **Dependences of pile bearing capacity on pile embedment depth in soils of different strength**

The obtained results show that the higher the compressive strength of any of the four analyzed soils, the higher the gradient of the pile bearing capacity variation. Meanwhile, the diameter of the pile has a smaller influence on the gradient of the variation of the bearing capacity of the pile.

The study also analyzed how the bearing capacity of the pile is distributed between the pile base and the pile side face. Figure 2 shows the results of the pile bearing capacity distribution.

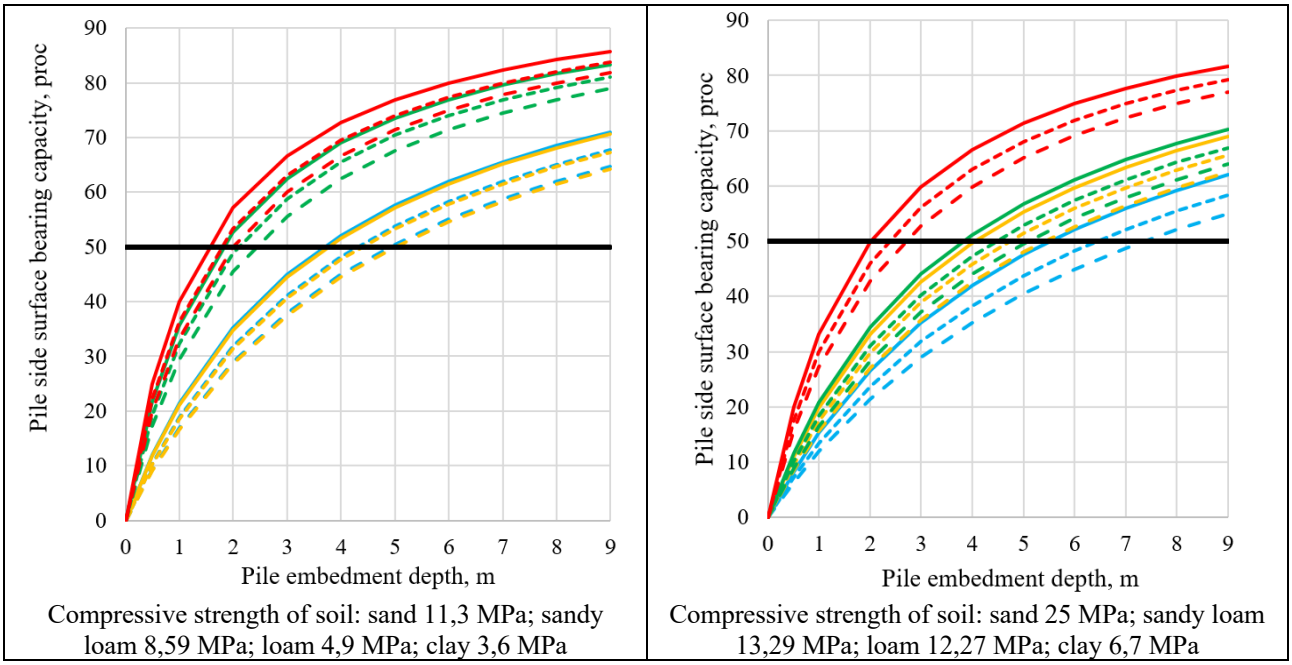



Figure 2. **Dependence of the bearing capacity ratio of the side surface of the pile to the bearing capacity of the pile base on the depth of pile insertion (**pile diameter: —— 0,30 m; ----- 0,35 m; - - - 0,40 m; soil: ■ sand; ■ sandy loam; ■ loam; ■ clay**)**

From the presented graphs, it can be seen that at the initial stage of pile insertion into the soil, more than 50% of the load-bearing capacity falls on the base of the pile. The bearing capacity of the side surface of the pile, at the same embedment depth, begins to dominate (exceeds 50%) in the soil with previously lower compressive strength.

## CONCLUSIONS

1. The highest bearing capacity when the soil is homogeneous is found in clay soil and the lowest in sand.
2. When the diameter of the pile is 0.3 m, compared to the sandy soil, the bearing capacity is higher in sandy loam by about 10%, in loam by 50%, and in clay by 100%. When the pile diameter is 0.35 m, compared to the sandy soil, the bearing capacity is about 20% higher in sandy loam, 45% in loam, and 110% in clay. When the pile diameter is 0.4 m, compared to sandy soil, the bearing capacity is about 10% higher in sandy loam, 30% in loam, and 45% in clay.
3. When the soil is sand, the bearing capacity of a 0.35 m diameter pile increases by 3.25 times compared to a 0.3 m diameter pile, and the bearing capacity of a 0.4 m pile increases by 5.5 times. When the soil is sandy loam, the bearing capacity of a 0.35 m diameter pile increases by 3.6 times compared to a 0.3 m diameter pile, and the bearing capacity of a 0.4 m pile increases by 5.5 times. When the soil is clay, the bearing capacity of a 0.35 m diameter pile increases by 3.4 times compared to a 0.3 m diameter pile, and the bearing capacity of a 0.4 m pile increases by 4 times.

## REFERENCES

1. Dong, S. et al. Numerical study on the installation effect of a jacked pile in sands on the pile vertical bearing capacities. Computers and Geotechnics. 2022, 145 [viewed at 2024-07-10]. https://doi.org/10.1016/j.compgeo.2022.104690.
2. Michail, S., Lopez-Querol, S. Numerical investigation of displacement pile installation in silica sand. Computers and Geotechnics. 2023, 161 [viewed at 2024-07-10]. https://doi.org/10.1016/j.compgeo.2023.105591.
3. Ling-Yu, X. ir kt. A simplified piecewise-hyperbolic softening model of skin friction for axially loaded piles. Computers and Geotechnics. 2019, 108 [viewed at 2024-07-07]. https://doi.org/10.1016/j.compgeo.2018.12.018.
4. Gajauskas, J., Šarakauskas, J., Motiekaitis, R. Statybos inžinieriaus žinynas. Vilnius, Technika, 2004. ISBN 9986–05–682–9.
5. Eurokodas 7. Geotechninis projektavimas. LST EN 1997 – 1:2003.
6. Ghiasi, V. ir Eskandari, S. Comparing a single pile's axial bearing capacity using numerical modeling and analytical techniques. Results in Engineering. 2023, 17 [viewed at 2024-05-11]. https://doi.org/10.1016/j.rineng.2023.100893.
7. Benjeminas, Č. Pamatų projektavimo pagal 7 eurokodą vadovas. Mokomoji knyga. Kaunas, Technologija, 2007. ISBN 9955-25-161-1.

PANEVĖŽIO KOLEGIJA ISSN 2029-1280, eISSN 2669-0071. Taikomieji tyrimai studijose ir praktikoje – Applied Research in Studies and Practice, 2024, 20.

# RELATIONSHIP BETWEEN SLEEP QUALITY AND PERCEIVED PSYCHOLOGICAL STRESS IN LITHUANIAN CLINICAL NURSES: A CROSS-SECTIONAL STUDY

***Marius BARANAUSKAS, Ingrida KUPČIŪNAITĖ, Jurgita LIEPONIENĖ***

*Panevėžio kolegija/ State Higher Education Institution, Lithuania*

**Abstract**. When sleep quality is one of the most important factors in determining a person's quality of life, it puts carers at increased risk of sleep disorders. It should be noted that without provoking factors (psychological stress), predisposing factors alone would not cause sleep disorders. The aim of the study was to identify and assess the association between psychological stress and sleep quality among nurses working in Lithuanian healthcare institutions. The results of the study showed that almost one in two nurses working in Lithuanian healthcare institutions is at risk of sleep disturbance and experiencing high levels of psychological distress. The analysis of the data showed that psychological stress is significantly correlated with poorer sleep quality among nurses working in Lithuanian healthcare institutions ($r = -0.4$, $p < 0.001$). In order to reduce psychological stress and improve sleep quality among nurses working in Lithuanian healthcare institutions, our study recommendations should be targeted at eliminating risk factors for psychological stress and rationalising the use of coping methods.

**Keywords:** clinical nurses, nurses' health, psychological stress, sleep quality

## INTRODUCTION

A third of a person's life is spent sleeping, which is why it is so important for the body. Sleep is a process that is essential for the recovery of the body's functions and the maintenance of energy used during the day (Smith et al., 2018). The quality of sleep is also one of the most significant factors determining the quality of human life.

On the one hand, sleep affects the ability to learn, memory consolidation, decision-making ability and critical thinking (Siddiqui et al., 2016). On the other hand, poor sleep quality can have a negative impact on a person's daytime performance, leading to fatigue, irritability, drowsiness, memory impairment, impaired concentration, and an increased risk of accidents or sick days. Thus, sleep disturbances are associated with a wide range of health conditions (Varoneckas et al., 2012). More specifically, both sleep duration and poor sleep quality are associated with the development of various health conditions such as type 2 diabetes (Baden et al., 2020; Knutson et al., 2006), cardiovascular disease (Kwok et al., 2018; Sofi et al., 2014), or even with higher mortality (Hoevenaar-Blom et al., 2011; Rod et al., 2011). While research has shown that sleep hygiene can determine sleep quality, there is still insufficient evidence on risk factors contributing to the symptomatology of sleep disorders.

Nurses are at increased risk of sleep disorders. Sleep disturbances in nurses cause irritability, affect mood, impair communication skills, can lead to interpersonal relationship problems, and impair responsiveness to patients' needs (Gomez-Garcia et al., 2016). Fatigue caused by sleep disturbances leads to reduced concentration, impaired cognitive function, which undermines nurses' productivity, decision-making ability and increases the likelihood of professional errors (Kaliyaperumal et al. 2017).

It should also be noted that psychological stress in nursing is inevitable and is of global concern in the current context. For example, a study in Australia found that as many as three-quarters of nurses experienced high levels of stress, which unequivocally impacted on the quality of their work performance (Happell et al., 2013). Among other things, one of the more important risk factors for sleep disturbances is the psychological stress experienced. Research has shown that higher levels of psychological stress lead to poorer sleep quality. Although it is well documented that sleep disturbances are prevalent among nurses working in healthcare settings (Dong et al., 2017; Leonavičiūtė, 2024), and that psychological distress can lead to clinically significant symptomatology of sleep disturbances, there are currently insufficient scientific data based on epidemiological studies to assess the association between sleep quality and psychological distress among nurses.

The Spielman or “3P” model of insomnia development was chosen as the theoretical basis for our study. The hypothesis of this model is based on one of the mechanisms that can explain how insomnia develops (Chawla, 2018). According to this model, 3 groups of factors (predisposing, provoking and supporting) determine the occurrence of insomnia. Based on the aforementioned model, stress is classified as a provoking factor (Perlis et al., 2011). Without provoking factors (psychological stress), predisposing factors alone would not cause sleep disorders. Therefore, it can be stated that psychological stress is a provoking factor for sleep disorders. Taking into account the above circumstances, the aim of our study was to identify and assess the links between psychological stress experienced by nurses working in Lithuanian healthcare institutions and sleep quality.

## SURVEY ORGANIZATION AND METHODOLOGY

A single-point cross-sectional study was conducted in October-November 2023. The estimated target population was 20,856 nurses working in Lithuanian healthcare institutions. The estimated and formed representative sample size with 10% accuracy and 95% reliability was 96 subjects. The inclusion criteria for respondents in the study were female nurses working in various Lithuanian healthcare institutions. By applying the non-probability convenience sampling method and using the official survey system (https://apklausa.lt/private/forms/) through 2 official Facebook social network groups, 40.8 ± 10.5 year-old subjects (n = 120) were surveyed from all Lithuanian nurses who were sent an invitation to participate in the study (n = 12,000). After applying the exclusion criteria, the final study sample size was 105 nurses.

The survey of the subjects was conducted using a confidential questionnaire method. In order to assess sleep quality, the Pittsburgh Sleep Quality Index (PSQI) (Buysse et al., 1989) was used. The sleep quality assessment methodology based on the calculation of the PSQI was designed to investigate the subjectively assessed quality of sleep over the past month. The PSQI assessment scale consisted of 18 statements that consistently corresponded to the most common characteristics reflecting sleep disorders. Taking into account the assessments of the statements presented in the PSQI scale, each statement acquired a numerical expression from 0 to 3. While there is currently no consensus on the PSQI score threshold referring to poor sleep quality, this study applied the PSQI I score threshold (≥ 7 points), which was established in clinical practice and was associated with poor sleep quality and an increased likelihood of sleep disorders (Beck et al., 2004; Carpenter & Andrykowski, 1989; Zhang et al., 2020). The overall internal consistency and validity of the Lithuanian version of the PSQI questionnaire were confirmed in a study of the Lithuanian population, and Kronbach's alpha was equal to 0.65 (Varoneckas et al., 2007). Using the Reeder Psychological Stress Scale (Metcalfe et al., 2003), translated and adapted into Lithuanian, the psychological stress experienced by nurses was determined and assessed. Taking into account the 7 statements presented to the respondents and evaluating them with a score from 1 to 4 (the maximum possible sum is 28 points), the level of psychological stress experienced was classified as follows: from 7 to 14 points - a high level of psychological stress is experienced, from 15 to 21 points - a medium level of psychological stress is experienced, from 22 to 28 points - a low level of psychological stress is experienced. The last part of the questionnaire consisted of 8 questions, with the help of which information was collected about the sociodemographic characteristics of the respondents, such as biological sex, age, education, income, position held, nature of the work performed, workload and time.

Statistical analysis of data was performed using the statistical program SPSS (Statistical Package for Social Sciences) v. 25.0. (Armonk, NY, USA). The Shapiro-Wilk test was used to check the reliability of the data. Arithmetic means and standard deviations (SD) were calculated for the analysis of quantitative continuous and discrete variables. Considering the single-point cross-sectional study design, the dependent variable was the sleep quality of nurses, and the independent variables were the psychological stress experienced by nurses. The Student's t-test for independent samples, ANOVA and the Pearson correlation coefficient (r) were used to analyze the study data. The difference in results was considered statistically significant, and the relationship was statistically reliable when the p value obtained was less than or equal to 0.05.

## RESULTS AND DISCUSSION

The study population consisted of 105 women working as nurses in healthcare institutions. The average age of the study participants was 40.8 ± 10.5 years. 44.8% of the study participants had higher non-university education, 34.2% had higher university education and 21% had medical school education.

According to the average monthly income, the study participants were distributed as follows: 61.9% of nurses earned an average of 1001 - 2000 euros per month, 24.8% earned 501 - 1000 euros per month and 13.3% earned more than 2001 euros per month. A more detailed distribution of nurses by sociodemographic indicators is presented in Table 1.

Table 1

**Sociodemographic characteristics of the study population and psychological stress experienced according to the sleep quality index (PSQI)**

| Variables | | n | % | PSQI (points) Mean ± SN | p |
|---|---|---|---|---|---|
| Age | 20 – 40 years | 53 | 50,5 | 6,4 ± 2,7 | 0,541 |
| | 41 – 63 years | 52 | 49,5 | 6,0 ± 3,0 | |
| Average monthly income (euros (€)) | 501 – 1000 € | 26 | 24,8 | 6,7 ± 2,8 | 0,584 |
| | 1001 – 2000 € | 65 | 61,9 | 6,0 ± 2,9 | |
| | ≥ 2001 € | 14 | 13,3 | 6,1 ± 2,4 | |
| Education | Post secondary (medical school) | 22 | 21,0 | 5,7 ± 3,0 | 0,186 |
| | Higher non-university | 47 | 44,8 | 5,9 ± 2,6 | |
| | Higher university | 36 | 34,3 | 6,9 ± 2,9 | |

| | | | | | |
|---|---|---|---|---|---|
| Work experience (seniority) in nursing positions (years) | ≤ 15 years | 58 | 55,2 | 6,0 ± 2,6 | 0,466 |
| | ≥ 16 years | 47 | 44,8 | 6,4 ± 3,1 | |
| Number of working hours per shift | < 10 hours | 52 | 49,5 | 6,1 ± 2,7 | 0,466 |
| | ≥ 11 hours | 53 | 50,5 | 6,3 ± 3,0 | |
| Level of psychological stress | Low to moderate stress levels | 60 | 57,1 | 5,3 ± 2,3 | < 0,001 |
| | High stress level | 45 | 42,9 | 7,4 ± 3,0 | |

Based on the research data presented in Table 1, according to the level of psychological stress experienced, nurses were divided into those experiencing high level (57.1%) and low or medium level (42.9%) psychological stress. When assessing sleep quality, the average PSQI was 6.2 ± 2.8 points, and poor sleep quality was determined in 42.9% and good sleep quality in 57.1% of nurses (Figure 1).

Taking into account the sleep quality index, when assessing the distribution of nurses depending on sociodemographic characteristics (age, average monthly income, education, length of service, number of working hours per shift), no statistically significant difference was determined between the analyzed variables ($p > 0.05$). On the other hand, the sleep quality of nurses experiencing high levels of psychological stress (PSQI scores: 7.4 ± 3.0) was significantly worse compared to the sleep quality of those experiencing low or moderate psychological stress (PSQI scores: 5.3 ± 2.3) ($p < 0.001$).

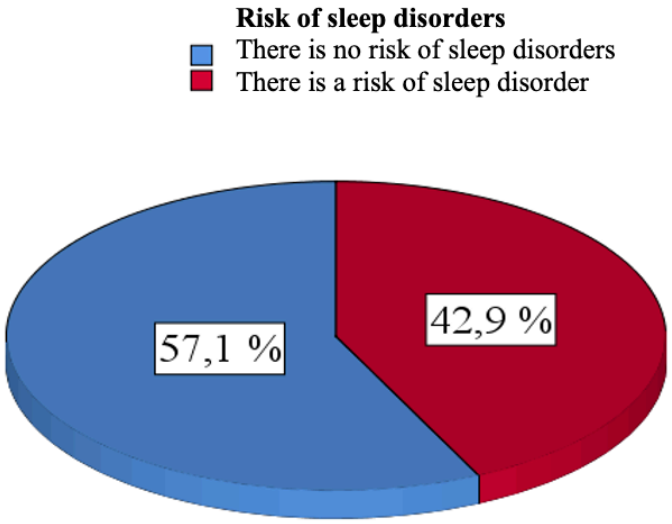



Figure 1. **Distribution of nurses according to potential risk of sleep disorders**

Finally, the correlation analysis of the study data confirmed a statistically significant inverse relationship of moderate strength ($r = – 0.4$, $p < 0.001$) between higher psychological stress experienced by nurses and sleep quality (Figure 2).

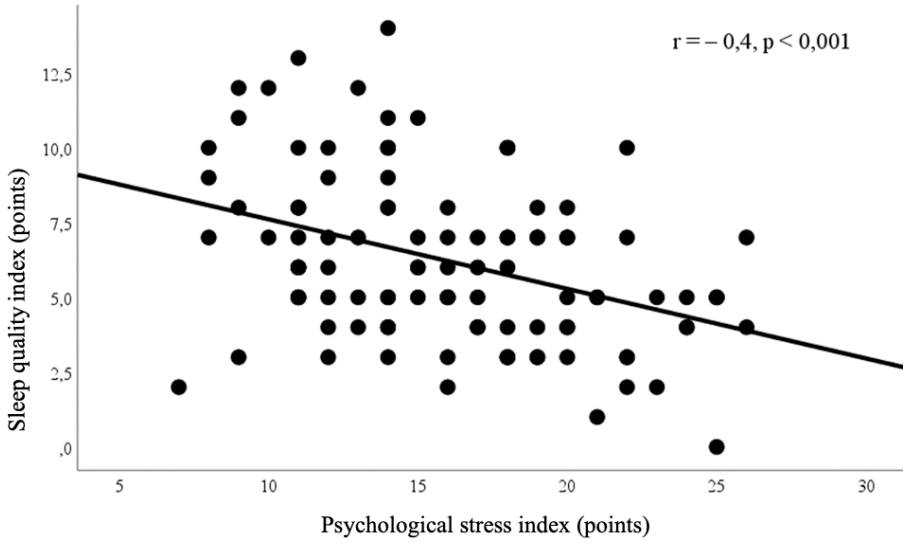



Figure 2. **Relationship between psychological stress experienced by nurses and sleep quality**

In summary, according to our study, the average PSQI of nurses was 6.2 ± 2.8 points. Comparing the results of our study with those obtained in studies conducted abroad (Xia et al., 2021), which refer to a similar level of sleep quality of nurses (PSQI: 5.33 - 7.34 points), determined before the COVID-19 pandemic, it can be stated that the

importance of early diagnosis of symptoms of sleep disorders in order to prevent possible complications related to the health of nurses. It is also noteworthy that the results of our study, which confirmed the relationship between psychological stress experienced by nurses and poorer sleep quality, were consistent when compared with the data published by Bilgiç et al. (2021), which revealed a reliable correlation between psychological stress experienced by nurses and sleep disorder symptoms. Therefore, taking into account the prediction that psychological stress may lead to poorer sleep quality, Lithuanian healthcare institutions are recommended to plan and implement preventive measures to reduce psychological stress among nurses.

## CONCLUSIONS

Almost every second nurse working in Lithuanian healthcare institutions is at risk of sleep disorders (42.9%) and experiences high levels of psychological stress (57.1%).

Psychological stress significantly predicts poorer sleep quality among nurses working in Lithuanian healthcare institutions.

In order to reduce psychological stress and improve sleep quality indicators among nurses working in Lithuanian healthcare institutions, the recommendations of our study should be purposefully directed towards eliminating risk factors that promote psychological stress and rationalizing the application of stress coping methods (Baranauskas et al. 2024).

## REFERENCES

1. Baden, M. Y., Hu, F. B., Vetter, C., Schernhammer, E., Redline, S., & Huang, T. (2020). Sleep duration patterns in early to middle adulthood and subsequent risk of type 2 diabetes in women. Diabetes Care, 43(6), 1219–1226. https://doi.org/10.2337/dc19-2371.
2. Baranauskas, M., Kalpokas, M., Kupčiūnaitė, I., Lieponienė, J. ir Stukas, R. (2024). Self-perceived stress in association with emotional experiences following patient death and coping adequacy among clinical nurses in Lithuania: A cross-sectional study. Journal of Clinical Medicine, 13(9), 2533. https://doi.org/10.3390/jcm13092533.
3. Beck, S. L., Schwartz, A. L., Towsley, G., Dudley, W., & Barsevick, A. (2004). Psychometric evaluation of the Pittsburgh Sleep Quality Index in cancer patients. Journal of Pain and Symptom Management, 27(2),140–148. https://doi.org/10.1016/j.jpainsymman.2003.12.002.
4. Bilgiç, Ş., Çelikkalp, Ü., & Mısırlı, C. (2021). Stress level and sleep quality of nurses during the COVID-19 pandemic. Work, 70(4), 1021-1029. doi:10.3233/WOR-210538.
5. Buysse, D. J., Reynolds, C. F., Monk, T. H., Berman, S. R., & Kupfer, D. J. (1989). The Pittsburgh Sleep Quality Index (PMKI): A new instrument for psychiatric research and practice. Psychiatry Research, 28(2), 193–213. doi:10.1016/0165-1781(89)90047-4.
6. Carpenter, J. S., & Andrykowski, M. A. (1989). Psychometric evaluation of the Pittsburgh Sleep Quality Index. Journal of Psychosomatic Research, 45(1), 5–13. doi:10.1016/s0022-3999(97)00298-5.
7. Chawla, J. (2018). What is the Spielman Model of chronic insomnia? https://www.medscape.com/answers/1187829-70509/what-is-the-spielman-model-of-chronic-insomnia.
8. Dong, H., Zhang, Q., Sun, Z., Sang, F., & Xu, Y. (2017). Sleep problems among Chinese clinical nurses working in general hospitals. Occupational Medicine, 67, 534–539. https://doi.org/10.1093/occmed/kqx124.
9. Gomez-Garcia, T., Ruzafa-Martinez, M., Fuentelsaz-Gallego, C., Madrid, J. A., Roi, M. A., Martinez-Madrid, M. J., &Mareno-Casbas, T. (2016). Nurses' sleep quality, work environment and quality of care in the Spanish National Health System: observational study among different shifts. BMJ Open, 6(8), e012073. https://doi.org/10.1136/bmjopen-2016-012073.
10. Happell, B., Dwyer, T., Reid-Searl, K., Burke, K. J., Caperchione, C. M., & Gaskin, C. J. (2013). Nurses and stress: recognizing causes and seeking solutions. Journal of Nursing and Management, 21, 638–647. https://doi.org/10.1111/jonm.12037.
11. Hoevenaar-Blom, M. P., Spijkerman, A. M., Kromhout, D., van den Berg, J. F., & Verschuren, W. M. (2011). Sleep duration and sleep quality in relation to 12-year cardiovascular disease incidence: the MORGEN study. Sleep, 34(11),1487–1492. doi:10.5665/sleep.1382.
12. Kaliyaperumal, D., Elango, Y., Alagesan M., & Santhanakrishanan, I. (2017). Effects of sleep deprivation on the cognitive performance of nurses working in shift. Journal of Clinical and Diagnostic Research, 11(8), CC01–CC03. doi:10.7860/JCDR/2017/26029.10324.
13. Knutson, K. L., Ryden, A. M., Mander, B. A., & Van Cauter, E. (2006). Role of sleep duration and quality in the risk and severity of type 2 diabetes mellitus. Archives of Internal Medicine, 166(16),1768–1774. doi:10.1001/archinte.166.16.1768.
14. Kwok, C. S., Kontopantelis, E., Kuligowski, G., Gray, M., Muhyaldeen, A., Gale, C. P., Peat, G. M., Cleator, J., Chew-Graham, C., Loke, Y. K., & Mamas, M. A. (2018). Self-reported sleep duration and quality and cardiovascular disease and mortality: a dose-response meta-analysis. Journal of the American Heart Association, 7(15), e008552. https://doi.org/10.1161/JAHA.118.008552.

15. Leonavičiūtė, M. (2024). Skubios pagalbos skyriuje dirbančių slaugytojų patiriamas stresas ir jo įtaka miego kokybei. https://portalcris.lsmuni.lt/server/api/core/bitstreams/b8d199c5-eb78-4987-ae5d-fa62aa91df9b/content.
16. Metcalfe, C., Smith, G. D., Wadsworth, E., Sterne, J. A. C., Heslop, P., & Macleod, J. (2003). A contemporary validation of the Reeder Stress Inventory. British Journal of Health Psychology, 8(1), 83–94. doi:10.1348/135910703762879228.
17. Perlis, M., Shaw, P. J., Cano, G., & Espie, C. A. (2011). Models of insomnia. Principles and practice of sleep medicine. Fifth edition. 850–865. https://www.researchgate.net/publication/284832404_Models_of_Insomnia.
18. Rod, N. H., Vahtera, J., Westerlund, H., Kivimaki, M., Zins, M., Goldberg, M., & Lange, T. (2011). Sleep disturbances and cause-specific mortality: results from the GAZEL cohort study. American Journal of Epidemiology, 173(3), 300–309. doi:10.1093/aje/kwq371.
19. Siddiqui, A. F., Al-Musa, H., Al-Amri, H., Al-Qahtani, A., Al-Shahrani, M., & Al-Qahtani, M. (2016). Sleep patterns and predictors of poor sleep quality among medical students in King Khalid university, Saudi Arabia. Malaysian Journal of Medical Sciences, 23(6), 94–102. doi:10.21315/mjms2016.23.6.10.
20. Smith, M. T., McCrae, Ch. S., Cheung, J., Martin, J. L., Harrod, Ch. G., Heald, J. L., & Carden, K. A. (2018). Use of actigraphy for the evaluation of sleep disorders and circadian rhythm sleep-wake disorders: An American academy of sleep medicine systematic review, meta-analysis, and GRADE Assessment. Journal of Clinical Sleep Medicine, 14(7), 1209–1230. https://doi.org/10.5664/jcsm.7228.
21. Sofi, F., Cesari, F., Casini, A., Macchi, C., Abbate, R., & Gensini, G. F. (2014). Insomnia and risk of cardiovascular disease: A meta-analysis. European Journal of Preventive Cardiology, 21(1), 57–64. doi:10.1177/2047487312460020.
22. Xia, L., Chen, Ch., Liu, Zh., Luo, X., Guo, Ch., Liu, Zh., Zhang, K., & Liu, H. (2021). Prevalence of sleep disturbances and sleep quality in Chinese healthcare workers during the COVID-19 pandemic: A systematic review and meta-analysis. Frontiers in Psychiatry, 12, 646342. doi:10.3389/fpsyt.2021.646342.
23. Varoneckas, G., Alonderis, A. ir Podlipskytė A. (2012). Miego kokybės sąsajos su psichoemocine būkle ir kardiologine patologija. Biologinė psichiatrija ir psichofarmakologija, 14(1), 13–16. https://biological-psychiatry.eu/wp-content/uploads/2014/06/Giedrius-VARONECKAS-Audrius-ALONDERIS-Aurelija-PODLIPSKYT%C4%96.pdf.
24. Varoneckas, G., Alonderis, A., Duonėlienė, I., Podlipskytė, A., Valytė, G. ir Zakarevičius, L. (2007). Miego kokybės ir struktūros pokyčiai sergantiesiems išemine širdies liga. Biologinė psichiatrija ir psichofarmakologija, 9(1), 7–10. https://biological-psychiatry.eu/wp-content/uploads/2014/06/2007_9_Varoneckas.pdf.
25. Zhang, C., Zhang, H., Zhao, M., Li, Z., Cook, C. E., Buysse, D. J., & Yao, Y. (2020). Reliability, validity, and factor structure of Pittsburgh sleep quality index in community-based centenarians. Frontiers in Psychiatry, 11, 573530. doi:10.3389/fpsyt.2020.573530.

PANEVĖŽIO KOLEGIJA ISSN 2029-1280, eISSN 2669-0071. Taikomieji tyrimai studijose ir praktikoje – Applied Research in Studies and Practice, 2024, 20.

# IMPROVING MIGRANTS' VOCATIONAL EDUCATION AND TRAINING (VET) SKILLS THROUGH ENTREPRENEURSHIP EDUCATION

***Miglė Eleonora ČERNIKOVAITĖ***

*Vilniaus kolegija/ Higher Education Institution, Lithuania,*

**Abstract**. With the increase in migration flows worldwide, migrants face various challenges that are determined by social, economic, cultural and political factors. Therefore, in order to ensure social cohesion and economic development in Lithuania, it is very important to create more favourable conditions for the integration of migrants. To achieve this goal, it is recommended to apply a multifaceted approach that includes improving the availability of languages and entrepreneurship education, promoting community engagement initiatives and raising public awareness. The aim of this study is to investigate the effectiveness of entrepreneurship education in vocational education and training institutions in order to facilitate the integration of migrants into Lithuanian society. The following research methods were applied: analysis and synthesis of scientific literature, quantitative research (questionnaire survey) and statistical data analysis in order to identify factors that promote entrepreneurship that can be used in educational strategies. This method will help to bridge the gap between a comprehensive entrepreneurial environment and the development of an entrepreneurial personality and apply it to migrants in Lithuania. The results of the study will be used in migrant integration strategies in Lithuania, defining factors that promote entrepreneurship through educational platforms, opening small businesses, and those that hinder their entrepreneurship.

**Keywords**: Migrant integration; entrepreneurship education; vocational education; social cohesion; educational strategies

## INTRODUCTION

**Relevance of the topic.** In 2019-2024, immigration in Lithuania increased significantly, creating both opportunities and challenges for our country. Williamson (2019) emphasizes that migration can have a positive impact on the economy, but requires “urgent and effective solutions to ensure the successful integration of migrants.” It is important to recognize that the integration of migrants is not only a social but also an economic process that can have a positive impact on the entire country. By promoting their professional training and improving their learning skills, Lithuania can not only benefit from the benefits of migration, but also contribute to social cohesion. (Castles, 2020).

First, the importance of vocational training for migrants needs to be discussed. Migrants often arrive with a variety of skills and knowledge, but in many cases their qualifications have not been recognized in Lithuania. It is necessary to create appropriate programs that would help migrants adapt their vocational skills, and at the same time develop new skills. Portes and Rumbaut (2014) argue that “migrants can contribute significantly to the local economy, so their vocational training is particularly important.” Such programs should focus on entrepreneurship development, as this can provide migrants with the opportunity to become independent and contribute to the local economy.

According to experts, "an entrepreneurial spirit can help migrants better adapt to new living environments and seek new opportunities" (Marbach et al. ,2018). Kumar (2020) emphasizes that entrepreneurship education is important not only in increasing migrants' employability, but also in encouraging their desire to start their own businesses. This, in turn, can have a positive impact on the entire community, as new businesses often stimulate job creation and economic development. On the other hand, it is also necessary to take into account the social dynamics that influence the integration process of migrants. Migrants often face one of the biggest obstacles - cultural differences and language barriers. "When assessing the needs of migrants, it is important to develop programs that cover not only professional, but also social and cultural aspects. Borell (2018) argues that social integration is necessary to manage cultural differences and enable migrants to fully participate in society." (Borell, 2018)

Finally, political systems and economic conditions have a significant impact on migrants' integration. Effective public policies aimed at integrating migrants into the labour market and communities can help reduce discrimination. OECD (2021) research highlights that based on social integration strategies, migrants can adapt more successfully to their new environment. The Lithuanian government and non-governmental organizations can cooperate in developing programs aimed at integrating migrants and promoting their entrepreneurship.

**The formulation of the problem of the work.** What vocational education and training programs and how do they provide an opportunity for migrants not only to find their place in a new country, but also to contribute to its economic and cultural diversity in Lithuania?

**The purpose of the work** is to assess the effectiveness of entrepreneurship education programs in vocational education and adult education institutions, which would facilitate the integration of migrants into the Lithuanian business community. This will allow identifying best practices and recommending strategies for strengthening integration efforts.

**The following tasks are required for the study:**

1. To examine the context of migrant entrepreneurship in Lithuania;

2. To analyse the development of entrepreneurship education in vocational education and adult education institutions in Lithuania;

3. To examine the challenges and opportunities for migrants in the field of vocational education and training, related to entrepreneurship as a means for further integration of migrants into Lithuanian society.

**Research methods of the work:** analysis and synthesis of scientific literature, quantitative research (questionnaire survey) and statistical data analysis, in order to identify factors promoting entrepreneurship that can be used in educational strategies.

## LITERATURE REVIEW

### *The context of migrant entrepreneurship in Lithuania*

According to the Global Entrepreneurship Survey (GEM) 2023, Lithuania has a favourable environment for entrepreneurship. The country's entrepreneurial ecosystem is strong in various areas, including physical, commercial and professional infrastructure, social norms and government support programs for entrepreneurs. However, entrepreneurship education is not sufficiently emphasized in schools (GEM, 2023).

According to Eurostat (Eurostat, 2021), at the end of 2021, there were 2,700 companies run by migrants in Lithuania. Of these, 89% were self-employed (2,400), while only 11% of companies (300 companies) employed other people. The entrepreneurship rate among migrants was recorded at 4%, which is half the rate among Lithuanian citizens (8%). The largest number of companies run by non-EU entrepreneurs came from Belarus (492), Russia (472) and the United Kingdom (309). (Eurostat, 2023)

Lithuania actively pursues policies aimed at attracting foreign entrepreneurs and facilitating their business establishment in the country, for example, the Startup Visa Lithuania program offers a simplified entry process to the Lithuanian startup ecosystem for innovative non-EU entrepreneurs. (Startup Lithuania, 2021) This visa allows applicants to apply for a temporary residence permit for one year, which can be extended for a total of five years if the startup secures at least EUR 30,000 in investment since its inception. Eligible migrant entrepreneurs must establish their business within 120 days of receiving the temporary residence permit (GEM, 2023). In Lithuania, non-EU migrants who wish to work independently can choose one of two forms of self-employment:

- Individual self-employment, which requires an individual activity certificate;
- Self-employment, which requires a business certificate.

From 2021, migrants will be able to obtain the status of Lithuanian e-resident and e- signature without a residence permit. This e-resident status allows foreigners to establish companies online, manage bank accounts, file tax returns and use various other administrative, public or commercial remote services. However, financing a business and the fear of failure are significant, without knowledge of Lithuanian culture, business environment and language. Therefore, a training period is needed to develop entrepreneurship. (GEM, 2023).

### *Development of entrepreneurship education in Lithuania*

Lithuania is one of the first EU countries to implement entrepreneurship education strategies in primary and secondary education (OECD, 2015). The importance of entrepreneurship education was first recognized in the Lithuanian National Education Strategy approved in 2003. This strategy emphasizes the need to focus on entrepreneurship and financial management at all levels of school education, with the aim of ensuring that every gymnasium student acquires the basics of economic literacy. This initiative gave rise to two specific strategies:

1) "Economic Literacy and Entrepreneurship Education" (2004) and,

2) "National Youth Entrepreneurship Education and Promotion Programme 2008-2012", which aim to focus more on entrepreneurship and financial management at all levels of education (OECD, 2022).

The Lithuanian Entrepreneurship Education Strategy 2014-2024 The aim of the action plan is to provide actions that would promote a consistent growth in the level of entrepreneurship in the country, by creating a consistent and continuous entrepreneurship education system, creating an environment conducive to business creation and development, and improving the accessibility of public services to entrepreneurs. This plan also pays great attention to improving the perception of entrepreneurship among the public, especially among certain groups and different regions.

In Lithuania, entrepreneurship education is integrated into primary education through compulsory subjects such as social and natural sciences (Cedefop, 2023). This approach is unique compared to many other countries, which follow a cross-curricular perspective, emphasizing entrepreneurial skills in all subjects. In secondary school, "Economics and Entrepreneurship Education" is a compulsory subject in grades 9 and 10, and entrepreneurship is also integrated into other core subjects, including social sciences, mathematics and technology. In upper secondary education, entrepreneurship continues to be integrated into compulsory subjects, but can also be chosen as an optional subject. A number of secondary schools cooperate with Junior Achievement Lithuania (JAL), a non-profit organization that aims to develop a free-market mentality, entrepreneurship and leadership skills in young people. The programmes developed by Junior Achievement Lithuania (2023) are tailored to specific local needs and circumstances. Furthermore, these programmes are provided free of charge to students. Junior Achievement Lithuania (JAL) operates in 40% of secondary schools and offers a variety of financial literacy, career development and entrepreneurship programs that strengthen students' creative thinking, teamwork and problem-solving skills. Evaluation results show that graduates of JAL programs are better prepared for the job market and are more likely to start their own businesses (European Commission, 2022).

It is acknowledged that the Lithuanian vocational education training (VET) system needs to be improved. (Cedefop, 2023, Tikkanenn et al, 2024) This action plan focuses on workplace learning initiatives, including apprenticeship models. Franczak et al. (2011) highlight that entrepreneurship education and cultural studies systems are relatively underdeveloped in the Lithuanian VET system. The low level of implementation represents a gap in the current educational structure that could be exploited to improve students' learning outcomes (Psifidou, & Pevec Grm, S. (2021). As Cedefop (2023) argues, a stronger integration of work-based learning into the VET system can significantly enrich entrepreneurship education. (Antera, 2021, Buligina, Sloka, (2022). Work-based learning provides students with a practical, hands-on approach that allows them to directly experience business practices, management skills and operational aspects related to business management. (Psifidou, Pevec, 2021). Such an experiential learning system enables students to better understand entrepreneurship, as they can learn not only theoretical concepts, but also how to apply them in real-world scenarios. Furthermore, this active learning approach to entrepreneurship education can improve the career guidance of migrants. By participating in a work environment, VET students can better reveal their interests and abilities, thus becoming familiar with a variety of career paths that match their skills and aspirations. This exposure can help them identify entrepreneurial opportunities or specific sectors in which they could excel after graduation.

In Lithuania, the Ministry of Social Security and Labour is responsible for overseeing entrepreneurship and innovation education outside the formal education sector. This is primarily implemented through Junior Achievement, which is the lead organisation in this field. Junior Achievement adapts international practices to local conditions, fostering a culture of innovation and entrepreneurship through various initiatives. These include enterprise programmes that allow students to run their own businesses under simplified requirements, as well as simulations, summer camps and innovation camps. Support for youth entrepreneurship is strengthened by several business associations that provide a range of services, including mentoring, business consultancy, seminars and internships, to help young people acquire the necessary skills and establish connections in industry. Among the most prominent organisations are the Lithuanian Confederation of Industrialists and the Confederation of Business Employers.

## METHODOLOGY

A questionnaire survey was chosen to conduct a quantitative study. The survey method was chosen for several main reasons: it is the least time- and cost-intensive method that allows collecting information from a large number of respondents, as well as from a wider group of respondents, thus, finding out the opinion of the general public on a certain issue (Bacon-Shone, 2022). This method is widely used in practice precisely when there are no other research methods, which indicates its reliability and popularity. A survey is a data collection method when people's opinions, intentions and preferences are found out using a pre-prepared set of questions, i.e. a questionnaire (Sreejesh & Mohapatra, Sanjay, 2014). The results of the survey method are expressed in numbers and percentages. After statistical calculations, all the results are presented graphically. In quantitative research, it is important to describe what is objective and real and try to explain it.

Based on the analysis of theoretical literature, questions were formulated for the quantitative study that aimed to clarify the respondents' attitude to the purpose and objectives of the study. After conducting a literature review, a questionnaire consisting of 15 questions was prepared for this study. The questionnaire for the quantitative study consisted of closed-ended questions (questions with multiple-choice answers, questions with multiple-choice answers and matrix questions with a Likert scale), which allowed respondents to express their opinions. 214 respondents were selected for the quantitative study by random non-probability sampling, the error rate was 6.7% (calculated according to the Pinot formula). Target group: Vilnius city and district residents aged 18-50, with migrant status, studying at the Vilnius Gabrielė-Petkevičaitė Bitė Adult Training Center (https://www.gpbite.eu/) The quantitative study was conducted in September 2024 in Vilnius, Lithuania, on-site and remotely. Participants were informed in advance about the purpose of the study, and their verbal consent for the interview and questionnaire survey was obtained. The study was conducted in accordance with the ethical principles of privacy, anonymity, and confidentiality.

## RESULTS

### *Identifying the educational needs of adult migrants*

These results can be explained by an imbalance in the educational provision for ethnic minority groups and "new" immigrants. As the statistical analysis shows, despite the increasing number of immigrants, who are considered to be the 'new' audience for adult education initiatives, language courses and teaching materials have been developed with the needs of minority groups in mind. There is a clear need for materials aimed at adult migrants to develop reading, listening, speaking and pronunciation skills. As adult migrants also need training, especially as learning the local language is a prerequisite for the successful integration of migrants, a new challenge arises. Educational measures for adult migrants need to be developed and implemented by qualified professionals.

A review of research at national level revealed a wider range of barriers to integration related to migrants' education. For example, studies examining the socio-economic circumstances of refugees have shown that the social environment in which refugees cope with everyday challenges plays a key role in their integration. Language barriers often limit refugees' access to skilled, well-paid jobs, forcing them into unskilled, low-paid work. Other studies on

refugee integration (Andersson, Köpsén, (2015), Žibas (2014)) confirm the importance of language as an integration factor. It has been stressed that language proficiency is not only a prerequisite for employment, but also for access to the health sector, housing and social support. It is regrettable that, in addition to those already mentioned, there are additional challenges to the integration of migrants. Žydžiūnaitė (2012) identifies the lack of a comprehensive settlement policy, limited social programme and limited access to medical services as the main factors contributing to poverty and insecurity among refugees. In addition, the absence of political and public discourse has politicised the concept of refugee, fuelling hostility between refugees and the wider society. Fragmented, sporadic and temporary assistance is provided to refugees as a result of inconsistent efforts by non-profit organisations.

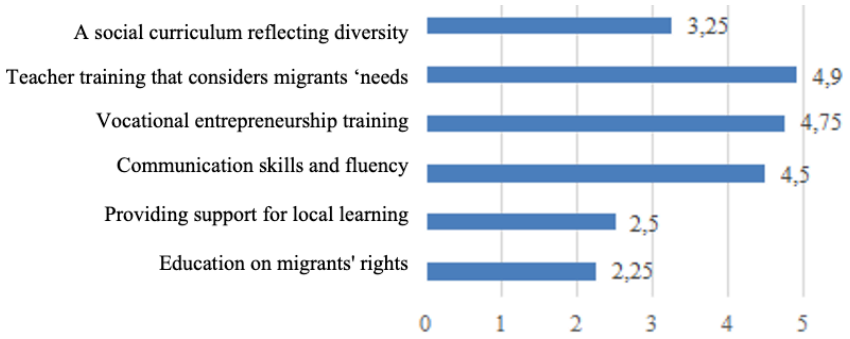



Figure 1. **Education needs of migrants in Lithuania**

The results show that effective communication skills (4.5 out of 5) and vocational entrepreneurship training (4.75 out of 5) are very important, suggesting that strengthening these areas could significantly facilitate the integration of migrants into the local community. Teacher training should reflect the needs of migrants (4.9), and curriculum development should reflect the need for educational institutions to adapt to changing demographics, as this can increase understanding and social cohesion (Andersson, Kopsen, 2015, Antera, 2021). Legal rights education (2.25) and support in the local language were scored relatively lower, suggesting a reassessment of how these areas are promoted and implemented to meet the practical aspirations of migrants. The above barriers can be illustrated by the types of social resources available to immigrants. For example, immigrants tend to turn to their employers or specialised institutions for help with language learning, recognition of qualifications and further education or training. It should be noted that these services, with the exception of the recognition of qualifications, are not provided by public institutions or employers, but by non-governmental organisations.

***Identifying opportunities for entrepreneurship education for adult migrants***

A holistic approach to integration seems to prevail, looking beyond academic and vocational training to the importance of social and cultural understanding, stressing the need for a comprehensive strategy that incorporates the different aspects of the migrant experience.

The study also looks at the needs for supporting migrant entrepreneurship in Lithuania.

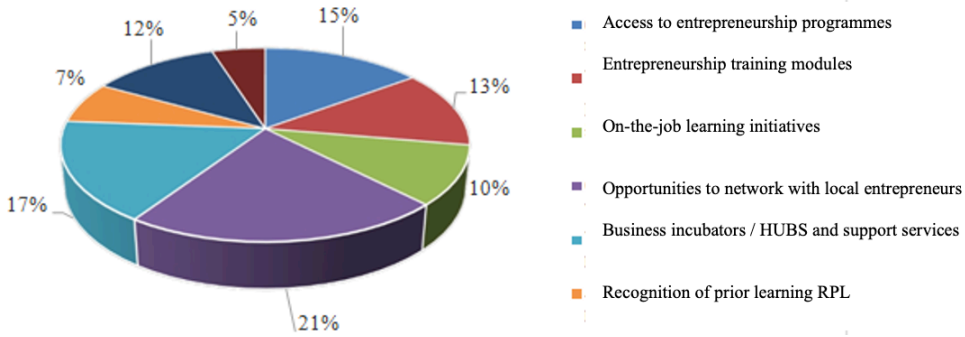



Figure 2. **Entrepreneurship needs of migrants in Lithuania.**

The focus is likely to be on networking opportunities (mentoring programmes) with local businesses (21%) and access to entrepreneurship training programmes (15%), reflecting the importance of networking and formal education in the entrepreneurial journey. Business incubators and access to finance (17%) are also very important, but slightly below networking in terms of perceived importance. Recognition of prior learning may be less important than the more immediate needs and resources required to start a business.

The study mentions the main aspects of this system and how migrants can benefit from it. The existing Lithuanian vocational training system offers a variety of programmes, tailored to different qualifications and specifically designed for immigrants. These initiatives prioritise language assistance, which is provided in many institutions to help non-Lithuanian speakers and facilitate their participation in these training programmes. However, there is a lack of entrepreneurial studies that could equip migrants with essential business skills. Vocational training institutions could also provide targeted entrepreneurship courses covering key areas such as business planning, financial management,

marketing and the legal framework relevant to Lithuania. Many programmes include hands-on learning opportunities, allowing participants to tackle real projects while gaining practical entrepreneurial experience. These programmes promote networking opportunities with local businesses, which helps migrants to connect with potential employers and partners. In addition, some institutions may offer mentoring programmes where experienced entrepreneurs guide aspiring migrants, share valuable insights into the local business environment and offer on-the-job learning initiatives.

**Assessing the potential of entrepreneurship education in VET centres**

Some VET centres work together with business incubators, which could provide important support for start-ups, including office space, administrative assistance and access to finance. As the existing Startup Visa programme, a new talent attraction scheme that provides innovative entrepreneurs from outside the European Union (EU) with a simplified entry process into the Lithuanian startup ecosystem, has not fully met the government's expectations (Psifidou& Pevec (2021). Thus, migrants can also benefit from advisory services on business plan development, financial support and understanding local market dynamics.

The Recognition of Prior Learning (RPL) system allows migrants to have their previous skills assessed and recognised, thus facilitating their entry into VET programmes without unnecessary retraining. In addition, the European Union funds a range of programmes that provide migrants with vocational training and entrepreneurial support, grants and scholarships to ease the financial burden.

To accommodate different timetables, many VET institutions have introduced distance learning opportunities to enhance competences in digital VET and allow migrants to learn while combining work and personal responsibilities. In addition, some programmes include cultural training focusing on Lithuanian customs, networking community business practices and community engagement, which are essential for successful entrepreneurship. Involvement in local community initiatives through vocational training would also help migrants to better understand the market and cooperate effectively.

## CONCLUSIONS

1. Lithuania's entrepreneurial environment, as highlighted in the Global Entrepreneurship Survey (2023), is favourable, with strong infrastructure and government support. However, there is room for improvement in entrepreneurship education in schools. At the end of 2021, there were 2,700 businesses in Lithuania run by migrants, most of them self-employed (89%). Migrants had a lower level of entrepreneurship than Lithuanian nationals (4% compared to 8%). Migrant entrepreneurs, especially from Belarus, Russia and the UK, are actively encouraged through policies such as the Startup Visa Programme, which provides a simplified entry procedure for non-EU entrepreneurs seeking to set up start-ups. Non-EU migrants in Lithuania have the opportunity to engage in individual self-employment or entrepreneurship. From 2021, migrants can also obtain a Lithuanian e-Residency, which allows them to run an online business without a residence permit.

2. At the end of 2022, there were a significant number of non-EU migrants living in Lithuania, the majority of whom were of working age. In response to labour shortages, the government has revised its migration policy to create pathways for entrepreneurial migrants through the Startup Visa Programme, which provides simplified opportunities for skilled non-EU entrepreneurs. In addition, the VET system provides valuable resources for migrants to help them develop entrepreneurial skills and improve their integration into the local business environment.

3. The study found that effective communication skills and entrepreneurial training are key factors in facilitating the integration of migrants into the Lithuanian market. Vocational training institutions need to adapt their curricula to better support migrants by offering entrepreneurial practices. The study highlights networking, mentoring, digital learning in the workplace and access to entrepreneurial training programmes that recognise prior learning as key elements in meeting migrants' entrepreneurial needs. While the Lithuanian vocational education and training system offers language support and various programmes for migrants, there is a lack of entrepreneurial-oriented courses that provide migrants with essential business skills.

## REFERENCES

1. Andersson, P., & Köpsén, S. (2015). “Continuing professional development of vocational teachers: Participation in a Swedish national initiative”. *Empirical Research in Vocational Education and Training*, 7(7), 1−20. https://doi.org/10.1186/s40461-015-0019-3
2. Antera, S. (2021). “Professional competence of vocational teachers: A conceptual review.” V*ocations and Learning*, 14(3), 459–479. https://doi.org/10.1007/s12186-021-09271-7
3. Bacon-Shone, John. (2022). *Introduction to Quantitative Research Methods*. Retrieved from URL
4. Borell, C. (2018) – Social Integration of Migrants
5. Buligina, I., & Sloka, B. (2022). “Latvia: Towards systemic approach to skill formation”.
6. Castles, S. (2020) Migration and Social Transformation“ –
7. Cedefop (2023). The future of vocational education and training in Europe: Volume 4: Delivering lifelong learning: the changing relationship between IVET and CVET (Cedefop research paper,No 91). Publications Office of the European Union. http://data.europa.eu/doi/10.2801/726631

8. European Commission (2022*). Education and training monitor 2022: Comparative report. Publications Office of the European Union*. https://op.europa.eu/webpub/eac/educationand- training-monitor-2022/downloads/comparative-report/Education-and-Training-Monitor- Comparative-Report.pdf
9. Eurostat, 2023, '*Asylum applicants by type of applicant, citizenship, age and sex - annual aggregated dat*a [migr_asyappctza]', compiled by MFC https://ec.europa.eu/eurostat/databrowser/view/migr_asyappctza/default/table?lang=en.
10. Eurostat, 2023, '*Population on 1 January 2023 by age group, sex and citizenship*[MIGR_POP1CTZ]', compiled by MFC, https://ec.europa.eu/ eurostat/databrowser/view/MIGR_POP1CTZ__custom_5955458/default/table?lang=en.
11. Franco, Peppino & Kearns, Liviana & Valtonen, David & Jaspers, Jos & Kommers, Piet. (2019). *Work-based Learning*. 10.13140/RG.2.2.14978.12482.
12. GEM (Global Entrepreneurship Monitor), 2023, Global Entrepreneurship Monitor 2022/2023 Global Report: Adapting to a "New Normal". London: Retrieved from URL: http://gemconsortium.org/report/20222023-global-entrepreneurship-monitor-global-reportadapting-to-a-new-normal-2.
13. Kumar, A. (2020) Entrepreneurship and Migrants: A Comparative Study.
14. Kvalifikacijų ir profesinio mokymo plėtros centras. (2022)". Teachers and trainers in a changing world – Lithuania: Building up competences for inclusive, green and digitalised vocational education and training (VET)". Cedefop ReferNet thematic perspectives series. http://libserver.cedefop.europa.eu/vetelib/2022/teachers_and_trainers_in_a_changing_worl d_Lithuania_Cedefop_ReferNet.pdf
15. Marbach, M., Hainmueller, J., & Hangartner, D. (2018) The long-term impact of employment bans on the economic integration of refugees. Sci. Adv.4,eaap9519(2018).DOI:10.1126/sciadv.aap9519.
16. Medbalt (2015). *Analysis of adult migrant education programmes and migrant integration policies (MEDBALT): Case study of Lithuania* (2015). Diversity Development Group. Vilnius. Retrieved from URL https://www.diversitygroup.lt/files/projects/medbalt/MEDBALT_LTU_Case_analysis_DDG.pdf
17. Nylund, M., & Rosvall, P. A. (2019). "Vocational education, transitions, marginalisation and social justice in the Nordic countries". *European Educational Research Journal*, 18(3), 271–277. https://doi.org /10.1177/147490 4119838893OECD (2021).
18. OECD (2015*), Education at a Glance 2015*: *OECD Indicators*, OECD Publishing, Paris, https://doi.org/10.1787/eag-2015-en.
19. OECD (2021) The Future of Work: Employment Outlook 2021.
20. OECD (2022) Preparing vocational teachers and trainers: Case studies on entry requirements and initial training". *OECD Publishing*. https://doi.org/10.1787/c44f2715-en
21. Portes, A., & Rumbaut, R. (2014) – „Immigrant America: A Portrait" – knyga apie imigrantų patirtis, integraciją ir jų indėlį į visuomenę.
22. Psifidou, I., & Pevec Grm, S. (2021). « VET teachers and trainers competence creating inclusion and excellence." In F. Bünning, G. Spöttl, & H. Stolte (Eds*.), Technical and vocational teacher education and training in international and development co-operation* (pp. 95–116). Springer. https://doi.org/10.1007/978-981-16-6474-8_7
23. Sreejesh S. & Mohapatra, Sanjay (2014). *Questionnaire Design*. 10.1007/978-3-319-00539-3_5.
24. Startup Lithuania, 2021, 'Changes In Procedures That Foreign Startups Need to Know WhenThey Want To Establish Their Business In Lithuania', https://www.startuplithuania.com/news/march-1st-changes-in-procedures-that-foreign-startupsneed- to-know-when-they-wantto-establish-their-business-in-lithuania/.
25. Teachers and leaders in vocational education and training: OECD reviews of vocational education and training. OECD Publishing. https://doi.org/10.1787/59d4fbb1-en.OECD (2022).
26. Tikkanen, Trija; Tūtlys Vidmantas, Vaitkutė L., Kaminskienė Lina, Ümarik Meril, Loogma Krista, Sloka Biruta, Bulgina Ilze, "VET Teachers' and Schools' Capacities to Tackle the Challenges of Vulnerable Students in the Baltic Countries and Norway". *Pedagogy,* 2024, t. 153, Nr. 1, p. 5–31 / Vol. 153, No. 1, pp. 5–31, 2024, ISSN 1392-0340 (Print), ISSN 2029-0551 (Online), https://doi.org/10.15823/p.2024.153.1
27. Tutlys, J. Markowitsch, J. Winterton, & S. Pavlin, *Skill formation in Central and Eastern Europe: A search for patterns and directions of development* (pp. 95–120). Peter Lang Verlag. https://doi.org/10.3726/b19799
28. Williamson, J. (2019) Influence of migration to economics and social systems.
29. Žibas K., 2014. *Chinese and Turkish Immigrants in Lithuania*. Monograph. Lithuanian Social Research Centre. Vilnius. ISBN 978-9955-862-43-7. P 228.
30. Žydžiūnaitė, V., 2012. Tool for the Evaluation of Integration of Foreigners Granted Asylum. Monograph. Tolerant Youth Association, the European Refugee Fund, Vytautas Magnus

PANEVĖŽIO KOLEGIJA ISSN 2029-1280, eISSN 2669-0071. Taikomieji tyrimai studijose ir praktikoje – Applied Research in Studies and Practice, 2024, 20.

# PREVALENCE OF PSYCHOACTIVE SUBSTANCE USE IN GENERAL EDUCATION SCHOOLS

***Rasa GLINSKIENĖ, Rimanta PAGIRIENĖ***

*Panevėžio kolegija/State Higher Education Institution, Lithuania*

**Abstract.** The prevalence of psychoactive substance use in mainstream schools is a significant public health and social problem that raises serious concerns about pupils' health, academic performance and future prospects. In Lithuania, as in many other countries, research is being carried out to determine the extent of psychoactive substance use among schoolchildren. Therefore, the aim of this study is to investigate the prevalence of psychoactive substance use among pupils of general education schools in Panevėžys. The method of the study is a questionnaire survey. The research instrument is a questionnaire developed by the authors of the study. Participants of the study - pupils of 5th, 7th, 9th and 11th grades of general education schools in Panevėžys. Sample size - 1030 respondents. The results of the survey showed that there is a problem of psychoactive substance use among pupils in grades 5, 7, 9 and 11. More than half of the respondents indicated that their school has students who use drugs. The age of those who have tried psychoactive substances ranges from 9 to 18 years, while the average age of adolescents who have tried smoking for the first time is only 13 years. The main places where students get intoxicated were found to be near or at school, on the street and in other public places.

**Keywords:** pupils, electronic cigarettes, drugs, alcohol

## INTRODUCTION

Psychoactive substances are substances that affect a person's psyche and cause health and behavioural problems. Their use is particularly dangerous at a young age, as they can disrupt a young person's development and adversely affect their psychological, social and physical well-being (Youth and Psychoactive Substances, 2022). The use of psychoactive substances leads to psychological and physical dependence, and the tendency to become intoxicated often starts in adolescence. As children spend most of their time at school at this age, the challenge for educators is to recognise and appropriately manage the risks associated with psychoactive substance use (Psychoactive substances and school: guidelines for prevention and intervention, 2023).

It is important to note that the use of psychoactive substances at a young age is not only a problem in our country. According to Moor, Winter, Rathmann, Ravens-Sieberer & Richter (2020), it is particularly problematic when the tendency is very early or too intense. According to the researchers, it often leads to violence and other unwanted behaviours and addictive diseases, and increases the risk of suicide, suggesting that psychoactive substance use is a major risk factor for morbidity and premature mortality around the world (Moor, Winter & others, 2020).

One of the main causes of health disorders and deaths in Europe's young people is the use of drugs. According to Norkienė, Jurgaitienė and Lazarevičiūtė (2018), this disease has no teritorial, national, religional boundaries, and it does not depend on the person's age, gender, education level, or social status. Studies have shown that adolescents who try drugs have already been involved in the use of other psychoactive substances. Their path to drug use starts with the first cigarette smoked and the first taste of alcohol (Psychoactive Substance Use Prevention Programme for Parents of Pupils: methodological guidelines for managers of care institutions, schools, teachers, professionals, 2018).

In order to reduce the increased use of psychoactive substances by young people in our society, it is necessary to consistently develop children's resilience to this negative social phenomenon from a very early age. Motivating young people to stop using psychoactive substances before addiction develops is essential. One of the tools to help young people aged 14-21 who are experimenting with or irregularly using alcohol and/or drugs is the Early Intervention Programme. According to a study carried out in Lithuania in 2021, 75-76% of participants were positively affected by this programme (Report on the implementation of the Early Intervention Programme 2021, 2021). The task of educators is to n and record the first cases of adolescent psychoactive substance use. Unfortunately, in our country, according to Norkienė, Jurgaitienė and Lazarevičiūtė (2018), "there is a missing link" for early identification of users of psychoactive substances, especially drugs, and for providing them with timely help. More frequent and in-depth sociological research and opinion polls are likely to help address this problem.

Hypothesis - Psychoactive substances start to be used in adolescence and are easily accessible to students.

The aim of the study was to investigate the prevalence of psychoactive substance use among pupils of general education schools in Panevėžys.

Objectives:

1. To determine the age of the students who are using and the psychoactive substances they are using.
2. Identify the places where pupils get intoxicated and the availability of psychoactive substances.

## RESEARCH METHODS AND ORGANISATION

**The research method** is a questionnaire survey (quantitative research method). The main research instrument is a questionnaire developed by the authors. The questionnaire was designed in such a way that the questions would be equally clear to both 12 and 18-year-olds. The questionnaire consists of closed or semi-closed questions (the answer 'other' is offered, with the possibility of expressing an opinion or providing a clarification), and most of the questions are alternative.

**Participants in the study**. The participants of the study were students of general education schools of Panevėžys city, grades 5, 7, 9 and 11. The sample was drawn by cluster sampling, the sampling unit (cluster) was the classroom. The aim was to ensure that the sample was representative of students in educational institutions in terms of gender, age and place of residence. The representative sample was based on the number of pupils enrolled in grades 5, 7, 9 and 11 in the city's general education schools. The Paniotto formula was used to calculate the sample: $n= 1/(\Delta 2 +1/N)$, where n is the sample size; Δ is the margin of error; N is the size of the general population. The total number of pupils in the general population is 3600. In order to be representative and reliable with a margin of error of 5%, the survey was planned to interview 348 pupils ($n=1/(0.0025+ 1/3600)$). Given the relevance of the topic of the survey, there was strong support from school leaders and 1041 pupils completed the questionnaires. 1030 questionnaires were found to be duly completed. The sample size in this case was 1030, thus reducing the margin of error to 2.63% ($n=1/(0.00069 + 1/3600)$).

**Research ethics**. Letters inviting participants to take part in the study were sent to the heads of 16 general education schools in the city. Consents were obtained from all schools invited to participate in the study. The schools, in turn, took parental permission to interview their children.

In November 2023, the address to the online survey on www.manoapklausa.lt was forwarded to the general education schools in Panevėžys that agreed to participate in the study. The preamble of the questionnaire states the purpose of the survey and emphasises that only the researchers will see the answers. In order to ensure full anonymity and confidentiality of the participants, the questionnaire did not ask them to indicate their school and the data is not comparable in any respect.

The survey data was analysed using descriptive statistics, calculating the arithmetic mean and percentage of respondents' opinions. The study allows for a margin of error of no more than 5% for statistical decisions. The data is illustrated by tables and graphs and presented in absolute numbers and percentages. Respondents' verbal comments in response to 'other' or open-ended questions shall be quoted in the text, grouped together and presented in tables. It is important to note that in the analysis, respondents' answers are quoted verbatim, in the form in which they were given in the questionnaire, i.e. neither grammatical nor punctuation errors have been corrected in order to preserve the authenticity of the students' speech.

## RESULTS OF THE STUDY

The study involved 1041 students from 16 general education schools in Panevėžys: 6 gymnasiums and 10 pro-gymnasiums. The gender distribution of respondents was as follows: 56% of women, 43% of men, 1% did not specify their gender. 11 questionnaires submitted on www.manoapklausa.lt were rejected as incorrect or incomplete, so the data from 1030 questionnaires (n =1030) was analysed further.

The aim was to have similar proportions of the sample in grades 5, 7, 9 and 11, as the total number of pupils in the city's public schools in all these grades is fairly evenly distributed. An examination of the distribution of respondents by grade reveals that one third of the respondents were students in grade 9, while the number of older students (grades 9 and 11) who participated is 55%. This distribution of respondents by grade can be justified by the fact that the issue is more relevant to students in the gymnasium (grades 9 and 11) (Figure 1).

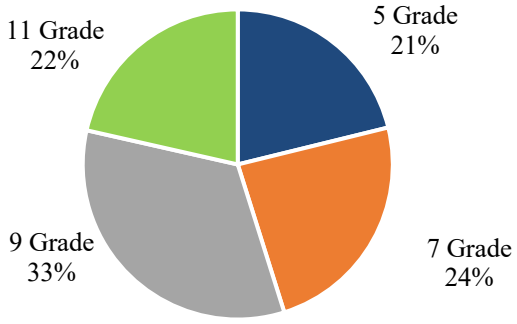



Figure 1. **Distribution of respondents by grades**

The use of psychoactive substances in Europe now covers a wider range of substances than before. Psychoactive substances are those whose biological structure or action is altered by use and absorption. In adolescence,

particular attention should be paid to those psychoactive substances that alter the functioning of the central nervous system and affect an adolescent's feelings, perception, thinking, behaviour (European Prevention Curriculum, 2019).

Participants were given a list of psychoactive substances and asked to indicate which ones they were aware of and whether they were aware of their harms. It showed that almost all students (95%) were aware of cigarettes, including e-cigarettes (91%), and weak and strong alcoholic beverages (86%-89%), but that one in ten had not heard of the harm caused by weak alcoholic beverages. The lowest proportion of students (40%) were aware of psychotropic substances such as impregnated leaflets, stamps, gum, etc., while 48% had heard of inhalants (glue, acetone, etc.). Just over half of the adolescents surveyed (55%) are familiar with chewing tobacco or snuff, while 57% are familiar with non-medically prescribed sedatives. Meanwhile, drugs are familiar to the majority of students (75%), although 15% said they had not heard of their harms.

More than half of the respondents answered positively to the question of whether there are students in the school who intoxicate themselves by smoking, vaping, using alcohol or drugs, while a third denied it, a few said they didn't know, and a small number of respondents chose the answer "other" in order to record their comments (Figure 2).

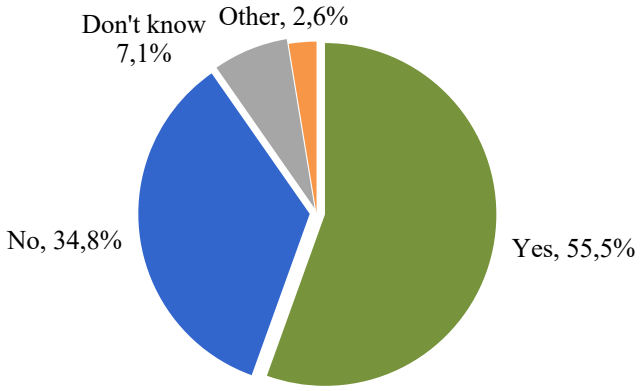



Figure 2. **Respondents' answers whether there are students who are intoxicating themselves**

Although the comments of the respondents who chose the answer "other" can be relatively divided into 3 groups, the majority of the respondents agree by mentioning the specific names of the students and the teachers in general: (Yes they are vaping a lot; Teachers; Yeah, I know who; Yeah, there are definitely but he's not from our grade; From 8c; <...> in the boys' toilets at the long break; name given).

Therefore, it can be said that the use of psychoactive substances does occur in schools, and more than half of the students are aware of it, and can even point to specific individuals, including, unfortunately, teachers. This negative example does not really contribute to the prevention of psychoactive substances in schools because, as we know, education can only have an impact when students see a teacher as a role model.

Respondents were asked to identify places where they knew students were intoxicating, given the known prevalence of psychoactive substance use. In this case, the questionnaire allowed for multiple choice answers. The most frequent use of psychoactive substances by students was found to be near the school, on the street, at school, at friends' houses or at home (Figure 3).

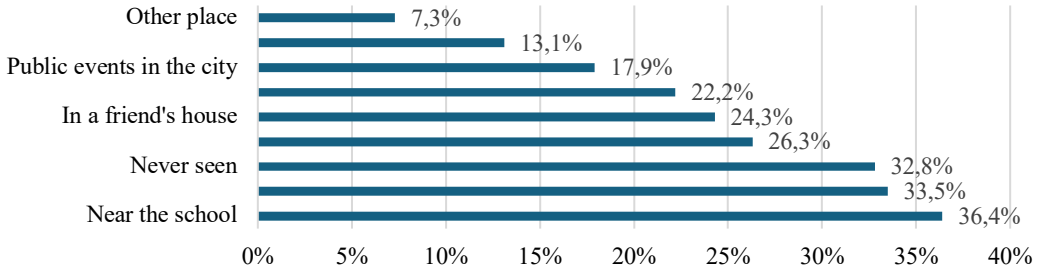



Figure 3. **Places where intoxication is most common**

Respondents who chose "Other places" only confirmed that the most frequent places where they get intoxicated are at school, and named specific places: toilets, the school basement, cloakrooms, behind the gym, in the corridors during lessons, in the back of the classrooms. It seems that school managers and professionals should pay more attention to the places named by students.

When asked whether they themselves had received offers to try psychoactive substances such as tobacco products, alcohol, drugs, sedatives, etc., a significant proportion of students (42%) found that such offers were not new, although more than half answered in the negative. In addition, psychoactive substances were found to be offered to students in the street, at a party with friends, near school, at school, at a public event in the city. Other places identified

by students were: in the street, at friends' houses, in the park, at school (classroom, club, toilet), on playgrounds and basketball courts, in the garage, in the car, in Freedom Square, on a trip, in another city, in a hotel (Figure 4).

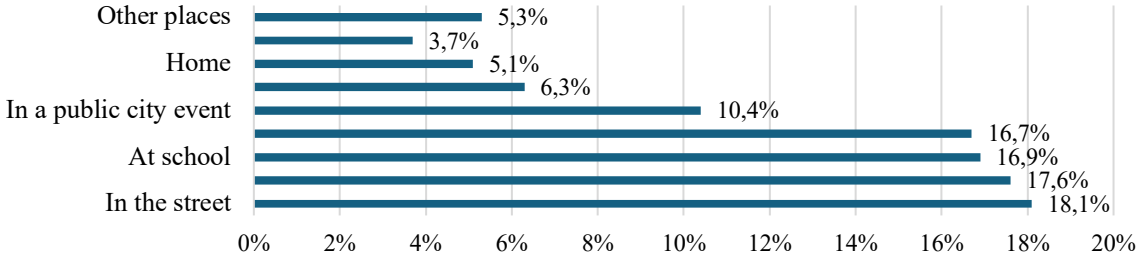



Figure 4. **Places where students are offered to get intoxicated (n=923)**

A higher proportion of participants (37.3%) would tell their parents if they received such an offer, but almost a third (30.8%) are likely to keep quiet about the offer to intoxicate themselves, and one in seven (14.4%) do not know who to reach out to. Among school staff, students trust their class teacher the most (5.8%).

In the next section of the survey, students were presented with a table listing various psychoactive substances and asked to indicate which ones they had tried. The results showed that light alcoholic beverages (such as beer, cider, alcoholic cocktails, etc.) were the most popular, with over 40% of respondents having tried them. One-third of the students reported trying e-cigarettes filled with nicotine liquid capsules. Additionally, 23.3% of participants admitted to using strong alcoholic beverages (such as vodka, brandy, whiskey, etc.), and 19.7% of teenagers had smoked cigarettes or tobacco. This was followed by heated tobacco devices, tried by 13% of respondents, and e-devices filled with cannabis products, tried by 10%.

The study revealed that a few students have experimented with various narcotic substances: 8.5% of respondents admitted to trying cannabinoid drugs (such as hashish, kif, and marijuana); 3% reported trying hallucinogenic drugs (like LSD, ecstasy, and hallucinogenic mushrooms); 2.5% had used stimulants; and 2.3% of teenagers acknowledged having tried cocaine and opioid drugs such as heroin, morphine, or dorsomorphin multiple times.

To refine the data collected, respondents were asked control questions: whether they had tried smoking or vaping, tasted alcoholic beverages, experimented with psychotropic substances (such as pills, inhalants, paper impregnated with psychoactive substances, etc.), or used narcotics. The summarized responses to all these questions are presented in a table. Participants who answered "yes" were asked to indicate the age at which they first tried these substances (illustrated in Figures 5, 6, 7, and 8).

**The number of students who have experimented with psychoactive substances**

| **Psychoactive substances** / **Respondents** | **Cigarettes** | **Alcoholic drinks** | **Psychoactive substances** (such as pills, inhalants, and others) | **Narcotics** |
|---|---|---|---|---|
| Number | 327 | 348 | 79 | 34 |
| Percent | 31,7% | 33,8% | 7,7% | 3,3% |

As seen in the table, nearly one-third of the surveyed students have tried smoking. The survey revealed that most initial smoking attempts occur between the ages of 12 and 14. However, 7.3% tried smoking as early as 9–10 years old, and about one in ten respondents said they couldn't remember when they first tried, which could also indicate an early experience (see Figure 5).

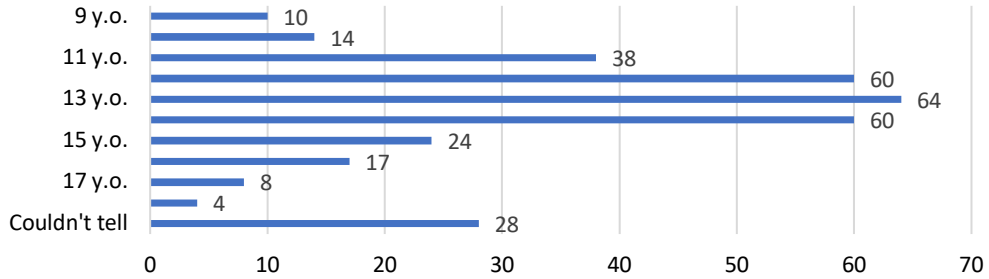



Figure 5. **The age of respondents when they tried smoking for the first time (n =327)**

When a similar question about alcoholic beverages was asked, it was found that 33.8% of respondents had tried them. However, in response to the earlier question about psychoactive substances, over 40% of respondents indicated they had tried light alcoholic drinks. This suggests that some students may not consider beer or cider to be alcoholic beverages. During adolescence—a period often referred to as a time of experimentation, experiences, and discoveries—

alcohol consumption sometimes becomes a common behaviour among young people (Šmigelskas, Lukoševičiūtė ir kt., 2019). According to survey data, the age at which teenagers first try alcohol ranges from 9 to 18 years, with the first attempts to consume alcohol most often occurring at the age of 14, as indicated by 17 percent of survey respondents. Approximately one in five students could not recall when they first tried it (see Figure 6).

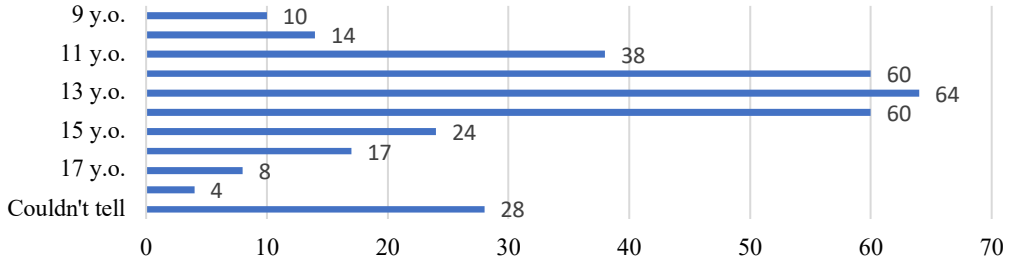



Figure 6. **The age of respondents when they first tried alcohol (n = 348)**

New and diverse types of psychotropic substances continue to emerge on the market today, including tablets, inhalants, and sheets impregnated with psychoactive substances. Teenagers inclined to experiment often struggle to resist the temptation to try something novel, unfamiliar, or prohibited. According to survey data, attempts with psychotropic substances are considerably less common compared to cigarettes and alcohol (7.7 percent of respondents reported having tried them) and tend to occur later, typically between the ages of 16 and 18, as indicated by more than half of the students who had experimented with these substances. Fourteen percent first tried these substances at the age of 14-15, and a third could not recall when they first did so (see Figure 7).

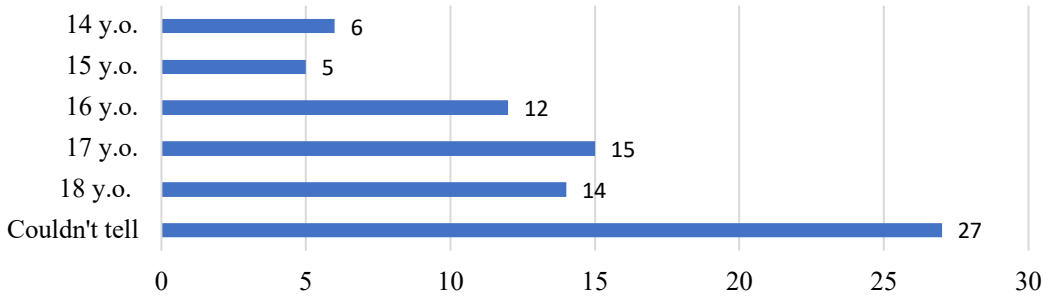



Figure 7**. The age of respondents when they first experimented with psychotropic substances (n =79)**

A control question about drug use revealed an even lower number of respondents who admitted to having tried drugs, with only 3.3 percent of survey participants acknowledging this. It is likely that students do not consider smoking "weed" or marijuana as drug use. Most commonly, substances are used in groups as a way to show off to peers. The highest numbers of first-time users are recorded at ages 15, 16, and 18, with isolated cases starting at ages 12-13. One in five or six respondents who admitted to trying drugs said they could not remember their first experience (see Figure 8).

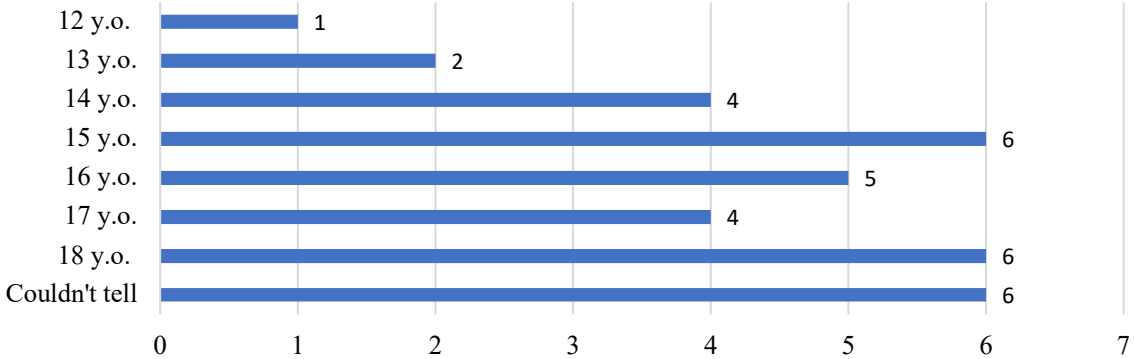



Figure 8**. The age of respondents when they first experimented with drugs (n =34)**

In summary, the age of study participants who have tried psychoactive substances ranges from 9 to 18 years. Students tend to try tobacco products (cigarettes, electronic cigarettes, etc.) relatively early, with an average starting age of 13.0 years. Initial alcohol tasting occurs slightly later, with an average age of 13.7 years. The average age for those who have experimented with drugs is 15.3 years, while for psychotropic substances (such as pills, inhalants, etc.), it is 16.5 years. This suggests that first encounters and experimentation with psychoactive substances generally occur during adolescence. During this challenging period, teenagers seek their identity and place in society. Parents are no longer as close, and friends and the social environment become key influences in trying psychoactive substances.

To determine the frequency of psychoactive substance use, respondents were asked which substances they had used and how often in the past 30 days. According to the study, 15 percent of participating students reported smoking cigarettes (tobacco), with 4.1 percent having smoked once or twice. A similar proportion (3.9 percent) indicated smoking up to 10 times, while the remaining 7 percent smoked even more frequently. Vaping electronic cigarettes is more popular than smoking tobacco among students. Twenty-one percent of students reported owning and using vaping devices filled with liquids or capsules. Of these, 3.2 percent vaped between 3 and 10 times, 4 percent more than 10 times, 4.9 percent vaped daily, and 6.1 percent several times a day.

Light alcoholic beverages (beer, cider, alcoholic cocktails, etc.) are also popular among students. In the survey, 16.7 percent of participants admitted to using these drinks, with 10.1 percent stating that they had done so at least 1-2 times. Additionally, 9.8 percent of respondents admitted to drinking strong alcoholic beverages (vodka, whiskey, brandy, etc.) in the past 30 days; of these, nearly 2 percent drank strong alcohol between 3 and 10 times, and a similar proportion consumed it more than 10 times. There were no respondents who reported daily use of strong alcoholic beverages.

The situation is quite different when assessing the frequency of drug use: 32 students in the study (3.1 percent) reported using various types of drugs in the past 30 days. A concerning fact is that nearly 2 percent of respondents admitted to using drugs daily or multiple times per day, which constitutes intensive problematic use that leads to addiction. If these admissions are sincere, it can be assumed that this group of students is in a high-risk zone or is already addicted to intoxicating substances.

The least interest among students is shown in inhalants or combinations of several psychotropic substances, with about 2-2.5 percent of participants in the study admitting to using them. Additionally, 3.4 percent of survey participants reported having used non-prescribed sedatives or sleeping pills, and among them, some use them regularly. The reasons why some students have used non-prescribed medications can only be speculated – they may be experiencing stress, anxiety, or insomnia, or the drugs may be easily accessible at home, leading to the temptation to try them.

In summary, it can be stated that some participants in the study use various psychoactive substances. Students who smoke or misuse alcoholic beverages gradually shift from recreational use with friends to individual, situational use, and for one in ten students, the use of electronic cigarettes has already become problematic. A particularly concerning issue is drugs, as they significantly alter the user's thinking, sensations, and behaviour. Their impact on physical and mental health is difficult to predict, and after a few innocent attempts, drug use can lead to addiction. The worrying fact is that there are individual students already involved in intensive drug use.

After examining the frequency of psychoactive substance use among students, questions arise regarding where minors obtain these substances, in which places they are accessible to students, and what can be done to reduce their availability. Therefore, survey participants were asked where students can purchase psychoactive substances. Nearly one-fifth of the students in the study reported that they could buy cigarettes (tobacco), electronic cigarettes (liquids or capsules), as well as both weak and strong alcoholic beverages at stores, even though selling these products to minors is prohibited. Just over ten percent indicated that all types of cigarettes can be obtained on the street, in known "spots," or at school. The most common places for the distribution of drugs or combinations of several psychoactive substances are on the street and at "spots," and sometimes even within schools. The results suggest that distributors may gain access to school grounds and offer drugs to students. Another assumption is that students themselves may share psychoactive substances with peers in remote areas of the school, where they can use them without being caught (see Figures 3 and 4). Survey participants also reported that alcoholic beverages are available at youth gathering places, such as clubs, cafes, and public city events. According to the study, weak and strong alcoholic drinks, cigarettes (tobacco), and even non-prescribed psychoactive medications are easily accessible in students' homes.

## CONCLUSIONS

It has been established that the main locations where students engage in substance use are near or within schools, on the streets, and in other public places such as bus stations, large shopping centres, parks, etc. In these places, as well as at friends' houses during parties, students are often offered the opportunity to try psychoactive substances. The research results revealed that teenagers have fairly broad access to psychoactive substances. They can purchase cigarettes (tobacco), electronic vaping devices (liquids or capsules), and both weak and strong alcoholic beverages at stores. Teenagers can also obtain all types of psychoactive substances on the street, at known "spots", near school grounds, and in youth gathering places. The primary location for drug acquisition is these "spots". Weak and strong alcoholic beverages, cigarettes, as well as non-prescribed sedative medications, are easily accessible to some students in their own homes.

The research results show that the issue of psychoactive substance use exists among 5th, 7th, 9th, and 11th grade students. Most respondents stated that they are aware of psychoactive substances and their harmful effects, and more than half of the participants reported that there are students in their school who engage in substance use. The age of students who have tried psychoactive substances ranges from 9 to 18 years, with the average age for first-time smokers being just 13 years old. Among students, weak alcoholic beverages, electronic cigarettes, and tobacco cigarettes are particularly popular. It is worth noting that some students have also experimented with hallucinogenic drugs, stimulants, cocaine, and opioid drugs. One in ten participants shows signs of intensive problematic use of electronic cigarettes. According to the survey data, there are individual students in schools who are involved in intensive drug use, leading to addiction.

## REFERENCES


1. Alkoholio, tabako ir kitų psichiką veikiančių medžiagų vartojimo prevencijos programa (2006), patvirtinta LR ŠMM ministro 2006 m. kovo 17 d. įsakymu Nr. ISAK-494. Valstybės žinios, 2006-03-25, Nr. 33-1197.
2. Ankstyvosios intervencijos programos įgyvendinimo 2021 m. ataskaita (2021) Prieiga per internetą:https://ntakd.lrv.lt/uploads/ntakd/documents/files/Ankstyvosios%20intervencijos%20programos%202021%20m_%20%C4%AFgyvendinimo%20ataskaita.pdf
3. Bankauskienė, I. (2013). Psichoaktyviųjų medžiagų vartojimo prevencija: samprata ir modeliai. Informacinis leidinys. Vilnius: Narkotikų, tabako ir alkoholio kontrolės departamentas.
4. Europos narkotikų vartojimo paplitimo ataskaita 2021. Tendencijos ir pokyčiai (2021). Europos narkotikų ir narkomanijos stebėsenos centras, Europos Sąjungos leidinių biuras, Liuksemburgas https://www.emcdda.europa.eu/system/files/publications/13838/2021.2256_LT_02feedback.pdf
5. Europos prevencijos mokymo programa **(**2019). Moksliškai pagrįstos psichoaktyviųjų medžiagų

vartojimo prevencijos vadovas, skirtas sprendimus priimantiems asmenims, nuomonės ir politikos formuotojams. Europos narkotikų ir narkomanijos stebėsenos centras.

6. Jaunimas ir psichoaktyviosios medžiagos (2022). 2021 m. vykdyto tyrimo „Psichoaktyviųjų medžiagų vartojimo paplitimas bendrojoje populiacijoje“ papildomos duomenų analizės rezultatų ataskaita. Narkotikų, tabako ir alkoholio kontrolės departamentas, Europos narkotikų ir narkomanijos stebėsenos centro nacionalinis centras Lietuvoje.
7. Kristjansson, A.J., Mann, M.J., Sigfusson, J., Thorisdottir, I.E., Allegrante, J.P. & Sigfusdottir, D.I. (2020) Development and Guiding Principles of the Icelandic Model for Preventing Adolescent Substance Use. Health Promotion Practice. Volume 21, Issue 1, January 2020, Pages 62-69.

https://doi.org/10.1177/1524839919849032

8. Moor, I., Winter,K., Rathmann, K. , Ravens-Sieberer , U.& Richter, M. (2020) Alkohol-, Tabak- und Cannabiskonsum im Jugendalter – Querschnittergebnisse der HBSC-Studie. 2017/18, p/ 72-93. Journal of Health Monitoring · 2020 5(3) DOI 10.25646/6895
9. Psichoaktyviosios medžiagos ir mokykla: prevencijos ir intervencijos gairės (2023). Metodinės rekomendacijos. Vilnius: Narkotikų, tabako ir alkoholio kontrolės departamentas.
10. Psichoaktyviųjų medžiagų vartojimo prevencijos programa mokinių tėvams: metodinės rekomendacijos globos įstaigų, mokyklų vadovams, pedagogams, specialistams (2018). Parengė I. Bankauskienė,. I.Jonutytė, V. Leonienė ir kt. Vilnius: Specialiosios pedagogikos ir psichologijos centras
11. Norkienė, S., Jurgaitienė, D. ir Lazarevičiūtė, V. (2018) Klaipėdos mokinių narkotikų vartojimas ir jų prieinamumas. Sveikatos mokslai / 2018, 28 tomas, Nr. 7, p. 30-35 DOI: https://doi.org/10.5200/sm-hs.2018.086
12. Šmigelskas, K., Lukoševičiūtė, J., Slapšinskaitė, A., Vaičiūnas, T., Bulotaitė, J., Žemaitaitytė , M., ir Zaborskis, A. (2019). Lietuvos moksleivių gyvensena ir sveikata: 2018 m. situacija ir tendencijos. HBSC tyrimas. LSMU, Kaunas.
13. Ubartienė, O. ir Šurkienė, G. (2021) 11-12 (III-IV gimnazijos) klasių mokinių sveikatos raštingumas ir alkoholio vartojimas. Sveikatos mokslai. 2021, 31 tomas, Nr.2, p. 11-16.

DOI: https://doi.org/10.35988/sm-hs.2021.028

PANEVĖŽIO KOLEGIJA ISSN 2029-1280, eISSN 2669-0071. Taikomieji tyrimai studijose ir praktikoje – Applied Research in Studies and Practice, 2024, 20.

# ARTIFICIAL INTELLIGENCE IN THE WORKPLACE: SKILLS TRANSFORMATION IN ENTERPRISES

***Jurgita LIEPONIENĖ, Gediminas SARGŪNAS***

*Panevėžio kolegija/State Higher Education Institution, Lithuania*

**Abstract**. The integration of Artificial intelligence (AI) technologies in enterprises inevitably faces various challenges, including technological, organizational, and workforce-related obstacles. This paper explores the concept and different types of AI, analyses the skills required for to design, develop, implement, and effectively use AI technologies and presents the results of a study. The study aims to assess the current state of AI technologies deployment in enterprises of Panevėžys region, with a particular focus on the importance of AI skills, analysing which AI skills are most lacking and how they can be developed in collaboration with higher education institutions.

**Keywords**: Artificial Intelligence technologies, AI skills, higher education

## INTRODUCTION

In an era marked by rapid technological advancements, the integration of Artificial Intelligence (AI) has emerged as a transformative force across various sectors, fundamentally reshaping the way organizations operate and compete (Thilagavathy & Venkatasamy, 2023). The ongoing development of business and the most recent advances in AI allow for the many business practices to be improved by the capacity to establish new forms of collaboration, which is a significant competitive advantage (Jasmin et al., 2023).

The rapid advancement of AI technologies presents both opportunities and challenges for businesses worldwide (Aljaber & Almushaili, 2022). AI helps improve operational efficiency, drives innovation, and facilitates data-driven decision-making. As enterprises strive to remain competitive in the digital market, the successful integration of AI technologies becomes a key priority. However, this process is associated with various challenges, including technological, organizational, and workforce-related issues (Njeru, 2023). One of the most important aspects of this transformation is the need for skill development, as companies must ensure that their employees possess the necessary competencies to effectively manage and apply AI technologies.

This paper explores the concept and different types of AI, analyses the skills required for to design, develop, implement, and effectively use AI technologies and presents the results of a study. The study aims to assess the current state of AI technologies deployment in enterprises of Panevėžys region, with a particular focus on the importance of AI skills, analysing which AI skills are most lacking and how they can be developed in collaboration with higher education institutions.

**The aim of the study** is to explore how AI technologies transform enterprise skills, focusing on key employee skill gaps critical for successful AI implementation and management, as well as opportunities to bridge these gaps through collaboration with higher education institutions. The objectives of the research: 1. To present the concept and types of AI. 2. To perform AI skills analysis. 3. To discuss the results of a study.

**Research methods**: analysis of scientific literature, questionnaire.

The rest of this paper is structured as follows. Section 1 explores the concept and different types of AI. Section 2 analyses AI skills. Section 3 presents the methodology of the study. Section 4 presents the results of the conducted study. Finally, Section 5 presents the conclusions.

## ARTIFICIAL INTELLIGENCE CONCEPT AND TYPES

Artificial intelligence (AI) refers to the interdisciplinary field that aims to replicate human cognitive abilities inside computational systems (Njeru, 2023). The pinnacle accomplishment within this domain would be the development of a computer capable of emulating or surpassing human cognitive capacities, including faculties such as logical deduction, comprehension, imaginative thinking, sensory perception, pattern recognition, inventive ideation, and affective responses. Although much progress has been made, we are still far from attaining this goal (Njeru, 2023). Nonetheless, notable accomplishments have been realized. Moreover, it is worth noting that the pursuit of these modest achievements in the field of AI has yielded a range of very valuable computational tools.

The primary objectives of AI focus on enhancing capabilities to automate routine tasks, analyze large datasets for informed decision-making, interact with users in a natural and intuitive way, and innovate in product and service development (Das, 2024). AI aims to extend and emulate human cognition, acting as a tool to magnify human expertise. AI is generally categorized into three types based on capabilities: Narrow AI (Weak AI), General AI (Strong AI), and Superintelligent AI (Amita, 2024).

**Narrow AI (Weak AI):** is a type of AI that is skilled of doing a definite duty intelligently (Amita, 2024). Narrow AI is the only type of AI currently achieved and involves systems designed for specific tasks, such as voice

assistants and facial recognition. Narrow AI appears intelligent but operates within strict constraints, performing predefined functions effectively (Aljaber & Almushaili, 2022).

**Artificial General Intelligence (AGI) (Strong AI or Deep AI)** represents a transformative milestone in the field of AI, characterized by the ability of a machine to perform any intellectual task that a human can (Joshi, 2024). This contrasts with Narrow AI, which excels in specific tasks but lacks general cognitive abilities. AGI aims to replicate human-like understanding and reasoning, though it remains unachieved.

**Artificial Superintelligence (ASI):** is a hypothetical stage of AI development where machines possess cognitive abilities far surpassing those of humans. ASI is characterized by superior intelligence, self-improvement capabilities, emotional intelligence, and autonomous decision-making (Zohuri, 2023). The advent of ASI would have profound implications across sectors, including scientific advancement, economic impact, and societal transformation.

The development of AGI and ASI presents significant risks that must not be ignored. The potential risks linked to AGI and ASI arise from their ability to exceed human intelligence and excel in a wide range of activities (Gulchenko, 2024). Responsible development and control are essential to harness ASI's potential while safeguarding humanity (Zohuri, 2023).

## AI SKILLS: LITERATURE REVIEW

In Lithuania, the significance of AI skills is emphasized in the Lithuanian Artificial Intelligence Strategy (2019), which advocates for the development of AI competencies from primary education through vocational training and higher education study programs. The integration of AI systems into organizations highlights the critical need to identify and cultivate AI skills within the workforce (Morandini et al., 2023). AI skills refer to the knowledge and abilities required to design, develop, implement, and effectively use AI technologies (Celik et al., 2024). These skills encompass various fields and roles, enabling professionals to effectively apply, develop, and manage AI solutions. Researchers classify AI skills into two primary categories: general (soft) skills and specific (hard) skills. General skills, such as critical thinking, problem-solving, lifelong learning, ethics, creativity, communication, and collaboration, are essential for working effectively with AI systems (Morandini et al., 2023). These competencies enable employees to adapt to new technologies and processes while fostering continuous development in the face of rapidly evolving advancements (see Table 1).

**Table 1.** Description of general or soft AI skills

| Skills | Description |
|---|---|
| Problem-Solving and Critical Thinking | The ability to select and implement appropriate AI solutions, analyze results, and make informed decisions. |
| Ethics | A strong understanding of the ethical considerations surrounding AI, including awareness of biases, societal impacts, and relevant regulatory frameworks. |
| Communication and Collaboration | The ability to effectively communicate complex AI concepts to non-technical stakeholders and collaborate successfully within interdisciplinary teams. |
| Lifelong learning | A commitment to staying current with the latest developments in AI research, tools, and practices, while demonstrating adaptability to emerging technologies and shifting trends. |
| Creativity | The capacity to leverage AI in the creation of innovative ideas and solutions. |

Specific or hard skills encompass technical expertise crucial for navigating the technology-driven landscape (Babashahi et al., 2024). These include proficiency in data processing and management, machine learning, programming, robotics and automation, mathematical modeling, cybersecurity, and other technological specializations (Babashahi et al., 2024). Such skills are the foundation of AI integration, driving innovation and efficiency across industries (see Table 2).

**Table 2.** Description of specific or hard AI skills

| Skills | Description |
|---|---|
| Data Processing and Management | Skills in handling large and complex datasets, ensuring that data is properly prepared and structured so that AI models can process, analyse and extract meaningful insights. |
| Machine Learning | Skills that include the design, implementation and optimisation of machine learning algorithms. |
| Programming | Coding skills in AI-specific programming languages for developing machine learning models, integrating AI systems into applications and products. |
| Robotics and Automation | Skills of developing and programming autonomous systems and robots, which involves integrating AI technologies with hardware. This includes understanding robotics algorithms, sensor integration, motion control, and the application of AI in automating complex tasks. |
| Mathematical Modeling | Skills to cover advanced mathematics and statistical models used in the field of AI, which are important for developing algorithms and analysing data structures in AI applications. |
| Cybersecurity | Skills include remediating vulnerabilities, ensuring data integrity and privacy, developing methods to protect AI applications from attack, ensuring secure data transfer and maintaining the security of AI-driven systems in the operating environment. |

AI skills ensure that staff can use, design, and develop AI solutions. As AI evolves rapidly, organizations must find ways to ensure their employees possess sufficient AI skills, which is crucial for remaining competitive in an ever-changing AI landscape. A culture of continuous learning and upskilling is essential to keep pace with these advancements and fully realize AI's potential.

## METHODOLOGY

**Research Design.** The study was conducted to explore the adoption of AI technologies in enterprises, focusing on the current state of AI deployment, the challenges organizations face during implementation, and giving particular attention to identifying the most lacking AI skills and how these can be developed in collaboration with higher education institutions.

The study was designed as a quantitative survey with questions divided into the following main groups: 1. Information about the respondents. 2. Impact of AI technologies on business operations. 3. The scope of AI technologies adoption and the main challenges. 4. AI skills lacking among employees in the implementation and application of AI solutions. 5. Strategy for AI skills development in enterprises. 6. Collaboration with higher education institutions to address skill shortages.

**Data Collection:** A structured online questionnaire was sent to 73 enterprises in the Panevėžys region to ensure a representative sample from various sectors. The selected enterprises were asked to have the questionnaire completed by several managers from different departments. A total of 55 companies responded, representing 75.3 percent of all companies surveyed. Notably, nearly half (49 percent) of the responding enterprises operate primarily in the manufacturing sector. The questionnaire was designed to be user-friendly, combining both closed and open-ended questions to collect comprehensive information.

**Data analysis.** The data collected were analyzed using descriptive statistics to summarize the main trends and patterns related to the issues analyzed. This analysis aimed to determine the level of AI implementation, the related challenges, identify the key AI skills most lacking among employees, and explore opportunities for their development. The results were structured and presented in tables and graphs to facilitate the visualization and interpretation of the findings. The use of these visual aids allowed for a better understanding of the distribution of responses and highlighted areas for further research.

**Ethical aspects.** Ethical standards were followed throughout the study to ensure the privacy and confidentiality of all participants. Respondents were assured that their participation was voluntary, and that their responses would be anonymized and used solely for the purposes of the research. The study results are presented only in summarized form to prevent the identification of individual respondents or companies, thereby maintaining the integrity of the data and protecting participant confidentiality.

## RESULTS OF THE STUDY

The study aimed to examine the adoption of AI technologies in enterprises, with a particular focus on the challenges organizations face during the adoption process and the importance of skills development for the effective integration of AI into business operations. The research objectives:

1. To determine whether enterprises are familiar with AI technologies and how they evaluate their importance for business operations.
2. To identify the scope of AI technologies adoption in enterprises and the main challenges they face in implementing AI in their business operations.
3. To identify the most essential AI skills that employees lack the most when applying, developing, and implementing AI technologies in enterprises.
4. To assess the strategic readiness of enterprises to develop the necessary skills, and identify key forms for collaboration with higher education institutions to strengthen employees' AI skills.

A total of 55 enterprises from the Panevėžys region completed the questionnaire. Of these, 18 percent were large enterprises, 44 percent were medium-sized enterprises, and 38 percent were small enterprises.

The study found that all the surveyed enterprises are aware of AI technologies. Respondents emphasized that AI technologies increase productivity (91 percent), make employees' jobs easier (82 percent), encourage employees to acquire new skills (87 percent), and reduce the number of jobs (64 percent) (see Table 3). Only 9 percent of respondents did not perceive any impact of AI technologies on their enterprise's operations. The results of the study show that most of the surveyed enterprises recognize the importance and impact of AI technologies on their operations and see their potential to improve operational efficiency and employee well-being. However, it is also worth noting that a significant proportion of respondents (64 percent) foresee a potential negative impact on the number of jobs, which may pose challenges for the labour market.

**Table 3.** The impact of AI technologies on business operations

| No | The impact of AI technologies on business operations | Number of enterprises in percent |
|---|---|---|
| 1. | Labour productivity is increasing | 91 |
| 2. | Fewer jobs | 64 |
| 3. | Ease of work for employees | 82 |
| 4. | Tensions within the company increase | 27 |
| 5. | Employees need to acquire new competences | 87 |
| 6. | No changes | 9 |

The study found that 38 percent of the surveyed enterprises use AI technologies in their operations, indicating a strong interest in utilizing them to improve business processes and decision-making capabilities (see Figure 1). Seven percent of enterprises not only use AI technologies but also develop them, becoming leaders in innovation. However, the majority of the surveyed companies - 55 percent - reported that they neither use nor develop AI technologies, citing insufficient employee skills (87 percent), lack of resources (82 percent), and fear of facing new challenges (64 percent) as the main reasons. This further emphasizes the need for education and support to create favourable conditions for the broader adoption and development of AI technologies across all enterprises.

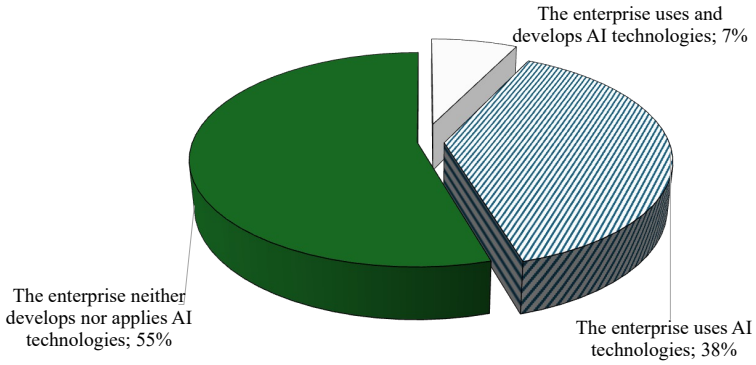



Figure 1. **AI technologies adoption in enterprises**

The study showed that, according to the surveyed enterprises, the most important general or soft AI skills required for applying and developing AI technologies are critical thinking (91 percent), lifelong learning (89 percent), problem-solving (85 percent), and communication and collaboration (73 percent) (see Figure 2). The surveyed companies emphasized that these are the skills their employees lack the most when applying, developing, or implementing AI solutions. Critical thinking is one of the most important skills, enabling specialists to analyse complex problems, evaluate options, and make sound decisions in the field of AI application and development. Lifelong learning is equally crucial, as it reflects the rapidly evolving nature of AI technologies, requiring continuous adaptation and knowledge acquisition. Problem-solving complements these skills by empowering employees to identify, assess, and address challenges that arise during the development or implementation of AI solutions. Similarly, communication and collaboration are essential for fostering teamwork and ensuring the seamless integration of AI solutions across various departments, facilitating a coordinated and effective approach to AI-driven transformation.

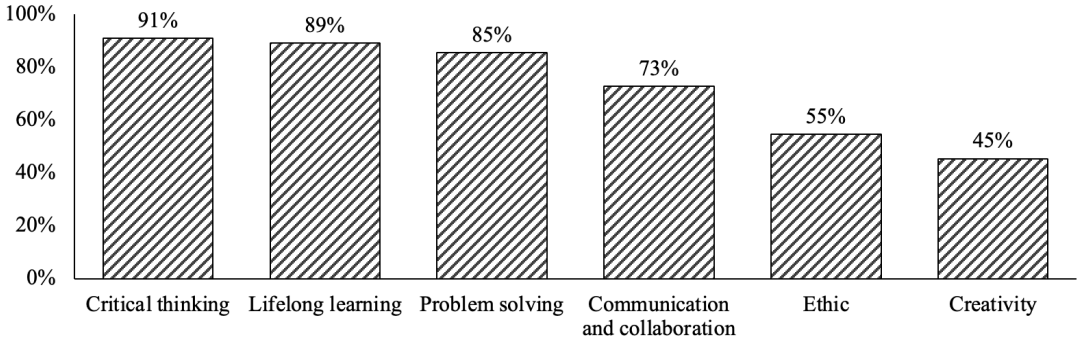



Figure 2. **The most important general or soft AI skills in enterprises**

As the most important specific or hard AI skills, the surveyed enterprises highlighted machine learning (91 percent), data processing and management (85 percent), cybersecurity (73 percent), and programming (51 percent) (see Figure 3). Regarding specific or hard AI skills, data processing and management are especially important, as they enable handling large volumes of data that serve as the foundation for AI models, ensuring their accuracy and relevance. Machine learning emphasizes the need for knowledge in developing and improving algorithms that enhance AI performance over time. Cybersecurity has emerged as a critical skill, especially as AI solutions become increasingly integrated into business operations. As AI systems handle sensitive data and are often connected to broader digital infrastructures, ensuring the

security of these systems is paramount. Cybersecurity skills are vital for protecting AI systems from vulnerabilities, preventing data breaches, and ensuring the safe and ethical use of AI technologies. These skills also play a key role in safeguarding organizational assets and maintaining trust with clients and stakeholders in an AI-driven environment. Given the rapid advancement of AI, the demand for cybersecurity expertise is expected to grow, making it a crucial skill for any AI-focused workforce. Programming skills are essential for implementing AI solutions and adapting them to specific business needs.

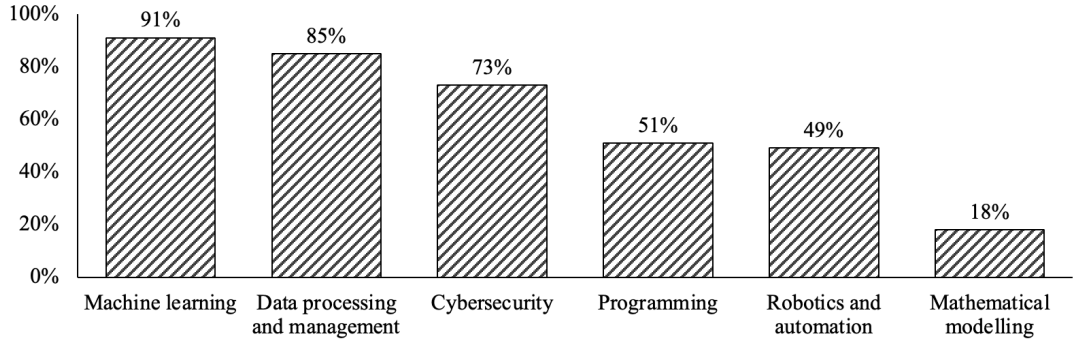



Figure 3. **The most important specific or hard AI skills in enterprises**

Although 91 percent of the surveyed enterprises believe that AI technologies enhance labour productivity, and 87 percent of enterprises not using AI technologies in their operations identified a lack of employee competencies as a key challenge for AI integration, 64 percent of all participating enterprises reported not having a dedicated strategy to develop AI skills (see Figure 4). This discrepancy underscores a significant gap between acknowledging the potential benefits of AI technologies and taking practical steps to implement these technologies and build the necessary skills within organizations.

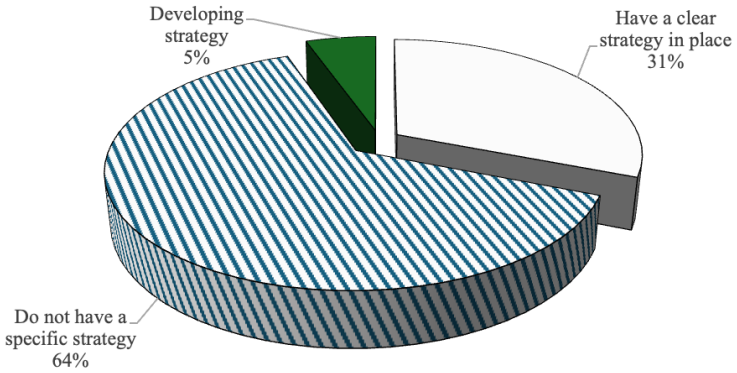



Figure 4. **Strategy for AI skills development in enterprises**

The surveyed enterprises indicated various forms of collaboration with higher education institutions in the development of AI skills: collaboration in the development of new study programs and the process of updating existing content (91 percent), organizing joint seminars for AI skills development (93 percent), collaboration in the development of instructional materials on the topic of AI skills development (82 percent), and providing students with internship opportunities in a enterprise to acquaint them with the significance of AI skills in specific workplaces (38 percent) (see Table 3). The collaboration between enterprises and higher education institutions is instrumental in developing a workforce that is well-equipped with the necessary AI skills, driving innovation and competitiveness in the industry. Continued partnership and investment in these collaborative initiatives will be vital for sustaining the growth and integration of AI technologies in various sectors.

**Table 3.** Collaboration with higher education institutions in developing AI skills

| No | Types of collaboration | Number of enterprises in percent |
|---|---|---|
| 1. | Collaboration in the development of new study programmes and the process of updating existing content | 91 |
| 2. | Collaboration in the development of instructional materials on the topic of AI skills development | 82 |
| 3. | Organizing joint seminars for AI skills development | 93 |
| 4. | Providing students with internship opportunities in a company to acquaint them with the significance of AI skills in specific workplaces | 38 |
| 5. | Collaboration in formulating topics for students' final projects and semester assignments related to the relevance of AI skills | 36 |

| | | |
|---|---|---|
| 6. | Conducting joint scientific research on the topic of AI transformation | 18 |
| 7. | Contributing to the development and implementation of informal education programs related to AI skills development | 33 |

In the Panevėžys region, a study involving 55 companies of varying sizes found that while most companies recognize the productivity and operational benefits of AI technologies, a significant portion lacks a strategic approach to developing the necessary skills, underscoring the need for enhanced collaboration with higher education institutions to address these skill gaps and ensure sustained competitiveness and innovation in the evolving technological landscape.

## CONCLUSIONS

Artificial Intelligence (AI) seeks to replicate human cognitive abilities within computational systems. It is typically categorized into three types based on its capabilities: Narrow AI (Weak AI), General AI (Strong AI), and Superintelligent AI.

In the scientific literature, AI skills are defined as the knowledge and abilities required to design, develop, implement, and effectively utilize AI technologies. Researchers divide AI skills into two categories: general (soft) skills and specific (hard) skills. General AI skills include critical thinking, problem-solving, lifelong learning, ethics, creativity, communication, and collaboration. Specific or hard AI skills encompass proficiency in data processing and management, machine learning, programming, robotics and automation, mathematical modelling, and cybersecurity.

The conducted study revealed that enterprises in the Panevėžys region recognize the value of AI in enhancing productivity and efficiency. They identify a lack of employee skills as one of the major challenges hindering the effective adoption and use of AI technologies. Despite this, only a small number of enterprises have developed strategies for fostering AI skills. The most important AI skills include critical thinking, lifelong learning, problem solving, communication and collaboration, machine learning, data processing and management, as well as cybersecurity. To improve these skills, special attention should be given to collaboration with higher education institutions. Enterprises highlighted key forms of collaboration, such as developing new study programs, updating existing curricula, organizing joint seminars, and creating educational materials focused on advancing AI skills.

## REFERENCES

Aljaber, S., Almushaili, T. (2022). Artificial Intelligence. International Journal of Engineering Research and Applications, 12(12), p. 52-57.

Amita, A. (2024). Research Paper on Artificial Intelligence & it's Types. International Journal for Research Trends and Innovation, 9(10), p. 202-206.

Babashahi, L.; Barbosa, C. E.; Lima, Y.; Lyra, A.; Salazar, H.; Argôlo, M.; Almeida, M. A.; Souza, J. (2024). AI in the Workplace: A Systematic Review of Skill Transformation in the Industry. Administrative Sciences, 14(6), p. 120-127. https://doi.org/10.3390/admsci14060127.

Celik, I., Gedrimiene, E., Siklander, S., & Muukkonen, H. (2024). The affordances of artificial intelligence-based tools for supporting 21st-century skills: A systematic review of empirical research in higher education. Australasian Journal of Educational Technology. https://doi.org/10.14742/ajet.9069.

Das, S. (2024). Influence of Artificial Intelligence-Based Skill Development Training on Employability. International Journal of Educational Reform, p. 1-26. https://doi.org/10.1177/10567879241238836.

Gulchenko, V. (2024). Navigating the Risks: An Examination of the Dangers Associated with Artificial General Intelligence and Artificial Superintelligence. Artificial Intelligence eJournal, p. 1-13. http://dx.doi.org/10.2139/ssrn.4941716.

Jasmin, B., Reji, T. & Farhan, A. (2023). Rise of Artificial Intelligence in Business and Industry. Journal of Engineering Research and Reports, 25(3), p. 85-103. DOI:10.9734/JERR/2023/v25i3893.

Joshi, K. (20240. Artificial General Intelligence (AGI): A Comprehensive Review. Journal of the Epidemiology, 3, p. 93-96. https://doi.org/10.56450/JEFI.2024.v2i03.004.

Lietuvos dirbtinio intelekto strategija. Ateities vizija. (2019). https://eimin.lrv.lt/lt/veiklos-sritys/skaitmeninepolitika/dirbtinis-intelektas.

Morandini, S., Fraboni, F., Angelis, M. (2023). The Impact of Artificial Intelligence on Workers' Skills: Upskilling and Reskilling in Organisations. The International Journal of an Emerging Transdiscipline, 26, p. 39-68.

Njeru, F. (2023). A Review of Artificial Intelligence and its Application in Business. Journal of Enterprise and Business Intelligence, 3(1), p. 44-53. https://doi.org/10.53759/5181/JEBI202303005.

Thilagavathy, N., Venkatasamy, R. (2023). Artificial Intelligence (AI) Technologies Adaptation in Business Management. The International Journal of Interdisciplinary Organizational Studies, 18(2), p. 2485-2495.

Zohuri, B. (2023). Artificial Super Intelligence (ASI) The Evolution of AI Beyond Human Capacity. Current Trends in Engineering Science (CTES), p. 1-5.

PANEVĖŽIO KOLEGIJA ISSN 2029-1280, eISSN 2669-0071. Taikomieji tyrimai studijose ir praktikoje – Applied Research in Studies and Practice, 2024, 20.

# THE CHALLENGES OF LEGAL IMPLEMENTATION OF THE RIGHT TO LIFE IN INTERNATIONAL CASE LAW AND IN CONTEXT OF LITHUANIAN LAW

***Sigita ŠIMBELYTĖ***

*Panevėžio kolegija/ State Higher Educational institution, Lithuania*

**Abstract.** Over time, case law is formed in the courts, which is followed to solve cases of a similar nature. Analyzing examples of case law in which liability for the taking of human life is investigated in context of Lithuanian law, the ECtHR was chosen for the discussion of decisions, since the ECtHR is one of the institutions that decides how correctly the provisions of Article 2 of the European Convention on Human Rights on the human right to life have been implemented. The relevance of the topic is determined by the fact that inappropriate actions of humanity require a new review of responsibility and legal regulation of liability for taking human life.

**Keywords:** right to life, natural right, international case law, Lithuanian law

## INTRODUCTION

Human life is one of the most important natural rights. Everyone has the right to life, liberty and security of person. From a legal point of view, human life and the right to life are the fundamental value from which the development of other human rights originates. It should be noted that the right to life is considered not only a natural, but also the most fundamental human right. Hence, this human right must be protected by law in every country. The right to life is one of the most important human rights, which is protected by the country's constitutional, civil, criminal, health and other laws, as the Constitution requires laws to ensure the right to life, not life itself. However, the legal regulation of this human right to life is not the same in all countries. Hence, the relevance of the topic is determined by the fact that inappropriate actions of humanity require a new review of liability and legal regulation of responsibility for taking human life.

**Research object.** Ensuring the implementation of the individual's right to life.

**Research purpose.** From a legal point of view, to reveal the aspects of the legal regulation of the implementation of the right to life, identifying the essential problematic issues in this area.

**Research tasks:**

1. Define the concept of the right to life.
2. Based on the analysis of case law, to determine the problematic aspects of the legal regulation of the right to life.

**Research methodology**: taking into account the topic, goals and objectives of the scientific article, the following research methods are applied: document analysis, systematic analysis, comparative analysis and generalization methods.

**Abbreviations** used in the work:

1. ECtHR – European Court of Human Rights
2. ECHR – European Convention on Human Rights

## THE CONCEPT OF THE RIGHT TO LIFE AS A NATURAL HUMAN RIGHT

The right to life refers to an inalienable human quality and is an essential aspect of the rights and freedoms protected by the European Conventions, it is life meant to enable the exercise of other rights and freedoms. The concept of the right to life "would be meaningless if it were only associated with the loss of life". The right to life belongs to the category of human rights, which are inalienable and common to all people. It is according to the right to life that a person enjoys all other rights established and guaranteed by constitutions and international documents.

The right to life is the most important of these basic human rights, as it guarantees a person his right to live. Almost every democratic country "guarantees this right not only to its own citizen, but also to every person in the world". Many authors state that the right to life is a natural human right, therefore it is appropriate to note that "the doctrine of natural human rights states that human rights and freedoms do not arise by the will of the state, but a person acquires them at birth, they are inseparable from the person and do not connect the person with territory, neither with the nation". However, "every person is born in the union of his parents, just as without their union he would not receive life, so without their constant help he would not be able to preserve it in childhood. In old age, the need for marriage and the family that arises from it, the weakening of strength in old age and the inability to live without the help and service of others, show that a person is born, grows, lives and dies in society". Hence, natural rights are given to man by nature and no government or person can deny or restrict them.

From the point of view of scientists, the concept of natural rights evolved from ancient and medieval theories of natural rights, which stated that individuals, as creatures of nature and God, should live their lives and create their societies according to natural or divine norms and provisions. Concepts of natural rights were supposed to emphasize that individuals, as natural creatures, have rights that cannot be violated by anyone or any community. Hence, the natural right to life is intended for every person, but a person, living in society, has to maintain this right, because a person is a part of society.

Right to life concepts still grapple with the changing status of humans and other life forms. Three approaches to the concept of the right to life are presented in the scientific literature:

- Naturalistic theories that describe the right to life as the protection of a person's natural interest in life or are clearly guided by a biological concept of life;
- Procedural theories that define the right to life as a form of mutual recognition;
- It is guided by cultural attitudes that determine the concept of life.

Thus, the provisions of these theories reveal that the human right to life is primarily a biological human nature, which must be realized by knowing the environment and the world.

However, the legal theory of the right to life as a legal right forms a normative concept of life that takes into account the systematic harmony with other basic human rights and constitutional values. Thus, the legal concept of a person's life is related to a person's life using other human rights.

Interpretations of the concept of the right to life based on philosophical analysis are distinguished by other scientists:

- The right to life, as the right to essential life-sustaining things or actions;
- The right to life, as the right not to be (unlawfully) killed;
- The right to life as the right not to kill.

These provisions show that the right to life is primarily the ability to enjoy life, not to be unlawfully killed, and not to take person's life.

In conclusion, it can be said that a person's right to life is a natural human right. The concept of the right to life has been analyzed since ancient times. It is described by philosophers, lawyers and representatives of other fields of science. However, a fundamental understanding of a person's right to life can be formed based on all scientific theories, but by distinguishing general aspects of a person's right to life. Hence, it can be said that a person's right to life is given by nature. Life is necessary for a person to be able to know the world, to follow the norms of the society in which he is born and live, to be able to exercise other human rights. Therefore, taking a person's life is illegal, which obliges states to seek maximum protection of the individual's right to life.

A crime against a person, the taking of his life, whether it is done intentionally or due to negligence, is dealt with in the courts. Over time, case law is formed in the courts, which is followed to solve cases of a similar nature. Analyzing examples of case law in which liability for the taking of human life is investigated, the ECtHR was chosen for the discussion of decisions, since the ECtHR is one of the institutions that decides how correctly the provisions of Article 2 of the European Convention on Human Rights on the human right to life have been implemented. Decisions are made in this institution only if the submitted complaint is admissible.

## ANALYSIS OF ECTHR DECISIONS ACCORDING TO ARTICLE 2 OF THE ECHR IN CASES AGAINST LITHUANIA

Analyzing the international case law, when the emphasis is placed on the inappropriate handling of the case for taking life. This subsection presents the case law formed by the ECtHR, when the issue of the right to life and liability for acts committed against human life is examined in accordance with the provisions of Article 2 of the European Convention on Human Rights.

The essence of the case Bakanova v. Lithuania - the applicant's complaint that the circumstances of her husband's death were not sufficiently investigated. The main reason for filing the complaint – the applicant's legitimate interest – in finding out the true cause of her husband's death. The main circumstances of the case cited by the applicant regarding the death of her spouse reveal that her husband worked as a mechanic on the private ship "Vega", where he was found dead in his cabin during the voyage. First of all, the captain of the ship formed a commission on the same day to investigate the circumstances of the death. The conclusion presented by the Brazilian doctor stated the cause of death – myocardial infarction. The remains were embalmed, using chemicals, the next day. The investigation conducted by the Brazilian police and the collected material were handed over to the local court. In Lithuania, after receiving the report, an investigation was launched (Article 176 of the Criminal Code of the Republic of Lithuania - violation of the requirements of worker safety and health). The applicant addressed to the prosecutor and the state labor inspectorate, which is responsible for work safety, stating that the working conditions were difficult and dangerous and could have influenced the death of the spouse. However, the prosecutor refused to continue the pre-trial investigation, arguing that there were no signs of a crime, not even mentioning any chemicals. Based on the applicant's new complaint, the Klaipėda Court recognized that the prosecutor had improperly examined the applicant's statement and resumed the pre-trial investigation. The court questioned the sailors of the "Vega" ship, whose testimony revealed that the applicant's spouse worked as a

mechanic in the engine room, where fires often broke out, which led to a strong smell of smoke in the engine room. The sailors' testimonies contained information that the deceased mechanic often worked with a gas mask.

While examining the complaint, it was established that the Lithuanian institutions, although it took a very long time, because the necessary witnesses had to go to sea for a long time, there was no person adequately prepared to perform competent translations of documents, etc., the investigation was conducted properly and the procedural obligations according to Article 2 of the European Convention on Human Rights were fulfilled. It can be noted that the circumstances of the case and the causes of death did not exempt Lithuania from conducting a detailed investigation, because in accordance with the provisions and purpose of Article 2 of the European Convention on Human Rights, it is necessary to ensure the implementation of national legal acts that protect the right to life. Consequently, upon occurrence of an event, the essence of which is human life and liability for the committed deed, it is necessary to assess the extent to which national legislation fulfills the international requirements of legislation.

The situation is similar in the case of Tumėnienė v. Lithuania (petition No. 10544/17), because the authorities did not properly investigate the circumstances of the applicant's brother's death. Deciding that the pre-trial investigation in this case was incomplete, the ECtHR drew attention to the fact that the shortcomings of the pre-trial investigation were also noted by the Klaipėda Regional Court and the General Prosecutor's Office in the conclusion of the Official Inspection. Noting the errors of the authorities and the excessively long duration of the investigation into the circumstances of the death of the applicant's brother, the Court decided that the procedural aspect of Article 2 of the Convention had been violated. Taking this into account, the Court awarded the applicant 10,000 euros in compensation for non-pecuniary damage and 3,315 euros to cover litigation costs.

Decisions are submitted to the ECtHR on various grounds and articles of the Convention. There are not many complaints in which improper reasons for the violation of the right to life or inadequate investigation of the case would be emphasized. Therefore, based on the presented summaries of ECtHR decisions, which are based on the provisions of Article 2 of the European Convention on Human Rights, on ensuring the right to life, essential observations are presented.

In the case Juozaitienė and Bikulčius v. Lithuania (petition No. 70659/01 and 74371/01), the Court found that the provisions of Article 2 of the Convention were violated during the examination of this case. It was found that material and procedural aspects were violated due to the illegal use of a firearm by a police officer and the failure to conduct an effective investigation.

The applicants' complaint states that their sons were unlawfully shot by police officers and that the investigation into this case was not effective. The applicants' sons were shot by a policeman during a private car chase. The sons of the applicants were traveling in this car as passengers. Summarizing the general principles of the right to life in cases like this, the Court emphasized that the use of lethal force by police officers can only be done when it is "absolutely necessary", i.e. strictly proportionate in the particular circumstances. It was also emphasized that, in principle, there can be no necessity when the detained person does not pose a threat to life and is not suspected of having committed a violent crime, even if not using deadly force would result in the loss of the opportunity to apprehend the fugitive. The Court found in this particular case that by firing continuously and indiscriminately at the car, the officers ran a high risk of shooting the passengers and should have reasonably anticipated that risk. The Court noted that such a high risk to life could only be justified if the shooting was used as a last resort to avoid a very clear and immediate danger that the driver of the car would pose, if allowed to escape. The Court, also taking into account the fact that the applicants' sons were shot during an unplanned operation, when the police officers had to react unprepared, nevertheless concluded that the risk to the lives of the passengers of the car, in the absence of an immediate danger caused by the driver, and therefore in the absence of the need to stop the car, shows that the police officers acted impulsively in this situation. The Court concluded that the death of the applicants' sons was caused by the use of force that did not meet the requirement of "absolute necessity" in the lawful arrest of a person. In considering whether the investigation into the death of the applicants' sons had been effective, the Court noted that the obligation to protect the right to life under Article 2 of the Convention also, by implication, required an effective official investigation if a person had been killed by the use of force (procedural aspect of Article 2 of the Convention). The court, summarizing the general principles of the effectiveness of the investigation, stated that the investigation must be independent, accessible to the victim's family, carried out quickly and reasonably operatively, and effective from the point of view that it can be determined whether the force used can or cannot be justified in specific circumstances, or was not although otherwise illegal. All the shortcomings of the investigation, due to which it is not possible to determine the circumstances of the case or the responsible person, can be evaluated as a lack of effectiveness. Inefficiency is also shown by the fact that the Court, while examining the specific circumstances of the case, drew attention to the fact that the investigation into the legality of the shooting was started almost 10 months after the incident. The Court also noted that the circumstances and legality of the officer's use of force were not assessed. The legal process of the person driving the car did not meet the requirement of an effective investigation, thus the requirement of an urgent investigation was not satisfied. The Court found that many important elements of the incident that should have been evaluated to determine whether the use of deadly force was necessary were not properly considered. Next, the Court emphasized that the institutions, while conducting the investigation, relied on only one, i.e. police version. These shortcomings of the investigation, especially the lack of completeness and comprehensiveness of the investigation, led to the fact that the Court concluded that the authorities did not conduct an effective investigation into the taking of life, and established a procedural violation of Article 2 of the Convention. The Court, having recognized a double (both material and procedural) violation of the aspects of Article 2 of the Convention, awarded each applicant EUR 30,000 in

compensation for pecuniary and non-pecuniary damage. Therefore, in a situation where a person's life is taken, it is necessary to evaluate all the possibilities of the effectiveness of the investigation and apply them to the case.

In other case Česnulevičius v. Lithuania (petition No. 13462/06), the Court also found that Lithuania violated the procedural aspect of Article 2 of the Convention due to the death of the applicant's son as a result of violent actions by prisoners. The applicant's son A. Česnulevičius was attacked and beaten several times by other prisoners. After the third beating, after providing medical aid and later being taken to the hospital, A. Česnulevičius died of his injuries the next day. The father of this convict appealed to the Court with a complaint that the prison institution did not ensure his son's safety during his imprisonment, and also that the state institutions did not conduct an effective investigation into the circumstances of his son's murder and did not identify the guilty persons. The Lithuanian courts did not establish a causal connection between the actions (inaction) of the correctional officers and the death of the applicant's son. However, according to the ECtHR, the state in certain cases has a positive obligation to take preventive measures to protect individuals so that a criminal act is not committed against them. In this case, the Court decided that A. Česnulevičius was not provided with a safe environment, because the officers failed to identify, prevent and control violence between convicts and to respond promptly and effectively to it. Also, it was established that the right to an effective investigation into the circumstances of the death of the applicant's son was not ensured. The Court noted that although the investigation in the prison was started urgently, it was not properly conducted and the guilty persons were not identified. Taking this into account, the Court awarded the applicant 30,000 euros for non-pecuniary damage and 2,015 euros for pecuniary damage, as well as 770 euros for legal expenses incurred. Consequently, prison officials have a duty to prevent violent behavior by inmates, which should be regulated by legislation, the non-compliance of which could regulate the officers' liability.

In the case Banel v. Lithuania[16] (petition No. 14326/11), the Court found that Lithuania violated the material and procedural aspects of Article 2 of the Convention due to the unprotected life of the applicant's son and the ineffective investigation of the circumstances of his death. The applicant's son was killed when a balcony panel of an abandoned farm building in one of the residential areas of Vilnius city fell. However, during the pre-trial investigation, it was not possible to identify the persons directly responsible for the damage caused by the abandoned building. During the pre-trial investigation, which was sometimes terminated and renewed again, the de facto owner of the abandoned building was determined, and the prosecutors urged the applicant to apply for compensation in a civil procedure, the civil process was not initiated. The applicant appealed to the Court with a petition regarding the failure of the state to protect her son's life and the ineffective investigation into the circumstances of his death. Based on the case law, in cases where the right to life is violated due to negligence, the positive duty of the state enshrined in Section 1 of Article 2 of the Convention does not always require the opportunity to defend violated rights by means of criminal proceedings. However, in this case, taking into account the long-lasting pre-trial investigation and its outcome, as well as the special circumstances of the case, the Court decided that the applicant was not obliged to apply separately to the Lithuanian courts in civil proceedings. Assessing the circumstances of this case, the Court noted that Article 2 of the Convention protects one of the fundamental values in a democratic society - the human right to life - and obliges states not only to refrain from intentional or unlawful taking of life, but also to take appropriate measures aimed at protecting the lives of persons under their jurisdiction. In addition, the Court indicated that in this context, the positive duty of the state includes both the need to take appropriate measures to ensure the safety of people in public places, and the duty to create an independent and efficient judicial system, which allows to ensure effective legal measures to bring liable persons to justice and adequately compensate the victim, also, the effective legal measures deriving from the positive obligation must be effective in practice and not merely provided for in domestic law. The Court noted that at the time of the accident, there were legal measures in Lithuania regulating the duty to control abandoned buildings and to be responsible for the damage caused by them, but they were not effective enough. An important point is that the municipality was already aware of the abandoned building and the threat it posed at the time of the accident, but did not fulfill the obligation assigned by law to take care of it. The Court awarded the applicant 20,000 euros in non-pecuniary damage and 8,135 euros in compensation for material damage. The example of this case reveals the negligent attitude of state institutions to the existing legislation, which leads to additional liability for accidents that have already occurred.

It is appropriate to note that the discussed cases were recognized as admissible due to their nature, as they met the requirements that are necessary for a complaint to be accepted and examined at the ECtHR. However, there are recorded cases when complaints are inadmissible. For example, the ruling of the ECtHR in the case Marė Šedbarienė v. Lithuania deemed the applicant's complaint inadmissible, which reveals that complaints at the ECtHR are not always examined. In this case, it was decided and ECtHR case laws was applied that the authorities investigating the cases are not obliged to satisfy every relative's request, whereas in the mentioned case, as many as 4 expert examinations were checked and evaluated for the determination of the cause of death, and the examination and verification of the fifth expert opinion was refused. Consequently, cases are heard at the ECtHR if it is determined that the complaint is admissible and can be examined.

## CONCLUSIONS

1. The analysis of scientific literature revealed that a person's right to life is defined as a natural right because it ensures a person's ability to live, therefore the application and protection of this right has been relevant since ancient times and is reflected in all world religions, cultures and the most important international and national legal acts of states.

2. At the international level of legal regulation of the right to life, the most important documents are conventions, on the basis of which the national legal acts of states are created, responding to their provisions and consolidating the requirements for the protection of human life.

3. The state implements its functions in the protection and defense of human life by creating legal mechanisms, the application and observance of the provisions of which form the system of the state's right to life protection.

4. Analyzing the case law, it was found that the essential problematic aspects of ensuring a person's right to life are related to the unequal understanding of legal regulation and the interpretation of legal norms. Complaints submitted to the ECtHR regarding the protection of a person's right to life are related to insufficiently effective investigation of the case, which shows a problematic understanding of the European Convention on Human Rights.

## REFERENCES


1. The European Convention on Human Rights, amended by the provisions of Protocol No. 15 (CETS No. 213).
2. Constitution of the Republic of Lithuania, Parliamentary record, 1992-11-01, Nr. 11.
3. The Criminal Code of the Republic of Lithuania. Valstybės žinios No. 89, 2741 (2000).
4. Dragne, L. (2013). The Right to Life – A Fundamental Human Right. Social economic denates, Vol. 2(2), p. 6.
5. Enabulele A. O. (2014). The Right to life or the right to compensation upon death: perspectives on an inclusive understanding of the constitutional Right to life in Nigeria. Online access: nOxCfIJ:https://www.ajol.info/index.php/jsdlp/article/view/122618/112166&cd=21&hl=lt&ct=clnk&gl=lt, [Accessed: 3.10.2024].
6. Famakinwa, J. O. (2012). Interpreting the Right to life. Diametros. *A Journal of philosophy*., No. 29.
7. Jain, H., Agarwal, A. (2019). Natural Rights. Online access: https://blog.ipleaders.in/natural-rights/, [Accessed: 11.09.2024].
8. Kirste, S. (2018). The Right to life as a Right to Self-Determination about One‘s Life. Online access: https://www.ufrgs.br/bioetica/kirste-righttolife.pdf, [Accessed: 4.10.2024].
9. Official constitutional doctrine. Most important provisions 1993-2020. Vilnius: Constitutional Court of the Republic of Lithuania. Online access https://lrkt.lt/lt/teismo-aktai/oficialioji-konstitucine-doktrina/704, [Accessed: 3.10.2024].
10. Popa, D., Ristea, G. (2021). The Right to Life in the Internetional Human Rigths Law. *Communication and Globalization,* No. 11(1), p. 12-19.
11. Pranevičienė, B., Amilevičius, D. (2012). Žmogaus teisių samprata krikščionybėje ir ulitaristinėje pasaulėžiūroje. *Soter,* Vol. 41(69).
12. Singh, A. (2022). Evolution of Right to Life in India. Online access: https://www.thelawgurukul.com/post/evolution-of-right-to-life-in-india , [Accessed: 17.10.2024].
13. Stroinovskis, J. (2011). *Prigimtinės teisės mokslas*. Vilnius: Lietuvos kultūros tyrimų institutas.
14. ECTHR 31.05.2016 case Bakanova v. Lithuania No. 11167/12 decision Online access http://lrv-atstovas-eztt.lt/uploads/BAKANOVA_2015_sprendimas.pdf [Accessed: 29.10.2024];
15. Cases in which the ECTHR found a violation of the Convention (us). P. 28. Online access: http://lrv-atstovas-eztt.lt/uploads/APZVALGOS_pazeidimai_2021-03-01.pdf [Accessed: 29.10.2024];
16. The ECHR: the complaint against Lithuania regarding the right to life was declared inadmissible. Online access: http://lrv-atstovas-eztt.lt/naujienos/paskelbtas-nepriimitinu-skundas-pries-lietuva-del-teises-i-gyvybe, [Accessed: 4.10.2024].
17. The ECHR: the complaint against Lithuania regarding the right to life was declared inadmissible. Online access: http://lrv-atstovas-eztt.lt/naujienos/paskelbtas-nepriimitinu-skundas-pries-lietuva-del-teises-i-gyvybe, [Accessed: 4.10.2024].

PANEVĖŽIO KOLEGIJA ISSN 2029-1280, eISSN 2669-0071. Taikomieji tyrimai studijose ir praktikoje – Applied Research in Studies and Practice, 2024, 20.

# ADVANCING SMART GRID RELIABILITY FOR ENHANCED PERFORMANCE BY INTEGRATING ARTIFICIAL INTELLIGENCE FOR MODELING RENEWABLE ENERGY AND OVERVOLTAGES

***Renata MILIŪNĖ***

*Klaipėdos valstybinė kolegija, Higher Education Institution, Lithuania*

**Abstract.** Smart grids have revolutionized energy systems by enhancing efficiency, reliability, and sustainability through the integration of advanced communication, control technologies, and renewable energy sources. However, their increased complexity introduces challenges in evaluating reliability, especially with the integration of distributed energy resources, communication disruptions, and cybersecurity risks. This paper reviews advancements in smart grid reliability evaluation, focusing on probabilistic modeling, artificial intelligence (AI), machine learning (ML), and big data analytics. Methods like Monte Carlo simulations and Markov chains are adapted to address uncertainties in grid operations. Key performance indicators (KPIs) such as SAIDI and SAIFI help quantify reliability, while AI and ML improve fault detection and predictive maintenance. Case studies from utilities like Pacific Gas and Electric and the UK's National Grid demonstrate the practical benefits of these approaches. Additionally, the paper explores overvoltage modeling and insulation reliability. Despite progress, challenges remain in standardizing models, mitigating cybersecurity threats, and optimizing renewable energy integration. Future research will focus on refining predictive models and exploring the impact of emerging technologies like IoT and blockchain.

**Keywords**: smart grid, reliability evaluation, artificial intelligence, machine learning, probabilistic modeling, re-newable energy, cybersecurity, overvoltage modeling

## INTRODUCTION

The advent of smart grids has revolutionized the way energy is produced, distributed, and consumed. These advanced electrical grids are designed to improve the efficiency, reliability, and sustainability of power systems through the integration of modern communication, control technologies, and renewable energy sources. As the complexity of these systems increases, assessing their reliability becomes paramount to ensure uninterrupted service and optimal performance. This paper focuses on evaluating the reliability of smart grids, particularly through the lens of recent advancements in modeling techniques and the integration of emerging technologies such as artificial intelligence (AI) and machine learning (ML).

## SMART GRID CONCEPTS

A smart grid is a modernized electrical grid that incorporates digital communication and control technologies to manage and respond to energy demands more effectively (Fig.1). Unlike traditional power grids, which rely on a one-way flow of electricity, smart grids enable two-way communication between consumers and utilities, enhancing grid responsiveness and enabling real-time monitoring and control.

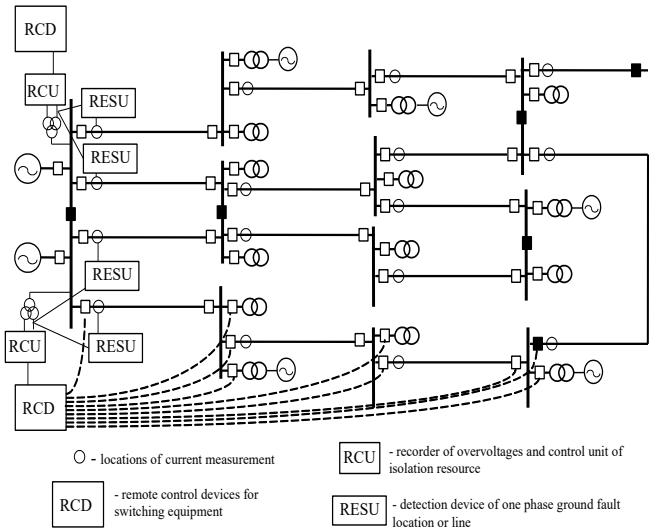



Figure 1. **The scheme of smart grid devices**

The key components of a smart grid include (Fig.1):

- **Advanced Metering Infrastructure (AMI)**: This includes smart meters that collect real-time data on energy consumption.
- **Communication Networks**: These networks facilitate data exchange between the grid, utility providers, and end users.
- **Renewable Energy Integration**: Smart grids allow for the efficient incorporation of renewable energy sources such as wind, solar, and hydropower.
- **Energy Storage Systems**: These systems help balance energy supply and demand, ensuring a reliable power supply.

Despite the numerous advantages, the implementation of smart grids introduces several challenges. These include issues related to cybersecurity, data privacy, high initial investment costs, and the integration of intermittent renewable energy sources.

## RELIABILITY EVALUATION IN SMART GRIDS

The reliability of a power grid is traditionally assessed through measures such as the system's ability to maintain service continuity and its capacity to handle faults. Conventional reliability evaluation methods, such as Monte Carlo simulations and probabilistic modeling, have been widely used in power systems but face limitations when applied to smart grids. The complexity of smart grids driven by advanced technologies, decentralized generation, and the integration of renewable energy requires more sophisticated approaches to reliability analysis.

Key factors influencing smart grid reliability include:

- **Distributed Energy Resources (DERs)**: These energy sources introduce variability and unpredictability into the grid, making reliability analysis more complex.
- **Communication Failures**: The smart grid's reliance on real-time data transmission makes it vulnerable to communication disruptions, which can affect the grid's reliability.
- **Cybersecurity Threats**: With increased connectivity, smart grids are exposed to cyber-attacks, which can compromise their functionality and reliability.

The evaluation of smart grid reliability is a dynamic process that requires the development of models that consider both traditional reliability metrics and the specific challenges posed by advanced grid technologies. These models typically involve a combination of mathematical simulations, real-time data analytics, and decision-making algorithms. The scheme of smart grid devices is presented in Figure 1.

## ADVANCEMENTS IN SMART GRID RELIABILITY EVALUATION

A common approach is to use **probabilistic models**, which account for the inherent uncertainty in grid operations. These models simulate different scenarios to estimate the likelihood of failures and identify potential vulnerabilities in the system. For instance, the **Monte Carlo method** has been applied in several studies to assess the reliability of power distribution systems with high penetration of renewable energy sources. Another popular technique is **Markov chains**, which are used to model the stochastic behavior of components in the grid.

Reliability evaluation in smart grids also involves the use of **key performance indicators (KPIs)** such as:

- **System Average Interruption Duration Index (SAIDI)**: This metric measures the average time customers are without power.
- **System Average Interruption Frequency Index (SAIFI)**: This metric tracks the frequency of power interruptions.

Recent advancements have incorporated **machine learning (ML)** and **artificial intelligence (AI)** to predict and mitigate potential failures. For example, AI-based models can analyze historical grid data to predict future outages and suggest optimal maintenance schedules. These techniques enhance the accuracy and efficiency of reliability evaluations, enabling grid operators to respond proactively.

Recent literature highlights several advancements in the field of smart grid reliability evaluation, focusing on the integration of AI, ML, and big data analytics. Some key studies in the last five years have explored the following areas:

1. **Machine Learning for Fault Detection**: AI and ML algorithms, such as decision trees, support vector machines (SVMs), and neural networks, have been employed for fault detection and diagnosis in smart grids. These methods improve the speed and accuracy of fault identification, reducing downtime and maintenance costs.
2. **Renewable Energy and Reliability**: As the penetration of renewable energy sources increases, assessing their impact on grid reliability has become a key research area. Studies have demonstrated how stochastic models can be adapted to account for the variability and intermittency of renewable generation, ensuring the reliability of the grid under different operational scenarios.

3. **Cybersecurity in Smart Grids**: The increased connectivity of smart grids raises concerns about cybersecurity. Researchers have developed frameworks that integrate reliability and cybersecurity, evaluating how attacks on communication networks can impact overall grid performance.
4. **Big Data Analytics**: The integration of big data analytics in reliability evaluation allows for real-time monitoring of grid performance. Machine learning algorithms analyze large datasets from sensors and meters, providing actionable insights into the grid's operational health.
5. **Resilience in Smart Grids**: Recent studies have focused on the resilience of smart grids, particularly in the face of extreme weather events and natural disasters. Advanced models now incorporate resilience measures to ensure that grids can recover quickly from disruptions.

## CASE STUDIES AND PRACTICAL APPLICATIONS

Several utilities around the world have implemented smart grid technologies and evaluated their reliability using advanced modeling techniques. For example, the Pacific Gas and Electric Company (PG&E) in California has used probabilistic models to assess the impact of distributed energy resources on grid reliability. Similarly, the integration of AI-powered systems in the United Kingdom's National Grid has enhanced fault detection and recovery times, demonstrating the practical benefits of these technologies.

## RELIABILITY MODELING OF LINE INSULATION

The duration of the line insulation function until it fails is variable and depends on factors such as the electrical strength characteristics of the insulation, environmental conditions (e.g., temperature, pressure, humidity, radiation, mechanical disturbances, etc.), and the extent of overvoltages. The operational lifespan of the line from installation or maintenance repair to failure, which would necessitate additional line maintenance, follows a (gamma) exponential statistical distribution. The distribution function can be expressed as:

$$F_T(t) = 1 - \exp\left(-\frac{t}{\tau}\right); \quad (1)$$

where $T$ and $\tau$ - represent the random and mean operational times, respectively, and t is the independent argument of the function (e.g., one year).

The reliability value $p$ represents the probability that the actual operational time exceeds a specified duration ttt:

$$p = 1 - q = P(T > t) = 1 - F_T(t); \quad (2)$$

Further, the reliability value $p$ represents the probability that the actual operational time is greater than the agreed duration $t$.

The unreliability, $q$, is defined as:

$$q = \int_{\max(V)}^{\min(V)} f_V(u) F_U(u) du; \quad (3)$$

where $f_v$ and $F_U$ are the probability density function of overvoltages and the distribution function of the electrical strength of the insulation against those overvoltages, respectively. The term $q$ represents the unreliability of the insulation in the presence of such overvoltages, or the probability of a random event where the overvoltage amplitude exceeds the insulation's electrical resistance limit. The variables $\min(V)$ and $\max(V)$ represent the minimum and maximum possible values of overvoltage within the network (Fig.2).

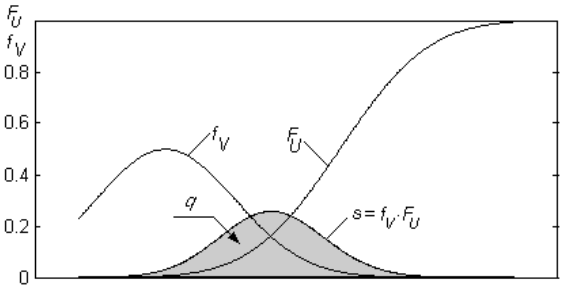



Figure 2. **Distribution density of overvoltages ($f_v$), distribution function of isoliation electric strength ($F_U$) and their product ($s$)**

Unreliability is product of multiplication of functions $f_V$ and $F_U$ (representing the correlation between $V$ and $U$ correlation), the $s=f_V F_U$ represents a bounded area. This curve, along with the distribution function, is illustrated in Figure 2. The area corresponding to the probability $q$ is increased by a factor of 10.

To assess the changes in insulation reliability under varying environmental conditions or levels of overvoltage, it is essential to consider not only the electrical resistance of the insulation and its stochastic variation, but also the dispersion in overvoltage values.

## CHALLENGES AND FUTURE DIRECTIONS

Despite the progress made in smart grid reliability modeling, several challenges remain. These include the need for standardized models that can be universally applied, the difficulty of integrating diverse energy sources, and the ongoing threat of cyber-attacks. Moreover, there is a need for further research into the long-term reliability impacts of emerging technologies such as blockchain and Internet of Things (IoT) in the context of smart grids.

Future research directions include improving the accuracy of predictive models using advanced AI technologies, developing a more reliable smart grid, and creating more robust cybersecurity frameworks.

## CONCLUSIONS

In conclusion, the reliability evaluation of smart grids is a critical area of research that has gained significant attention in recent years. The integration of AI, ML, and big data analytics has opened up new possibilities for enhancing grid reliability. However, challenges remain, particularly with regard to cybersecurity, data privacy, and the integration of renewable energy sources. Moving forward, ongoing research and collaboration between academia and industry will be key to developing more reliable and resilient smart grids.

## REFERENCY

Bishowjit P., (2024). Potential smart grid vulnerabilities to cyber attacks: Current threats and existing mitigation strategies. Heliyon, Volume 10, Issue 19, 15 October 2024, e37980

Brown, D., et al. (2022). Artificial intelligence for predictive maintenance in smart grids. Energy Journal, 56(3), 253–270.

Chen, L., et al. (2021). Cyber-physical system vulnerabilities in smart grids: A survey. IEEE Transactions on Industrial Informatics, 17(6), 4193-4203.

Ghelani D., (2022). Cyber Security in Smart Grids, Threats, and Possible Solutions. American Journal of Applied Scientific Research, ISSN: 2471-9722 (Print); ISSN: 2471-9730 (Online).

Huang, Z., et al. (2021). Enhancing smart grid resilience under extreme weather events. Renewable and Sustainable Energy Reviews, 134, 110436.

Kumar, R., et al. (2021). Evaluation of distributed energy resources in smart grid reliability. Energy Conversion and Management, 239, 114207.

Kumar, S., et al. (2023). Machine learning techniques for smart grid reliability assessment. Electric Power Systems Research, 211, 107298.

Li J., et al (2024). A study on big data analytics and innovation: From technological and business cycle perspectives .Renewable and Sustainable Energy Reviews, Volume 202, May 2024, 123328.

Li, X., et al. (2020). Data-driven models for smart grid fault detection. Applied Energy, 278, 115586.

Liu, H., et al. (2023). Optimization of power system reliability with renewable integration using deep learning. Energy, 248, 123357.

Meier, S., et al. (2020). Markov chains in reliability analysis of power distribution systems with renewable energy integration. Renewable and Sustainable Energy Reviews, 119, 109540.

Shao Q., et al. (2021). Exploring the determinants of renewable energy innovation considering the institutional factors: A negative binomial analysis. Volume 67, November 2021, 101680

Shao, Q., et al. (2021). Reliability evaluation of power distribution systems with high penetration of renewable energy. Renewable and Sustainable Energy Reviews, 145, 111072.

Singh, S., et al. (2021). A survey on AI-based fault detection and management for smart grid systems. Energy Reports, 7, 3190–3205.

Wang Z., et at. (2022). Trends in modern power systems resilience: State-of-the-art review. Renewable and Sustainable Energy Reviews, Volume 162, July 2022, 112397.

Wang, X., et al. (2023). Renewable energy integration and its impact on smart grid reliability. Renewable Energy, 178, 1373–1384.

Yu, M., et al. (2023). Big data analytics for smart grid reliability and resilience. IEEE Transactions on Smart Grid, 14(1), 567-576.

Zhang, L., et al. (2020). Artificial intelligence for fault detection and diagnosis in smart grids: A comprehensive review. Applied Energy, 275, 115334.

Zhang, Y., et al. (2021). Reliability analysis of the power grid considering renewable energy intermittency. IEEE Access, 9, 54318-54330.

Zhao H., et al (2022). Deep learning for cybersecurity in smart grids: Review and perspectives. Energy Conversion and Economics, Energy Convers. Econ. 2023; 4(2): 233–251.

Zhao, J., et al. (2022). Cybersecurity in smart grids: A review of attack detection and mitigation techniques. Electric Power Systems Research, 196, 107154.

PANEVĖŽIO KOLEGIJA ISSN 2029-1280, eISSN 2669-0071. Taikomieji tyrimai studijose ir praktikoje – Applied Research in Studies and Practice, 2024, 20.

# ASPECTS OF RECONSTRUCTION TECHNICAL PROJECT EXPERTISE PROGRESS

***Danguolė PLUNGYTĖ***

*Panevėžio kolegija/State Higher Education Institution, Lithuania*

**Annotation.** The article describes the course of the technical design expertise of a building construction project. Based on a specific example, the stages of the project expertise are discussed, the chronology of the submission of the necessary documents, the reasons for the delay in the completion of the work, and how the estimated cost of the project changed when changing the technical solutions.

The object chosen for the study: the technical project of the reconstruction of the water supply networks of the city of Panevėžys, prepared by a closed joint-stock company, after the preparation of the construction project, and the execution of the technical expertise. By analyzing the content and chronology of the correspondence, the aim was to determine how smoothly the technical project expertise procedure was carried out and whether this time could have been shortened, another aspect was how much the estimated cost of the project changed after the expertise.

**Keywords**: legal acts, construction, expertise, technical project

## INTRODUCTION

Construction activities in Lithuania are carried out in accordance with the Construction Law and other legal and regulatory acts in force in the Republic of Lithuania. Construction works may be carried out with private funds or with money allocated from the budget for the implementation of approved projects. According to the Construction Law, in order to obtain a construction permit, it is necessary to have an approved construction project for the future construction work. When construction projects are important to society and are planned to be financed from state or municipal budgets, then public tenders are announced for the performance of individual project works. Companies participating in public tenders that have won the tenders for the performance of works must comply with the established regulatory requirements when performing project works. (Construction Law of the Republic of Lithuania, Summary version).

The client himself selected the expertise company to conduct the expertise of the technical project of the water supply reconstruction selected for the study. (Construction Technical Regulation STR 1.04.04:2017).

Usually, it is important for all project participants to complete the work on time as agreed in the work performance contracts. Sometimes the implementation of projects can be delayed due to various bureaucratic reasons, which are usually related to institutional arrangements. The article describes the progress of the implementation of a technical project for the reconstruction of one company's water supply system submitted for examination.

Analyzing the information provided by the company's designer, the aim was to find out how the expertise was carried out after submitting the project and other mandatory documents. As the project expertise lasted for more than three months, it was important to find out the reasons that prevented a smoother execution of the project expertise procedure. The prices of the reconstruction project submitted before and after the expertise were also compared.

The construction sector is closely related to the economic situation in the country, so the smooth implementation of construction projects is very important. Another important aspect is the deadlines for the completion of the works according to the signed contracts, so work productivity is always important. (Pyrantas et al. 2023; Stundziene et al. 2022)

Subject: Technical expertise of the water supply network reconstruction technical project of the city of Panevėžys, a closed joint-stock company, after the preparation of the construction project.

Objective: To conduct a correspondence analysis of the progress of the general expertise of a building technical project and compare the change in the estimated project prices after the evaluation.

Tasks:

1. To create a chronology of electronic correspondence for the execution of the project expertise, according to which the project expertise work was carried out.
2. To determine the time for the execution of the technical project expertise.
3. To analyze the comments of the experts due to which negative interim project assessments were received.
4. To compare the estimated prices of the technical project of the water supply reconstruction project before and after the project expertise.

Research method: case analysis, analysis of project expertise reports.

# ANALYSIS OF ELECTRONIC CORRESPONDENCE BETWEEN THE PROJECT EXPERTISE PERFORMER AND THE DESIGNER

The electronic version of the technical project for the reconstruction of the water supply system was uploaded to the data repository by the designer, and a login link was sent to the experts. (Technical work project for the reconstruction of water supply network, 2023) The entire process of conducting the expertise consisted of electronic correspondence. Based on the data of the electronic correspondence that took place between the expert and the designer, an electronic correspondence table (Table 1) was compiled with a chronology of dates and responses to queries. The information grouped in the table makes it easier to analyze the consistency of the correspondence and monitor how quickly the feedback is provided.

The entire chronological sequence of electronic correspondence between the designer and the expert is divided into two stages. The first stage consists of a general expert assessment of the technical reconstruction project, the second stage is the assessment of the estimated prices calculated for the reconstruction project. The figure shows the consistency of the intermediate, partial and final expert reports drawn up during the examination. (Fig. 1)

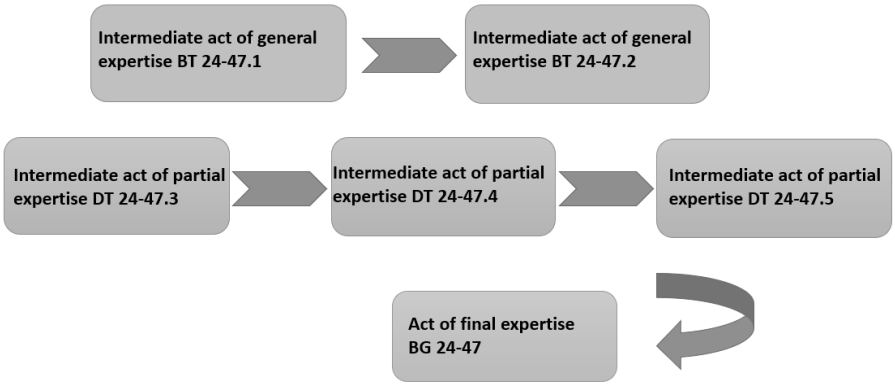



Fig. 1. **The order of drawing up expert reports for the technical design of the water supply reconstruction.**

During the first stage, the experts assessed the technological solutions for the construction of the technical project for the reconstruction of the water supply system and whether the project complies with the applicable technical construction requirements. (Construction technical regulation STR 1.04.02:2011) The initial estimated price calculations were also checked. This stage of the expertise was not very long, it took nineteen working days. During the second stage of the expertise of the project, the estimated price calculations were checked, which changed depending on the extent to which the technical solutions of the project were changed. The entire expertise process took about three months. (Table 1)

Table 1

**Chronological event dates of the construction technical project expertise**

| Date | Letters sent by the designer to the expert | Date | Answers and expertise reports sent by the expert |
|---|---|---|---|
| | **The first stage of expertise** | | |
| 02 23 | Initial presentation of the project to the expert. | 02 26 | It is asked to submit the project signed by e-signature |
| 02 26 | Project signed by e-signature is sent. | 03 06 | Comments are provided for the performed expertise. |
| 03 12 | Corrected project is sent. | 03 13 | Expert comment and additional request to group comments in a table. |
| 03 13 | Corrected project with a template table of corrected places in the project, according to the expert's comment. | 03 20 | An expert assessment is obtained Date of the expert report 03 06, BT 24-47.1. |
| 03 21 | Corrected project is sent again. | 03 26 | It is required to submit the estimate and project in one place as one file. |
| | **Second stage of expertise** | | |
| 03 27 | Estimate and project are sent. | 04 03 | The interim report of the general expertise BT 24-47.2 with comments for the estimate is provided. |
| 04 10 | Sending a response to expert comments, revised project draft. | 04 12 | Expert commentary. |
| 04 17 | Response to expert comments, revised part of project. | 04 24 | The interim report DT 24-47.3 of the partial expertise is submitted |

| | | | |
|---|---|---|---|
| 05 06 | Repeated request due to not receiving expert's response. | 05 06 | Expert assessment DT 24-47.4 with comments. |
| 05 08 | A reply is sent again after the project has been corrected. | 05 10 | Expert commentary. |
| 05 13 | A revised part of the project is sent. | 05 13 | It is informed that the SSKN part has been agreed, only the accompanying documents and parts of the project need to be submitted with PV and PDV e-signatures |
| 05 14 | An additional link is being sent regarding the missing documents. | 05 14 | Request for additional documents |
| | | 05 14 | Conclusions and general expertise report BG 24-47 is sent. |

*Description of the first stage of the expertise of the water supply network reconstruction project.*

Analyzing the content of the electronic correspondence, it can be seen that the designer sends a link to the data repository where the project is located and receives a response with a note that in order to start the expertise work, it is necessary to submit a project signed with an electronic signature as specified in STR 1.04.04: 2017 „Design of a structure, project expertise". The signed project is sent to the expertise again with an electronic signature. In this way, the process of submitting a project for the reconstruction of water supply networks is completed and it takes two working days. (Table 1)

Within seven working days, the interim act of the General Expertise BT24-47.1 is received. (Intermediate act of general expertise BT24-47.1) The act contains mandatory comments from the general part of the waterworks, the part of preparation for construction and organization of construction works, and the part of determining the estimated cost of construction. A response is received indicating that the technical project must be corrected in accordance with the written comments and submitted for re-examination. (Table 1)

Within five days, the reconstruction project is revised according to the comments received and sent for re-examination. (Table 1) The next working day, a response is received from the expert that an additional table must be drawn up in which the revised project must be listed according to the expert's comments.

After five working days, the designer sent a table with grouped comments and instructions for correcting specific points in the project. The next working day, the expert's comments are received, classified and listed in a table. The designer promptly corrects the errors based on the comments and resubmits the corrected project.

This completes the first stage of the technical project expertise for the water supply reconstruction. (Table 1)

*Description of the second stage of the expert examination of the water supply reconstruction project.*

After three working days (Table 1), the expert requests the submission of project estimates based on the comments provided for other parts of the project and requires all project files to be submitted in one place. The next working day, the designer sends a link to download electronic documents for all parts of the project in the data repository.

After five working days, the general expert examination interim report BT 24-47.2 with comments to the estimate, expert assessment, comments and recommendations are received. (Intermediate act of general expertise BT24-47.2) The project is not approved, but is returned for revision.

After five days, a revised project is sent based on the comments received. The revised parts of the project with links to the place in the project where the corrections were made are sent in a table.

After two working days, the expert sends a response to the corrections with repeated comments. (Intermediate act of partial expertise DT24-47.3)

After three working days, the designer sends the revised project according to the instructions and waits for a response. After fourteen days, the designer sends a request for the execution of the project expertise because he did not receive a response from the expert on the revised project. On the same day, the expert sends comments and attaches the interim act of the partial expertise DT 24-47.4, which was drawn up on 04 24, that is, seven working days ago. (Intermediate act of partial expertise DT24-47.4), (Table 1)

After two working days, the designer sends a link to the revised project again.

After two days, the interim act of the partial examination DT24-47.5 with mandatory comments is sent. (Intermediate act of partial expertise DT24-47.5)

The revised project is sent the next working day and a response is received on the same day that the SSKN (Building Construction Price Determination) part is coordinated and it is necessary to submit a fully completed PV (Project Manager) and PDV (Project Part Manager) project part signed with electronic signatures for the preparation of expert opinions.

The designer promptly sends a link to download the document.

The next working day, the expert asks where the documents required for the project are: Extract from real estate registers, list of objects where the network will be laid.

On the same day, the designer explains where to find the documents the expert is inquiring about.

Finally, on the same day, a general expertise report is sent with a brief overview and positive conclusions that the reconstruction project, version B, complies with the essential requirements for structures set out in Regulation (EU)

No. 305/2011, the requirements of mandatory project preparation documents, other laws and legal acts of the Republic of Lithuania, and normative technical construction documents.

Upon receipt of the final positive conclusions of the technical expertise of the water supply reconstruction project, the project evaluation procedure is completed. (Final act of general expertise BT24-47)

A review of the sequence of work execution shows that communication went quite smoothly. The entire technical project coordination took 55 working days.

## ANALYSIS OF INTERMEDIATE ACTS AND WRITEN NOTES OF PROJECT EXPERTISE

During the entire period of the project expertise, five interim expertise reports and a final sixth report with positive conclusions on the project's compliance with the established requirements were drawn up. (Table 2)

Table 2

**Estimated project prices indicated in the expertise reports**

| No. | Date of document creation | Title of the expert report | Estimated construction cost in thousand EUR. | Construction and installation work cost in thousand EUR |
|---|---|---|---|---|
| 1 | 2024-03-06 | BT24-47.1 Intermediate act of general expertise | 295.422 | 295.117 |
| 2 | 2024-04-03 | BT24-47. Intermediate act of general expertise | 295.422 | 295.117 |
| 3 | 2024-04-12 | DT24-47.3 Intermediate act of partial expertise | 325.250 | 287.682 |
| 4 | 2024-04-24 | DT24-47.4 Intermediate act of partial expertise | 344.002 | 290.836 |
| 5 | 2024-05-10 | DT24-47.5 Intermediate act of partial expertise | 347.313 | 294.333 |
| 6 | 2024-05-14 | BG24-47 Act of final expertise | 349.668 | 294.333 |

In the first interim report of the general expertise of the technical project of the water supply reconstruction BT 24-47.1, the designer receives comments on the incompletely completed project. The main comments are as follows: that the legal documents of ownership have not been submitted, that the engineering geological research documents have not been submitted, that the documents on the public information procedure have not been submitted, that the owners' consents regarding the newly designed water supply inlets have not been found, that the revised project documents of the new edition are incorrectly numbered according to regulatory documents. The experts additionally demanded to supplement the project with agreements or consents with the owners of those plots whose plots will be temporarily used during construction, requested to indicate in the project the schemes for installing road signs at the places of work, and also demanded to number the editions of the revised documents and to re-submit estimated calculations. The general conclusion is that the project does not comply with the requirements established by Regulation (EU) No. 305/2011 and cannot be approved.

After coordinating the technical design solutions for the water supply reconstruction project, the second stage of the expertise focused on coordinating the estimated prices and the expert wrote another interim report of the general expertise BT 27-47.2. The expert indicated the following main comments regarding the estimated prices: the percentage of the customer's reserve and design work and engineering services was incorrect; the selections made in the Sistela program for construction work were not suitable, the quantities of materials were not suitable; he demanded to revise the estimated calculations when the technical design solutions were changed and the prices of materials and work changed. The design solutions were changed more than once, so it was necessary to coordinate the estimated calculations several times. Therefore, the project was returned for revision again.

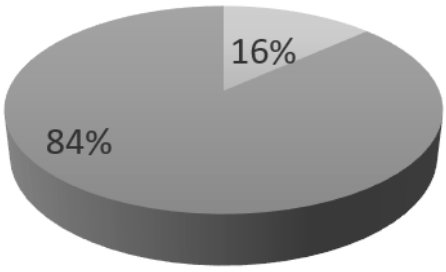



Fig 2. **The change in the calculated construction price of the technical project after the expert assessment, the price increased by 16 percent.**

The estimated calculations of the technical project for the reconstruction of the water supply system were revised several more times and three more interim acts of partial expertise were drawn up: DT 27-47.3, DT 24-47.4, DT 27-47.5. Summarizing the main comments written in the expertise acts, it can be seen that the expert assessed the prices of construction materials and labor costs in sufficient detail. The designer received comments regarding incorrectly calculated prices for design work and engineering services and regarding incorrectly calculated customer reserves for reconstruction works. ("Sistela" information database)

After correcting all errors in the project, the final general expertise report BG 24-47 was signed with a positive assessment of the water supply reconstruction project.

After the expertise, estimated construction cost for the water supply reconstruction technical project increased by about 16 percent. (Fig. 2)

## CONCLUSIONS

1. A table of electronic correspondence shows that the designer and the expert sent each other 25 e-mails. The entire project expertise procedure is divided into two stages. The first stage of the expertise took 19 working days. The second stage of the expertise took 36 working days.

2. The execution of the expertise of the technical project for the reconstruction of water supply networks after the preparation of the construction project took 55 working days. Before the final positive assessment was received, five interim assessments of the general expertise and partial expertise were written, which included comments and what needed to be corrected in the project or what needed to be corrected in the estimated project calculations. During the correspondence, delays occurred that extended the expertise time. After the expert's interim assessment comments, the designer made design corrections on average within five working days.

3. When submitting the technical design of the reconstruction for examination, the designer received comments regarding the improperly completed design, requiring the submission of missing documents. During the second stage of the examination, the main comments were regarding the material prices, incorrectly calculated customer reserve and the percentage of design work and engineering services.

4. When correcting the technical solutions of the project, the estimated calculations also changed. The final estimated cost of construction increased by 16 percent. because additional work had to be included, and the cost of construction and installation work also decreased by about 0.3 percent. because it was required to change the construction work technologies.

## REFERENCES

1. Technical work project for the reconstruction of water supply network in Kėdainių g. Babtų mstl., Babtų sen., Kauno raj. sav. (2023).
https://drive.google.com/folders/18mDzdY1JAkgcg8GuFh8GSNn2dcxyDKVT?usp=sharing
2. Technical work project for the reconstruction of water supply network in Kėdainių g. Babtų mstl., Babtų sen., Kauno raj. sav., intermediate act of general expertise BT24-47.1 (2024 03 06 Company archive).
3. Technical work project for the reconstruction of water supply network in Kėdainių g. Babtų mstl., Babtų sen., Kauno raj. sav., intermediate act of general expertise BT24-47.2 (2024 04 03 Company archive).
4. Technical work project for the reconstruction of water supply network in Kėdainių g. Babtų mstl., Babtų sen., Kauno raj. sav., intermediate act of partial expertise DT24-47.3 (2024 04 12 Company archive).
5. Technical work project for the reconstruction of water supply network in Kėdainių g. Babtų mstl., Babtų sen., Kauno raj. sav., intermediate act of partial expertise DT24-47.4 (2024 04 24) Company archive.
6. Technical work project for the reconstruction of water supply network in Kėdainių g. Babtų mstl., Babtų sen., Kauno raj. sav., intermediate act of partial expertise DT24-47.5 (2024 05 10 Company archive).
7. Technical work project for the reconstruction of water supply network in Kėdainių g. Babtų mstl., Babtų sen., Kauno raj. sav., final act of general expertise BT24-47 (2024 05 14 Company archive).
8. Pyrantas, R., Giziene, V., Laskiene, D. (2023). The impact of macroeconomic factors on the performance of the construction sector in Lithuania. // 2023 Journal of management, Business College, Klaipėda, Lithuania. https://epubl.ktu.edu/object/elaba:178735026/index.html
9. Stundziene, A., Baliute, A. (2022). Personnel costs and labour productivity: the case of European manufacturing industry // 2022 Economies, Basel. https://epubl.ktu.edu/object/elaba:117874353/index.html.
10. Zykiene, I., Leskauskienė, A., Mičiulienė, I.; Daugėlienė, R. (2023). Driving Growht Innovation: Exploring Foreign Direct Investment in the Manufacturing Sector (The Case of Lithuania). https://doi.org/10.5755/j01.eis.1.17.34264.
11. Construction technical regulation STR 1.04.04:2017 „Statinio projektavimas, projekto ekspertizė".
12. Construction technical regulation STR 1.04.02:2011 „Inžineriniai geologiniais ir geotechniniai tyrimai".
13. Construction Law of the Republic of Lithuania, Summary version.//Republic of Lithuania Ministry of Environment. https://am.lrv.lt/lt/veiklos-sritys-1/statybos-ir-bustas/statyba-ir-bustas/statybos-produktu-

tiekimas-rinkai/pagrindiniai-statybos-produktu-tiekima-rinkai-reglamentuojantys-teises-aktai/lietuvos-respublikos-statybos-istatymas/
14. “Sistela” information database. https://www.sistela.lt/Informacine/baze.
15. Regulation (ES) Nr. 305/2011. https://eurlex.europa.eu/legalcontent/LT/TXT/?uri=CELEX%3A32011R0305.

PANEVĖŽIO KOLEGIJA ISSN 2029-1280, eISSN 2669-0071. Taikomieji tyrimai studijose ir praktikoje – Applied Research in Studies and Practice, 2024, 20.

# STUDY OF THE CONTACT PRESSURE ON FIT DEVIATION IN AN INTERFERENCE FIT JOINT

***Gustas KUNIGONIS, Dainius VAIČIULIS***

*Panevėžio kolegija/State Higher Education Institution, Lithuania*

**Annotation.** This work investigates the influence of dimensional deviations of pressed hollow two-layer coils on the contact pressure. Two possible calculation schemes are presented. Calculations were performed using the finite element method. It was determined how the contact pressure depends on the deviations, the outer diameter of the pressed joint, the thicknesses of the layers and the "arrangement" of the materials in the joint, i.e. whether the inner or outer layer is more rigid. It was found that when the bias is about 1 percent. of the outer diameter of the joint, or about 10 percent. of the total wall thickness of the joint, the contact pressure, when changing the deviations, can change by more than 10 percent.

**Keywords**: pressed connection, tension, radius deviations, wall thickness deviations, plane axisymmetric stress state, contact pressure

## INTRODUCTION

Pressed joints are widely used in industry, especially in manufacturing processes where different materials need to be joined. These joints are used in various industries, such as automotive manufacturing, furniture manufacturing, etc. Even when pipes are joined without an initial stress (most multilayer pipes), under the influence of internal pressure, contact pressure occurs at the contact of the pipe or tube layers, i.e. a working stress occurs [1, 2].

A classic press joint is formed by joining two hollow rolls (pipes). The initial stress is obtained when the outer diameter of the inner roll is larger than the inner diameter of the outer roll. By changing the deviations of these diameters, it is possible to obtain stresses of different sizes. The stresses arising in such a press joint can be calculated using the Lame formulas. Pressed joints are studied taking into account various effects, e.g., the influence of vibrations on the formation of a pressed joint (pressing depth and force) [3], the influence of the size of the stress on the occurrence of microcracks in the connecting elements [4], the influence of the adhesion phenomenon on the size of the pressing force [5], etc. In work [6] it was established that knowing only the type of pressed joint (e.g., H8/z8) in advance, i.e. without performing calculations, it is impossible to say whether elastic or elastic-plastic deformations will occur in the contact of the connected parts. The contact pressure arising in the contact of two rolls, injected with stress, can be calculated, e.g., using the methodology of [7] (it is based on Lame formulas):

$$p_k = \frac{\frac{\Delta_{1;2}}{r_1} + \frac{2\left(1-v_1^2\right)r_0^2}{E_1\left(r_1^2-r_0^2\right)}p_0 + \frac{2\left(1-v_2^2\right)r_2^2}{E_2\left(r_2^2-r_1^2\right)}p_2}{\left(1+v_1\right)\left[\frac{\left(1-v_1\right)\left(r_1^2+r_0^2\right)}{E_1\left(r_1^2-r_0^2\right)}-\frac{v_1}{E_1}\right]+\left(1+v_2\right)\left[\frac{\left(1-v_2\right)\left(r_2^2+r_1^2\right)}{E_2\left(r_2^2-r_1^2\right)}+\frac{v_2}{E_2}\right]}; \quad (1)$$

where r0 – inner radius of the inner (1st) roll; r1 – nominal outer radius of the 1st roll and nominal inner radius of the outer (2nd) roll; r2 – outer radius of the 2nd roll; p0 – internal pressure; p2 – external pressure; Δ1; 2 – initial tension between the rolls; E1 and v1 – elastic modulus and Poisson's ratio of the material of the 1st roll; E2 and v2 – elastic modulus and Poisson's ratio of the material of the 2nd roll.

Applying formula (1) to the joints $D_{-a}$ with $d^{+v}$ and $D_{-v}$ with $d^{+a}$, the contact pressure would be the same (here D = d; D – inner diameter of the outer roll; *d* – outer diameter of the inner roll; a and *v* – absolute value of the lower or upper deviation). It is obvious that in large-sized joints with a small bias, the influence of deviations will be negligible. However, in a small-sized pressed joint with a large bias (e.g., the wall thickness is only up to several times greater than the deviation value), the deviations can significantly affect the stress state in the pressed joint.

**The aim of the study** is to determine the dependence of the contact pressure of the pressed joint on the deviations of the surfaces being pressed, at the same initial bias.

## MODEL USED IN THE RESEARCH

The flat deformation state will be studied, i.e. it is assumed that there are no axial deformations. Friction and surface roughness between the injected rolls are neglected. It is assumed that the joint can be affected only by the internal pressure $p_0$ . In this work, the stress $N$, when changing the deviation of the outer diameter of the inner (1st) roll $n_1$ and the deviation of the inner diameter of the outer (2nd) roll $n_2$ , remains the same, i.e. the deviation $n_1$ will be changed in the range from 0 to $N$, and the deviation $n_2$ – from - $N$ to 0, so that

$$N = \text{const.} = n_1 - n_2 .$$

Two flat, axisymmetric models were created. The geometry of these models is presented in Fig. 1:

- In model 1, the pipe wall thicknesses remain unchanged when changing the deviations;
- In model 2, the inner and outer diameters of the pipe remain unchanged when changing the deviations.

In the contact area of the two-layer roll, the finite element mesh in the computational model is about 10 times denser than at the inner or outer radius of the roll (see Fig. 2). Two types of connections M-H and H-M were studied in the work. Here, the first letter indicates the material of the inner layer, and the second - the material of the outer layer. "M" (soft) indicates that the layer material is high-temperature polyethylene (PE-RT), with an elastic modulus $E_P$ = 0.65 GPa, Poisson's ratio $\nu_P$ = 0.42. Accordingly, the letter "H" (hard) indicates that the layer material is an aluminium alloy with an elastic modulus $E_A$ = 69 GPa, Poisson's ratio $\nu_A$ = 0.33.

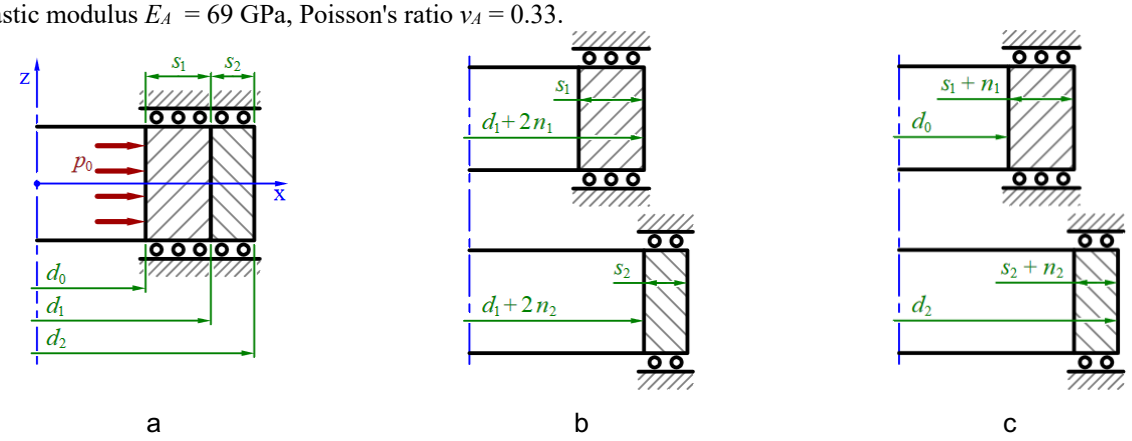



Fig. 1. **Flat, axisymmetric model of a two-layer roll: a – calculation scheme; b – model I; c – model II. Here n1 and n2 – deviation of the geometry of the inner and outer layers of the roll from the nominal value, respectively**

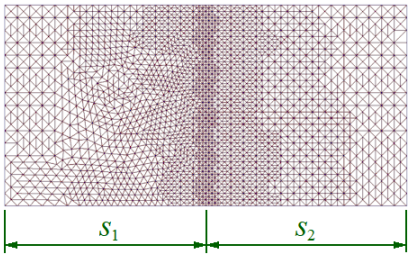



Figure 2. **Mesh of a two-layer roll finite element model (flat, axisymmetric model)**

## ANALYSIS OF RESEARCH RESULTS

The influence of deviations on the contact pressure, and at the same time on the stress state, at different sizes of the interference is presented in Fig. 3. Model 2 was “more sensitive” to the change in the interference size. At a small interference, when the interference is about 0.36 or less percent. of the outer diameter of the connection (or about 5 percent. of the total wall thickness of the connection), changing the dimensional deviations almost does not change the contact pressure (changed by only about 1.04 carats). When the interference is not less than 1.43 percent. of the outer diameter (or about 20 percent. of the total wall thickness), then when the deviations change from the smallest possible to the largest possible value, the contact pressure changes by up to 1.21 times. If we consider that a significant change in contact pressure is 10 percent or more, then dimensional deviations should be evaluated when the interference is about 0.7 percent. or more of the outer diameter of the joint (this would correspond to approximately 10 percent of the total wall thickness of the joint).

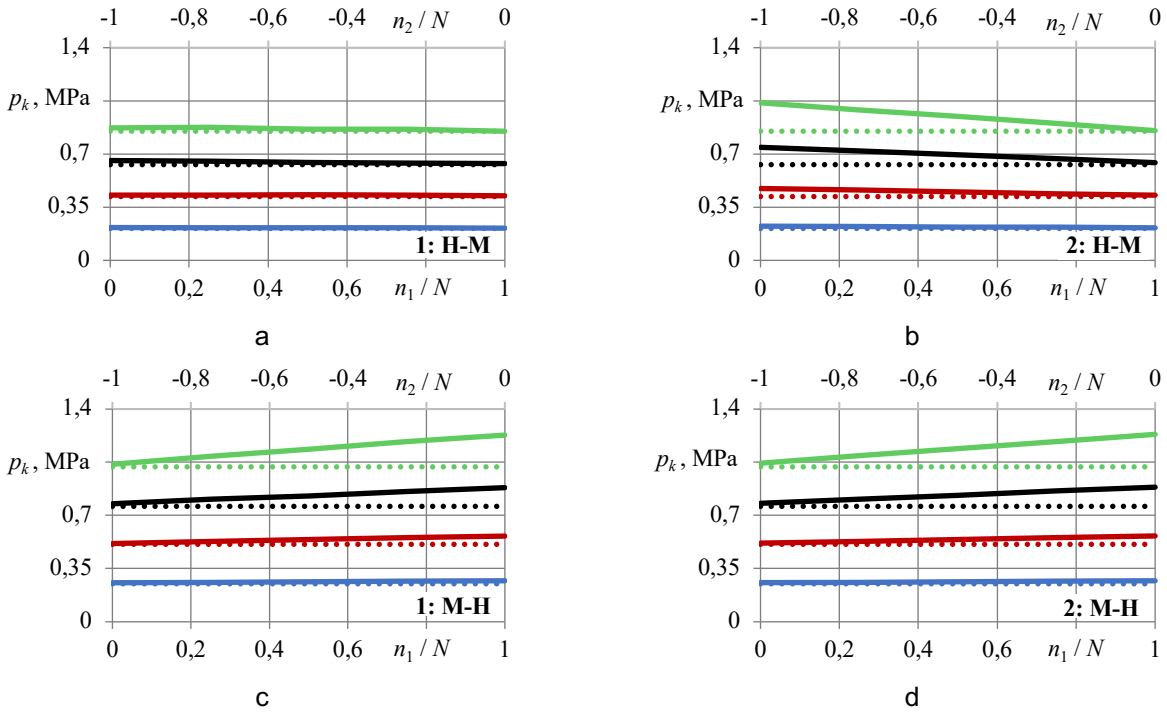



Fig. 3. **Dependence of contact pressure pk on deviations *n1* and *n2* and stress N, when: $p_0 = 0$; $d_2 = 14$ mm, $s_1 = s_2 = 0.50$ mm; ■ – $N = 0{,}025$ mm; ■ – $N = 0{,}050$ mm; ■ – $N = 0{,}075$ mm; ■ $N = 0{,}100$ mm; a – 1st model H-M type; b – 2nd model H-M type; c – 1st model M-H type; d – 2nd model M-H type; ( ——— ) – calculated using BEM; ( · · · · ) – calculated according to formula (1)**

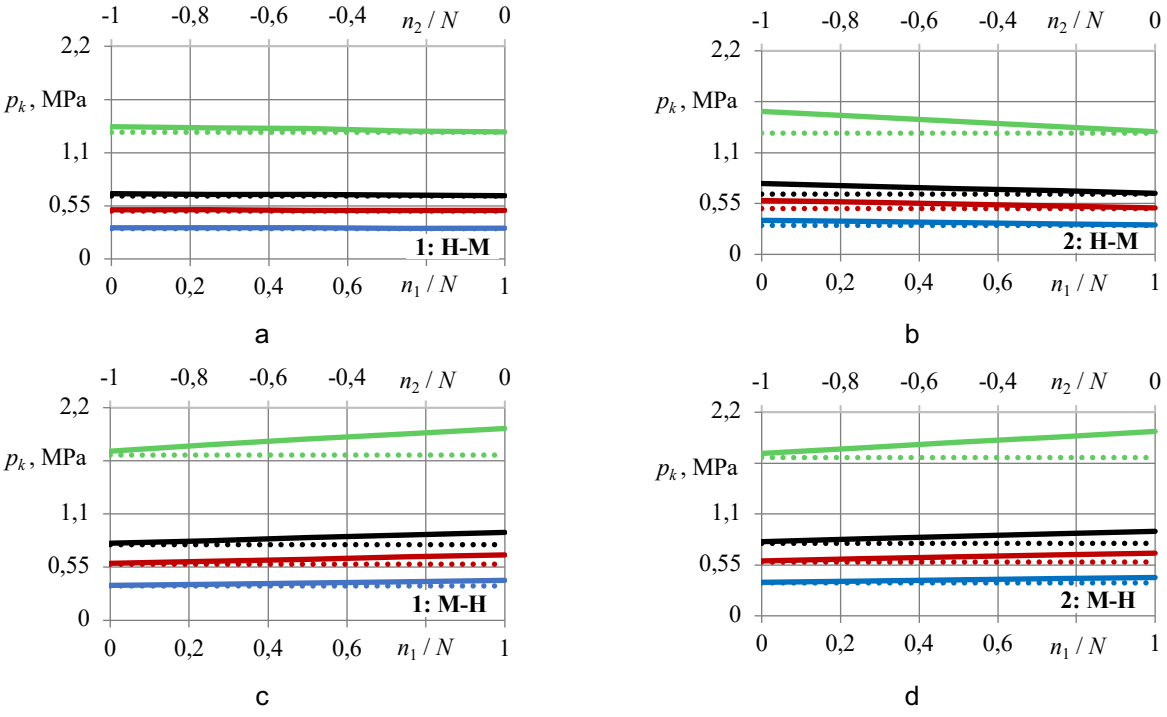



Fig. 4. **Dependence of contact pressure $p_k$ on deviations $n_1$ and $n_2$ and outer diameter $d_2$ , when: $p_0 = 0$; $N = 0{,}077$ mm; $s_1 = s_2 = 0{,}5$ mm; ■ – $d_2 = 20$ mm;■ – $d_2 = 16$ mm; ■ – $d_2 = 14$ mm; ■ –$d_2 = 10$ mm; a – 1st model H-M type; b – 2nd model H-M type; c – 1st model M-H type; d – 2nd model M-H type; ( ——— ) – calculated using BEM; ( · · · · ) – calculated according to formula (1)**

The influence of deviations and the outer diameter of the double-layer roll on the contact pressure is presented in Fig. 4. The contact pressure increases with decreasing diameter. The least "sensitive" to the change in deviations was the H-M type of model 1. Calculations showed that when changing the outer diameter, the "sensitivity" of the contact pressure to deviations, i.e., the ratio pk / pk (1), changes very slightly (here pk – contact pressure calculated using the finite element method; pk (1) – contact pressure calculated according to formula (1)). When the outer diameter is increased

by 2 times, when the resistance is constant and the deviations are changed, the maximum change in pk / pk (1) from 16.3 percent. decreased to 16.1 percent.

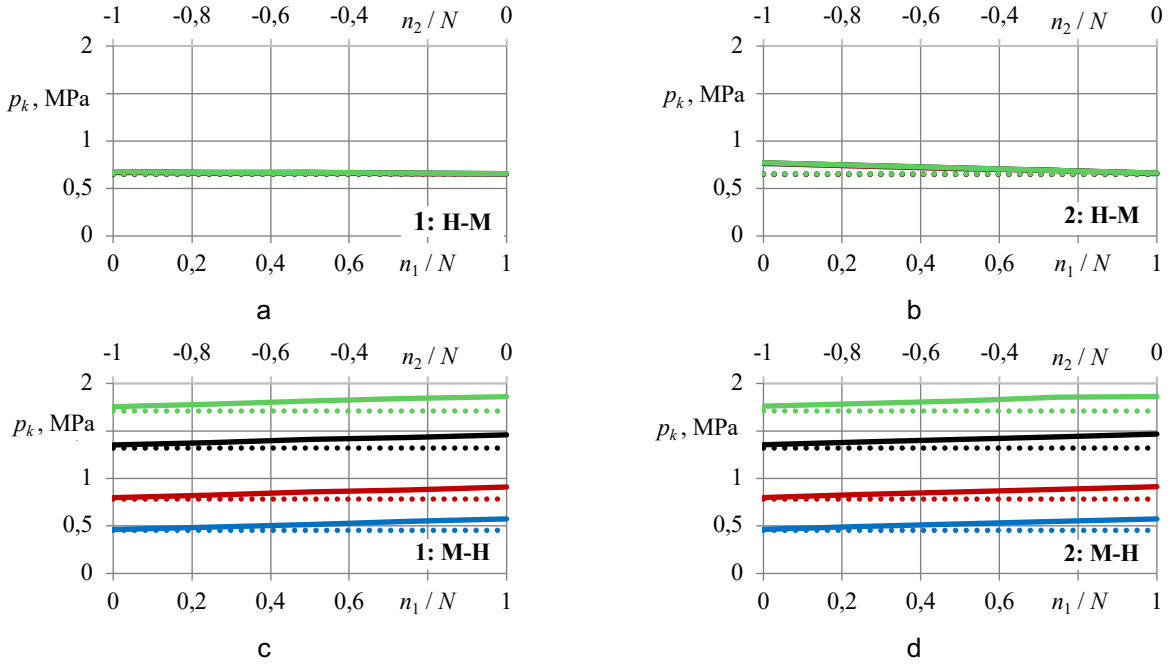
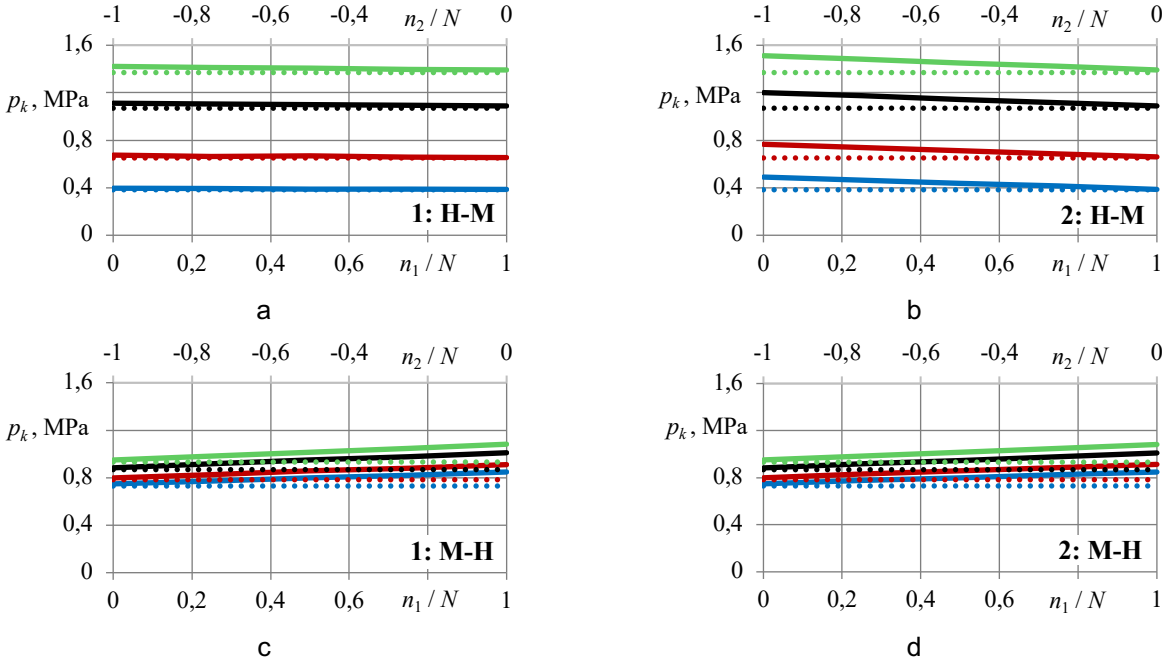



Fig. 5. **Dependence of contact pressure $p_k$ k on deviations $n_1$ and $n_2$ and inner layer thickness $s_1$ , when: $p_0$ = 0; $N$ = 0.077 mm; $d_2$ = 14 mm; $s_2$ = 0.5 mm; ■ – $s_1$ = 0.3 mm; ■ – $s_1$ = 0.5 mm; ■ – $s_1$ = 0.8 mm; ■ – $s_1$ = 1.0 mm; a – 1st model H-M type; b – 2nd model H-M type; c – 1st model M-H type; d – 2nd model M-H type; ( ——— ) – calculated using BEM; ( · · · · ) – calculated according to formula (1)**




6 Fig. **Kontaktinio slėgio $p_k$ priklausomybė nuo nuokrypių $n_1$ ir $n_2$ bei išorinio sluoksnio storio $s_2$ , kai: $p_0$ = 0; $N$ = 0,077 mm; $d_2$ = 14 mm; $s_1$ = 0,5 mm; ■ – $s_2$ = 0,3 mm; ■ – $s_2$ = 0,5 mm; ■ – $s_2$ = 0,8 mm; ■ – $s_2$ = 1,0 mm; a – 1-o modelio H-M tipas; b – 2-o modelio H-M tipas; c – 1-o modelio M-H tipas ; d – 2-o modelio M-H tipas; ( ——— ) – apskaičiuota taikant BEM; ( · · · · · ) – apskaičiuota pagal (1) formulę**

The influence of deviations and the thickness of the inner layer of the two-layer roll on the contact pressure is presented in Fig. 5. By increasing the thickness of the inner layer in both models 1 and 2, the contact pressure increases in the H-M type joints, while in the H-M type joints it practically does not change. By increasing the inner wall thickness by about 3 times, when the stress is constant and the deviations are changed, the maximum change in $p_k$ / $p_{k\,(1)}$ (1) obtained in the M-H type joint from 27.6 percent. decreases to 8.8 percent., while in the H-M type joint the change in $p_k$ / $p_{k\,(1)}$ increases slightly - in the 1st model from 2.6 to 4.3 percent., and in the 2nd model from 17.2 to 18.6 percent.

The influence of deviations and the thickness of the outer layer of the two-layer roll on the contact pressure is presented in Fig. 6. By increasing the thickness of the outer layer in both models 1 and 2, the contact pressure increases faster in H-M type joints than in M-H type joints. By increasing the outer wall thickness by about 3 times, when the stress is constant and the deviations are changed, the maximum change in $p_k / p_{k(1)}$ obtained in the M-H type joint practically does not change, while in the H-M type joint the change in $p_k / p_{k(1)}$decreases - in model 1 from 4.2 to 3.8 percent, and in model 2 from 28.9 to 10.4 percent.

The influence of deviations and internal pressure on the contact pressure is presented in Fig. 7. When increasing the internal pressure in both models 1 and 2, the contact pressure increases in the M-H type joints, while it practically does not change in the H-M type joints. When increasing the internal pressure from 0 to 1 MPa, when the stress is constant and the deviations are changed, the maximum change in $p_k / p_{k(1)}$ obtained in the M-H type joint decreases from 16.6 percent to 7.9 percent, and in the H-M type joint the maximum change in $p_k / p_{k(1)}$ decreases slightly - in model 1 from 3.6 to 5.1 percent, and in model 2 from 17.7 to 17.1 percent.

Regardless of the model used or the type of joint, the contact pressure calculated using the finite element method is always higher than the theoretical one, i.e. calculated using formula (1) (see Fig. 3-7).

Regardless of the model used, the contact pressure in M-H type joints obtained by applying the finite element method best agrees with the contact pressure obtained using formula (1) when the deviation of the inner layer is equal to 0, and the deviation of the outer layer is the largest possible (in absolute value), i.e. equal to the magnitude of the stress. The opposite trend was obtained in H-M type joints: the contact pressure obtained by the finite element method best agrees with the theoretical contact pressure when the deviation of the inner layer is the largest possible, and the deviation of the outer layer is equal to 0 (see Fig. 3-7).

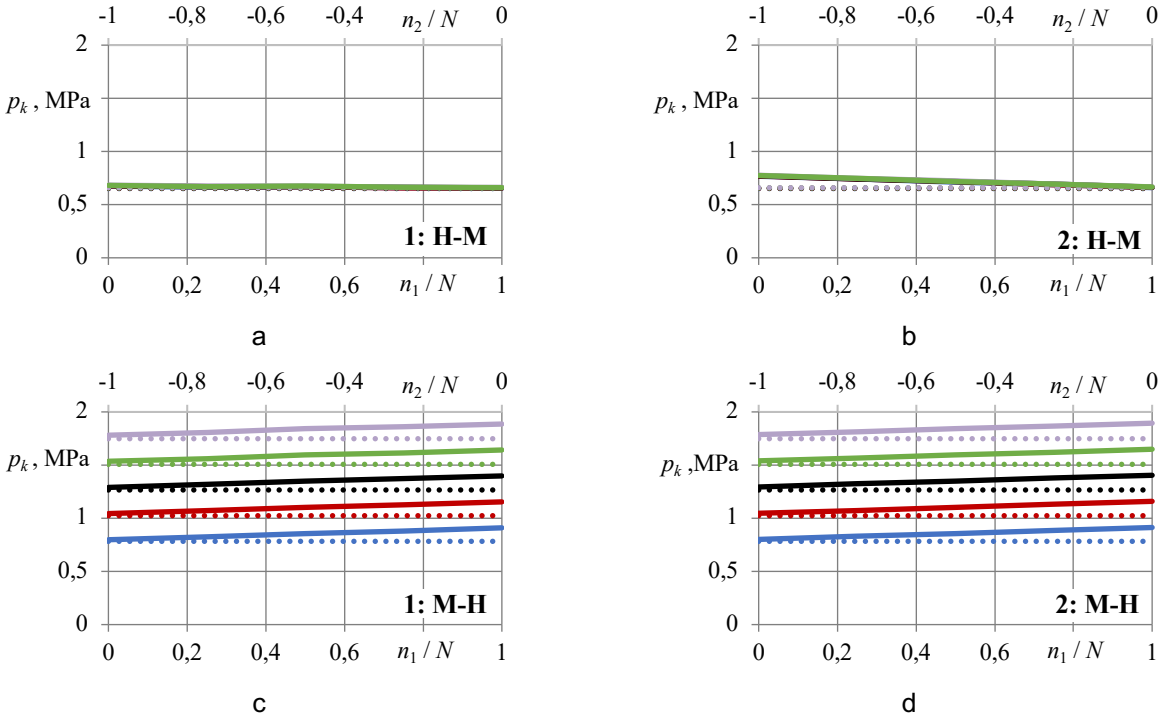



Fig. 7. **Dependence of contact pressure $p_k$ on deviations $n_1$ anf $n_2$ and internal pressure $p_0$, when: $N$ = 0.077 mm; $d_2$ = 14 mm; $s_1 = s_2$ = 0,5 mm; ■ – $p_0$ = 0; ■ – $p_0$ = 0,25 MPa; ■ – $p_0$ = 0,5 MPa; ■ – $p_0$ = 0,75 MPa; ■ – $p_0$ = 1 MPa; a – 1st model H-M type; b – 2nd model H-M type; c – 1st model M-H type ; d – 2nd model M-H type; ( ——— ) – calculated using BEM; ( · · · · ) – calculated according to formula**

## CONCLUSIONS

1. The geometric model, in which the stress is obtained by changing the wall thicknesses so that the inner and outer diameters of the double-layer roll remain unchanged, is from 0 to 25 percent more “sensitive” to deviations than the geometric model, in which the stress is obtained by changing the diameters so that the wall thicknesses of the roll remain unchanged.

2. In M-H type joints (the inner layer is less rigid), the contact pressure obtained by applying the finite element method best coincides with the theoretical contact pressure when the deviation of the inner layer is equal to 0, and the deviation of the outer layer is the largest possible (in absolute value), i.e. equal to the stress value. And in H-M type joints (the outer layer is less rigid), the contact pressure obtained by the finite element method best agrees with the theoretical contact pressure, when the deviation of the inner layer is the largest possible, and the deviation of the outer layer is equal to 0.

3. By changing the geometry of the joint (outer diameter from 10 mm to 20 mm, inner and outer layer thicknesses from 0.3 mm to 1 mm) and the deviation values from the smallest possible to the largest, at a stress of 0.077 mm, the calculated (using the finite element method) contact pressure differed from the theoretical one by approximately 2 to 18 percent.

4. In a pressed joint, where the stress is about 1 percent. of the outer diameter of the joint, or about 10 percent. of the total wall thickness of the joint, the contact pressure calculated by the finite element method can be more than 10 percent higher than the theoretical contact pressure. higher if the sizes of the deviations of the injected parts are evaluated.

5. Regardless of the model used or the type of connection, the contact pressure calculated using the finite element method is always higher than the theoretical one.

## REFERENCES

1. Bražėnas, A., Partaukas, N. (2009). Stress Strain State of the Two-Layer Mechanically Inhomogeneous Pipe at Elastic Loading Subjected to Internal Pressure. Proceedings of 4th International Conference ITELMS'2009, 72-77. https://itms.ktu.edu/wp-content/uploads/sites/311/2019/09/ITELMS-2009.pdf
2. Vaičiulis, D. (2013). Determination of Stress Strain State in Two-Layer Pipe Subjected to Hydrostatic Pressure at Plane Strain Condition under Elastic Loading. Proceedings of 8th International Conference ITELMS'2013, 262-266. https://itms.ktu.edu/wp-content/uploads/sites/311/2019/09/ITELMS-2013.pdf
3. Mikolainis, J., Bakšys, B. (2011). Experimental investigation of interference fit connection of mechanical components. Journal of vibroengineering. March 2012. Volume 14, issue 1, 73-78. https://core.ac.uk/download/pdf/323313132.pdf
4. Adhitheyan, A. M., Ananth, A., Ajith Kumar, S., Deepanraj, B., Saravanan, A. (2018). Comprehensive Analysis of Interference Fit and its Attributes. ICONNECT - 2k18 Conference Proceedings. Volume 6, Issue 07, 1-5. https://www.ijert.org/research/comprehensive-analysis-of-interference-fit-and-its-attributes-IJERTCONV6IS07124.pdf
5. Nguyen H. L., Lam V. P. (2022). Study of interference fit between steel and brass parts. EUREKA: Physics and Engineering, 5, 140-149. DOI: 10.21303/2461-4262.2022.002524.
6. Madej, J., Śliwka, M. (2021). Analysis of Interference-fit Joints. Appl. Sci. 2021, 11, 11428. https://www.mdpi.com/2076-3417/11/23/11428
7. Vaičiulis, D. (2020). Determination of Stress Strain State in Multilayer Cylinder Subjected to Hydrostatic Pressure under Elastic Loading. International Scientific Conference Intelligent Technologies in Logistics and Mechatronics Systems – ITELMS'2020, 81-86. http://www.edlearning.it/ebook/DX01_ITELMS.pdf

PANEVĖŽIO KOLEGIJA ISSN 2029-1280, eISSN 2669-0071. Taikomieji tyrimai studijose ir praktikoje – Applied Research in Studies and Practice, 2024, 20.

# FUTURE HEALTHCARE DELIVERY VIA TELE-NURSING AND TELE-REHABILITATION

***Justina CHANKINIENĖ[ab], Domilė AUGULĖ[b]***

*[a] Panevėžys Republican Hospital, Lithuania*
*[b] Panevėžio kolegija / State Higher Education Institution, Lithuania*

**Annotation.** To combat healthcare-associated infections, especially during coronavirus disease (COVID-19) period, access to face-to-face or traditional consultations has been significantly limited, and the healthcare systems have resorted to remote service delivery techniques such as tele-health. Tele-health can be defined as any intervention in which clinical information is transferred remotely between patients and healthcare professionals. Tele-health helps to provide health education, to give effective applications of various therapies and monitor of symptoms and adverse events. One of the more frequently, widely and modernly used health care services are tele-nursing and tele-rehabilitation. Telehealth care, led by nurses, was expanded with the advent of the COVID-19 pandemic, which had as its strengths care provided without the risk of transmission of SARSCoV-2, greater access to healthcare, continuous and patient-centered care and increased satisfaction among patients and nurses. Several studies related application of tele-rehabilitation already demonstrates effectiveness, safety, and feasibility for individuals with different physical impairment. However, some factors still need better understanding in tele-nursing and tele-rehabilitation implementation stages, highlighting the different strategies used and its' beneficial aspects for patients using services remotely more often and health care professionals providing the best health care delivery by telephone, text message, email, chat or video call.

**Keywords**: tele-health, tele-nursing, tele-rehabilitation

## INTRODUCTION

To combat healthcare-associated infections, access to face-to-face or traditional consultations has been significantly limited, and the healthcare systems have resorted to remote service delivery techniques such as tele-health (Abuyadek et al., 2024). Growing evidence supports the viability and efficacy of remote healthcare (Braga et al., 2024). Tele-medicine, tele-rehabilitation, and tele-health are part of the health informative technologies trend (Azhar et al., 2024).

According to Sharma (2024), American Tele-medicine Association states that tele-health has the potential to offer 50% of medical services. Tele-nursing refers to nursing activities that support the delivery, management, and coordination of healthcare services for patients and their families from a physical distance using information and communication technologies (Kamei et al., 2024). Tele-nursing approach transcends spatial limitations and enables nurses to promptly offer services based on the patient's needs. Tele-nursing is positioned to emerge as a pioneering healthcare delivery system in the digital age and poised for substantial growth (Mun et al., 2024).

The idea of tele-rehabilitation got popularized in times of pandemics such as COVID-19 to provide medical services and avoid the spread of infections because health care systems have undergone great transformations because of evolution in digital communication (Aman et al., 2024). Due to the lockdown, patients experienced delays, discontinuances, and cancellations to their treatments, weakening their effectiveness. As a result, the pandemic created the need for new health services by enhancing remote performances and developing national guidelines for tele-health (Lauriello et al., 2024). With remote care, the range of nursing care and rehabilitation services continues to expand (Ariyanto & Rosa, 2024). It is important to successfully implement these forms of tele-health, considering the needs for care and rehabilitation, the comfort provided by personalized medicine technologies (Vladymyrov et al., 2024).

A growing number of papers and research works on tele-medicine highlight an increasing interest in this field (Lauriello et al., 2024). In view of the need to deal with high healthcare costs, on the one hand, and increased demand for provision and accessibility of services, on the other hand, it is expected that the use of tele-medicine will intensify (Grinberg & Sela, 2023). Digital health solutions are rapidly growing, both in number and capability – despite this, confidence in these solutions among stakeholders – including clinicians and patients – remains low. In such a fast-advancing field where it is challenging to determine what is best for implementing health tele-services such as tele-nursing and tele-rehabilitation, considering benefits and difficulties of using it becomes an issue (Du Toit et al., 2024).

In our own thoughts, the scientific problem of future healthcare delivery via tele-nursing and tele-rehabilitation revolves around the challenges of implementing and optimizing these remote healthcare services to effectively meet the growing demand for accessible, high-quality, and cost-effective care. Since the tele-health topic is still being implemented in a medicine field of research, there is currently a lack of new knowledge, how the health system and patients can benefit from tele-services and what obstacles it can create during the implementation process of tele-services such as tele-nursing and tele-rehabilitation. Also, no studies have been observed that would link the provision of nursing and rehabilitation services together in tele-way.

**The aim of the research:** to review future healthcare delivery via tele-nursing and tele-rehabilitation theoretically.

**The tasks of the research:**

1. To present the concept of tele-medicine.
2. To highlight the benefits to health care by using tele-nursing and tele-rehabilitation services.
3. To discuss the difficulties of implementation of tele-nursing and tele-rehabilitation in health care.

**Research method**: analysis of scientific literature – by using the EBSCO Publishing, MDPI, NCBI PubMed and ResearchGate scientific publication databases, scientific articles in English from 2024 were searched and analysed using main keywords of the topic such as tele-health, tele-nursing and tele-rehabilitation. Overall, 16 scientific and the newest articles describing and investigating the most important information related concept of tele-medicine, the benefits of healthcare by using tele-nursing and rehabilitation services, the difficulties of implementation of tele-nursing and tele-rehabilitation in healthcare, were found. The analysed scientific sources not only helped to understand the research problem, relevance and significance, but also to predict the larger course of the research.

## CONCEPT OF TELE-MEDICINE: LITERATURE REVIEW

Tele-medicine, now defined as tele-health or e-health, is becoming a popular alternative method to provide healthcare services supported by information and communication technologies (Lauriello et al., 2024). Remote care for users of healthcare services has been applied for various purposes, from screening to rehabilitation, reducing waiting times for appointments and travel costs (Gimenez et al., 2024). Allied healthcare professionals predominantly turned to tele-practice as an alternative means of service delivery. Tele-practice is defined as the use of tele-communication technologies to deliver services, such as health promotion, assessment or intervention, to those who are in a different physical location than the service provider (Du Toit et al., 2024). Instead of having face-to-face meetings, patients and their caregivers communicate through media made available to patients and their families (Ariyanto & Rosa, 2024).

Rehabilitation services found new opportunities through digitisation, which led to the tele-rehabilitation, a specialized branch of tele-medicine for rehabilitation, consultation, and monitoring activities (Lauriello et al., 2024). The degree to which tele-rehabilitation was accepted among different rehabilitation professionals during the COVID-19 pandemic. Results showed that 52% of the therapists who participated in one study used tele-rehabilitation for most or all their patients during the first wave of COVID-19. Of the professionals who engaged in tele-rehabilitation during the pandemic, 46% planned to continue using it regularly after the pandemic (Braga et al,, 2024).

Tele-rehabilitation provides rehabilitatory facilities to people even if the client or patient is not able to reach the rehab center due to financial, geographic or disability such as virtual diagnosis, assessment, prognosis and treatment of patients or clients (Aman et al., 2024). Tele-rehabilitation can serve as the next step for patients discharged from inpatient rehabilitation, allowing them to continue physical therapy and promote further recovery (Vladymyrov et al., 2024). For example, unlike web-based or mobile app-based exercise interventions, and exergaming, tele-exercise enables synchronous two-way video and audio transmission, allowing both the instructor and the participants to see, hear and interact with each other in real-time, like exercise intervention delivered in physical settings (Lee et al., 2024). Also, must be noted, Du Toit et al. (2024) analysed 30 province mothers' experience who used tele-assessment format for their children. Results showed majority of users reported positive experience of tele-services and user-friendly platform. Most of users felt the meeting as natural as if the assessment were conducted in person and communication with clinician was good enough (Figure 1). Furthermore, tele-rehabilitation presents higher levels of satisfaction and adhesion among patients, with scores equal to traditional rehabilitation (Braga et al., 2024).

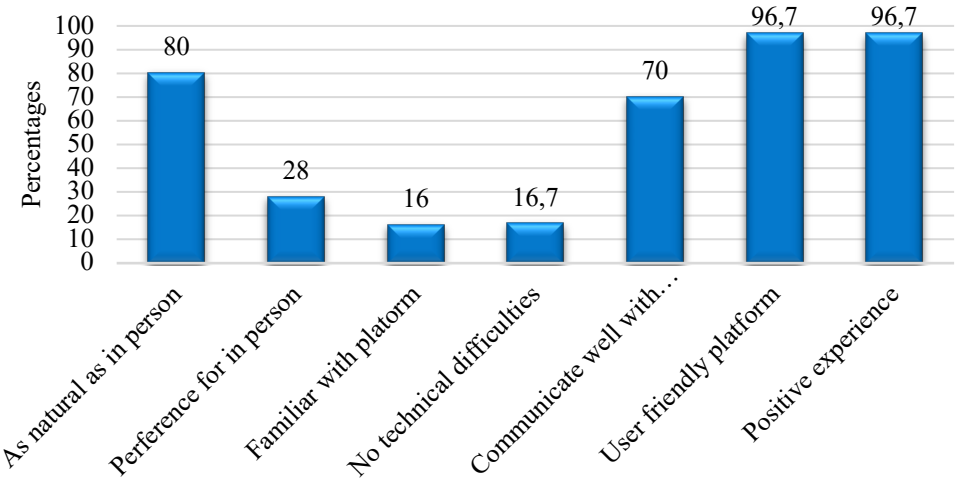



Figure 1 **Experience of tele-assessment format (**Du Toit et al., 2024)

In the context of nursing, in mid-2004, several tele-nursing services in Canada, England and Wales already had the method implemented which, like tele-medicine, is one of the methods of monitoring healthcare users with specific role of nurses. Tele-health care, led by nurses, was expanded with the advent of COVID-19 pandemic (Gimenez et al., 2024). Tele-nursing represents a facet of tele-health wherein nurses deliver healthcare services from a distance, utilizing

diverse audio or visual methods (Nejad et al., 2024). Tele-nursing encompasses a spectrum of activities, ranging from nurses counselling patients over the phone to delivering further complex nursing services at the patient's home via cameras and remote monitoring devices (Mun et al., 2024). The focus on lowering the cost of health care services, the rise in elderly and chronically ill people, and the growing desire to provide health care to remote, rural, and sparsely inhabited areas might all contribute to the tele-nursing delivery trend (Sharma, 2024). These days, tele-nursing includes health education services such as such as tele-diagnosis, tele-consultation, and tele-monitoring. It can be named more specifically like regular remote monitoring of vital signs, electrocardiogram or blood pressure, and remote doctor or nurse-patient consultations as needed (Sharma, 2024). Nejad et al. (2024) claims that continuous monitoring in tele-nursing promotes positive changes in health behaviour. Many care domains, by Ariyanto & Rosa (2024) thoughts, can benefit from the application of tele-nursing practices, such as:

- home visits;
- secure email messaging systems with hotline support;
- discharge planning;
- chronic tele-nursing in the department;
- tele-nursing for illnesses and emergencies, including outpatient care;
- call center services; triage.

Tele-communication technologies in health care are used to approach and as well as to improve the care in people in vulnerable and remote areas with different disabilities with the goal to save time and resources in system of health (Aman et al., 2024). Tele-services result in the improvement of accessibility and affordability of care services for all people who face difficulties (Kamei et al., 2024). Researches about tele-health concern the use of informative communication technologies to bridge geographic gaps between patients and providers and between providers and each other (Azhar et al., 2024). According to Vladymyrov et al. (2024), tele-services should be viewed as a process that includes two key aspects:

1. Services at the individual level, involving the diagnosis and attention to the patient's own attitudes.
2. Services at the social level, which involves creating favorable conditions for the patient's successful social adaptation and addressing society's negative attitudes towards the patient.

To conclude, Gimenez et al. (2024) highlights the important fact that tele-services should be used as a complement to healthcare, with the aim of promoting better access conditions, not replacing actions already carried out in person in healthcare services.

## THE BENEFITS OF HEALTHCARE BY USING TELE-NURSING AND REHABILITTION SERVICES

The tele-health trend, with its potential to address many key challenges in healthcare, has been emerging worldwide (Abuyadek et al., 2024). Azhar et al. (2024) states that using technology to provide health services remotely has several advantages. Tele-services, a field that relies heavily on information technology, offers many benefits to patients, healthcare workers, and governments too (Ariyanto & Rosa, 2024). Healthcare workers like nurses and physiotherapists can continuously oversee, educate, follow up, and provide multidisciplinary treatments for patients such consultations, interventions, support, etc. Tele-medicine, from the point of view of governments, helps the health system face the complex challenges of aging populations, increased chronic illness, and lack of manpower (Grinberg & Sela, 2023).

The main idea of delivering tele-services is that technology is part of disease prevention measures aimed at reducing the burden on healthcare services and reducing the risk of disease transmission (Arifin et al., 2024). Rehabilitation is significant for people in order to enhance their ability to work, live an independent life and improve their daily life activities. In a constantly changing modern world transformations occur with the passage of time as new technologies are being introduced in health care industry – tele-rehabilitation is one of the most important transformations occurred in rehab system (Aman et al., 2024). Meanwhile, tele-nursing can also be equated with today's transformation, since it can bring nursing care to proximity involvement in public health and family practices (Sharma, 2024).

Tele-services help to increase patient's commitment towards improving their condition in many ways such as the care given to patients through tele-rehabilitation sessions are affordable and are more convenient (Aman et al., 2024). Azhar et al. (2024) explain that patients are empowered and given the ability to take responsibility for their medical needs and interventions when, for example – tele-rehabilitation, is used to provide care in their home or other living environment. This is because it allows for individual care, control and choice. Sharma (2024) adds that tele-health services enhance the decision-making of the patients and their families by educating them on their illnesses.

One of the most important benefits of tele-services is increasing access to customers living in remote areas (Du Toit et al., 2024). Tele-rehabilitation gives access to people from all parts of global village, underprivileged communities can get access to rehabilitation sessions easily (Aman et al., 2024). This is crucial particularly in public health crises such as epidemics and natural disasters, in remote and rural areas, especially in countries with a large population (Abuyadek et al., 2024). Despite some usability issues, using health services remotely offers much-needed benefits for individuals who live in remote areas or who want access to medical information and treatment (Azhar et al., 2024). For example, tele-rehabilitation can be used for the prescription and evaluation of aids, orthoses, and prostheses (Lauriello et al., 2024).

Lee et al. (2024) note that tele-services most important addresse patients‘ environmental barriers, such as transportation and accessibility.

Tele-rehabilitation is essential as it helps in reducing high demands which results in saturation of sources and generation of waiting lists so people will have more chances of access to health care services (Aman et al., 2024). While tele-nursing interventions are easier to accept and are efficient in terms of time and place (Arifin et al., 2024). Overall, virtual facilities address disparities in health services stemming from shortages of professionals, brief visit durations, and the increasing prevalence disorders (Abuyadek et al., 2024). With the use of informative communication technologies healthcare providers can contact patients who cannot access traditional medical services thereby improving continuity of care for individuals with disabilities (Azhar et al., 2024).

Lauriello et al. (2024) in their paper asked 48 patients, who were using tele-rehabilitation services, to express the main advantages of tele-rehabilitation. Most of the survey participants emphasized the time saving, more than a third of the respondents singled out the cost-efficiency and a fifth of the respondents highlighted no individual protection devices (DPI). Only a little more than 6 percent of participants saw no advantages in tele-rehabilitation (Figure 2). Meanwhile, Nejad et al. (2024) distinguish that there are essential advantages of tele-nursing from the patients' perspective also – it provides cost-effective interventions, facilitates early diagnosis of symptoms, ensures quality assurance, provides health education and identifies gaps in post-discharge care. Braga et al. (2024) say that many conducted studies show that tele-health services may result in similar or lower costs than in-person. Gimenez et al. (2024) adds that tele-nursing improves patients‘ outcomes such as increased user satisfaction, reduced visits to hospital services due to lack of assistance, quality of care and reduced costs associated with the long distances travelled by patients to access in-person care. Sharma (2024) summarizes that tele-health services overall enhances patient comfort to get services from home and can cause even a shorter duration of hospitalization.

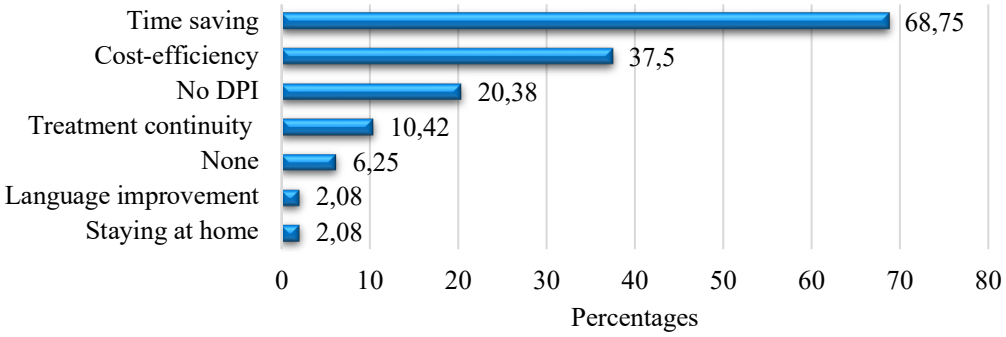



Figure 2 **Tele-rehabilitation advantages according to users’ points of view (**Lauriello et al., 2024)

There are a lot of positive outcomes of the research how tele-rehabilitation is very effective for various conditions such as rheumatoid arthritis, multiple sclerosis, and stroke (Aman et al., 2024) as well as other important occupational, communication, deglutition, behavioural, cardiological, and respiratory disorders (Lauriello et al., 2024). Also, Sharma (2024) emphasizes that remote health care can also help with monitoring patients who suffer from chronic illness very well because tele-nursing:

1. aids in distance monitoring and coordinating home care.
2. teaches how to manage disease symptoms.
3. helps improve compliance with prescribed care.
4. decreases both emergency visits and outpatient department visits.

To sum up with Grinberg & Sela (2023) statements, tele-medicine services such as tele-nursing and tele-rehabilitation main benefits are about providing accessibility to treatment for patients who have so far avoided using face-to-face health services; empowering health care specialists with the use of technology and distant services by helping to develop their role; reducing the number of ‘no-shows’; improving the nurse-patient ratio, and radically cutting costs.

## THE DIFFICULTIES OF IMPLEMENTATION OF TELE-NURSING AND TELE-REHABILITATION IN HEALTHCARE

Technical issues are among the reasons that lacked in providing the facility of tele-rehabilitation (Aman et al., 2024). Tele-rehabilitation required technological supports (tablet, smartphone, computer), as well as a stable and high-quality Internet connection and a therapy-dedicated station (Lauriello et al., 2024). Sharma (2024) explains that implementation of tele-nursing also requires extremely plenty, modern and high-quality technologies such as the tele-health hardware (monitor, electronic board, pressure cuff, pulse oximeter, scales, video camera, laptop, computer, electrocardiogram leads, etc.) and the software that helps to create electronic health records (demographics, vital signs, weight, blood sugar results, etc.).

High cost is one of the most limitation or barrier to use tele-rehabilitation from specialists‘ side (Aman et al., 2024). Viewing from the other side, there is a high cost in equipment purchase and monitoring and the inability of the

patient to use the equipment for tele-health services (Sharma, 2024). In simple terms, inefficiently allocation many resources for the new tele-medicine technologies in an attempt to attract a younger, healthier, and more profitable population can have huge economic damage (Grinberg & Sela, 2023).

The main barriers to implement tele-services include data costs, trouble establishing rapport with clients, lack of access to necessary technologies and ethical issues including confidentiality, payment and clinician's competency to provide tele-practice. (Du Toit et al., 2024). Sharma (2024) adds that the legal issues, such as malpractice, negligence, and accountability, are still repeated and challenging to address. Ethical issues also include maintaining autonomy and patient integrity and being harmless to clients.

Gimenez et al. (2024) explain that to perform tele-health services all health care professionals, including nurses and physiotherapists, must have a have scientific knowledge, technical skill and creativity to give such services properly and efficiently. Kamei et al. (2024) specify the need of health care specialists to acquire new knowledge, skills, and key competencies, such as tele-communication and information risk management prior to entering tele-services to practice. Mun et al. (2024) highlight that preparation for implementation of tele-nursing or tele-rehabilitation enhancing future health care professionals' understanding of tele-services and establishing a robust human infrastructure is pivotal. Grinberg & Sela (2024) emphasize that healthcare profesionals are required to have high social and interpersonal skills, and communication skills to provide quality care similar to face-to-face sessions.

Lauriello et al. (2024) research results showed that the majority of the tele-rehabilitation users defined distraction aspect as a most common disadvantage. More than a third of the respondents admitted the logistical difficulties and almost a fifth of the respondents revealed that lack of comparison with other users is one of the key disadvantages of tele-rehabilitation. Almost one tenth of participants said that they cannot describe any disadvantages of using tele-rehabilitation services (Figure 3). However, Azhar et al. (2024) claims that to provide health services remotely may have difficulty reaching a hospital, clinic, or doctor. Lee et al. (2024) report that there are some negative perceptions of tele-services, such as mostly technical barriers and compromised supervision quality compared to direct consultations.

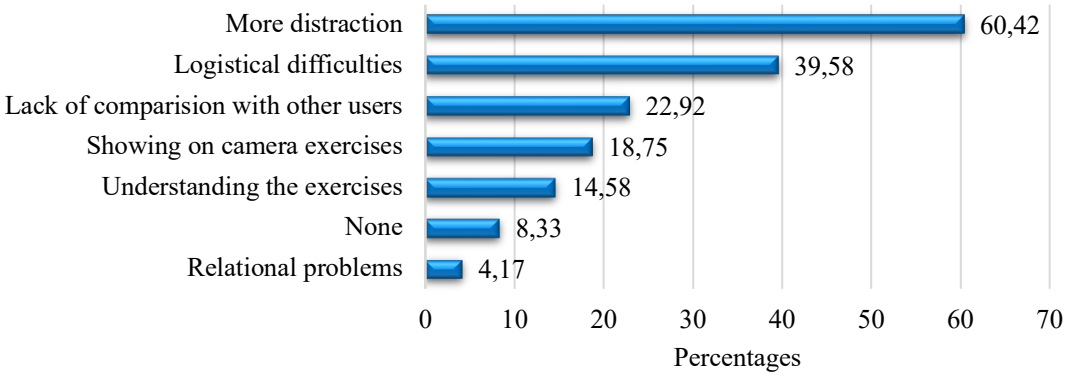



Figure 3 **Tele-rehabilitation disadvantages according to users' points of view (**Lauriello et al., 2024)

Mun et al. (2024) made research from 188 nurses about their individual, technology acceptance and perceptions factors of implementing tele-nursing. Tele-nursing experience, observation of tele-nursing during clinical practice, and exposure to tele-nursing education was found as a significant factors of attitude formation towards tele-nursing. Lack of knowledge and awareness could impede the recognition and utilization of tele-health services and potentially hinder the broader adoption of these advancements. Perceived usefulness, social influences, innovativeness, and self-efficacy were identified as key determinants in shaping nurses' attitudes toward tele-nursing. Kamei et al. (2024) add that if nurses will not have enough positive motivation, confidence, understanding, skills and attitude to implement tele-nursing in practice despite individual factors this process can get worse desperately. Grinberg & Sela (2023) discusses in their paper that using technology in practice could undermine their confidence in the question of whether nurses or physiotherapists professional qualifications and skills, which were acquired through face-to-face sessions, would suffice to cope with the unfamiliar ground in a way that allows them to provide high-quality professional care and rehabilitation, and to implement their and their colleagues' authority.

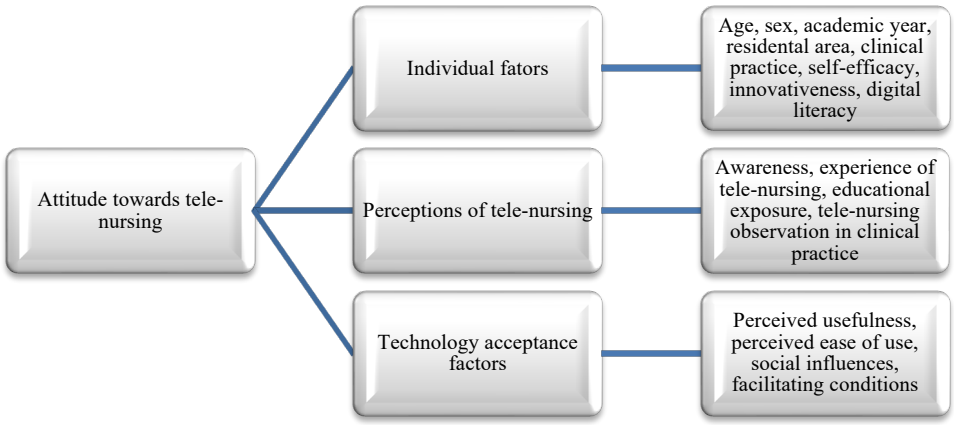



Figure 4 **Individual factors, technology acceptance factors and perceptions of nurses' attitude towards tele-nursing (**Mun et al., 2024)

Braga et al. (2024) claim that access to tele-health services and implementation of it, could be a viable means of service delivery in countries of high, mid, and low socioeconomic status, nevertheless, some barriers need to be surmounted. To summarize, Sharma (2024) explains, that real obstacles of implementation are mostly related to cost, medical competences and communication skills of professionals, patients' comfort and digital literacy.

## CONCLUSIONS

1. Tele-medicine means all encounters between patients and medical staff in which the parties are not in the same location, but connected using technological means such as telephone, text message, email, chat, and video call. Tele-nursing and tele-rehabilitation are subgroups of telemedicine and are defined as providing remote nursing (such as management, guidance, and control) or rehabilitation (such as assesment, intervention and monitoring) services.
2. The main benefits of using tele-nursing and tele-rehabilitation services can be divided to physical, social, geographical, and financial.
3. The significant challenges of implementation tele-nursing and tele-rehabilitation services can be attributed to medical, technological, social and economic.

## REFERENCES

Abuyadek, R. M., Hammouda, E. A., Elrewany, E., Elmalawany, D. H., Ashmawy, R. Zeina, S., Gebreal, A. & Ghazy, R. (2024). Acceptability of Tele-mental Health Services Among Users: A Systematic Review and Meta-analysis. BMC Public Health, 24(1), 1143-1161. 10.1186/s12889-024-18436-7.

Aman, Z., Shakeel, K., Iqbal, A., Sareer, R., Shah, I. A. & Ullah, I. (2024). Knowledge, Attitude, and Barriers Towards Telerehabilitation Based Physical Therapy in Peshawar: A Descriptive Cross-Sectional Study. African Journal of Biological Sciences, 6(15), 5981-5992. https://doi.org/10.48047/AFJBS.6.15.2024.5981-5992

Arifin, A., Yudha, E. K. & Haryanto, M. S. (2024). Impact of Telenursing Implementation on Diet Compliance and Blood Pressure in Patients with Hypertension. Fundamental and Management Nursing Journal, 7(1), 1-7. https://doi.org/10.20473/fmnj.v7i1.49450

Ariyanto, H. & Rosa, E. (2024). Effectiveness of telenursing in improving quality of life in patients with heart failure: A systematic review and meta-analysis. Journal of Taibah University Medical Sciences, 19(6), 664-676. 10.1016/j.jtumed.2024.04.009.

Azhar, M. P., Kristiyanto, A. & Riyadi, S. (2024). Differences in the interaction effect between telerehabilitation self-stretching and telerehabilitation self-massage on DOMS. Health Technologies, 2(2), 52-59. 10.58962/HT.2024.2.2.52-59.

Braga, L. W., Oliveira, S. B. & Souza, L. M. N. (2024). Telerehabilitation from the perspective of patients and healthcare providers: A 3-year follow-up study. NeuroRehabilitation, 55(1), 103-115. 10.3233/NRE-230385.

Du Toit, M. N., Eccles, R., Westwood, K., Graham, M. A. & Van der Linde, J. (2024) Caregivers' perspectives of early developmental tele-assessments in challenging circumstances. South African Journal of Communication Disorders, 71(1), 1-9. 10.4102/sajcd.v71i1.1037.

Gimenez, V. C. A., Almeida, G. M. F., Cyrino, C. M. S., Lemos, C. S., Favoretto, C. & Avila, M. (2024). Telenursing in the postoperative period: a scoping review. Revista Brasileira de Enfermagem, 77(3), 20240066-20240077. 10.1590/0034-7167-2024-0066.

Grinberg, K. & Sela, Y. (2023). The Quality of Telenursing—Israeli Nursing Staff's Perceptions. Healthcare, 11(22), 2915-2925. 10.3390/healthcare11222915.

Kamei, T., Kawada, A., Kakai, H., Yamamoto, Y. Nakayama, Y., Mitsunaga, H. & Nishimura, N. (2024). Japanese nurses' confidence in their understanding of telenursing via e-learning: A mixed-methods study. Digital Health, 10, 1-16. 10.1177/20552076241257034.

Lauriello, M., Angelone, A. M., Iannotti, S., Nardecchia, E., Scopano, B., Fioretti, A., Ciancarelli, I. & Eibenstein, (2024) A. Audiophonologopedic Telerehabilitation: Advantages and Disadvantages from User Perspectives. Children, 11(9), 1073-1084. https://doi.org/10.3390/children11091073

Lee, J. L. C., Chan, K. O. W., Kwan, E. Y. C. & Wong, A.Y. L., Kwan, Rick. (2024). Vitality at home: a phenomenological study of tele-exercise in women aged 80 and older. European Review of Aging and Physical Activity, 21(1), 25-37. 10.1186/s11556-024-00360-9.

Mun, M., Subin, C. & Kyungmi., W. (2024). Investigating perceptions and attitude toward telenursing among undergraduate nursing students for the future of nursing education: A cross-sectional study. BMC Nursing, 23, 236-250 10.21203/rs.3.rs-3872078/v1.

Nejad, F. A., Naderifar, M., Asadi-Bidmeshki, E., Firouzkouhi, M, reza & Abdollahimohammad, A. (2024). Effect of Telenursing Training on Job Burnout in Nurses with a History of COVID-19. Frontiers in Health Informatics, 13, 184-191. 10.30699/fhi.v13i0.544.

Sharma, S. (2024). Future Healthcare Delivery via Telenursing: A Prospective Vision. Research Exploration: Transcendence of Research Methods and Methodology, 216-227. Source: https://www.researchgate.net/publication/382337420_Future_Healthcare_Delivery_via_Telenursing_A_Prospective_Vision

Vladymyrov, O., Semykopna, T., Vakulenko, D., Syvak, O. & Budnyk, M. (2024). Telerehabilitation Guidelines for Patients with Breast Cancer. International Journal of Telerehabilitation, 1-76. 10.5195/ijt.2024.6640.

PANEVĖŽIO KOLEGIJA ISSN 2029-1280, eISSN 2669-0071. Taikomieji tyrimai studijose ir praktikoje – Applied Research in Studies and Practice, 2024, 20.

# VIABILITY OF THE HYDROGEN ENERGY

*Iker Diaz ELIPE[ab] , Haritz Dominguez JARAMILLO[ab], Daiva STANELYTĖ[c]*

[a] *Klaipedos valstybine kolegija – Higher Education Institution, Lithuania*
[b] *Universidad del País Vasco UPV/Euskal Herriko Unibertsitatea EHU*
[c] *Lithuanian Energy Institute, Lithuania*

**Annotation.** This article review examines the potential of hydrogen as a key solution to decarbonize energy systems and reduce global greenhouse gas emissions. In the research has been analysed various production methods, focusing on electrolysis powered by renewable energy sources, evaluating the environmental and technical challenges associated with scaling up renewable hydrogen production. Using a combination of studies, the article evaluates the efficiency and sustainability of current hydrogen related technologies. The research reveals that while big progress has been made in improving electrolyser efficiency and reducing costs, challenges remain in achieving large-scale deployment due to infrastructure limitations and energy storage issues. The study concludes that green hydrogen has substantial potential to contribute to the global energy transition, but its widespread adoption will require continued investment in research, policy support and infrastructure development. These results suggest that hydrogen, if integrated with existing renewable energy systems, could play a critical role in achieving net-zero emissions targets by nearly future.

**Keywords**: green hydrogen; renewable energy; energy transition; decarbonization

## INTRODUCTION

Raw materials are getting scarce due to the constant development of new technologies and the needs of people. The mitigation of climate change depends on the use of different kinds of energy sources away from fossil fuels.

Despite the fact that numerous renewable energies have been developed during the last years, none of them have had the impact to substitute the polluting energies. This is the main reason for the several side effects in the daily life of the people. It is important to consider all the benefits given by different sorts of possibilities, analysing and applying them.

Green hydrogen has the potential to solve those problems in a wide range of aspects, such as industry, transport and residential applications. Especially in terms of decreasing the contamination of the planet which is provoking heavy changes on it. Unless drastic measures are taken to reduce the carbon dioxide released, the outcome will be catastrophic.

The objective of this article is demonstrating the potential of the hydrogen as a sustainable energy source. For that, the main tasks to take in account are:

1. To analyse the production of hydrogen and its use in the industrial area.
2. To compare the hydrogen storage and transportation methods.
3. To determine the current hydrogen use given to hydrogen.

## THE RESEARCH METHODS

This research has used a quantitative research method focused at analysing the data from diverse studies. The principal keywords used are all related with hydrogen, from the production to the usage of hydrogen in different scenarios. The research has analysed the advantages and disadvantages of the implementation of hydrogen as an alternative energy source. The principal databases used are *Science Direct* and *IEEE*, with articles from 2018 to present.

The main keywords used in the research are the ones shown in the following table. All of them are related to green hydrogen and its use. Example of that is the transport and production of this new renewable source.

Additionally, the research incorporates statistical tools to evaluate trends and patterns in the adoption of green hydrogen technologies across various sectors. Data from the selected studies were systematically categorized and analysed to identify key challenges and opportunities associated with scaling up hydrogen production and its integration into existing energy systems. The findings from this analysis provide valuable insights into the current state of green hydrogen development and the potential pathways for its widespread implementation.

Table 1

**Keywords research**

| Key words | *Science Direct* | *IEEE* | Total |
|---|---|---|---|
| Hydrogen | 871 047 | 9089 | 880 136 |
| Green hydrogen | 382 404 | 1149 | 383 553 |
| Hydro production | 52 475 | 2050 | 54 525 |

| | | | |
|---|---|---|---|
| Hydro electrolysis | 5129 | 61 | 5190 |
| Hydro transport | 33 660 | 312 | 33 972 |
| Hydro energy | 63 473 | 9426 | 72 899 |

The diversity of keywords used further ensures a well-rounded investigation into different aspects of hydrogen's role in energy systems.

## HYDROGEN PRODUCTION IN THE INDUSTRIAL AREA

Based on the technique used to produce hydrogen, the energy source used and its effects on the environment, hydrogen is categorised into various colour shades, including blue, grey, brown, black and green (Squadrito, Maggio, Nicita, 2023). Using the steam-reforming/auto-thermal reforming method, grey hydrogen is extracted from natural gas, but $CO_2$ is emitted into the atmosphere as a by-product. When the steam-reforming method converts natural gas into hydrogen and the $CO_2$ emissions from the process are captured, this is known as blue hydrogen (Nicita et al., 2020). The most prevalent type of hydrogen used today is brown hydrogen, mainly produced via the gasification of hydrocarbon-rich fuel, in which $CO_2$ is released into the atmosphere as a by-product.

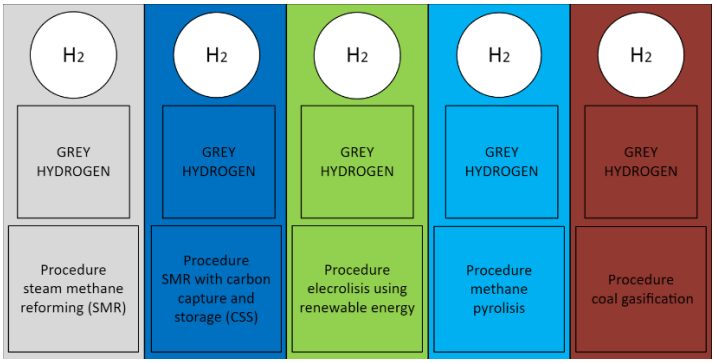



Figure 1. **Different hydrogen types**

Green hydrogen refers to hydrogen produced using renewable energy sources, typically through a process called electrolysis (Squadrito, Maggio, Nicita, 2023). This method uses electricity from renewable sources such as wind, solar, or hydropower to split water ($H_2O$) into its constituent parts hydrogen ($H_2$) and oxygen ($O_2$). When powered by renewable energy, the process results in zero carbon emissions, making it a key component of the energy transition towards sustainability. Also, this technology has been known for a long time, and is applied on the industrial scale (Chatenet et al., 2022) usually for production processes requiring high purity hydrogen.

$$2H_2O(l) \rightarrow 2H_2(g) + O_2(g) \quad (1)$$

$$H_2O + \text{energy} \rightarrow H_2 + \tfrac{1}{2} O_2 \quad (2)$$

For every kilogram of hydrogen produced by electrolysis, approximately 8 kilograms of oxygen is produced using about 9 kilograms of pure water and consuming about 50–55 kWh of electricity (depending on the electrolysis technology). But, usually, only hydrogen is cost-assessed without considering oxygen; only in recent few years the valorisation of oxygen was considered (Maggio, Nicita, Squadrito, 2019).

It is important to mention that another method, the so-called photoelectrochemical (PEC) hydrogen production technique, depends on the use of solar radiation to drive the water-splitting process directly; PEC cells transform solar energy into hydrogen (Song et al., 2022). Although this technology is still in its infancy, it indicates promise for producing hydrogen sustainably and effectively (Cao et al., 2020).

Due to the increasing large diffusion of PV and wind technologies converting sun and wind power into electric power, and a vision for the transition to 100% electric energy from RES, water electrolysis is considered the most suitable way for hydrogen production.

Although green hydrogen holds great promise in the transition to a cleaner energy future, challenges like high production costs and energy demands remain. Emerging technologies, such as photoelectrochemical hydrogen production, offer exciting possibilities for improving efficiency. As renewable energy technologies advance, green hydrogen could become a crucial part of our energy system, but continued innovation and investment will be key to unlocking its full potential.

## COMPARISON OF THE HYDROGEN STORAGE AND TRANSPORTATION

The hydrogen can be stored in the form of liquid, gaseous fuel or solid state and the storage method is based on the use given to the hydrogen or the exportation method (Maka, Mehmood, 2024). Using high pressure tanks is one of the most effective ways of storing hydrogen but the most cost-effective, compressed hydrogen can be stored in gas form (Sarpong-Mensah, 2023). To get the hydrogen in liquid form, Joule-Thompson expansion cycle is the most used and simplest liquefaction technique, the problem is that storing the hydrogen in liquid form makes necessary high energy usage (Ahmad, Oko, Ibhadon, 2024). Hydrogen in solid form is obtained by chemical bonding to the form of metal hydrides, it is needed a delay between initial heating and the release of the hydrogen gas, and insufficient heat to generate hydrogen from the hydride (Sarpong-Mensah, 2023).

The selection of the storage form of the hydrogen strongly depends on the use or on the energy conversion it will be applied. On the one hand the costs of the gas form are lower, on the other hand in liquid form the volumetric energy density is high; also stored in solid form is considered safer and more efficient (Sarpong-Mensah, 2023).

The main ways to transport the hydrogen are by ship and by pipeline (Schmitz et al., 2024). The hydrogen in liquid form can be transported via ship and also, in some cases via trucks or other vehicles; by pipelines the hydrogen is transported commonly in gas form (Andeobu, Wibowo, Grandhi,2024). In the case of the ships, which are commonly used, the hydrogen has to be in liquid form. To get the hydrogen in liquid form has to be under -253ºC and the flashpoint is at -231ºC at 1 atm pressure (Cordazo et al., 2024). To get the liquid state, the pressure of the hydrogen is decreased, to the point that it can be dangerous on numerous occasions due to their high volatility (Zhu et al., 2024).

Currently pipelines are getting more and more common in the hydro transport sector. Proof of it is that Portugal and Spain reaffirmed they are willing to bolster the construction of a submarine green hydrogen pipeline, whose execution should begin in 2027, given the commitment to renewable energies. However, it has some drawbacks too. In these pipelines gas can be transported in gas or liquid form, but liquid hydrogen has some unique properties that give advantages over gas hydrogen, including higher energy density, ability to be transported over long distances and lower investment cost (Cordazo et al., 2024). The fluid mechanics of hydrogen transport present unique challenges due to hydrogen's low viscosity and high diffusivity, which influence turbulence and flow regimes within pipelines (Raj, et al, 2024). Due to the constant contact between the hydrogen and the pipeline, the pipeline easily gets embrittled by hydrogen, that is why it is important to elect proper materials such as high-strength steel pipelines (Sarpong-Mensah, 2023). Pressure drop in hydrogen pipelines is also a significant concern, affecting both the efficiency and safety of the transport system (Raj et al., 2024).

Choosing the right way to store hydrogen whether as a gas, liquid, or solid depends on the specific needs of the application and involves balancing factors like cost, energy density, safety, and efficiency. Liquid hydrogen, for example, can store more energy in a smaller space, but it requires a lot of energy to keep it cold and comes with risks, like being more volatile. As for transporting hydrogen, the infrastructure, including pipelines and ships, is improving, but there are still challenges to address, such as finding the right materials, controlling pressure, and ensuring smooth flow.

## CURRENT HYDROGEN USAGE IN ENERGY SYSTEMS

Hydrogen is one of the least complex and plenteous elements on the planet, endowed with some special characteristics from being harmless, flexible, transportable and storable (Lui, Chen, Tsang, 2020). There are many different uses for hydrogen, such as energy storage, power generation, industrial production and fuel for fuel cell vehicles (Communication from the commission to the European parliament, the European Council, the Council, 2022).

The main usage of hydrogen currently is to decarbonize the polluted areas in crowded places and industrial areas, example of that is the efficiency that green hydro has in mining labours. In addition to the chemical and oil and gas sectors, it can also be utilised in transportation applications such as Internal Combustion Engines (ICEs) and fuel cells. A fuel cell vehicle powered by pure hydrogen is considered an emission-free vehicle because the only byproduct is water. While maintaining comparable characteristics in terms of peak speed, range, and acceleration, fuel cell vehicles are considered way more efficient than conventional vehicles (Staffell et al., 2019). Hydrogen can be converted into energy and methane, powering homes, industries, refineries and used as fuels for vehicles, trucks, ships and airplanes (Andeobu, Wibowo, Grandhi, 2024). In this way hydrogen provides high utilisation efficiency when converted into different forms of energy and also being one of the safest fuels in relation to the toxicity and fire hazards (Zayed, Sopian, Al-Hinai, 2020). That's why they are implementing hydro daily on heating private affairs such as buildings or public areas.

Hydrogen has a lot of promise as a clean and efficient energy source, offering real solutions for reducing emissions across industries and transportation. Its versatility makes it a key player in the shift toward more sustainable energy systems, especially when paired with other low-carbon technologies. As it will continue to explore and implement hydrogen in more areas, it could play a crucial role in creating a cleaner, more efficient energy future for everyone.

## CONCLUSIONS

1. Hydrogen production is categorized into different colors based on the method of extraction, energy sources and environmental impact. Grey hydrogen, produced from natural gas with high CO2 emissions and blue hydrogen, where

CO2 is captured, represent conventional methods that still contribute to greenhouse gas emissions. On the other hand, brown hydrogen, produced via the gasification of hydrocarbon-rich fuels, also results in significant CO2 emissions. Green hydrogen, produced through electrolysis powered by renewable energy sources such as wind, solar or hydropower, emerges as the most environmentally friendly option, offering a pathway to zero carbon emissions. Though electrolysis has been established as a reliable industrial process for high-purity hydrogen production, emerging technologies like photoelectrochemical cells, which directly utilize solar energy, hold potential for further improving sustainability in hydrogen production. As renewable energy technologies continue to proliferate, electrolysis powered by renewable sources is posed to be a central method for producing hydrogen for a sustainable, low-carbon future.

2. Hydrogen storage and transport methods are chosen based on factors like application, cost, energy density and safety. Hydrogen can be stored in gaseous, liquid or solid form, each with its advantages and limitations. Gaseous hydrogen is cost-effective but has a lower energy density, while liquid hydrogen offers higher volumetric energy density but requires significant energy for its liquefaction, making it less efficient. Solid-state storage, typically through metal hydrides, is considered safer and more efficient, though it requires additional heat for hydrogen release. Hydrogen transport is primarily done through ships or pipelines, with liquid hydrogen being preferred for maritime transport due to its higher energy density. However, transporting liquid hydrogen presents challenges, including its extremely low temperature requirements and volatility. Pipelines, increasingly used for hydrogen transport, also face challenges such as the risk of hydrogen embrittlement and pressure drops, which can affect efficiency and safety. Advances in materials, such as high-strength steel and the development of new infrastructure, such as the planned submarine hydrogen pipeline between Portugal and Spain, are expected to help overcome these hurdles and support the growing hydrogen economy.

3. Hydrogen is a versatile and abundant element with a wide range of applications across industries, from energy storage and power generation to fuel for vehicles and heating. Its primary use today is in decarbonizing industrial and densely populated areas, such as in mining operations and the chemical, oil and gas sectors. In transportation, hydrogen fuel cell vehicles offer a promising solution for reducing emissions, as they produce only water as a byproduct and provide higher efficiency compared to conventional internal combustion engine vehicles. Additionally, hydrogen can complement other low-carbon technologies, serving as an alternative to natural gas for heating and being used in various sectors, including homes, industries, profile, and hydrogen, plays a key role in the transition to a more sustainable and cleaner energy system.

## REFERENCES

Ahmad, A., Oko, E., Ibhadon, A. (2024). Comparative energy and exergy analysis of ortho-para hydrogen andnon-ortho-para hydrogen conversion in hydrogen liquefaction. International Journal of Hydrogen Energy. 78, 991-1003. DOI https://doi.org/10.1016/j.ijhydene.2024.06.368

Andeobu, L., Wibowo, S., Grandhi, S., (2024). Renewable hydrogen for the energy transition in Australia - Current trends., challenges and future directions. International Journal of Hydrogen Energy. 87, 1207-1223. DOI https://doi.org/10.1016/j.ijhydene.2024.08.499

Cardozo, P., Bo, C., Hyung, K., Choi, B., (2024). Risk assessment of hydrogen leakage and explosion in a liquid hydrogen facility using computational analysis. International Journal of Hydrogen Energy. 91, 950-964. DOI https://doi.org/10.1016/j.ijhydene.2024.10.129

Chatenet, M., Pollet, B., Dekel, D., Dionigi, F., Deseure, J., Millet, P., Braatz, R., Eikerling, M., Staffell, I., Balcombe, P., Shao-Horn, Y., Schäfer, H., (2022). Chem. Soc. Rev.. Water electrolysis: from textbook knowledge to the latest scientific strategies and industrial developments. 186, 109547. DOI https://doi.org/10.1039/D3CS00883E

Communication from the commission to the European parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions REPowerEU (2022), https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2022%3A230%3AFIN

Lui, J., Chen, W., Tsang, D., You, S., (2020). A critical review on principles, applications, and challenges of waste-to-hydrogen technologies. Renew. Sustain. Energy Rev.. 134, 110365. DOI https://doi.org/10.1016/j.rser.2020.110365

Maggio, G., Squadrito, G., Nicita, A., (2022). Hydrogen and medical oxygen by renewable energy based electrolysis: a green and economically viable route. Appl. Energy. 306, 117993. DOI https://doi.org/10.1016/j.apenergy.2021.117993

Maka, A., Mehmood, M., (2024). Green hydrogen energy production: current status and potential. Clean Energy. 8(2), 1-7. DOI https://doi.org/10.1093/ce/zkae012

Raj, A., Larsson, S., Ljung, A., Forslund, T., Andersson, R., Sundstrom, J., Lundstrom, T., (2024). Evaluating hydrogen gas transport in pipelines: Current state of numerical and experimental methodologies. International Journal of Hydrogen Energy. 67, 136–149. DOI https://doi.org/10.1016/j.ijhydene.2024.04.140

Sarpong-Mensah, J., Wadhawan, J., (2023). Green Hydrogen work from University of Hull. Retrieved from: https://www.researchgate.net/publication/369794068_GREEN_HYDROGEN

Schmitz, R., Brandes, J., Nolte, H., Kost, C., Lux, B., Haendel, M., Held, A., (2024). Implications of hydrogen import prices for the German energy system in a model-comparison experiment. International Journal of Hydrogen Energy. 63, 566-579. DOI https://doi.org/10.1016/j.ijhydene.2024.03.210

Squadrito, G., Maggio, G., Andaloro, A., Nicita, A., (2020). Distributed hydrogen generation & energy communities for a zero-emission energy economy, in: E-Book of Abstracts of Hydrogen Power Theoretical and Engineering Solutions. International Symposium -HYPOTHESIS XV, On-Line Conference/, 18-19.

Squadrito, G., Maggio, G., Nicita, A., (2023). The green hydrogen revolution. Renewable Energy. 216, 119041. DOI https://doi.org/10.1016/j.renene.2023.119041

Staffell, I., Scamman, D., Abad, A., Balcombe, P., Dodds P., Ekins, P., Shah, N., Ward, K., (2019). The role of hydrogen and fuel cells in the global energy system. Energy & Environmental Science. 12 (2), 463-491. DOI https://doi.org/10.1039/C8EE01157E

Zayed, A., Sopian, K, Al-Hinai, A., (2020). Review of energy storage services, applications, limitations, and benefits. Energy Reports. 6, 288-306. DOI https://doi.org/10.1016/j.egyr.2020.07.028

Zhu, S., Fang, S., Bao, S., Zhi, X., Wang, K., Qiu, L., (2024). Efficient cooling strategies for liquid hydrogen pipelines: A comparative analysis. Renewable Energy. 236, 121488. DOI https://doi.org/10.1016/j.renene.2024.121488

PANEVĖŽIO KOLEGIJA ISSN 2029-1280, eISSN 2669-0071. Taikomieji tyrimai studijose ir praktikoje – Applied Research in Studies and Practice, 2024, 20.

# ASSESSMENT OF THE USE OF CLOUD TECHNOLOGIES

***Birutė RAGALYTĖ, Alma PAUKŠTIENĖ***

*Panevėžio kolegija / State Higher Education Institution, Lithuania*

**Annotation.** The article analyzes the importance of using cloud computing services. It presents how the size of the company influences the use of cloud computing. The results of a statistical study are presented, which provides statistical information on what cloud computing services Lithuanian businesses use in 2023.

The results of a study in which full-time students of Panevėžys kolegija participated are discussed. The aim of the study was to find out what and how often students use cloud computing services, what problems and challenges they face while using them.

**Keywords**: cloud application, cloud security, challenges in the use of cloud technologies

## INTRODUCTION

Without the use of cloud technologies, the modern world is difficult to imagine. Cloud technologies are widely used in business. It is very important to prepare and equip students with competence in the use of cloud technologies.

In the Universal Lithuanian Encyclopedia, the cloud is defined as a set of Internet services that connect information resources and software on various servers, creating conditions for their use.

Cloud technologies are used not only in the field of education but also over a wide range of applications in public fields such as industry, marketing, telecommunication, tourism, healthcare, insurance, transportation, banking, shopping, hospital and library as well as in personal services, even cloud technologies are considered as the fifth facility following water, electricity, gas and telephone services (Monroy et al., 2013).

Cloud technologies are used in many areas of business. The advantages of cloud technologies in many areas play an important role (Korucu & Karakoca, 2020).

Technology is great, but it doesn't work perfectly 100 percent of the time. Even with redundancies and backups, it is possible to lose data because of corrupted hard drives or other types of hardware malfunctions. (Ferguson, 2021).

The combination of the potential of cloud technologies in learning and the development of critical thinking in students allows the most optimal solution of the contradictions between the needs of a modern society, which is undergoing dramatic changes due to the accelerated informatization of all spheres of human life. (Shemshuchenko et. al. 2020)

To run a profitable business, it's important to save money where you can, and cloud computing is an excellent way to do it. (Ferguson, 2021).

When preparing for future specialists in various fields, it is very important to develop their abilities to use the ever-renewed capabilities of cloud technologies, to develop the ability to use them safely.

Working in the cloud gives your company a greater degree of mobility and flexibility. (Ferguson, 2021).

**Purpose of the research**: Analysis of self-assessment of the use of cloud computing services by full-time students of Panevėžio kolegija.

**The objectives of the research are:**

1. To analyze the use of cloud computing services in Lithuanian companies.
2. To analyze how much full-time students at Panevėžys College use cloud technologies, what tools they use, and what security challenges they have encountered.

## CLOUD COMPUTING SERVICES IN BUSINESS

According to the Official Statistics Portal (2023), at the beginning of 2023, 38.4% of companies purchased cloud computing services: 78.9% of large companies, 57.4% – medium and 32.7% – small businesses. It indicates that 32.1% of companies used e-mail as a cloud computing service, 20.2% – office software use service, company database hosting service – 20.2%, data file storage – 24.8%, use of financial or accounting software – 21.8%, customer relationship management software usage service – 6.6% (Figure 1.)

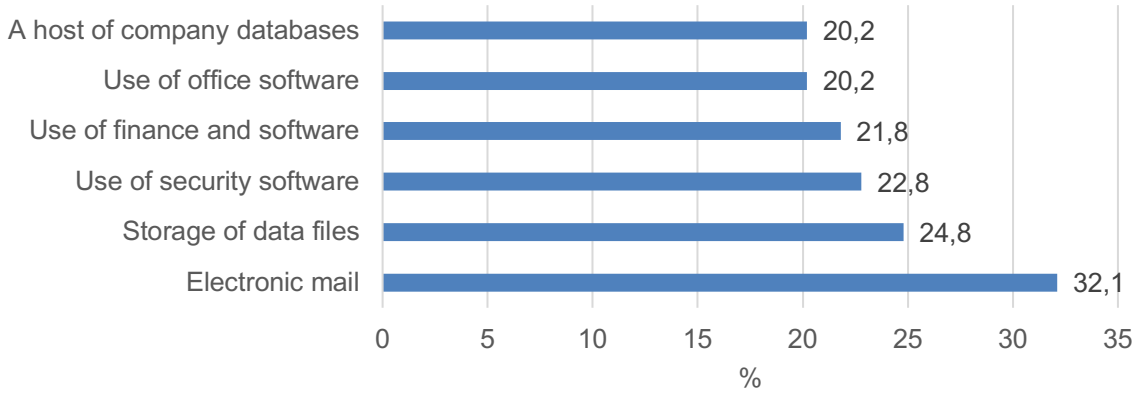



Figure 1. **Cloud computing services via the Internet in 2023**
*Adapted by the author according to the Official Statistics Portal (2023). Lietuva skaičiais (2023 m. leidimas). https://osp.stat.gov.lt/informacines-technologijos1*

Analyzing the data of the official statistics portal Digital Economy and Society in Lithuania edition (2023), it can be observed that the number of companies purchasing cloud computing services is increasing. In 2019, the number of such enterprises was 22.6%, in 2020 – 30.8%, in 2021 – 33.6%, in 2022 – 37.7%, in 2023 – 38.4%.

According to the official statistics portal (2023), at the beginning of 2023, the more employees a company has, the higher the proportion of them using cloud computing services. This portal indicates that if a company has more than 250 employees, 78.9% purchase cloud computing services. If a company has 49-249 employees, 57.4% of companies purchase cloud computing services (Figure 2).

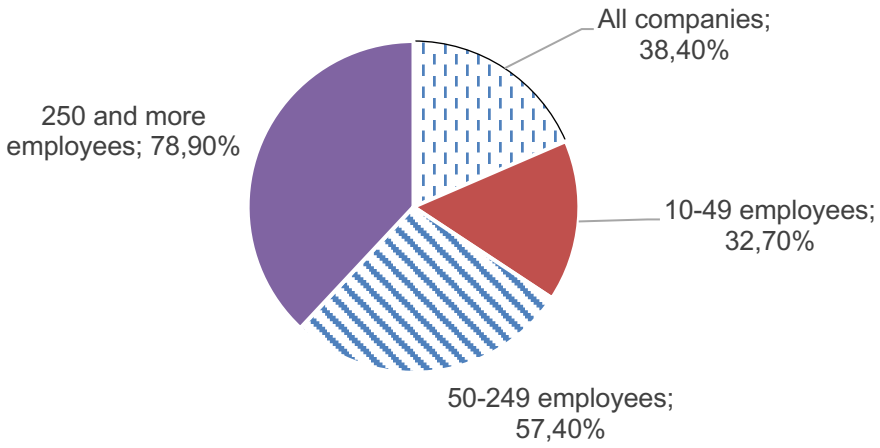



Figure 2. **Lithuanian companies purchasing cloud computing services online in 2023**
Adapted by the author according to the Official Statistics Portal (2023). *Skaitmeninė ekonomika ir visuomenė Lietuvoje (2023 m. edition)* https://osp.stat.gov.lt/skaitmenine-ekonomika-ir-visuomene-lietuvoje-2023/interneto-saugumas-ir-debesu-kompiuterija/debesu-kompiuterija

Cloud computing is one of the best IT services that will increase the productivity of the company.

In the training of specialists for the labor market, it is very important for them to develop the ability to use cloud computing services.

## RESULTS OF THE RESEARCH

We found out the opinion of 73 student's full-time students of Panevėžio kolegija. The survey was designed to find out the opinion of the respondent about the use of cloud computing: what tools they use, what security challenges they have faced.

Students of 3 faculties participated in the research. Student participation by faculty is shown in Figure 3. The most active were the students of the Faculty of Technology Sciences in 39.7% of the respondents who participated in the research, 32.9% of the Faculty of Biomedicine Sciences, 27.4% of the Faculty of Social Sciences.

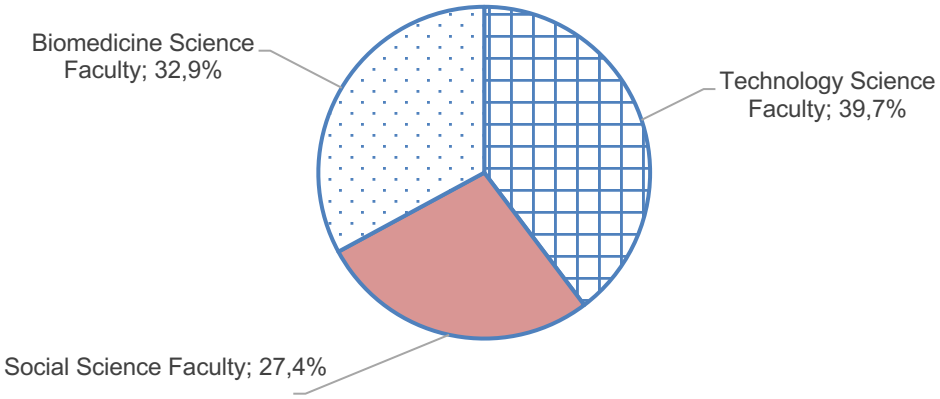



Figure 3. **Distribution of respondents by faculty**

The distribution of survey respondents by study course is shown in Figure 4. The most active participants in the survey were 1st year students (38.4%). 34.2% and 27.4% of the 2nd and 3rd year students took part in the survey.

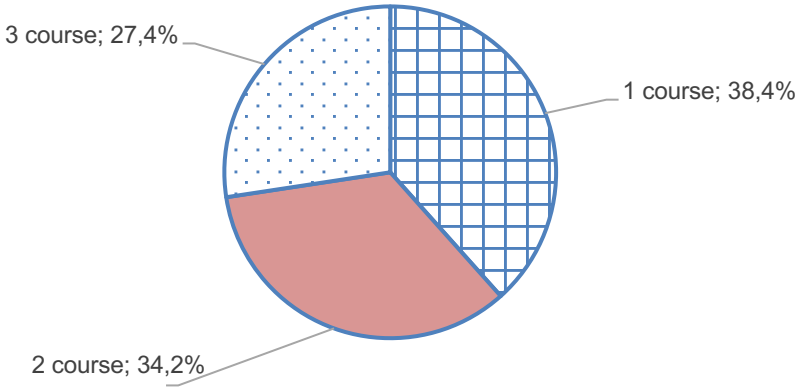



Figure 4. **Distribution of respondents by course**

Cloud computing capabilities are widely used in various fields. It was studied where students use cloud computing services. The results are presented in Figure 5. A total of 45.2% of respondents use cloud computing for both personal and work purposes, as well as for academic activities. Meanwhile, 30.1% use it exclusively for academic purposes, 12.3% use it only for personal matters, 6.8% use it strictly for work-related tasks.

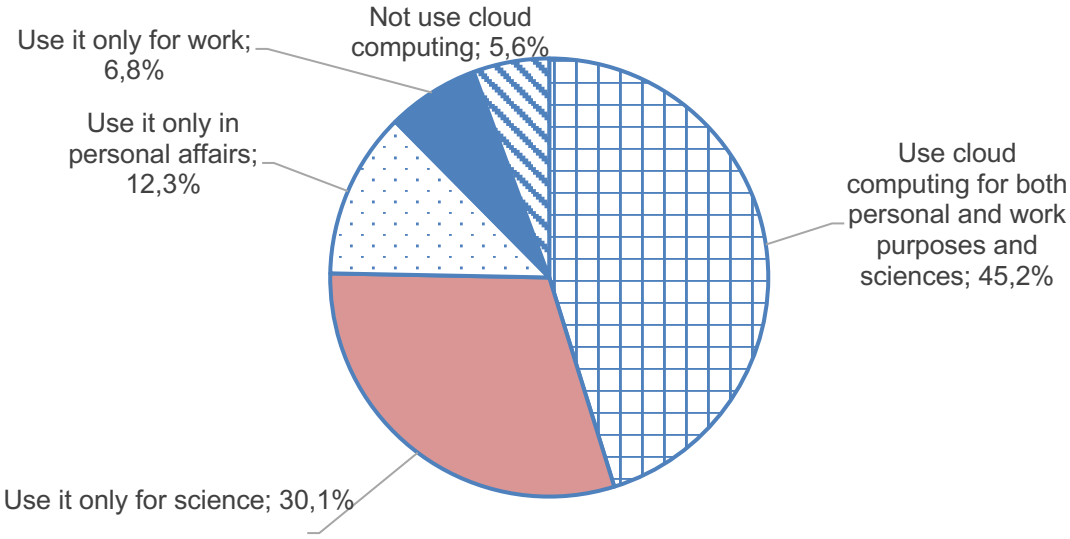



Figure 5. **Using cloud computing**

The study wanted to find out how often students use cloud computing services. The results of the study are shown in Figure 6. 22.0% of respondents use cloud computing services every day, compared with 27.4% every week. These indicators are low enough. Therefore, students should be more active and use cloud computing more often.

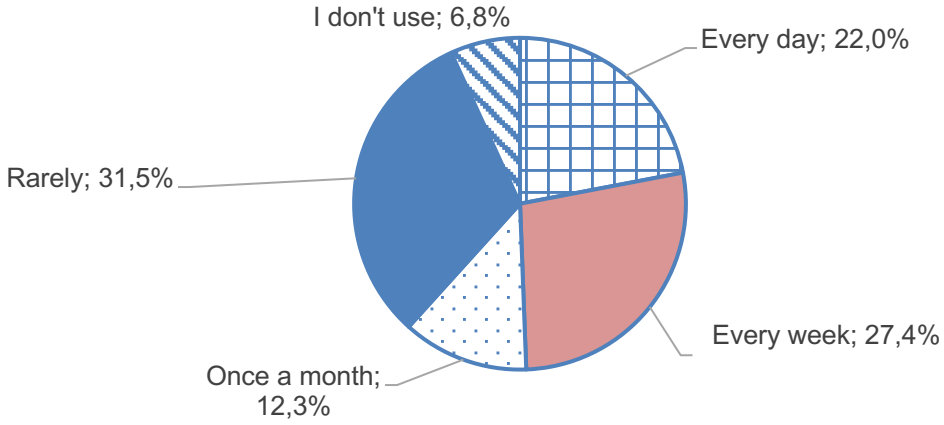



Figure 6. **Frequency of cloud computing**

The supply of cloud computing services is large. We tested what cloud computing services students use. The results of the study are shown in Figure 7. The most used service on Google Drive is 80.8%, and OneDrive is used by 72.6% of respondents. Students use Google Cloud – 37.0%, as well as college internal cloud services – 28.8%.

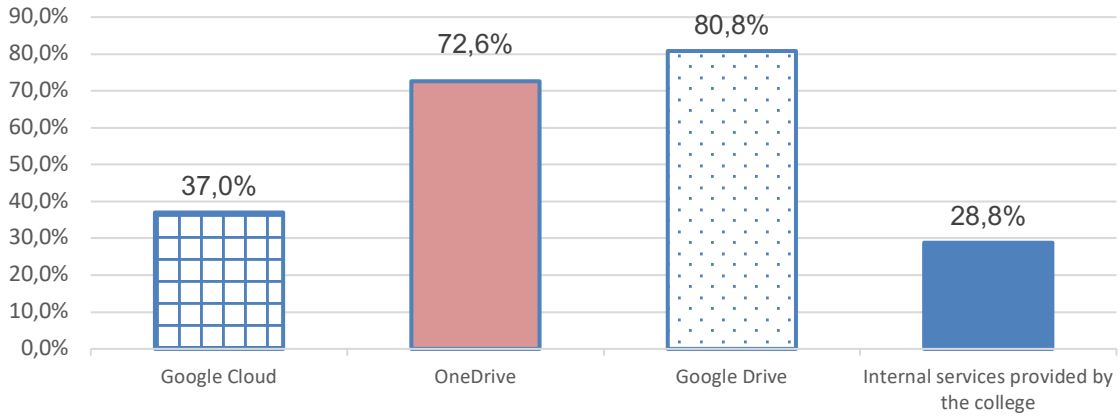



Figure 7. **Using cloud computing services**

Students use cloud computing services for data storage (80.8%), backup (57.5%), software use (13.7%), data analysis and processing (13.7%) (see Figure 8). In the "other" option, they indicated that files are stored on the college's OneDrive, and that teachers provide information on Google Drive and use it to share data from one computer to another.

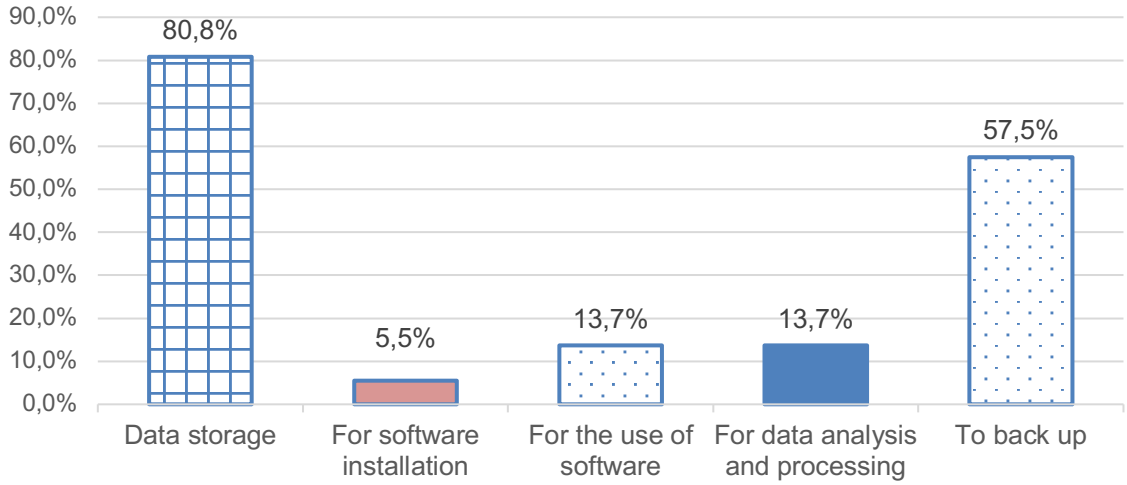



Figure 8. **Using cloud computing technologies**

Using cloud computing gives users a fairly large number of advantages. Students cited the biggest advantage of convenient data availability (74.0%), data security and backups (60.3%). The results of the study are presented in Figure 9. When answering the survey questions, it also indicated the minus that it is possible to lose information.

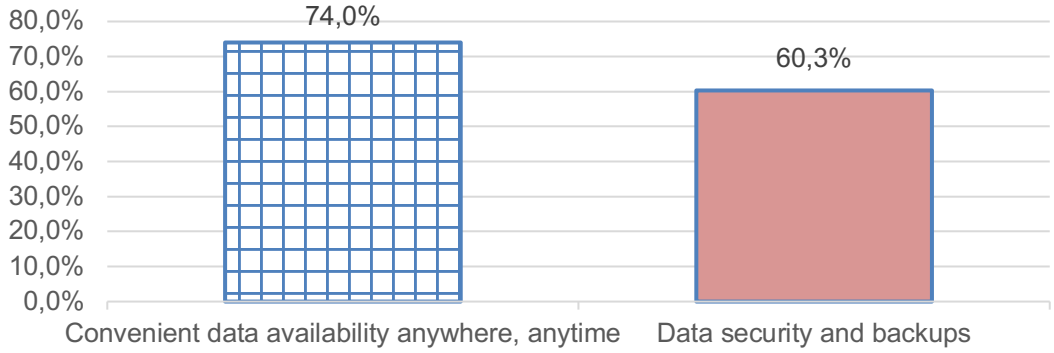



Figure 9. **Benefits of using cloud technologies**

The use of cloud technologies also faces problems and challenges. Students see the biggest problem with internet connection dependence (75.3%) and data privacy and security issues (27.4%). The results of the study are presented in Figure 10.

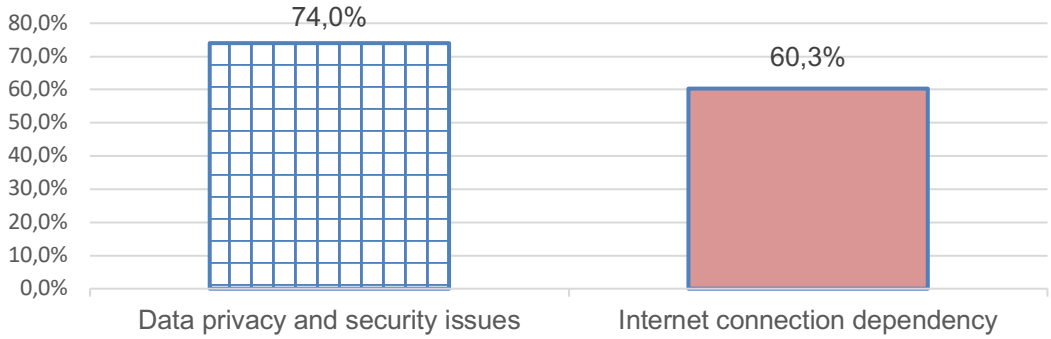



Figure 10. **Challenges and disadvantages of using cloud technologies**

The college provides cloud computing services to students. The number of students who are completely satisfied with the services provided is 43.8%, and partially satisfied is 26.0%. Considering that 27.4% of students do not use the services offered by the college, the information literacy and education of students should be improved so that they use cloud computing services more effectively.

After analyzing how students use the cloud technologies offered by the college (table), we could state that the first-year students of the Faculty of Technological Sciences are the most satisfied with the cloud computing services provided. (73% answered Yes, I am completely satisfied), and third-year students of the Faculty of Social Sciences (71% answered Yes, I am completely satisfied).

Table

**Evaluation of cloud computing services offered to Panevėžys kolegija/ State Higher Education Institution students**

| | At the Faculty of Biomedicine Sciences | At the Faculty of Social Sciences | At the Faculty of Technology Sciences | Grand total |
|---|---|---|---|---|
| 1 course | 38% | 40% | 38% | 38% |
| I don't use the cloud services provided by the college | 67% | 13% | 27% | 36% |
| ***Yes, I am completely satisfied*** | ***22%*** | ***50%*** | ***73%*** | ***50%*** |
| ***Yes, partially satisfied*** | ***11%*** | ***38%*** | ***0%*** | ***14%*** |
| 2 course | 38% | 25% | 38% | 34% |
| No, I am not satisfied with the services | 0% | 0% | 9% | 4% |
| I don't use the cloud services provided by the college | 44% | 40% | 9% | 28% |
| ***Yes, I am completely satisfied*** | ***11%*** | ***0%*** | ***55%*** | ***28%*** |
| ***Yes, partially satisfied*** | ***44%*** | ***60%*** | ***27%*** | ***40%*** |
| Course 3 | 25% | 35% | 24% | 27% |

| | | | | |
|---|---|---|---|---|
| No, I am not satisfied with the services | 17% | 0% | 0% | 5% |
| I don't use the cloud services provided by the college | 17% | 14% | 14% | 15% |
| ***Yes, I am completely satisfied*** | ***33%*** | ***71%*** | ***57%*** | ***55%*** |
| ***Yes, partially satisfied*** | ***33%*** | ***14%*** | ***29%*** | ***25%*** |

After evaluating the results of the student survey, we can say that students need to be more informed about the opportunities and applications of cloud technologies provided to college students, both in their studies and in their work activities.

The security of cloud technologies is very important. Most students are concerned about data security (The answer yes was chosen by 16.4%, Yes a little 35.6%). Students should be given more information about data security using cloud technologies.

The use of cloud technologies can lead to data loss. Most students have never lost data using cloud technologies (68.5%). 13.7 respondents admitted to losing data.

The college uses advanced data protection measures, so students do not lose data using the cloud technology services it offers. Their data and information are safe. To reduce the likelihood of data loss, it is necessary to have a backup copy of data. Most students believe that having backup copies is very important (20.5%), important (49.3%). (Figure 11).

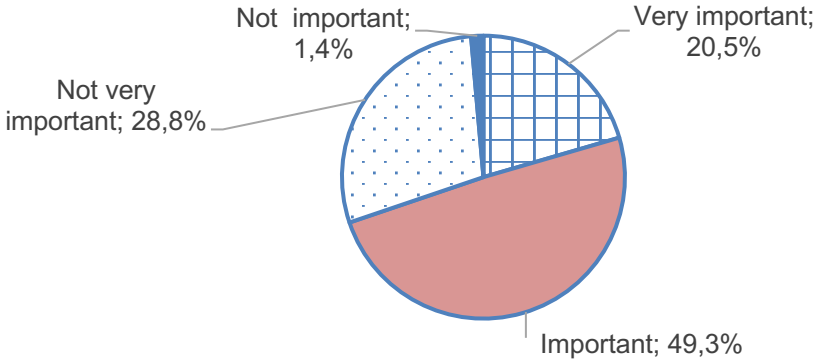



Figure 11. **Student opinion on having backups**

Only a small percentage of students use backup services in cloud computing (21.9% regularly, rarely 42.5%). 26% of students do not use full backup services. Students, while not backing up their data, believe that having a backup of their data is very important

Students trust cloud providers. They believe that they provide sufficient data security. The answers "Yes, I have full confidence in the data security provided by the suppliers" or "Yes, but I still have some doubts" were chosen by 20.5% and 53.4%, respectively.

In the media, we can often hear information about cyberattacks. 8.2% of respondents say they have experienced cyberattacks.

When analyzing students' opinions about what are the main risks that pose a threat to data security, the majority singled out data theft (82.2%). According to respondents, a significant threat to data security in cloud computing is influenced by cyberattacks (65.8%) and human error (56.2%). We can see the results of the study in Figure 12.

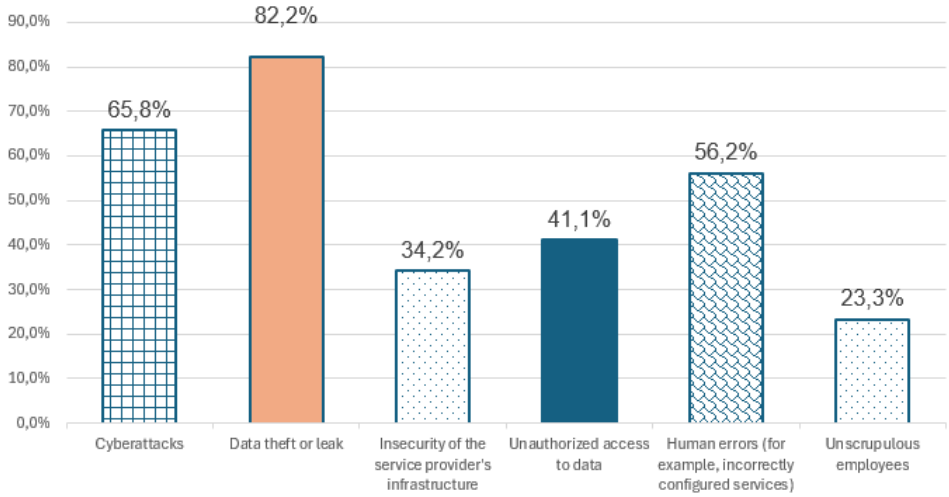



Figure. 12 **Student opinion on the threat to data security in cloud computing**

One of the important factors ensuring data protection in the cloud is password updating. Students rarely update their passwords, which may affect the hacking of their data. 2.7% of respondents update their passwords regularly every month. 15.1% update their passwords once every six months. A significant proportion of students update their passwords only when necessary (56.2%). 26.0% of students never update their passwords. It is necessary to educate students about the importance of data security in cloud technologies.

## CONCLUSIONS

1. An analysis of the data of the official statistics portal showed that the use of cloud computing services in Lithuanian companies is growing. Most of these services are acquired by companies with more than 250 employees. The most used cloud computing services are e-mail, storage of data files, and the use of security software.
2. Analysis of the survey of Panevėžys kolegija students showed that 94.4% of students use cloud computing services, such as Google Drive, OneDrive, Google Cloud. Internal services are provided by the college. Students use cloud computing services for data storage, backups, software use, data analysis and processing. Students are satisfied with the cloud computing services provided by the college. After conducting the survey analysis, we can state that students need to be more familiar with cloud computing security measures.

## REFERENCES

Ferguson, B. (2021). Exploring the benefits of cloud computing. The Enterprice – Utah's Business Journal

Korucu, A. T., Karakoca, A. (2020). Development and validation of cloud technologies usage in education scale. Bartın University Journal of Faculty of Education, 9(1), 69-82.

Monroy, C. R., Arias, C. A., Guerrero, Y. N. (2013). The new cloud computing paradigm: the way to IT seen as a utility. Latin American and Caribbean Journal of Engineering Education, 6(2)

Official Statistics Portal (2023). Lietuva skaičiais (2023 m. leidimas). https://osp.stat.gov.lt/informacines-technologijos1

Official Statistics Portal (2023). Skaitmeninė ekonomika ir visuomenė Lietuvoje (2023 m. leidimas) https://osp.stat.gov.lt/skaitmenine-ekonomika-ir-visuomene-lietuvoje-2023/interneto-saugumas-ir-debesu-kompiuterija/debesu-kompiuterija

Shemshuchenko, Y., Gerasymova, E., Vykhovanets, Z., Mosenkis, I., Strokal, O. (2020). Use of Cloud Technologies in the Process of Professional and Linguistic Training of Law Students for the Development of Academic Performance, International Journal of Higher Education, Vol. 9, No. 7, p. 310-320 : https://doi.org/10.5430/ijhe.v9n7p310

Universal Lithuanian Encyclopedia. https://www.vle.lt/straipsnis/debesija/

PANEVĖŽIO KOLEGIJA ISSN 2029-1280, eISSN 2669-0071. Taikomieji tyrimai studijose ir praktikoje – Applied Research in Studies and Practice, 2024, 20.

# ANALYSIS OF SMART HOME MANAGEMENT SYSTEMS AND SECURITY SOLUTIONS

*Vakaris ŽILINSKAS[a], Oskaras PABRĖŽA[a], Daiva STANELYTĖ[ab]*

[a] *Klaipedos valstybine kolegija – Higher Education Institution, Lithuania*
[b] *Lithuanian Energy Institute, Lithuania*

**Annotation.** This paper presents a smart home management system with a special focus on security. Smart homes are becoming increasingly popular, incorporating features such as artificial intelligence control and automation, but face unique security challenges. The authors evaluate the different communication standards - ZigBee, Z-Wave and KNX - analyzing each of them according to their security advantages and disadvantages. The aim of the study is to shed light on these differences, explaining the potential threats and providing practical recommendations on how to protect the smart home from cyber threats.

**Keywords**: smart home, safety, standards, smart systems

## INTRODUCTION

The development of smart technologies makes everyday life easier, increasing comfort and safety at home. These systems allow you to automate home functions, control appliances remotely and monitor your environment. However, these devices can be the target of cyber-attacks, so it is important to understand the characteristics and risks of different control systems.

Equipment security is a key aspect of the smart home. IoT devices such as smart cameras and sensors can pose threats. To protect assets, it is essential to choose reliable devices with common standards that ensure stable operation and protection against malicious activities. A centralized system that relies on the internet is vulnerable to loss of network access.

The uniqueness of the paper lies in its systematic analysis and recommendations for improving cyber security, drawing on a variety of sources. In addition, future trends and existing standards to address these issues are discussed.

**The subject of the study** is Smart Home Management Systems.

**Objective** - Analysis of Smart Home Management Systems with Integrated Artificial Intelligence

**Study objectives**:

1. Differentiate smart home standards for cyber security applications.
2. Examine cyber security threats in smart homes.
3. Provide recommendations for cybersecurity solutions in the smart home.

**Research methods -** comparative analysis and synthesis of data from literature and electronic sources.

**The databases used for the analysis** *EBSCO ASP, EBSCO CEEAS,* and *Science Direct*.

## DIFFERENCES IN SMART HOME STANDARDS FOR CYBERSECURITY APPLICATIONS

*The ZigBee* wireless standard has been developed using the IEEE 802.15.4 standard introduced by the IEEE and the *ZigBee Alliance* to create a common standard for *ZigBee* applications. The network operates in three frequency bands: 868 MHz, 915 MHz, and 2.4 GHz. The most used frequency is 2.4 GHz. There is a 5 MHz separation between the channels to avoid interference and to ensure stable communication (Grzegorz et.al, 2024). The IEEE 802.15.4 *ZigBee* standard enables wireless technologies for heterogeneous sensors in personal home and building environments. Wireless sensing technologies and their devices are moving from the research level to the industrial stage with applications in smart building monitoring and automation (Hayat et.al, 2016).

Table 1

**Comparing communication standards for building automation**

| Parameters | KNX | Z-WAVE ALLIANCE | zigbee |
|---|---|---|---|
| PHY/MAC standard | ISO/IEC 14543-3-10 | ITU-T G.9959 | IEEE 802.15.4 |
| Frequency band | Twisted pair bus control cable (TP), 30V | 900 MHz | 2.4 GHz |
| Nominal range (0 dBm) | Up to 1000 m (above TP) | 30 - 100 m | 10 - 100 m |
| Data transfer rate | 9600 bit/s | 40-100 kbit/s | 250 it/s |

*Z-Wave* is a low-power radio wave, wireless communication standard for smart home automation. *Z-Wave* has higher latency (100 MS), and lower network reliability compared to *ZigBee. Z-Wave* operates at a frequency of 908.42

MHz in the US and Canada with regional variations (Kim et.al, 2014). *KNX* acts as a data communication system for exchanging data in a home control system. Shielded twisted-pair bus control cables are used for communication via *KNX* TPs and supply power to the devices. Up to 256 devices can be connected on each line and the system can be expanded using connectors. *KNX* uses the ISO/IEC 14543-3-10:2020 standard. (Grzegorz et.al, 2024).The table below provides comparisons of communication standards for building management systems.*KNX* uses a twisted-pair bus control cable and supports the highest communication range, making it suitable for large building systems. *The Z-Wave* and *ZigBee* standards use wireless frequencies (900 MHz and 2.4 GHz respectively) but have lower range and data rates. ZigBee has higher data rates, but Z-Wave works better in the US and Canada due to regional regulations.

***ZigBee* network architecture and security**. *ZigBee* network topologies include star, hierarchical and mesh structures, where routers can communicate with other routers or coordinators, allowing the network to "self-heal" and optimize message routes (Hillman, 2017). *ZigBee* networks typically use a star or wire topology where devices communicate with a central coordinator or through intermediaries. The communication system uses a standard in which data units contain both control information and transmitted data (Li et.al, 2010).

The Remote Smart Home system uses wireless *ZigBee* devices and a *ZigBee* web interface to control various devices such as switches, blinds, and power sockets. The CC2530 chip manages ZigBee communication and GPRS transmits alarm information to mobile phones (Yuhan, 2024). The CC2530 chip is a wireless chipset for controlling *ZigBee* communication. The CC2530 chipset connects various communication modules that provide wireless communication in a computer monitoring center. The center, which connects to a video module and a GPRS module (Xinyuan, 2018), which transmit alarm information to mobile phone users via a GPRS network. The user can also view video information through a smart device to determine if there is a false alarm in an unsafe situation (Yuhan, 2024).

The CC2530 functional connection socket diagram is shown in Figure 4 below to show how this chipset connects to other devices in the system and provides wireless connectivity.

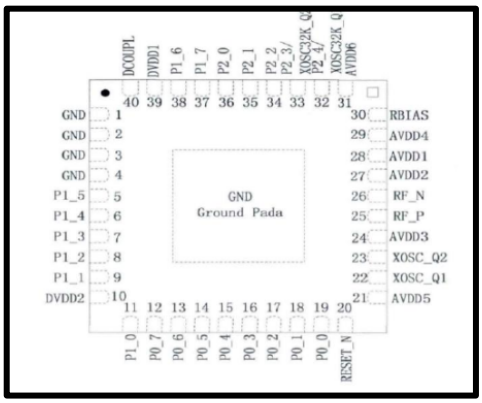



Figure 4: **Functional diagram of the CC2530 connection sockets. Source: Du Yuhan. (2024). *Research on Security System of Smart Home Based on ZigBee. International Journal of Computer Science and Information Technology*, 4, 37-45.**

The CC2530 chip supports the 2.4GHz IEEE 802.15.*4/ZigBee* standard and has three memory buses: SFR, DATA and CORE/XDATA. The interrupt can trigger the active mode, while the SFR bus connects the CPU, DMA, and physical memory to external devices (Xiaoguang, 2012). The CC2530 chip is important for ZigBee communication management due to its compatibility and efficient memory architecture. The CC2530 chip provides reliable and flexible data communication in smart home systems.

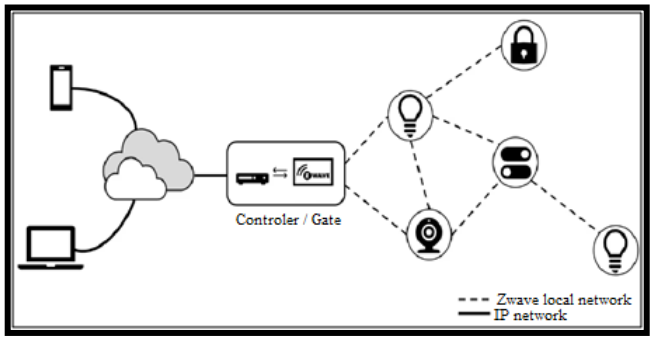



Figure 5: ***Z-Wave* network node diagram. Source. Mailloux. (2017). *The Z-Wave routing protocol and its security implications*. *Computers & Security*, 68.**

***Z-Wave network architecture and security.*** *The Z-Wave* network topology supports up to 232 devices connecting through nodes, allowing you to extend the communication range to 100 meters in an open space. Frequency-shift-locked modulation at 868.42 MHz (Europe) and 908.42 MHz (USA) is used, with a routing algorithm that optimizes

the best communication paths (Rahman, 2018). *A Z-Wave* network consists of a controller and slave devices. The controller manages the network topology, while the slave nodes execute commands and enable communication with nodes outside the direct range, as shown in Figure 5 (Xiaoguang, 2012).

*The Z-Wave* standard uses AES-128 encryption and ECDH key exchange to ensure security and has been evaluated against UL security standards (Sigma Design press release, 2017). *The Z-Wave* S2 standard includes three security classes, S2 Access Control, S2 Authenticated and S2 Unauthenticated, and allows for secure connection establishment with temporary keys (Ujwala et.al, 2018). *Z-Wave* is suitable for larger and more complex building management systems due to its more reliable connectivity and elevated level of security, but compatibility issues with older devices can lead to security gaps.

***KNX network architecture and safety.*** *The KNX* network topology supports different physical layer media, the most popular of which is *KNX-TP*, which uses a data rate of 9600 bps and a CSMA/CA access method. In addition, *KNX* supports other media such as *KNX-PL* (power line), *KNX-RF* (radio frequency) and *Knelt/IP* based on IP networking (Goltz et.al, 2019). *KNX* is widely used in building automation in Europe. *The KNX-Secure* add-on module provides encryption and authentication, but only certified devices can use this security mechanism, which limits the security of the system (Goltz, 2021). The segmentation of the *KNX* network becomes necessary to avoid high loads and to ensure a stable connection, as shown in Figure 6.

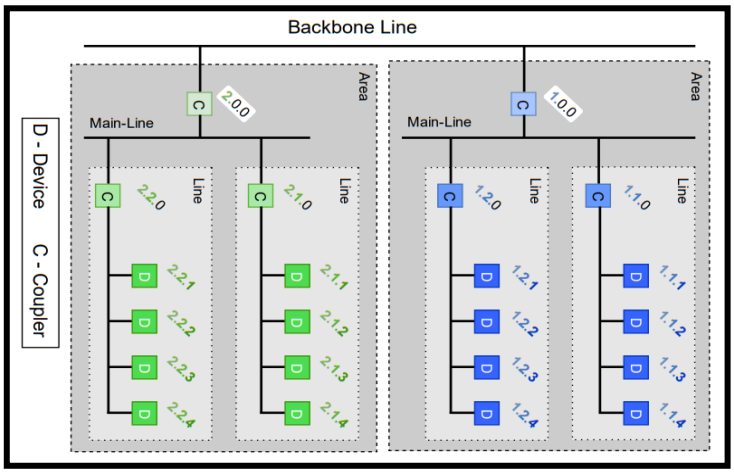



Figure 6: **Logical structure of a *KNX* Network (Capture image). Source. *Investigating the Filter Capacity of Line couplers in KNX regarding network security*. *International Wireless Communications and Mobile Computing Conference (IWCMC)*, Limassol, Cyprus**

KNX devices have unique physical addresses consisting of three digits separated by slashes. Group addresses are used during network operation and only multicasting ensures the functionality of communication. As each line can only contain 256 devices, segmentation of the *KNX* network becomes necessary to avoid high load and to ensure stable communication (Goltz, 2020). KNX can use an IP network for a higher control layer or directly access the automation layer via ZigBee or BACNet, where devices function as a bridge between the cyber and physical world (Ciholas et.al, 2019).

KNX is a reliable data transmission system for building automation, but the KNX-Secure standard is only applicable to certified devices, so its level of security may be limited. Nevertheless, KNX is appreciated for its applicability in complex systems and its ability to use multiple communication layers.

## CYBER SECURITY THREATS IN SMART HOMES

***Threats to the ZigBee standard***. *ZigBee* is a wireless communication standard based on IEEE 802.15.4, used in smart homes for its low power consumption and cost-effectiveness. However, security vulnerabilities arise because *the ZigBee* protocol uses standardized Global Trust Center Link Keys, which can be known to individuals with malicious intent and used to intercept data traffic. (Leeuwen et.al, 2019). This allows hackers to not only intercept data traffic, but also to analyze the activity of lights, temperature, or other devices in the home, which can help identify when the building is empty, which poses an additional threat (Santos, 2015).

*ZigBee* is also vulnerable to several types of attacks, including replay attacks. Those with malicious intent can intercept and re-send identical signals, taking advantage of the fact that some *ZigBee* systems do not have effective sequence number validation (Abomhara et.al, 2014). This further exacerbates the security concerns of the smart home network.

In summary, the *ZigBee* standard has advantages in terms of cost-effectiveness, but security weaknesses such as easily accessible encryption keys and ineffective sequence number validation make it vulnerable to malicious intent.

Threats to the Z-Wave standard. Z-Wave, a popular standard that uses robust encryption methods such as AES-128, but it also has its own security flaws. The main threat comes from man-in-the-middle attacks, where hackers can gain access to network authentication keys due to security vulnerabilities while the device is connected (Pen Test Partners,

2021). Despite these vulnerabilities, Z-Wave is improving security with S2 encryption and ECDH authentication, but older devices that cannot support the new security standards remain vulnerable.

In addition, some *Z-Wave* devices use unused or unencrypted data transmission methods (e.g., CS-8 or CRC-16), which can lead to risks of unauthorized remote access and data tampering. This opens the possibility for replay attacks and theft of personal information, which further complicates network security (Badenhop et.al, 2017).

*The Z-Wave* protocol, while using advanced encryption technologies, remains vulnerable to older devices and certain weaker encryption methods. Upgrading devices to newer security standards is necessary to ensure better security.

***Threats to the KNX standard****. The KNX* standard, widely used in Europe for building automation, is not immune to cyber-attacks. *KNX-TP* technology is more secure because it is harder to access by outsiders, but the use of *KNXnet/IP* makes the IP network vulnerable to vulnerabilities (Goltz et.al, 2019). *KNX-Secure* provides encryption and authentication, but only certified devices can use it. Uncertified devices remain vulnerable, and many devices in a network can reduce performance and cause delays (Goltz, 2020). *KNX* networks are vulnerable when *KNXnet/IP* technology is used, as it opens the door to cyber-attacks. Although *KNX-Secure* provides encryption, older or non-certified devices remain vulnerable. Also, network performance can be reduced in the presence of many devices.

## CYBERSECURITY SOLUTIONS FOR SMART HOMES: RECOMMENDATIONS

Security is a key concern in smart homes as they can store and transmit sensitive information, making them vulnerable to security and privacy breaches (Abie et.al, 2012). Smart homes need to meet six important security objectives: confidentiality, authentication, integrity, authorization, availability, and non-repudiation (He et.al, 2014). Security threats are classified into internal and external: internal due to network configuration errors or weak passwords (Abomhara et.al, 2014), and external due to external threats such as RF and wireless (Abomhara et.al, 2015).

***The main threats to the smart home.*** Denial of Service (DoS) attack: a Denial of Service (DoS) attack is one of the most common threats in smart homes. In this attack, hackers flood the network or system with a series of requests that block the ability to properly process legitimate requests. This can lead to smart devices such as heating, cooling systems or lighting controls becoming inaccessible (Kouicem, 2018).

Eavesdropping: In an eavesdropping attack, hackers intercept traffic between smart devices and the network. This can lead to the theft of sensitive information such as passwords or login credentials. Using tools such as Wireshark, hackers can connect to the network and monitor the data sent by devices, compromising personal privacy and security (Geneiatakis et.al, 2018).

Impersonation attack: In this attack, hackers try to impersonate a legitimate user to gain unauthorized access to smart home devices or systems. This can be achieved through social engineering or by intercepting login credentials. Identity theft allows hackers to manipulate the home automation system and cause security breaches such as theft or unauthorized access to CCTV cameras (Talal et.al, 2019).

Malicious software, such as viruses and Trojan horses, can be installed on smart devices. This can steal personal information, damage functions or open back doors to control devices. Weak authentication procedures, such as poor passwords, are often used (Ali et.al, 2018).

Information Theft: Hackers can take advantage of vulnerable smart devices to steal sensitive information, such as credit card numbers, personal identification data or even records of daily activities. This data can be used for financial fraud or privacy breaches (Ali et.al, 2017).

The most common cyber threats in smart homes, such as DoS attacks, eavesdropping, identity spoofing and malware, can cause serious security breaches. Proper authentication and device security are essential to protect personal information and devices.

***Cybersecurity guidelines and preventive measures.*** Regular software updates are essential to ensure protection against vulnerabilities. Updates prevent hacks and strengthen defenses, while firewalls protect against external threats (Ali et.al, 2018).

Encrypt data transmissions: using encryption can protect data from interception and malicious attacks. Encryption ensures that even if a hacker intercepts the data, they will not be able to read it. This is particularly important when devices transmit personal data or other sensitive information (Perera et.al, 2016).

Secure communication channels (VPNs): Virtual Private Networks (VPNs) can ensure that only authorized users have access to the network. Using VPNs can ensure that all communications between smart home devices and the network are encrypted and inaccessible to unauthorized people, thereby strengthening the network's security against unauthorized access (Ali et.al, 2018).

Use strong and unique passwords: it is important to create strong passwords made up of numbers, letters, and special characters. It is also necessary to use different passwords for different devices and not to use the same password for all devices. In addition, passwords should be changed regularly to reduce the risk of theft and malicious attacks (NetFormation, 2019).

Backup: backups are important to protect valuable information from loss or theft. Regularly backing up data and storing it in secure locations ensures that data will not be lost even if devices fail or become the target of hacking (Abdullah et.al, 2019).

Keeping your smart home devices secure requires regular software updates, encryption, VPNs, and strong passwords. It is also important to back up your data and make sure your devices are protected against known threats.

## CONCLUSIONS

1. Smart home control system standards such as ZigBee, Z-Wave and KNX have fundamental differences in terms of frequency range, data rate and communication range. Each standard has its own advantages and disadvantages which determine their suitability for specific conditions. For example, ZigBee and Z-Wave are better suited for wireless communication, while KNX is effective for wired solutions in large building systems.

2. Each of the standards under consideration faces specific security risks. The ZigBee standard has low power consumption, but its encryption solutions may be insecure due to publicly available keys. Meanwhile, the Z-Wave system is vulnerable to middle layer attacks. The KNX standard, although often seen as dependable for building automation, has limited security due to compatibility with older devices and mediocre performance when many devices are connected on one line.

3. It is recommended that you keep your smart home device software up to date, use secure, encrypted communications, and use firewalls to protect against external attacks. It is also necessary to constantly change default passwords and use unique login credentials for different devices.

## REFERENCES

8 best practices for securing the Internet of Things (IoT). (2024, January 10). SecurityScorecard. https://securityscorecard.com/blog/best-practices-for-securing-internet-of-things/

Abdullah, T. A. A., Ali, W., Malebary, S., & Ahmed, A. A. (2019). A review of cyber security challenges, attacks and solutions for Internet of things based smart home. http://paper.ijcsns.org/07_book/201909/20190917.pdf

Abie, H., & Balasingham, I. (2012). Risk-based adaptive security for smart IoT in eHealth. BodyNets, 269–275. https://doi.org/10.4108/ICST.BODYNETS.2012.250235

Abomhara, M., Department of Information and Communication Technology, University of Agder, Norway, Køien, G. M., & Department of Information and Communication Technology, University of Agder, Norway. (2015). Cyber security and the internet of things: Vulnerabilities, threats, intruders and attacks. Journal of Cyber Security and Mobility, 4(1), 65–88. https://doi.org/10.13052/jcsm2245-1439.414

Abomhara, M., & Køien, G. M. (2014). Security and privacy in the Internet of Things: Current status and open issues. IEEE. https://doi.org/10.1109/prisms.2014.6970594

Ali, B., & Awad, A. (2018). Cyber and physical security vulnerability assessment for IoT-based smart homes. Sensors (Basel, Switzerland), 18(3), 817. https://doi.org/10.3390/s18030817

Cc, C. (n.d.). A true system-on-chip solution for 2.4-GHz IEEE 802.15.4 and ZigBee applications. Www.ti.com. Retrieved November 13, 2024, from https://www.ti.com/lit/ds/symlink/cc2530.pdf?ts=1731484894353&ref_url=https%253A%252F%252Fwww.ti.com%252Fproduct%252FCC2530

Geneiatakis, D., Kounelis, I., Neisse, R., Nai-Fovino, I., Steri, G., & Baldini, G. (2017). Security and privacy issues for an IoT based smart home. IEEE. https://doi.org/10.23919/mipro.2017.7973622

Ghayvat, H., Mukhopadhyay, S. C., & Gui, X. (2016). Issues and mitigation of interference, attenuation and direction of arrival in IEEE 802.15.4/ZigBee to wireless sensors and networks based smart building. Measurement: Journal of the International Measurement Confederation, 86, 209–226. https://doi.org/10.1016/j.measurement.2016.01.045

Goltz, J. (2020). Investigating the Filter Capacity of Linecouplers in KNX regarding network security. IEEE. https://doi.org/10.1109/iwcmc48107.2020.9148402

Goltz, J. (2021). Securing Building Automation Systems. IEEE. https://doi.org/10.1109/ntms49979.2021.9432650

Goltz, J., Mundt, T., & Wiedenmann, S. (2019). Risk analysis in fieldbus networks using the example of KNX. International Conference on Information Networking, 310–315. https://doi.org/10.1109/ICOIN.2019.8718149

Chen, H. C., & Chang, L. Y (2012). Design and Implementation of a ZigBee-Based Wireless Automatic Meter Reading System. PRZEGLĄD ELEKTROTECHNICZNY (Electrical Review), 88(1b). https://www.researchgate.net/publication/290712491_Design_and_Implementation_of_a_ZigBee-Based_Wireless_Automatic_Meter_Reading_System

Johannes, G., Thomas, M., & Wiedenmann, S. (2019). Risk analysis in fieldbus networks using the example of KNX. IEEE. https://doi.org/10.1109/icoin.2019.8718149

Khanji, S., Iqbal, F., & Hung, P. (2019). ZigBee security vulnerabilities: Exploration and evaluating. IEEE. https://doi.org/10.1109/iacs.2019.8809115

Kouicem, D. E., Bouabdallah, A., & Lakhlef, H. (2018). Internet of things security: A top-down survey. Computer Networks, 141, 199–221. https://doi.org/10.1016/j.comnet.2018.03.012

Leeuwen, D. V., & Ayuk, L. T. (2019). Security testing of the Zigbee communication protocol in consumer grade IoT devices. https://urn.kb.se/resolve?urn=urn%3Anbn%3Ase%3Ahh%3Adiva-40189

Li, H., Jia, Z., & Xue, X. (2010). Application and analysis of ZigBee security services specification. IEEE. https://doi.org/10.1109/nswctc.2010.261

Liang, C. B., Tabassum, M., Kashem, S. B. A., Zama, Z., Suresh, P., & Saravanakumar, U. (2021). Smart home security system based on zigbee. In Advances in Intelligent Systems and Computing (pp. 827–836). Springer Singapore. https://doi.org/10.1007/978-981-15-5029-4_71

Perera, C., McCormick, C., Bandara, A. K., Price, B. A., & Nuseibeh, B. (2016). Privacy-by-design framework for assessing internet of things applications and platforms. ACM. https://doi.org/10.1145/2991561.2991566

Rahman, A. A. (2015). Comparison of Internet of things ( IoT ) data link protocols. https://www.cse.wustl.edu/~jain/cse570-15/ftp/iot_dlc.pdf

Santos, D. F. S., Almeida, H. O., & Perkusich, A. (2015). A personal connected health system for the Internet of Things based on the Constrained Application Protocol. Computers & Electrical Engineering: An International Journal, 44, 122–136. https://doi.org/10.1016/j.compeleceng.2015.02.020

Unwala, I., Taqvi, Z., & Lu, J. (2018). IoT Security: ZWave and Thread. IEEE. https://doi.org/10.1109/greentech.2018.00040

Xu, C.S., Chen, X.J., Li, D., & Zhong, X.-H. (2008). Automatic electric meter reading system based on ZigBee. IEEE. https://doi.org/10.1109/wicom.2008.712

PANEVĖŽIO KOLEGIJA ISSN 2029-1280, eISSN 2669-0071. Taikomieji tyrimai studijose ir praktikoje – Applied Research in Studies and Practice, 2024, 20.

# CHARACTERISTICS OF FAMILY MEMBERS' CARE IN NURSING CARE OF PATIENTS WITH AMYOTROPHIC LATERAL SCLEROSIS

*Vida ELIJOŠAITIENĖ, Daiva JANKAUSKAITĖ*

*Panevėžio kolegija / State Higher Education Institution, Lithuania*
*Pulmonology Department of Panevėžys Republican Hospital*

**Annotation.** Amyotrophic lateral sclerosis is a rapidly progressive and fatal neurodegenerative disease. The relative number of patients throughout the population with this disease is small. There is no effective way to treat the disease or to halt its progression, therefore only symptomatic treatment is available and continuous nursing care of relatives is essential. Around 50% of the patients die within 30 months of the onset of symptoms, often as a result of respiratory failure, and around 10% may survive for more than a decade. Amyotrophic lateral sclerosis is characterised by degeneration of the upper and lower motor neurons and frontotemporal systems. Although the cause of the disease is largely unknown, 10-20% of the cases have a certain genetic aetiology.

**Keywords**: amyotrophic lateral sclerosis, neurodegenerative disease, nursing care

## INTRODUCTION

Neurodegenerative diseases affect around one billion people worldwide, and the root causes of these diseases are unclear. Neurodegenerative diseases can occur due to a combination of genomic, epigenomic, metabolic and environmental factors. In the context of progressive neurodegenerative processes and neuroinflammation, no therapy or treatment can slow down or stop the progression of these diseases. Amyotrophic lateral sclerosis, multiple sclerosis, Parkinson's, Alzheimer's and Huntington's diseases can severely affect patient's daily life (Ruffini et al., 2020). Neurodegenerative diseases are chronic diseases that damage nerve cells in the brain and cause memory loss, behavioural, speech and mobility disorders and have similar cellular and molecular development mechanisms. According to Geevasinga et al. (2016), oxidative stress is considered to be one of the most important pathophysiological mechanisms underlying neurodegenerative diseases.

One of the most rapidly progressive neurodegenerative diseases is amyotrophic lateral sclerosis (hereinafter referred to as ALS) (Benatar et al., 2019). The name of the disease refers to the changes that occur in a human body when it strikes. "Amyotrophic" refers to the atrophy of a person's muscles; "lateral sclerosis" refers to the presence of sclerotic changes in the lateral parts of the spinal cord. ALS is a neurological disease that affects the neurons involved in the transmission of nerve impulses to muscles (motor neurons) and is classified under motor neurone disease group.

Different number of ALS cases is observed in various countries around the world. The age of people with ALS also varies between countries. The average age of patients at the time of diagnosis varied between 54 and 66 years. This high prevalence is thought to be due to the higher proportion of older people (Longinetti & Fang, 2019).

**The aim of the study is to** assess the characteristics of family members' care in nursing care of patients with amyotrophic lateral sclerosis.

**The object** is the characteristics of family members' care in nursing care of patients.

**The objectives of the study** are as follows:

1. To analyse the factors of amyotrophic lateral sclerosis onset in amyotrophic lateral sclerosis patients and the basis for its management based on scientific literature.
2. To identify the challenges experienced by family members in nursing care of patients with amyotrophic lateral sclerosis.
3. To identify the major nursing care factors in the care of patients with amyotrophic lateral sclerosis.

**Research methods:** 1. Analysis of scientific literature. 2. Qualitative research: unstructured interviews. 3. Descriptive analysis of the data collected.

## THE CONCEPT OF NEURODEGENERATIVE DISEASE: LITERATURE OVEREVIEW

ALS is a rare and progressive neurodegenerative disease that affects nerve cells in the brain and spine. ALS is a fatal neurodegenerative disorder that affects adults and is characterised by degeneration of both upper motor neurons in the primary motor cortex and lower motor neurons in the brainstem and spinal cord. Initially, symptoms of ALS manifest in muscle atrophy and weakness. This is often followed by the development of progressive paralysis of the voluntary muscles and eventually of the respiratory muscles. Corcia et al. (2017) observed that the initial onset of ALS usually develops in the limbs, masticatory and swallowing muscles, spreading into other areas of the body, and resulting in dysfunction of respiratory muscles. The majority (more than 90%) of ALS cases are of the sporadic form, while a small proportion (around 5-10%) are of the familial form. The onset of the disease is usually manifested by weakness in the limbs, called spinal onset, or difficulty with speech or swallowing, called bulbar onset. Other forms of ALS may also be observed in patients, including mixed spinal and bulbar form, chest onset, thoracic or dementia symptoms, respiratory

symptoms, thoracic or respiratory symptoms, or cognitive change (Longinetti & Fang, 2019). Scientific progress in genetic research has led to the identification of genes contributing to the pathogenesis of this disease. However, there is currently no effective treatment for patients with ALS.

It has been observed that the majority of ALS patients die of respiratory failure, usually within 3-5 years of the onset of signs and symptoms (Longinetti &Fang, 2019). Recent studies also emphasise that longer survival is associated with male gender, younger age at the onset of disease and diagnosis, higher body mass index and weight gain following diagnosis. Tracheostomy is another factor prolonging the patient's life. It leads to a significant increase in survival time of patients. Benjaminsen et al. (2018) demonstrated in their study that the median survival from the symptom onset to death can be longer than five years if tracheostomy was performed on ALS patients.

## SYMPTOMS OF AMYOTROPHIC LATERAL SCLEROSIS AND THE DEMAND FOR NURSING CARE IN PATIENTS WITH AMYOTROPHIC LATERAL SCLEROSIS

ALS is a neurodegenerative disease characterised by progressive muscle paralysis. Benatar et al. (2022) note that men are slightly more likely to suffer from this disease than women. The highest incidence of the disease is observed between 58 and 63 years of life, and only about 5% of cases are diagnosed before the age of 30 years. The concept of ALS identifies two phases of the disease: asymptomatic and symptomatic. The asymptomatic (clinically silent) phase begins at the onset of the disease, but it is not identifiable at that time. ALS is a progressive neurodegenerative disease involving both upper and lower motor neurons, leading to paralysis and eventually death. Symptomatic treatments, such as suppression of salivation, relief of muscle cramps and relief of spasticity and pain, still play an important role in improving the quality of life (Xu et al., 2021). Benatar et al. (2022) report that in some patients, the clinical onset of ALS is preceded by a prodromal phase characterised by non-specific symptoms (e.g. muscle cramps, reduced exercise tolerance), signs (e.g, fasciculation, isolated loss of ankle reflexes, diffuse hyperreflexia), abnormalities (e.g. positive sharp waves in the muscles of one limb or in the thoracic paraspinal muscles) in the absence of progressive muscle weakness. As a sign of progressive disease, patients may develop limb spasms that affect hand dexterity, balance and gait. Early symptoms of ALS may involve muscle twitching, cramps, stiffness or weakness, slurred speech and/or difficulty in chewing or swallowing. As the disease progresses, people may develop weakness and eventually become dependent on a wheelchair.

Nursing care has always been focused on preserving health, comfort and providing care. Nursing care addresses a wide range of patient needs, from the most complex procedures to the simple act of gently taking a patient's hand and giving him or her reassurance. The main purpose of nursing care is to meet physical, spiritual, emotional and social needs of patients. Therefore, nursing care is about caring for others. Chronic progressive neurological diseases require integrated palliative care. Advance planning of care is an integral part of this process (Seeber et al., 2019). The severity of illness and uncertainty about the timing of disability and the evolving burden of care cause significant stress not only for the affected individuals but also for their families. Upon hearing a diagnosis of ALS, the lives of everyone around patients change and health care providers themselves are faced with the enormous task of caring for these individuals affected by ALS (Bromberg et al., 2011). Family members of patients with ALS are very much involved in the treatment process from the earliest stages of the disease and take on a huge share of the responsibility in helping patients.

## ANALYSIS OF THE STUDY RESULTS

In order to achieve the aim and objectives of the study, a qualitative research method, unstructured interviews, was selected. This method allows for a better assessment of a person's experiences and emotions. The qualitative research was aimed at describing and understanding how different people involved in the study understand the phenomenon under investigation, what meanings they give to the phenomenon, and disclose the characteristics of nursing care of a severely ill person. As the survival time of people with ALS is limited, interviews were conducted with relatives of patients who were with their loved one during their illness. All respondents were consulted in advance of the scheduled interview. Out of 10 contacted people, only 5 agreed to take part in the study. The study was carried out with the consent to use the information obtained for scientific purposes, ensuring the anonymity of the respondents and confidentiality of the information, respecting the ethical principles (goodwill, privacy, voluntary nature, respect and fairness) and not violating the participants' rights.

The sample of the study consists of 5 respondents: 3 female and 2 male. The age of respodents participating in the study ranged from 45 to 55 years old, with an average age of 48 years. All respondents had a higher education degree. The respondents had been providing nursing care as follows: two for 1 year, two for 5 years and one for 7 years. The age of the patients was between 49 and 79 years, with an average age of 63 years.

The analysis of the study is linked to the knowledge of the most important factors in the situation. The questions and challenges raised relate to the search for meaning and a new approach to certain situations.

The interview was structured into 4 categories and 7 sub-categories.

*Category 1:* **Experiences in the care of patients with amyotrophic lateral sclerosis.** Family members face a variety of problems related to nursing care. They have different experiences, positive and negative emotions and gain new experience. Uncertainty, fear, physical and emotional fatigue are common symptoms, experienced not only by

the patient but also by the entire family. Caregivers suffer from psychological stress in the form of depression, anxiety and sleep disorders. Psychological support for patients and family members is essential.

*Category 2:* **Interventions to promote independence.** Caregivers say that the disease is slowly taking away the patient's capacity to function, but the mind remains lucid and all skills are lost. Therefore, assistance from a variety of specialists is required: physiotherapists, occupational therapists, speech therapists and dieticians. A properly adapted home environment is essential for comfortable nursing care and better quality of life of the patient. However, with the rapid progression of the disease, it is often impossible to continuously change the environment according to the needs of the patient. A special feeding table, a bathroom bench, a toilet chair and many other items are required, as well as armrests for comfortable and safe access at home. If the person being cared for walks, mobility aids such as a walker, a cane must be provided, and the layout of the room where the person lives must be adapted to allow safe movement. If the patient is bedridden, a hydraulic bed is required, and the position of the patient must be changed to prevent pressure sores, he or she must be fed, washed, dressed, hygiene products must be changed, and the patient must be given or administered medication at the right time.

*Category 3:* **Contribution of the family to supporting the patient with amyotrophic lateral sclerosis**. The help and support of close relatives is an important factor. It covers sharing information or experiences, sharing tasks, supporting each other psychologically, spending meaningful time with the patient. The family provides security, support and care. The most important step is regular health monitoring.

*Category 4:* **Self-awareness**. Information can be sought from information dissemination means, most of them in English, however there is no specific information on how to increase self-care for patients and family members caring for them (self-awareness means personal freedom, the pursuit for improvement, the pursuit of the individual's potential and desires). Mental health and self-awareness are key factors determining the effectiveness of nursing care. Initial information should always be provided by a doctor. All caregivers, whether a nurse or a family member, experience stress to a lesser or greater extent. Engaging in positive activities, sports, work that a person loves, can prevent burnout. There are also meditations and prayer, as well as inner dialogues and conversations with psychologists (see Figure 1).

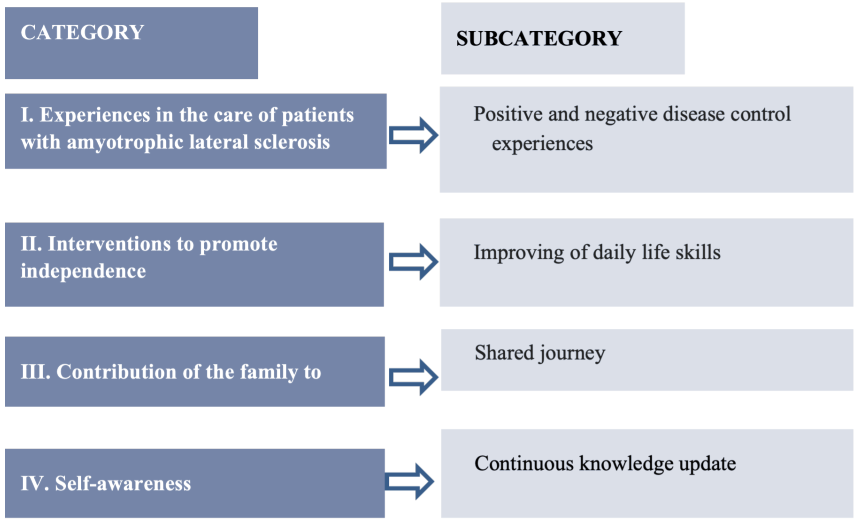



Figure 1. **Instrument for the Analysis of Characteristics of Nursing Care Provided by Family Members**

The key need is to adapt quickly to the patient's changing deterioration in condition, as social needs and skills disappear. Challenges, which are divided into three groups and are essential for meeting the needs of the patients, are outlined below:

**Domestic** (household) challenges are faced in the provision of suitable accommodation for the comfortable care of a seriously ill patient, special equipment, and a comfortable vehicle for transporting the patient.

**Physical** challenges include heavy strain (caring for a sick person, having a formal employment), and physical exhaustion.

**Psychological** challenges include uncertainty, fear, anxiety, sleep disturbances, emotional exhaustion, and depression (see Figure 2).

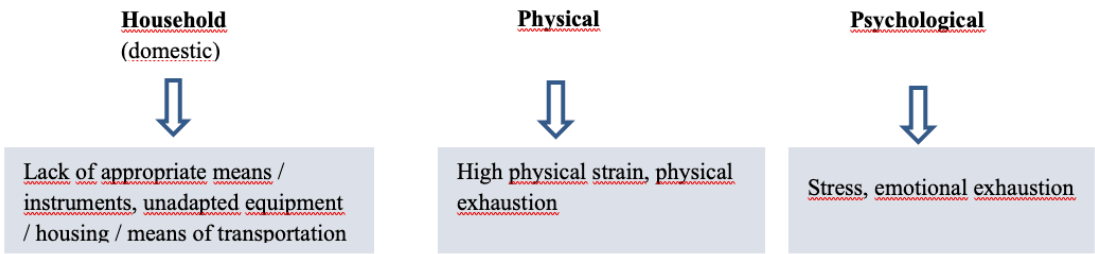



Figure 2. **Challenges Faced by Family Members in Nursing Care of Patients with Amyotrophic Lateral Sclerosis**

The family members help to adapt to the changed living conditions, adapt the environment to meet the patients' needs and try to give meaning to their lives. Adaptation to the disease is determined by personal qualities and the interaction of the support system (family, friends, various medical institutions, caregivers), while psychological adaptation is affected by internal (age, heredity, gender, other illnesses) and external factors (stress, harmful habits, diet, physical fitness) affecting the patient and family members. The most important are as follows:

**Multidimensional nursing care support** includes the provision of comfortable accommodation adapted to the patient's needs, adaptation of the transportation vehicle, provision of hygiene and nursing care products, and the provision of necessary information about the illness through the support of relatives.

**Continuous knowledge update** includes access to the necessary information and cooperation with the doctors.

**Regular health monitoring** means that the patient should never be left alone, his or her condition should be constantly monitored, the necessary tests should be carried out, and the necessary medicines should be taken and/or administered.

**Consistent and good quality care** includes providing appropriate and comfortable conditions for nursing care, and consistent and high quality care (see Figure 3).

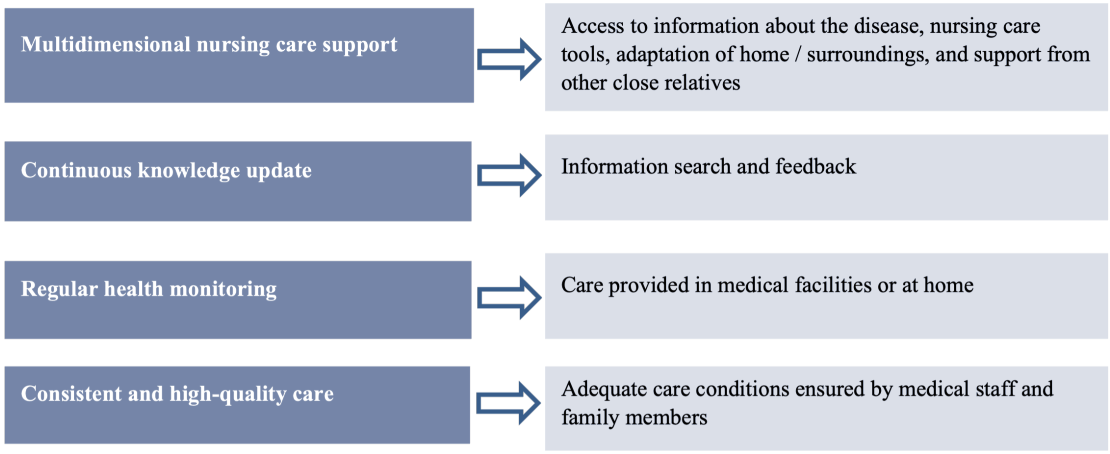



Figure 3. **Key Nursing Care Factors in Nursing Care of Patients with Amyotrophic Lateral Sclerosis**

In summarising all ALS cases, it was revealed that, based on the respondents' accounts, the course of the disease varies for all patients, although the outcome of the disease is unfortunately identical. It is evident from the data obtained that there are differences in the onset and course of the disease, as well as in the medical treatment used. It is probable that the caregivers' emotions and reactions to the disease may also differ.

## CONCLUSIONS

• Amyotrophic lateral sclerosis is a rapidly progressive and incurable disease, with oxidative stress and heredity being the most common factors of its onset. There is currently no available cure, and symptomatic and palliative care form the basis for disease management.

• It has been disclosed that the disease causes many inconveniences and a variety of domestic and psychological challenges for the patient and the caregiver, and therefore requires disease management and improvements in daily living skills.

• Nursing care support, continuous knowledge update, regular health monitoring, and consistent and high-quality care are essential to sustain the patient's vital functions as long as possible.

## REFERENCES

Benatar, M., Turnerr, M.R. & Wuu, J. (2019). Defining pre-symptomatic amyotrophic lateral sclerosis. Amyotroph Lateral Scler Frontotemporal Degener. 20(5-6):303-309. DOI: 10.1080/21678421.2019.1587634

Benatar, M., Wuu, J., McHutchison, C., B Postuma, R., F Boeve, B., Petersen, R., A Ross, C., Rosen, H., J Arias, J., Fradette, S., P McDermott, M, Shefner, J., Stanislaw, Ch., Abrahams, S., Cosentino, M Andersen, P., S Finkel, R., Granit, V., Grigon, A.L., S. Turner, M.R. (2022). Preventing amyotrophic lateral sclerosis: insights from pre-symptomatic neurodegenerative diseases. Brain.145 (1): 27-44. DOI: 10.1093/brain/awab404

Benjaminsen, E., Alstadhaug, K.B., Gulsvik, M., Baloch, F.K., & Odeh, F. (2018). Amyotrophic lateral sclerosis in Nordland county, Norway, 2000-2015: prevalence, incidence, and clinical features. Amyotroph Lateral Scler Frontotemporal Degener. 19(7-8):522–527. DOI: 10.1080/21678421.2018.1513534

Bromberg, M.B., Schenkenberg, T. & Brownell, A.A. (2011). A survey of stress among amyotrophic lateral sclerosis care providers. Amyotrophic lateral sclerosis: official publication of the World Federation of Neurology Research Group on Motor Neuron Diseases. 12(3):162–167. https://doi.org/10.3109/17482968.2011.562512

Corcia, P., Couratier, P., Blasco, H., Andres, C.R., Beltran, S., Meininger, V. & Vourch, P. (2017). Genetics of amyotrophic lateral sclerosis. Rev Neurol (Paris). 173(5):254-622. DOI: 10.1016/j.neurol.2017.03.030

Geevasinga, N., Menon, P., Özdinler, P.H., Kiernan, M.C. & Vucic, S.(2016) Pathophysiological and diagnostic implications of cortical dysfunction in ALS. Nat Rev Neurol. 12(11):651-661.DOI: 10.1038/nrneurol.2016.140

Longinetti, E. & Fang, F. (2019). Epidemiology of amyotrophic lateral sclerosis: an update of recent literature. Curr Opin Neurol. 32(5):771-776 DOI: 10.1097 / WCO.0000000000000730

Ruffini, N., Klingenberg, S., Schweiger, S. & Gerber, S. (2020). Common Factors in Neurodegeneration: A Meta-Study Revealing Shared Patterns on a Multi-Omics Scale. Cells. 9(12):2642. DOI: 10.3390/cells9122642

Seeber, A.A., Pols, A.J., Hijdra, A., Grupstra, H.F., Vilemsas, D.L. & de Visser, M. (2019). Advance care planning in progressive neurological diseases: lessons from ALS. BMC Palliative Care. 18(50).https://doi.org/10.1186/s12904-019-0433-6

Xu, X., Shen, D., Gao, Y., Zhou, Q., Ni, Y., Meng, H., Shi, H., Le, W., Chen, S., & Chen, S., (2021). A perspective on therapies for amyotrophic lateral sclerosis: can disease progression be curbed? Translational Neuradegeneration. 10(1):29. DOI: 10.1186/s40035-021-00250-5

PANEVĖŽIO KOLEGIJA ISSN 2029-1280, eISSN 2669-0071. Taikomieji tyrimai studijose ir praktikoje – Applied Research in Studies and Practice, 2024, 20.

# ANALYSIS OF ENERGY STORAGE METHODS FOR SOLAR POWER PLANTS

***Karolis TOLEIKIS*[a], *Daiva STANELYTĖ*[ab]**

[a] *Klaipedos valstybine kolegija – Higher Education Institution, Lithuania*
[b] *Lithuanian Energy Institute, Lithuania*

**Abstract.** The paper looks at ways of storing excess energy generated by solar power plants. The aim of the study is to present the results of the analysis of the storage of the energy generated by solar power plants. Based on the results of the analysis, it can be concluded that, in the absence of infrastructure constraints, the most efficient way of storing the energy generated by solar power plants is by using a hybrid system. This energy storage system reduces the risk to the supply or storage of the energy generated by the PV plants in the event of a failure of the grid or the energy storage system. Where geographical conditions are limited, lithium-ion batteries are the most effective option due to their high efficiency and long lifetime, despite the higher initial investment cost.

**Keywords**: Solar power plants, energy storage systems, electricity grids, renewable energy

## INTRODUCTION

**Relevance**: Renewable energy is key to stabilizing climate change. Most consumers are installing solar power plants in their own homes. One of the reasons for this is that the Environmental Management Project Agency in Lithuania supports the installation of solar power plants up to 10 kW. According to the Environmental Project Management Agency, the payback period varies between 3-5 years. The clean energy produced by a solar power plant is also an investment, and although the initial investment is high, in the long term it can pay for itself and even make a profit by selling the surplus energy it generates.

**Research problem:** Choosing the optimal way of storing the energy produced is very important, and to do this, it is necessary to analyze the possible ways of doing so. Since the performance of a solar power plant is directly dependent on the sun, this means that in cloudy weather, in the dark, in the shade, or in the winter, when there is less sun, the efficiency of the plant is reduced. At night, solar power plants do not generate any electricity at all. Energy storage technologies require large investments, and their availability is not always optimal. Also, energy storage systems are not perpetual and have a limited capacity, so other alternatives must be found to store the energy produced by the power plant and use it when needed.

**Research methods:** analysis of scientific literature.

**The analysis was carried out on the following databases:** EBSCO Publishing, IEEE and Science Direct.

**The object of the study** is solar power plants.

**Objective of the study**: Analysis of energy storage methods for solar power plants.

**Objectives of the study:**

1. To analyze the energy storage methods used to store the energy generated by solar power plants.
2. To compare the energy storage methods used to store the energy generated by solar power plants.
3. To present the most efficient way of storing the energy produced by solar power plants.

## RESEARCH METHODOLOGY

This study employed a quantitative research method aimed at analyzing synthesized data from various primary studies. Publications by international authors were among the studied sources, enabling a thorough analysis of the topic. Research data and theoretical reviews published in *EBSCO Publishing*, *IEEE* and *Science Direct* were analyzed. Titles, abstracts, and full texts of scientific articles were reviewed to determine their appropriateness for analysis. The most pertinent databases, where the findings of studies on the topic were published, were chosen for the systematic and comprehensive literature search.

Table 1

**Results of the literature search in scientific article databases**

| Key words | EBSCO Publishing | IEEE | Science Direct | Total |
|---|---|---|---|---|
| Solar power plants | 3343 | 18016 | 179226 | 200585 |
| Energy storage systems | 5000 | 92308 | 1000000+ | 1097308+ |
| Electricity grids | 2888 | 65145 | 162846 | 230879 |
| Renewable energy | 5000 | 126326 | 527162 | 658488 |
| **Total** | 16231 | 301795 | 1869234+ | 2187260 |

A literature search was performed using every search word that may be utilised to describe the concept under investigation. Number of publications were found based on the keyword combinations used. The table that follows displays the outcomes.

Since the data needed for the investigation is available in scientific databases, the study complies with research ethical guidelines.

## ANALYSIS OF THE METHODS OF SAVING ELECTRIC POWER GENERATION IN SOLAR PLANTS

As renewable energy has the disadvantage of being a volatile energy source, energy management systems require appropriate energy storage methods to make the most efficient use of energy (Gupta, 2021). In today's world, electricity has become very important in daily life, and batteries have become an integral part of the energy source. More advanced energy storage technologies are needed to enable the transition to renewable energy sources and smart grids (Gurung, 2018).

Solar power plants can be classified as grid-connected, off-grid, or hybrid. Grid-connected ones transfer excess energy to the grid, non-grid-connected ones to batteries, and hybrid ones can transfer to both the grid and batteries (Gupta, 2021). Solar batteries can be divided into four types: lead-acid, lithium-ion, nickel-cadmium, and flow.

The lead-acid storage system is the most mature and the cheapest energy storage system of all available energy storage systems (Kousksou, 2014). Lead-acid batteries are durable and cheap, making them a popular choice for stationary applications such as renewable energy storage (Faunce, 2018). Lead-acid batteries lead the rechargeable battery market, both in terms of sales value and MWh production (May, 2018). Lead-acid batteries are being used and increasingly developed by the Lead Acid Consortium for sustainable markets, such as next-generation hybrid cars and grid-scale energy storage applications (Prengaman, 2017). However, one of their drawbacks is that lead is heavy, and while the battery has sufficient power density, the energy density is not very high (Gutmann, 2009).

Lithium-ion batteries are mainly applied as a power source for portable electronic devices, especially mobile phones and laptops. The scope of application is currently expanding to large-scale energy sources and energy storage devices such as electric vehicles and renewable energy systems (Ariyoshi, 2023). Lithium-ion batteries have the highest energy density among practical secondary batteries (Hosaka, 2023). Lithium-ion batteries are most suitable for home energy storage systems, although this is not economically feasible compared to other batteries (Gupta, 2021).

Nickel-cadmium batteries, with electrodes made of cadmium metal and nickel oxide hydroxide. Nickel-cadmium batteries are also known as Ni-Cd batteries, where Ni refers to the nickel element and Cd refers to the cadmium element (Pandey, 2022). Ni-Cd batteries have high power and energy density, high charge/discharge efficiency, and a short lifetime. The main disadvantage is the relatively high cost due to the expensive manufacturing process. Cadmium is a toxic, heavy metal, which raises problems with the disposal of Ni-Cd batteries (Abdin, 2019).

A flow battery is a rechargeable battery in which energy is stored in one or more electroactive species dissolved into liquid electrolytes (Kularatna, 2021).

The development of renewable energy requires advanced energy storage technologies to ensure the stability of electricity supply under intermittent generation conditions. The analysis of the scientific literature shows that lithium-ion batteries, although they have the highest energy density, have a high initial investment. Lead-acid batteries are the most mature and the cheapest, but their energy density is quite low.

Nickel cadmium batteries have a high power and energy density but pollute due to the toxic metal cadmium. Further progress in this area is therefore necessary to achieve efficiency, sustainability, and wider use in different sectors.

## COMPARISON OF THE STORAGE METHODS OF SOLAR PLANTS PRODUCED ENERGY

The advantages of grid-connected solar power plants are: long lifetime (25–30 years), low operation and maintenance costs, and no need for energy storage systems. However, mass connection of solar power plants to the grid can lead to grid congestion (Obi, 2016). The figure shows the operating principle of a grid-connected solar power system. First, the solar modules absorb the sun's rays and convert them into direct current electricity. This energy is then transferred to an inverter, which converts it into alternating current. The energy generated primarily meets the direct electricity demand of the home, while the excess energy is fed into the grid via the electricity meter. This meter records both the energy transferred to the grid and the energy consumed. Unlike stand-alone systems, which store excess energy in energy storage systems, here the excess energy is stored in the grid itself. In the event of a power shortage, consumers can use the energy stored in the grid. The advantage of a grid-connected solar PV system is that it does not need an expensive energy storage system to store excess energy, as it can store it on the grid.

Off-grid solar power plants are independent of grid disturbances. Off-grid solar power plants are mobile, which makes them particularly useful in settlements where it is not possible to connect the solar power plant to the electricity grid. (Ortega-Arriaga, 2021). The disadvantage of off-grid solar plants is that they require expensive batteries to store energy. The electricity supply is limited by the energy stored, but this ensures independence from the grid and operation even in the event of disturbances (Cho, 2020). According to the Lithuanian electricity and gas distribution and grid

operators, an off-grid system is the more expensive solution, as its inverter is 30–40% more expensive than a grid-connected inverter. The grid of a microsolar power plant is shown below.

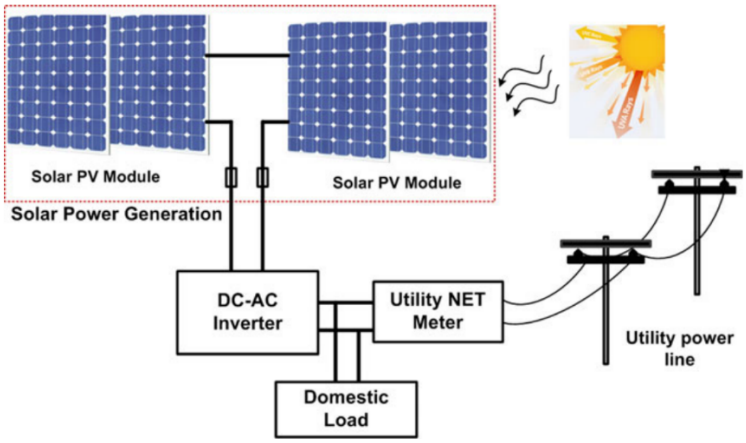



Figure 1. **Grid-connected solar power plant system**
Source: Karthikeyan, V., Rajasekar, S., Das, V., Karuppanan, P., & Singh, A. K. Grid-Connected and Off-Grid Solar Photovoltaic System. Green Energy and Technology, 2017

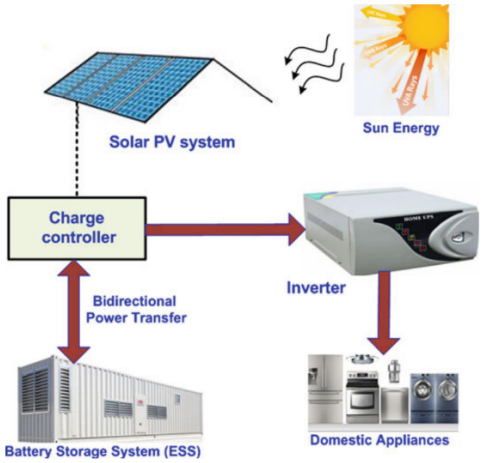



Figure 2. **Off-grid solar power plant network**
Source: Karthikeyan, V., Rajasekar, S., Das, V., Karuppanan, P., & Singh, A. K. Grid-Connected and Off-Grid Solar Photovoltaic System. Green Energy and Technology, 2017

In the figure, you can see the network and energy path of an off-grid solar power plant. First, the solar modules absorb sunlight and convert it into DC electricity. This energy is fed to a charging controller, which controls the flow of electricity and ensures that the energy storage system is charged safely and efficiently. The inverter converts the DC power supplied by the batteries into AC power. Excess energy that is not currently being used by household appliances is stored in the energy storage system. In the event of a power shortage, the stored energy from the energy storage system is used to supply electricity. The advantage of an off-grid solar PV system is that excess energy can be stored in the energy storage system, allowing the excess energy to be used in times of energy shortage.

The most commonly used battery types, lead acid and lithium-ion, have their pros and cons. According to research, lithium-ion batteries have a higher capacity and energy density, lower maintenance requirements, and a higher number of cycles compared to lead acid batteries (Kebede, 2021). Nickel-cadmium batteries are also direct competitors with lead-acid batteries since these batteries offer similar technical characteristics but with superior cycling abilities and energy density (Johnson, 2019). Ni-cd batteries have a higher power density and a slightly greater energy density (50-75 Wh/kg), and the number of cycles is higher (>3500 cycles) compared with lead-acid batteries (Revankar, 2019). However not like lead-acid batteries Ni-Cd batteries are made of highly toxic materials (Johnson, 2019). The recommended discharge rate for lead-acid batteries is 50%, while for lithium-ion batteries it is 80-90% (Gupta, 2021). Since large-scale energy storage systems require long-lasting power, flow batteries are one of the solutions, because they have longest lifetime (Kularatna, 2021). While lithium-ion batteries have higher efficiency of 90% compared to 80% in flow batteries, the following one has lower environmental impact with decreased $CO^2$ emissions (30 g/kWh) and a lower toxicity rating (Vafaeva, 2024). At higher temperatures, nickel cadmium, lead acid, and lithium ion batteries are the most resistant, with the lithium ion battery being the most resilient and the lead acid battery the least responsive. The materials and technologies used in lithium-ion batteries (e.g., ceramic separators) provide additional protection against high

temperatures (May, 2023). Lithium-ion batteries are more economically sustainable and have a lower negative environmental impact compared to other batteries. Lithium-ion batteries are more expensive than lead-acid, nickel cadmium, or flux batteries (Phap, 2024). However, lead is the most efficiently recycled metal in the European Union and the United States, with more than 99% of lead-based batteries collected and recycled. In the West, 95-99% of batteries that reach end-of-life are recycled (May, 2018).

Table 2

**Characteristics of lithium-ion and lead-acid batteries**

| Batteries | Capacity (MW) | Efficiency (%) | Capital costs ($/kWh) | Lifetime (in years) | Lifetime (in cycles) | Response time | Environmental impact |
|---|---|---|---|---|---|---|---|
| Lithium-ion | 0.1 | 75-97 | 1000-2000 | 5-30 | 1000-10000 | Fast | Very small |
| Lead acid | 0-40 | 70-90 | 300-600 | 3-15 | 500-1000 | Fast | Average |

Source: Liu, J., Chen, X., Cao, S., & Yang, H. *Overview on hybrid solar photovoltaic-electrical energy storage technologies for power supply to buildings.*2019

According to the table, lithium-ion batteries with 75-97% efficiency outperform lead-acid batteries with 65-90% efficiency, which means that lithium-ion batteries can store and deliver energy more efficiently. In terms of capital costs, lead-acid batteries are more cost-effective, with a price between 300 and 600 $/kWh compared to lithium-ion batteries with a price between 1000 and 2000 $/kWh. In terms of number of life cycles and lifetime, lithium-ion batteries are superior, with a lifetime of 1 500 to 10,000 cycles and a lifespan of 5 to 30 years, compared to lead-acid batteries, which can only withstand 500 to 1 800 cycles and a lifespan of 3-15 years. In summary, lithium-ion batteries are more efficient, longer lasting, and less harmful to the environment, but more expensive, while lead-acid batteries are more affordable, although with lower efficiency, a shorter lifespan, and a higher environmental impact. Flow batteries have a low energy density but are distinguished by their longevity and environmental friendliness. Nickel-cadmium batteries, although quite durable and with a low energy density, are very harmful due to cadmium. When comparing grid-connected and off-grid solar power plants, according to ESOs, the cheaper option is the grid-connected solar power system, as the inverter of an off-grid solar power plant costs 30-40% more, but the off-grid solar power plants are protected against grid disturbances that could lead to power outages.

## THE MOST EFFICIENT WAY OF STORING ENERGY PRODUCED BY SOLAR PLANTS

Finding the most efficient way to store surplus energy requires making the most of the advantages of a particular technology or finding a good compromise by combining different technologies (Ferreira, 2013). In the absence of difficulties due to geographical location or in the presence of certain infrastructures, the most efficient way to store surplus electricity is through a hybrid system. Hybrid system offers enhanced reliability, as they can switch to stored energy during grid outages and feed excess energy into the grid when connected (Nwaigwe, 2019). For isolated communities, hybrid systems offer a more sustainable and good quality electrical system to meet the community's energy demand (Tabora, 2021). Many technical studies have been carried out on the hybrid solar PV energy storage system, and it has been observed that by stabilizing the voltage and providing power balance, the efficiency of the energy storage system can be increased (Liu, 2019). When faced with geographical or infrastructure problems, the most commonly used method for solar energy storage is batteries (Hou, 2011). Therefore, the most common way of storing the energy produced by solar power plants is in a solar farm, where a battery energy storage system is used so that the stored energy of the solar power plant is instantaneously stored and the grid is used to keep the power losses to a minimum (Mannepalli, 2022). All energy storage devices incur losses. To evaluate the performance of a storage system, the following must be considered: charging, maintaining, and discharging that charge; capacity; power and energy density; reliability; lifetime; and initial cost (Ferreira, 2013). The table below will give details of the four main batteries for energy storage.

Table 3

**Detailed battery characteristics and prices**

| Technology | Lead acid | Ni-Cd | Lithium-ion | Flow batteries |
|---|---|---|---|---|
| Power (MW) | 0.001-50 | 0.2-50 | 0.01-50 | 0.001-10 |
| Discharge duration (h) | 0.5-5 | 0.5-5 | 0.1-5 | 2-12 |
| Gravitational energy (Wh/kg) | 30-50 | 30-50 | 150-250 | 20-40 |
| Volumetric energy (Wh/L) | 50-90 | 50-150 | 200-400 | 15-35 |
| Power (W/kg) | 75-300 | 150-230 | 150-2000 | 10-40 |
| Productivity (%) | 70-90% | 60-70% | 85-95% | 65-85% |
| Durability (years) | 5-15 | 5-20 | 5-15 | 10-20 |
| Durability (cycles) | 500-2000 | 1500 | 2000-10000 | 13000+ |

| | | | | |
|---|---|---|---|---|
| Capital cost (€ per kW) | 380-1140 | 570-1425 | 950-3325 | 570-2375 |
| Capital cost (€ per kWh) | 95-285 | 285-665 | 285-1140 | 237-760 |
| Tchnological development | 4 | 4 | 5 | 3 |
| Availability | 99.5%+ | 98-99% | 97%+ | 96-99% |

Source: Ferreira, H. L., Garde, R., Fulli, G., Kling, W., & Lopes, J. P. *Characterisation of electrical energy storage technologies*, 2013.

It can be seen that when all aspects are taken into account - efficiency, energy density, lifetime, and cost - lithium-ion batteries are considered the most efficient choice. They have a high energy density (200-400 Wh/L), a high efficiency (85-95%), and a longer lifetime (more than 2000 cycles), which makes them suitable for a wide variety of applications. These characteristics allow lithium-ion batteries to operate for long periods of time without loss of efficiency, which is particularly important for high-cycling applications such as power storage. In addition, although their initial cost (around 285–1140 €/kWh) is higher than some other batteries, the long-term efficiency and lower maintenance costs of lithium-ion batteries compensate for the initial investment. Lithium-ion batteries have become significantly cheaper over the last few decades due to advances in research, battery chemistry, and materials science. According to research, the cost of lithium-ion batteries has fallen by 97% between 1991 and 2018 (Ziegler, 2021). Based on the scientific literature on energy storage systems, it can be argued that the most efficient way to store the excess energy produced by solar power plants is by using a hybrid system, but in the face of infrastructural challenges, battery storage systems are the most used. Based on performance data, the most efficient battery is lithium-ion. Looking ahead, scientific literature (Li., 2020; Li., 2021) has consistently highlighted that one of the biggest challenges with energy storage systems is the limited energy capacity and lifetime. Research shows that other alternative materials are possible in the future. One such alternative is sodium-ion batteries, which are considerably cheaper because they do not use the expensive lithium metal, although their density is slightly lower, and with technological improvements in the future it could become a much more efficient way to store energy. Electricity grids will also be able to move to a new level with advanced smart grids that will optimize energy distribution and ensure more efficient integration of renewable energy into the grid.

## CONCLUSIONS

1. The analysis of the energy storage methods used by solar power plants shows that even if the energy storage methods used by solar power plants are not the same as lithium-ion, nickel-cadmium, flow, or lead-acid batteries. All energy storage systems have a high initial investment, and energy storage systems are not forever and energy storage capacities are not infinite, so new technologies are needed to make energy storage systems more efficient and with a lower initial investment.

2. A comparison of the energy storage produced by a solar power plant shows that the main advantage of off-grid solar power plants is their independence from the grid, so that they are not affected by power outages, while the main disadvantage is the limited energy available, which is dependent on the capacity of the energy storage system.

The main advantage of grid-connected solar power plants is that the initial investment is lower than that of off-grid systems due to the energy storage system. A comparison of batteries for energy storage systems shows that the most efficient is the lithium-ion battery, which, although it is the most expensive, is the most efficient in the long term.

3. After analyzing and comparing the ways of storing the energy produced by a solar power plant, it can be said that without geographical or infrastructural problems, the most efficient way of storing energy is by using a hybrid system. Although the initial investment is high, the flexibility and efficiency of the hybrid system allow the most efficient use of solar energy. Reducing dependency on one or the other method of energy storage. The hybrid system allows for the storage of intermittent energy in energy storage systems for use in the event of grid failures and the need to sell surplus energy to the grid to earn credits or revenue, making it a long-term investment. When faced with geographical or infrastructural problems, the most efficient way to store the energy produced by a solar power plant is through a battery system. Considering all aspects - efficiency, energy density, lifetime, and cost - lithium-ion batteries are considered the most efficient choice.

## REFERENCES

Abdin, Z., Rahman, F., & Doyle, J. (2019). Challenges in nickel-cadmium battery recycling. Environmental Impact Journal. 77-131. Rettrieved from: https://doi.org/10.1016/B978-0-12-813306-4.00004-5.

Ariyoshi, K. (2023). Negative electrode: Lithium titanium oxides. In Encyclopedia of Electrochemical Power Sources (2nd ed.) .Vol. 4, 207-217. Retrieved from: https://doi.org/10.1016/B978-0-323-96022-9.00065-7.

Cho, J. H., Kim, M. S., & Lee, H. S. (2020). Power system stability in renewable energy grids. Journal of Electrical Systems. 766-777. Retrieved from: https://doi.org/10.1016/j.solener.2020.08.023.

Faunce, T. A., Prest, J., Su, D., Hearne, S. J., & Iacopi, F. (2018). On-grid batteries for large-scale energy storage: Challenges and opportunities for policy and technology. MRS Energy & Sustainability, 5, Article 11. Retrieved from: https://doi.org/10.1557/mre.2018.11.

Ferreira, A., Silva, P., & Andrade, J. (2013). Energy storage technologies: Efficiency and applications. International Journal of Power Engineering.288-298. Retrieved from: https://doi.org/10.1016/j.energy.2013.02.037.

Gupta, N., Kaur, N., Jain, S. K., & Joshal, K. S. (2021). Smart grid power system. Delhi: Academic Press, Retrieved from: https://doi.org/10.1016/B978-0-12-824337-4.00003-5.

Gurung, A., & Qiao, Q. (2018). Solar Charging Batteries: Advances, Challenges, and Opportunities. Joule, 2(7), 1217–1230. Retrieved from: https://doi.org/10.1016/j.joule.2018.04.006

Gutmann, E. (2009). Electrochemical energy storage systems. Journal of Power Sources. 219-235. Retrieved from: https://doi.org/10.1016/B978-044452745-5.00087-3

Hosaka, T., Kubota, K., & Komaba, S. (2023). Electrode materials for K-ion batteries. In Comprehensive Inorganic Chemistry III. 83-127. Retrieved from: https://doi.org/10.1016/B978-0-12-823144-9.00053-4.

Hou, Y., Vidu, R., & Stroeve, P. (2011). Solar energy storage methods. Industrial & Engineering Chemistry Research, 50(15), 8954–8964. Retvrieved from: https://doi.org/10.1021/ie2003413

Johnson, S. C., Todd Davidson, F., Rhodes, J. D., Coleman, J. L., Bragg-Sitton, S. M., Dufek, E. J., & Webber, M. E. (2019). Selecting favorable energy storage technologies for nuclear power. In Storage and Hybridization of Nuclear Energy (pp. 119–175). Retrieved from: https://doi.org/10.1016/b978-0-12-813975-2.00005-3

Karthikeyan, V., Rajasekar, S., Das, V., Karuppanan, P., & Singh, A. K. (2017). Grid-connected and off-grid solar photovoltaic system. Green Energy and Technology. 125-157. Retrieved from: https://doi.org/10.1007/978-3-319-50197-0_5.

Kasebede, A., Gebremedhin, Y., & Assefa, M. (2021). Comparison of lithium-ion and lead-acid batteries. Energy Storage Research Journal. Volume 40. Retrieved from: https://doi.org/10.1016/j.est.2021.102748

Kousksou, T., Bruel, P., & Jamil, A. (2014). Energy storage technologies: Review and advances. Renewable and Sustainable Energy Reviews.59-80. Retrieved from: https://doi.org/10.1016/j.solmat.2013.08.015.

Kularatna, N., & Gunawardane, K. (2021). Recent developments of high-performance battery systems. In Energy Storage Devices for Renewable Energy-Based Systems (2nd ed., pp. 173-180). Retrieved from: https://doi.org/10.1016/B978-0-12-820778-9.00012-7.

Li, H., Zhang, X., Zhao, Z., Hu, Z., Liu, X., & Yu, G. (2020). Flexible sodium-ion based energy storage devices: Recent progress and challenges. Energy Storage Materials, 26, 83–104. Retrieved from https://doi.org/10.1016/j.ensm.2019.12.037

Li, Y., Li, Y., Ye, X., Han, Y., & Dong, D. (2024). A review of strategies for the application of artificial intelligence technologies in the operation of grid enterprises. In 2024 IEEE 6th Advanced Information Management, Communicates, Electronic and Automation Control Conference (IMCEC) (pp. 1487–1491). IEEE. Retrieved from: https://doi.org/10.1109/IMCEC59810.2024.10575326

Liu, Y., Zhang, W., & Sun, X. (2019). Voltage stability and power balancing in hybrid energy storage systems. Energy Systems Engineering.103-121. Retrieved from: https://doi.org/10.1016/j.enconman.2019.02.080.

Mannepalli, R., Kumar, N., & Venkatesan, S. (2022). Battery storage systems in solar power plants. Journal of Sustainable Energy. 836-846. Retrieved from: https://doi.org/10.1016/j.egyr.2022.10.033.kaz

May, G. J., & Hildebrandt, T. (2023). Batteries – Battery types – Lead-acid battery: Design for performance. Encyclopedia of Electrochemical Power Skaources (2nd ed., Vol. 3, pp. 338–353). Retrieved from: https://doi.org/10.1016/B978-0-323-96022-9.00077-3

May, G., Davidson, D., & Miller, L. (2018). Battery technologies and market trends. Energy Storage Journal. 145-157. Retrieved from: https://doi.org/10.1016/j.est.2017.11.008.

Nwaigwe, K. N., Mutabilwa, P., & Dintwa, E. (2019). An overview of solar power (PV systems) integration into electricity grids. Materials Science for Energy Technologies, 2(3), 629–633. Retrieved from: https://doi.org/10.1016/j.mset.2019.07.002

Obi, M., & kumBass, R. (2016). Trends and challenges of grid-connected photovoltaic systems. Renewable and Sustainable Energy Reviews.1082-1094. Retrieved from: https://doi.org/10.1016/j.rser.2015.12.289

Ortega-Arriaga, R. (2021). Challenges in energy storage and battery systems for renewable energy integration. Renewable Energy Journal.143 Volume. Retrieved from: https://doi.org/10.1016/j.rser.2021.110864.

Pandey, A. K., Kumar, R. R., & Samykano, M. (2022). Solar energy: direct and indirect methods to harvest usable energy. In Dye-Sensitized Solar Cells: Emerging Trends and Advanced Applications. 1-24. Retrieved from: https://doi.org/10.1016/B978-0-12-818206-2.00007-4.

Phap, V. M., Huyen, C. T. T., Tung, N. T., Thao, N. T. N., & Thanh, D. Q. (2024). Study on technical, economic, environmental efficiency of self-consumption rooftop solar power using lithium-ion battery for households in Vietnam. Journal of Energy Storage, 99, Article 113446. Retrieved from: https://doi.org/10.1016/j.est.2024.113446

Prengaman, R. D., & Mirza, A. H. (2017). Recycling concepts for lead–acid batteries. Lead-Acid Batteries for Future Automobiles, 575–598. Rtetrieved from: https://doi.org/10.1016/B978-0-444-63700-0.00020-9.

Revankar, S. T. (2019). Chemical energy storage. In Storage and Hybridization of Nuclear Energy (pp. 177–227). Retrieved from: https://doi.org/10.1016/b978-0-12-813975-2.00006-5

Tabora, J. M., Paixão Júnior, U. C., Rodrigues, C. E. M., Bezerra, U. H., Tostes, M. E. d. L., Albuquerque, B. S. d., Matos, E. O. d., & Nascimento, A. A. d. (2021). Hybrid System Assessment in On-Grid and Off-Grid

Conditions: A Technical and Economical Approach. Energies, 14(17), 5284. Retrieved from: https://doi.org/10.3390/en14175284

Vafaeva, K. M., P. Sanjeeva (2024). Comparative analysis of lithium-ion and flow batteries for advanced energy storage technologies. MATEC Web of Conferences, 392, 01176. Retrieved from: https://doi.org/10.1051/matecconf/202439201176

Ziegler, M., Trancik, J., & Johnson, A. (2021). The rapid decline of lithium-ion battery costs. Energy Policy Journal. Retrieved from: 6074-6098, 10.1039/D1EE01313K.

PANEVĖŽIO KOLEGIJA ISSN 2029-1280, eISSN 2669-0071. Taikomieji tyrimai studijose ir praktikoje – Applied Research in Studies and Practice, 2024, 20.

# CHILDREN'S PHYSICAL EDUCATION IN OUTDOOR SPACES IN PRE-SCHOOL: NEEDS AND EXPECTATIONS

***Lilija KRYŽEVIČIENĖ, Reda JONUŠAUSKIENĖ***

*Panevėžio kolegija / State Higher Education Institution, Lithuania*

**Annotation.** This paper analyses the quality and diversity of outdoor spaces in pre-schools in order to assess how well they meet the needs of the kindergarten community for children's physical activity education. Outdoor spaces in kindergartens are essential for children's physical, emotional and social development, and their quality, safety and adaptability are crucial for children's holistic development. The results of the study reveal the expectations and satisfaction of the kindergarten community with the provision of outdoor spaces and assess the impact of these spaces on children's physical activity.

**Keywords**: outdoor spaces, pre-school education, physical education

## INTRODUCTION

The image of a pre-school and the content of its curriculum are often of key importance to parents when choosing an educational establishment. One of the important factors that can influence the decision is the institution's attitude towards children's physical education and the use of outdoor spaces to promote active participation. Every educational establishment should strive for distinctiveness and find ways to attract children and their parents, which helps to maintain its relevance and sustainability. A kindergarten that actively invests in outdoor spaces for children's physical education creates a more attractive image. As a service provider, it is also important for a pre-school to apply management principles effectively and to respond to the needs of society and parents. In a changing environment, it becomes an innovator, providing opportunities for children to explore, move around and be physically active in a natural environment, with the community as the main driving force behind this process.

*The Standards for Educational Provision* (2011) state that learning environments should be designed and developed according to the principles of functionality, modernity, aesthetics, human safety and ergonomics. The basic health safety requirements for the design of schools and the organisation of the educational process are laid down in *the Lithuanian Hygienic Standard HN 75:2016 "General health safety requirements for the implementation of pre-school and pre-primary education programmes"* (2024), which recommends that the physical school environment should be designed in accordance with health safety principles. While *the Standards for Educational Equipment* focus on the teaching aids necessary to implement the content defined in the curricula, *the Lithuanian Hygiene Standard HN 75:2016* focuses on the requirements related to child safety and health. However, in order to ensure a quality education process, it is necessary to take both documents into account in an integrated manner and to use them as a basis for designing functional spaces suitable for children's outdoor physical activity education.

The problem of this paper concerns the quality and diversity of outdoor spaces for physical activity in pre-schools to meet the needs of the kindergarten community. Well-designed and varied physical education spaces can provide significant benefits for children's physical and emotional development by promoting healthy lifestyles and skills development. However, there are questions about the extent to which these spaces meet the expectations and requirements of the kindergarten community in terms of functionality, safety and variety. It is therefore necessary to analyse how the kindergarten community perceives the existing physical education spaces, their quality and the possibilities to improve them according to the children's educational needs. **The study focuses** on the opinion of the pre-school community on the suitability of outdoor spaces for children's physical education.

**The aim** is to determine the opinion of the pre-school community on the suitability of outdoor spaces for children's physical education.

**Objectives:**

1. To describe the meaning of the environment for children's physical education from a theoretical point of view.
2. To reveal the views of the pre-school community on the need for outdoor spaces and their suitability for children's physical activity education.
3. To identify the benefits of outdoor spaces in the context of promoting children's physical education and well-being.

**Methods:** analysis of scientific literature, questionnaire survey.

# THE IMPORTANCE OF CHILDREN'S PHYSICAL EDUCATION ENVIRONMENT: A THEORETICAL PERSPECTIVE

*The Law on Sport of the Republic of Lithuania* (2024, p. 3) defines the concept of *physical activity* as "physical activity of a person aimed at strengthening health, improving physical and mental qualities and skills, without the aim of preparing for and/or participating in high-level sports competitions, as well as activities aimed at educating the public about sport, physical activity and the improvement of health that can be achieved by such activities". According to Adaškevičienė & Strazdienė (2013), *physical education* of preschool and pre-school children is understood as a scientifically based pedagogical process, where the educator purposefully influences the pupil on the basis of the values of physical culture, communicates in order to implement a certain programme of development of the physical and mental state of the personality (Adaškevičienė & Strazdienė, 2013). Physical activity in pre-school education institutions is implemented in accordance with the *Guidelines for the Pre-school Curriculum* (2024) and *the General Framework for Pre-school Education* (2022).

In order to achieve the objectives set out in the curricula for pre-school and pre-primary education, it is necessary to organise educational activities appropriately. In accordance with Article 12(1) of *the Law of the Republic of Lithuania on Sport* (2024), in the implementation of pre-school and pre-primary education programmes, children must be provided with active physical activity for at least two hours a day throughout the entire period of education. Therefore, the provision of sports facilities for physical activity in pre-school education is of great importance for the implementation of the programmes.

D'Elia et al. (2020) stress that movement is a particularly important developmental function in the pre-school and pre-primary years. This age is characterised by a greater receptivity to change and learning compared to the later stages of life (adulthood and older age). The above-mentioned researchers argue that the structuring of functional movements and the development and strengthening of motor skills are of particular importance at this age. Functional movements include the biological structure of the body, balance, posture, coordination, spatial and temporal awareness, muscle tone and relaxation. The effects of physical activity education are not only related to motor skills, but also to children's cognitive, emotional, relational and social development. Through movement and physical and sporting activities, children develop, stimulate and improve the functionality of afferent sensory pathways.

Thus, it can be argued that physical education in pre-school and pre-primary education enhances cognitive processes and promotes the development of basic (attention and memorisation), intermediate (analysis, processing, choice) and higher cognitive functions (intuition, convergent and divergent thinking). Moreover, Beliauskienė & Bagdonas (2016) point out that skills and habits formed in the preschool and pre-primary years are the most durable and long-lasting.

The pre-school setting is the main environment in which pre-school and pre-primary children spend most of the day and have opportunities for physical activity. According to Senol (2021), physical education in pre-school settings is a key health promotion tool, allowing for the simultaneous promotion of physical activity habits and healthy lifestyles in large numbers of children. Although children of this age are often naturally inclined to move, their physical movement skills do not develop automatically. As Cheung (2020) points out, pre-schools play an important role in ensuring and promoting children's physical education as this is where they spend most of their time. Research shows that physical activity is a prerequisite for children's development and that regular and systematic physical education activities are therefore essential in pre-school settings. This not only contributes to promoting physical activity in children, but also lays the foundations for healthy lifestyle habits.

The outdoor educational environment is an important component of education, where the overall educational baggage is directly accumulated. It develops the child's cultural identity, gives meaning to self-directed learning, fosters a love of sport and a desire to be physically active, and creates favourable conditions for the development of a self-conscious personality (Burškaitienė & Vilkonis, 2012). A sports ground can contribute to the quality of physical activity classes and other events, and help to shape pupils' attitudes towards movement, exercise and trying out different sports. It is an excellent place for community gatherings and joint sport and health events. The outdoor educational environment of an educational establishment should be vibrant, humanistic and spiritual, giving meaning to the culture, individual needs (including physical activity) and creativity of children. The insights of Strazdienė and Burkė (2019) have highlighted features of the educational environment that can be used to assess outdoor environments in pre-school education. Such environments should be age-appropriate, flexible, dynamic, open, mobile and functional, sustainable and material. It should also have barriers, but be safe, comfortable and playful, all of which encourage children's natural movement.

## RESEARCH METHODS AND ORGANISATION

In order to determine the opinion of the preschool community on the suitability of outdoor spaces for children's physical education, a survey was carried out in Panevėžys Nursery School "Žibutė" on 02-22 January 2024, using a questionnaire survey method. The general population of the study consisted of 31 employees and 79 families (110 respondents in total). The survey used a global sampling approach, combining the nursery staff and family respondents into a common master set (N = 110). The sample size was determined using the Paniotto formula:

$$n = \frac{1}{\Delta^2 + \frac{1}{N}}, \quad (1)$$

where: $n$ – the sample size; $\Delta$ – the margin of error; $N$ – the general population.

Based on this, the minimum sample needed to ensure a margin of error of 5% is estimated to be 87 respondents:

$$n = \frac{1}{0{,}05^2 + \frac{1}{110}} \approx 87, \quad (2)$$

Respondents were randomly selected from a general pool, irrespective of their initial affiliation to preschool staff or family groups. The survey questionnaires were submitted electronically using the online platform www.manoapklausa.lt. The survey was completed by 87 respondents (corresponding to the calculated minimum sample) who answered the survey questionnaire. Quantitative analysis of the collected data was carried out using descriptive statistical methods.

The study adhered to the ethical principles of scientific research: respect for personal privacy, confidentiality, anonymity, non-maleficence, fairness and goodwill.

## RESULTS

The study to investigate children's physical education in the outdoor spaces of the kindergarten "Žibutė" was actively participated in by the administrative staff (5), pre-school and pre-primary teachers (14), other staff (9), as well as by the majority of the families of the children attending the kindergarten (68). The survey sample meets the criteria of representativeness and reliability. The representation of all sides of the community in the study suggests that the study has produced objective and reliable results.

Each school and its local community is unique and has its own specific needs for a physical learning environment. In order to determine whether the facility's spaces meet the needs of the nursery community for physical activity education, the participants were asked to rate the quality and variety of the outdoor spaces of the pre-school facility. Just under a quarter of the community members are fully satisfied with the existing variety of outdoor spaces, while almost two thirds are somewhat satisfied (see Figure 1). However, a tenth of the respondents have significantly different opinions. They are critical of the number and variety of outdoor spaces (playgrounds, facilities, etc.) available in the nursery, and note that they are not or only partially satisfied with the current situation.

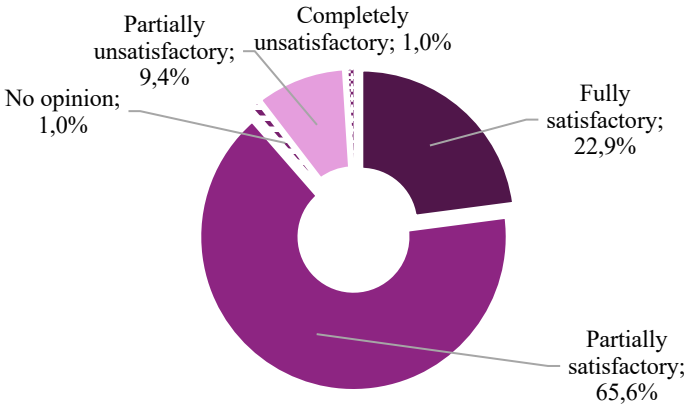



Figure 1: **Satisfaction with the variety of outdoor spaces**

Adapted spaces for physical education become one of the educational factors that contribute to improving the quality of education and the school's microclimate. High-quality outdoor spaces increase the efficiency of activities, generate positive emotions, develop taste and improve the quality of life. Almost two thirds of the respondents say they are somewhat satisfied with the current quality of the nursery's outdoor spaces, while just under a quarter say they are completely satisfied. However, almost one in nine community members surveyed are either partially dissatisfied or completely dissatisfied with the quality of the current outdoor spaces in the nursery (see Figure 2).

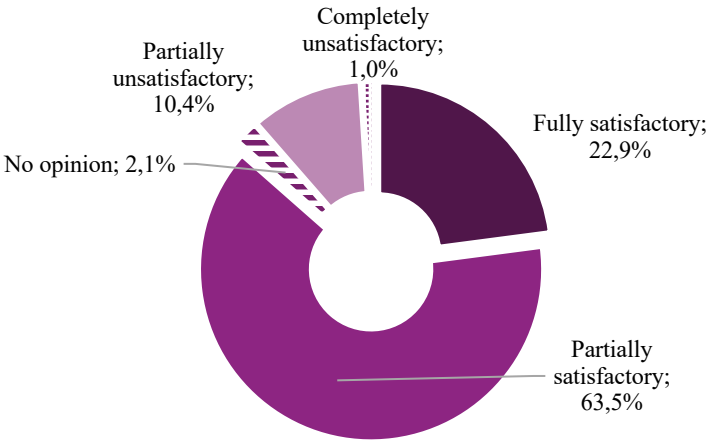



Figure 2: **Satisfaction with the quality of outdoor spaces**

Every pre-school has a duty to ensure the safety of children. Therefore, physical activity activities must be safe and fun for all children at play, whatever their age or ability. The provision of appropriate outdoor spaces would help to achieve this. This is the perception of more than two thirds of respondents (67.7%), who indicate that a sports field would be the most useful in ensuring children's safety (see Figure 3). Slightly more than half (53.1%) of the respondents consider that a sports field would significantly improve the quality of education. This shows that the importance of such a facility is primarily related to the well-being of children and their opportunities for active participation. Exactly half of the respondents indicated that a sports field will allow for a variety of mobile and sporting games, which will give children more choices for active activities. Social aspects such as the organisation of events (15.6%) or a place for community gatherings were considered less important, with the latter aspect being mentioned very rarely (3.1%).

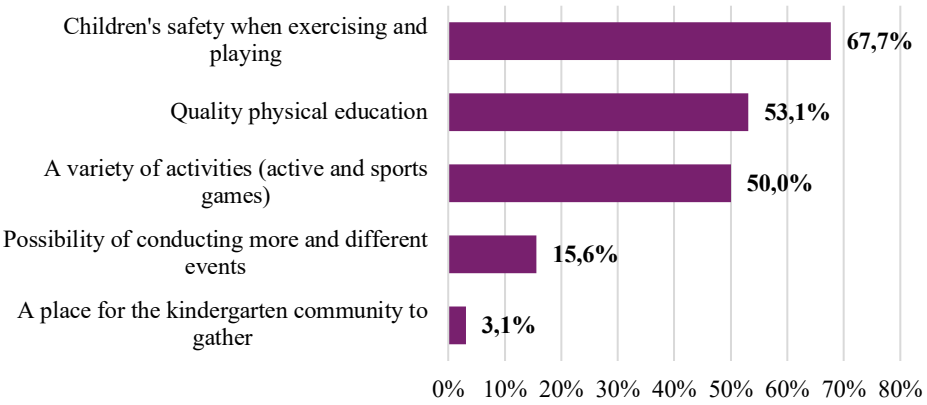



Figure 3. **Potential benefits of improving the sports field**

The updated general education curricula should provide a physical environment for each competence.

A sports field offers many significant advantages for a pre-school institution, meeting the expectations of the community. It is a space that provides opportunities for children to be physically active, promotes healthy lifestyles and creates a safe environment for children's education and recreation, which is agreed by the vast majority of respondents (96.9 % and 95.8 % respectively). As a larger space with a wider range of activities for sporting self-expression, the playground can accommodate a larger number of community members. The majority of community members surveyed agree that the course could be used for a variety of event projects (89.6%), and is a favourable environment for children to experience good adult influence and to learn from appropriate behavioural models (85.4%). The sports field can be used for various meetings, information and educational activities that promote social activity and community spirit, with 83.3% of respondents agreeing with this. Only a slightly lower proportion of respondents (80.2%) agree that a sports ground is an opportunity to foster a culture of cooperation between community members, family and neighbourhood relations and solidarity. More than three quarters of the respondents believe that the strategic location and the larger space of the sports field can be used for national, calendar and traditional celebrations. Knowing the specificities of the work of their kindergarten, more than two thirds of the respondents indicated that they would like to see the playground become a publicly accessible venue for all families to celebrate family festivities.

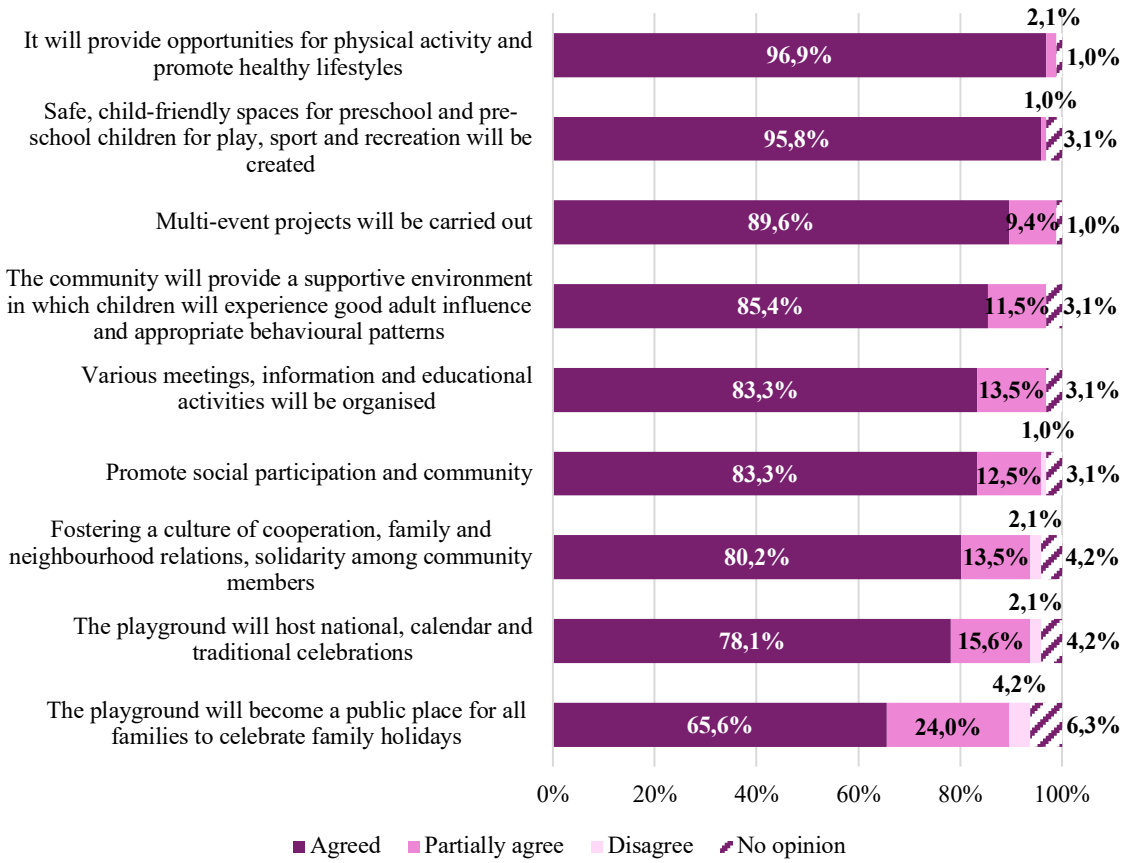



Figure 4: **Advantages of an outdoor sports pitch**

This paper analyses the importance of outdoor spaces for the physical activity and health of pre-school children. It highlights that well-equipped outdoor spaces not only promote children's physical activity but also contribute to the development of their social, emotional and cognitive skills. However, it is noted that inadequately designed outdoor spaces, such as playgrounds, sports facilities or running tracks, can limit these opportunities and reduce children's motivation to move. Against this background, the paper presents the main conclusions reflecting the results of the study and the problems highlighted.

## CONCLUSIONS

In pre-school settings, the physical education environment plays an important role in keeping children physically active. Well-equipped outdoor spaces, such as sports fields, shape children's long-term healthy lifestyle habits and create conditions for a well-rounded personality development.

The community assessment of the pre-school has shown that the existing outdoor spaces do not fully meet children's physical education needs. They are not functional enough, limiting children's opportunities for active and meaningful outdoor time. Insufficient functionality hinders the achievement of physical education objectives and poses safety challenges. This is particularly important in educational settings where children's well-being is a top priority.

Outdoor spaces, such as sports fields, in pre-school settings have many significant benefits that meet community expectations. They provide opportunities for children's physical activity, healthy lifestyles, safety and recreation. A sports field can become an important space for community events, educational activities and social participation. Most community members believe that this space strengthens cooperation, family and neighbourhood relations and solidarity, and is a good place for celebrations and traditions.

## REFERENCES

Adaškevičienė, E. ir Strazdienė, N. (2013). Vaikų sveikatą stiprinančio fizinio aktyvumo ugdymas. Klaipėdos universiteto leidykla.

Beliauskienė, D. ir Bagdonas, A. (2016). Priešmokyklinio amžiaus vaikų sveikos gyvensenos ugdymas. Ikimokyklinio ir priešmokyklinio ugdymo pedagogų rengimo problematika: tarptautinė mokslinė praktinė konferencija, 50–56. Kauno kolegija.

Burškaitienė, R. ir Vilkonis, R. (2012). Ikimokyklinės ugdymo įstaigos lauko ugdomosios aplinkos tobulinimo modeliavimas tėvų refleksyviojo vaikų patirčių suvokimo koncepcijų kontekste. Tiltai, (4(61)), 165–173. https://etalpykla.lituanistika.lt/object/LT-LDB-0001:J.04~2012~1367188919838/

Cheung, P. (2020). Teachers as role models for physical activity: Are preschool children more active when their teachers are active? European Physical Education Review, 26(1), 101–110. https://doi.org/10.1177/1356336X1983524

D'Elia, F., Tortella, P., Sannicandro, I. & D'Isanto, T. (2020). Design and teaching of physical education for children and youth. Journal of Human Sport and Exercise, 15(Proc4), S1527–S1533. https://doi.org/10.14198/jhse.2020.15.Proc4.48

Ikimokyklinio ugdymo programos gairės: September 4, 2023, No. V-1142. (2024). Valid edition from February 15, 2024. https://www.e-tar.lt/portal/lt/legalAct/be8a5a304add11ee9de9e7e0fd363afc/asr

Lietuvos higienos norma HN 75:2016 „Ikimokyklinio ir priešmokyklinio ugdymo programų vykdymo bendrieji sveikatos saugos reikalavimai“: April 22, 2010, No. V-313. (2024). Valid edition from November 12, 2024 to April 30, 2025. https://www.e-tar.lt/portal/lt/legalAct/TAR.AF02472A1EBF/asr

Lietuvos Respublikos sporto įstatymas: December 20, 1995, No. I-1151. (2024). Valid edition from January 1, 2024 to December 31, 2024. https://e-seimas.lrs.lt/portal/legalAct/lt/TAD/TAIS.23317/asr

Priešmokyklinio ugdymo bendroji programa. September 30, 2022, No. V-154. (2022). Valid edition from October 1, 2022. https://emokykla.lt/bendrosios-programos/visos-bendrosios-programos/8

Senol, F. (2021). Physical activity and preschool children: Preschool teachers' perceptions. Southeast Asia Early Childhood Journal, 10(2), 132–146. https://doi.org/10.37134/saecj.vol10.2.9.2021

Strazdienė, N. ir Burkė A. (2019). Ikimokyklinio ugdymo įstaigos dinaminės ugdymo(si) aplinkos ir vaikų fizinio aktyvumo sinergija. Acta Paedagogica Vilnensia, 43, 156–171. https://doi.org/10.15388/ActPaed.43.11

Švietimo aprūpinimo standartai: 2011 m. gruodžio 12 d. Nr. V-2368. (2011). Valid edition from December 21, 2011. https://e-seimas.lrs.lt/portal/legalAct/lt/TAD/TAIS.415146

PANEVĖŽIO KOLEGIJA ISSN 2029-1280, eISSN 2669-0071. Taikomieji tyrimai studijose ir praktikoje – Applied Research in Studies and Practice, 2024, 20.

# REVIEW OF AUTOMATED WIND TURBINE BLADE MAINTENANCE

***Kristupas PETRAUSKAS[a], Daiva STANELYTĖ[ab]***

*[a] Klaipedos valstybine kolegija / Higher Education Institution, Lithuania*
*[b] Lithuanian Energy Institute, Lithuania*

**Annotation.** Wind turbines are one of the most popular solutions for generating and using renewable energy. But studies have shown that wind turbine blade maintenance is essential for the longevity of blades and the whole power plant. The maintenance itself is basically cleaning of wind turbine blades from contamination, which consists of dust, salt, and icing on the surface of blades. If wind turbine blades are not properly cleaned by the schedule, then these three factors of contamination—dust, salt, and icing—cause blade deformation, a double-stall effect, and reduce the efficiency of wind turbine power plants by 10 to 40%. Since most of the cleaning is done manually by humans, which is dangerous for human life, takes more time, and requires more equipment and water usage, this article proposes an automated and autonomous wind turbine maintenance system. The studies have found that using SCADA for monitoring blade condition and integrating automated elements for maintenance itself, such as lifting arm, cleaning robots, and guide rails, makes the whole maintenance cheaper, safer, and more efficient, as it is unstoppable and uses less, if any, economic and human recourses.

**Keywords**: maintenance robots, automated lifting arm, SCADA, wind turbine blades

## INTRODUCTION

Wind farms are being developed more intensively as demand for renewable energy increases. However, there are factors that reduce the efficiency of this renewable energy source. Forced stall is the loss of blade lift due to a change in the aerodynamic properties of the blade itself. In the absence of forced stall, the rotor speed would increase without limit, which would cause mechanical damage to the engine. This stop is therefore foreseen. The double forced stop is an unforeseen change in aerodynamic properties, which reduces the amount of electricity produced and the power of the engine. Dust, salt, and icing on wind turbine blades, without proper maintenance, cause blade erosion, deformation, and a double-forced stopping effect, which reduces the efficiency of the wind turbine between 10 and 40% (depending on the climatic conditions, the geographical location, and the condition of the blades). Wind turbine blade erosion is not a new problem, but damage to blades has increased recently, especially for offshore wind turbines (Papi, Balduzzi et al., 2021). Therefore, wind turbines require specific maintenance. Maintenance does not require the intervention of technical staff, so cleaning is carried out manually or semi-manually, which is already the case in some wind farms. Manual maintenance has many disadvantages. Manual maintenance is dangerous for the operators because of the changing weather conditions and the high altitudes involved. For example, regular maintenance requires equipment consisting of a crane that lifts a platform on which operators are hoisted to the top of the plant, special ropes that hold the operators at a high altitude, and in some cases, a large amount of water to wash the blades. The biggest financial loss is the need to completely shut down the plant while cleaning is carried out. During manual cleaning, two to four operators carry out the maintenance. It takes at least four hours per blade to carry out the maintenance. Thus, such cleaning is very wasteful. In order to solve the problem of cleaning the blades of wind turbines with a minimum of resources and without stopping the turbine at all, a fully automated blade cleaning system is proposed, which will be analyzed later in this article.

**Subject.** Wind turbines.

**The aim of the research:** To analyze and provide recommendations for integrating autonomous and automated wind turbine maintenance system.

**The objectives of the research:**

1. To provide a framework for fully automated wind turbine maintenance.
2. To analyze the implementation of fully automated maintenance of wind turbines.
3. To review the effectiveness of fully automated maintenance of wind turbines.

**Research methods:** analysis of scientific literature.

**Value of research:** this article primary objective is to close the research gap, as there haven't been many studies that are entirely focused on automating wind turbine blade maintenance and implementing autonomous balde condition monitoring. Therefore, this article introduces new looks and solutions considering automated wind turbine blade maintenance, examines an existing blade condition monitoring system, and proposes an additional monitoring system, SCADA, to fill the gap between real-time condition tracking and data transfer, and briefly and methodically discusses the effectiveness of an automated and autonomous wind turbine blade maintenance system if integrated. The article's analysis can be used as a theoretical foundation and offer useful solutions for creating a safe, cost-effective, and low energy-loss maintenance system for wind turbine blades.

## RESEARCH METHODOLOGY

The implementation of automated wind turbine blade maintenance and condition monitoring was examined through a review of scientific literature sources. This study combined secondary data from multiple main studies and analyzed it using a quantitative research approach. Foreign authors' works were among the sources analyzed, allowing for a detailed analysis of the use of automated wind turbine blade maintenance and condition monitoring using one of the most popular condition monitoring systems, which is SCADA. To provide the most thorough literature search possible in databases, research data and theoretical reviews from IEEE and Science Direct were examined. By looking over the titles, abstracts, and full texts, the scientific article's suitability for analysis was evaluated. Because the most pertinent databases were chosen, where research findings on the adaptation of automated wind turbine maintenance and condition monitoring systems were published, a global literature search was carried out, and every search term that could be used to describe the concept under investigation was used. The search of scientific literature was methodical, accurate, detailed, and comprehensive. The used keyword combinations led to the identification of 114 924 publications. Table 1 displays the findings of the databases' search for scientific publications.

1 Table

**Findings from a database search for scientific articles**

| Keywords | Science Direct | IEEE | SUM |
|---|---|---|---|
| Maintenance robots | 50 382 | 4593 | 54975 |
| Automated lifting arm | 7283 | 44 | 7327 |
| SCADA | 12 871 | 6033 | 18 904 |
| Wind turbine blades | 29 823 | 3895 | 33 718 |
| **Sum** | 100 359 | 14 565 | 114 924 |

Source: made by an authors, 2024

The interpretation of the results obtained comes next: How can the results be applied? What relevance do the results obtained have for future research? Since the data needed for the study is found in scientific databases, the research is conducted in accordance with research ethics guidelines.

## AUTOMATED BLADE MAINTENANCE METHODOLOGY

The wing is the part of the blade that maintains the structural integrity of the blade as a whole, and if the failure factors continue to develop, the blade will no longer be usable and will need to be replaced (Lopez et al., 2021). So, the whole manual maintenance is done on wind turbine blades, but as mentioned before, manual maintenance is dangerous, so automated maintenance is proposed. Automated maintenance of wind turbines improves plant efficiency because it keeps the plant running without interruption while also cleaning the wind turbine blades with less water equipment and technical staff involvement, which puts operators at risk, (Yaqub et al., 2017). The main risk for technical staff that is mentioned here is hight and moving parts of the plant. Manual cleaning of wind turbine blades is shown in Figure 1.

Figure 1. **Manual cleaning of wind turbine blades.**

Improving wind turbine performance, operation, and efficiency requires evolving Operation and Maintenance (O&M) methods, (El-Naggar et al., 2023). A new maintenance system is proposed. The automated maintenance system consists of three maintenance robots, guide rails, and an automated lifting arm, (Dipankar et al. 2017). Actually, each

element has its own operational system, which makes them three separate subsystems of one common automated maintenance system. The automated blade cleaning system components are shown in Figure 2.

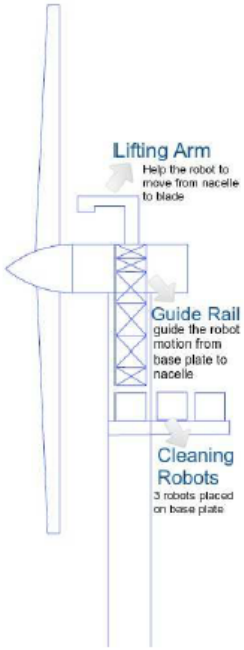



Figure 2. **Automated blade maintenance system components**.

To fulfil automated blade maintenance system, whole new construction is needed alongside the wind turbine tower, because automated system needs to be mounted at the top of the tower and if any installation or update is needed for any of mentioned parts, there has to be an option for technical staff to get up there, so some kind of lift form might be required.

## STRUCTURE OF ROBOTS

Since maintenance robots will be used outside and sometimes in harsh conditions (depending on where the wind farm is located), these robots have to have enough sensors to work reliably and confidently. To do that, robots have to scan and gather information about the terrain and environment in which they are. Each robot contains five sensors: two distance measure sensors, a pressure sensor, an edge detection sensor, and a thickness measuring sensor, (Dipankar et al., 2017). Sensors are the main output signals for robots to understand the movement in space. But those five sensors might not be enough for reliable work since distance, pressure, and other physical quintity measuring sensors cannot define environment and terrain type. As mentioned before, wind turbine blades might be dusted, covered in ice, or already deformed. So there is a solution to how wheeled robots could scan and analyze the environment to correct their movements.

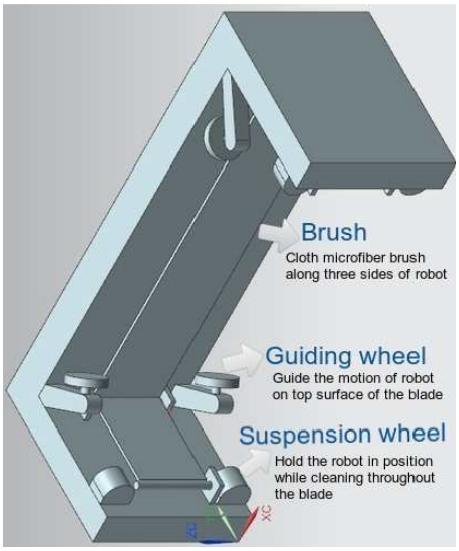



Figure 3. **Structure of robot performing the maintenance**

Accelerometer and gyroscope could be added in addition to those five already existing sensors. The data of the accelerometer and the gyroscope were tested separately and together, and different processing window sizes were also applied. Data from inertial sensors were collected for different outdoor terrain types using a prototype measurement system. The achieved results show that above 99% classification efficiency can be achieved using the collected data, (Csík et al., 2021). So, the gyroscope and accelerometer do not actually scan the environment; SCADA does that. The gyroscope and accelerometer are just additional sensors for all wheeled robots to help them to control their movement and correct their trajectory.

Four DC motors rotate the steering wheels that move the robot on the blade's surface, stop wheels keep the robot still while cleaning, and microfibre brushes attached on the base of the robot body are used for cleaning itself, (Nisarg et al., 2017). The robot performing the technical cleaning is shown in Figure 3.

To prevent varying blade moments of inertia, which could result in structural damage to the blade, the robots must be the same size, weight, and shape (Nisarg et al., 2017).

## STRUCTURE OF GUIDE RAILS AND LIFTING ARM

Five sensors are required for guide rail functioning, which also includes three stands connected to the individual robot systems, (Nisarg et al., 2017). Guide rails are actually part of the construction shown in Figure 2, because, as it can be seen, there is a lift-type construction from the base plate up to the nacelle. And the guide rails are mounted inside that construction together with the robot detecting sensors and pressure sensors.

The automated lifting arm, which is built of a high-resolution camera, a spacial sensor, and pressure and maintenance sensors for robot detection, is intended to move the robots from the top position of the guide rails to the wind turbine blade itself (Nisarg et al., 2017). Though in this study there is little information on how the sensors were picked, it seems that some sensors could be replaced with a simpler and cheaper alternative; for example, for robot detection, a simple movement sensor could be used instead of pressure and maintenance sensors. A tiny subsystem consisting of the camera and the spatial sensor seeks to precisely position the wind turbine blade in various weather scenarios (Dipankar et al., 2017).

So, to conclude the structure of guide rails and lifting arm, the statement can be made that guide rails and lifting arm together form a one maintenance robot transportation system, but the same system could be realized with a smaller number of sensors, which are overused in this case, and that means a higher price.

## AUTOMATED MAINTENANCE

Before initiating automated maintenance, information and signals about bad wind turbine blade conditions are required. There are a lot of information and data gathering sources, but most of them are pretty expensive to install and maintain. Minimization of the maintenance costs requires as precise as possible maintenance scheduling (Nurseda et al., 2020). So, the proposal is to use SCADA. Moreover, the proposed solution implies low deployment costs because it relies solely on the information collected from the widely available supervisory control and data acquisition (SCADA) system (Yingying et al., 2017). Therefore, the SCADA-based condition monitoring is mostly performed by using an industrial standard, which is data averaging on a ten-minute basis. However, such an averaging time leads to the drawback that SCADA-based methods are considered to provide a late-stage indication of incoming faults (Murgia et al., 2023). But as mentioned earlier, it is cheap and quite effective.

All the cleaning events are triggered by the scheduling function. When the scheduler prompts that scheduled cleaning time has reached, the ODS (Operations and Decision-making Subsystem) sends a message to NCS (Network Communication Subsystem). NCS activates the communication link and acquires necessary information from the local sensors and remote servers. So, in this whole SCADA, ODS, and NCS communication system, the real-time information is acquired and evaluated.

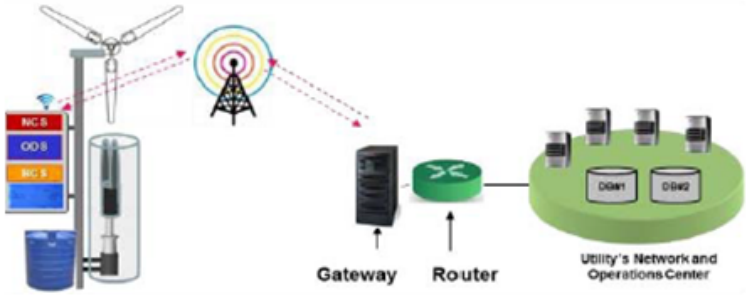



Figure 4. **Local network communication subsystem**

When a signal is applied to the microcontroller to perform maintenance, the microcontroller sends a signal to the maintenance robots to take positions on the guide rail (Dipankar et al., 2017). The robot and pressure detection sensors detect that the robots have taken up positions on the stands and start their movement up until a second robot detection

sensor at the top of the system is activated, which sends a signal that the robots have reached a set height and the guide rail system stops moving (Nisarg et al., 2017). In this case, the most basic automation principles are used for starting and stopping the process, making this system very easy to install because basically there are two position sensors at the top and at the bottom of the system, which start and stop the movement of the guide rail, but no emergency stop is provided. When the guide rails stop, the microcontroller sends a signal to the automated lifting arm, whose camera and spacial sensor subsystem detects the positioning of the robots and accurately moves them from the guide rails to the surface of the blade (Dipankar et al., 2017). On the blade surface, the robots adjust their direction of movement with the guide and stop wheels and with an attached microfibre brush. The blade is cleaned. Instead of the microfibre brush, sponge pads can be used with sensor nodes that measure the thickness of the plaque on the surface of the blade that needs to be cleaned (Yaqub, 2017).

Once cleaning is complete, the same operation is executed, but in reverse. Execution is initiated by feedback – an automated lifting arm picks up the robots from the blades and moves them onto the guide rails, where object detection and pressure sensors detect that the robots have taken up positions on the stands, and the system starts moving downwards until it reaches the base plate (Nisarg, 2017).

The individual components of the automated system form a single system whose purpose is to autonomously monitor the condition of the wind turbine blades and carry out regular maintenance.

## EFFICIENCY OF AUTOMATED MAINTENANCE

The fault mode of interest can incur a long period of downtime if not detected and acted upon before the functional failure of the generator, forcing the wind turbine to a standstill until the failed generator has been replaced (Hansen et al., 2024). Also, depending on the geographical location, dust, icing, and salts cause blade erosion, which has a negative effect on the aerodynamic performance of wind turbine blades (Mishnaevsky Jr. et al., 2020). Erosion degrades the aerodynamic performance, reduces the maximum lift force, increases the total drag force at all values of blade angle, and reduces the forced stop threshold, which is dependent on the reduction of blade angle and wind direction (Castorrini et al., 2023). So as mentioned before, the main goal of an automated maintenance system is to prevent wind turbines from causing double-stall effects, failure of the generator, and blade erosion, considering all the effects and risks of damaged blades. Since downtime of wind turbines is a loss in energy and finances, the automated system has to be effective enough to prevent wind turbines from stopping at all. To understand the actual losses of wind turbine failures, some numbers will be provided.

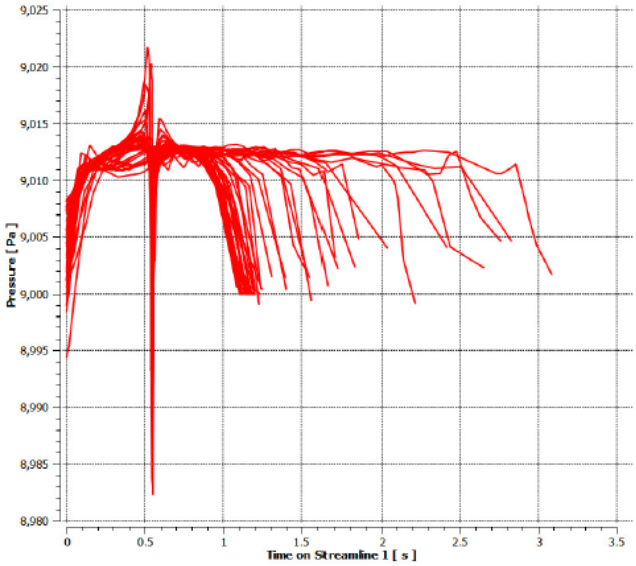



Figure 5. **Wind pressure of uneven dust deposition.**

More than 3800 failures are reported annually; over a 20-year period, downtime for a 500 MW offshore wind farm can result in production losses of approximately 12 million euros per year (So Young Oh et al., 2024). Also, it should be mentioned that if a wind farm is located on an offshore site, maintenance is even more expensive. Offshore wind farms are located in remote areas that are often subjected to harsh conditions; therefore, they require special equipment for maintenance (e.g., vessels), which significantly increases the operation and maintenance (O&M) costs (Saleh et al., 2023). Therefore, early detection of failures and decreasing downtime is crucial to minimize losses and ensure the longevity of the system. Also, some simulations were done to show the difference in wind pressure to wind turbine blades depending on dust deposition if an automated maintenance system was integrated.

Figure 5 illustrates the wind profile that is impacted by uneven deposition density, with two blades having dust depositions that are 1 mm thick and the third blade having dust that is 1.5 mm thick. This diagram illustrates the connection between wind pressure and time. The abrupt shift in pressure suggests the existence of a positioned wind turbine blade in

the hollow cylinder of the simulation. Because of the unequal distribution of dust, the wind pressure does not, in contrast, converge after passing the wind turbine to the one in Figure 6 that converges in the clean blade simulation.

Figure 6 displays the wind pressure profile caused by clean blades. After the incoming wind force has interacted with the cleaned wind turbine blades, this profile amply illustrates the convergence of wind pressure.

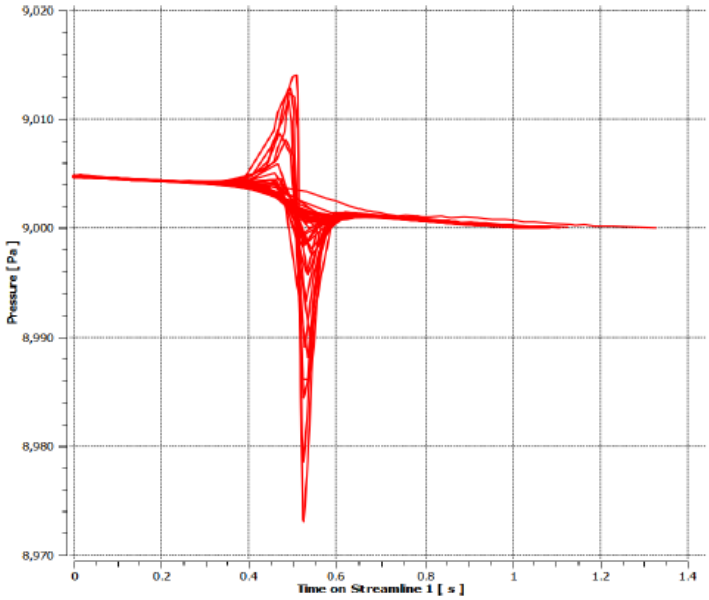



Figure 6. **Wind pressure of clean blades.**

So, the simulation above showed the importance of clean blades, because in the case where blades are clean, the pressure of the wind on the blades is not so abrupt and scattered. If the proposed automated maintenance system is used, the risk and danger to the technical staff are reduced, the consumption of water resources and equipment is reduced, the operation of the wind turbine is not interrupted, and breakdowns are avoided, resulting in no losses (Nisarg et al., 2017). Below, there is a table that compares the existing maintenance and proposed solutions.

2 Table

**Comparison of existing and proposed solutions.**

| Specifications | Manual | Semi-automatic | Automatic |
|---|---|---|---|
| Cleaning time | 4x3 hours | 1.5x3 hours | ½ or ¾ hour |
| Intensity of work | High | Medium | Low or none |
| Water consumption | High | Medium | Low or none |
| Operational status | Suspended | Suspended | Working |
| Safety | Unsafe for blades and staff | Safe | Safe |
| Cost-effectiveness | Not cost-effective | Not cost-effective | Cost-effective |

Manual maintenance of wind turbine blades is costly, inefficient, and dangerous for staff, so the proposed automated wind turbine maintenance system helps to solve the problems of cost-effectiveness, safety, and efficiency. As it can be seen from the table, that automated wind turbine blade maintenance system reduces cleaning time to half a time compared to manual cleaning. Intensity of work, water consumption is very low, since there are no humans involved in the process, it is completely safe, and the most important thing is that wind turbine status is operational, so basically, if the proposed system were to be installed and with proper maintenance of the system itself, losses of 12 million euros per year per one wind turbine could be eliminated.

## CONCLUSIONS

Renewable energy sources are one of the fastest growing directions in electrical energy generation and consumption, but as demand for wind turbines grows, maintenance of these wind turbines becomes more and more complex because of manual maintenance dangers. Maintenance includes not only physical cleaning of wind turbine blades but also gathering and collecting real-time data on wind turbine blade condition to even prevent any known damage to blades from happening. So, as solutions were proposed and found for maintenance and condition monitoring for wind turbine blades, the conclusions of this study are:

1. The automated wind turbine maintenance structure consists of three maintenance cleaning robots, an automated lifting arm, and guide rails. All components are separate subsystems that, combined, build one whole functioning automated blade cleaning system.

2. The execution process consists in making the maintenance of wind turbines as automated and autonomous as possible and requiring minimal, if no, intervention by technical staff. Blade condition is monitored using the widely used SCADA system, which makes condition monitoring cheap and effective, despite it's minor flaws. Also, a local network communication subsystem makes maintenance fully autonomous and, combined with the SCADA real-time monitoring system, is implemented.

3. As mentioned in this article, wind turbine standstill is huge power and financial losses, and since renewable energy sources are in high demand, on-time maintenance is very important to prevent wind turbine failures. Now more and more people depend on this energy, so considering the effectiveness of automated maintenance systems, it is clear that these systems have to be in higher priority of development and research. But as of now, all the studies have shown that automated maintenance is a more efficient, cost-effective, less resource and time-consuming, and safer solution compared to manual maintenance.

## REFERENCES

Brahmbhatt, N. Mrunal, P. Dipankar, D. (2017). Micro-controller Driven Wind Turbine Blade Cleaning Peripheries. International Conference on Advances in Computing, Communications and Informatics (ICACCI). 847-851. Retrieved from: https://doi.org/10.1109/ICACCI.2017.8125947

Castorrini, A. Ortolani, A. Campobasso Sergio, M. (2023). Assessing the progression of wind turbine energy yield losses due to blade erosion by resolving damage geometries from lab tests and field observations. Renewable Energy, 218, 119296. Retrieved from: https://doi.org/10.1016/j.renene.2023.119256

Csík, D., Odry, Á., Sárosi, J. Sarcevic, P. (2021). Inertial sensor-based outdoor terrain classification for wheeled mobile robots. 2021 IEEE 19th International Symposium on Intelligent Systems and Informatics (SISY)**.** 159-164. Retrieved from: doi: 10.1109/SISY52375.2021.9582504.

Dipankar, D. Mrunal, P. Himmat, S. (2017). Automated cleaning of wind turbine blades no downtime. 2017 IEEE International Conference on Industrial Technology (ICIT). 394-399.

El-Naggar, M. Sayed, A,. Elshahed, M,. EL-Shimy, M,. (2023). Optimal maintenance strategy of wind turbine subassemblies to improve the overall availability. Ain Shams Engineering Journal, 14(10), 102177. Retrieved from: https://doi.org/10.1016/j.asej.2023.102177.

Hase, H.H. MacDougall, Jensen, C.D., Kulahci, M., Nielsen, F.B. (2024). Condition monitoring of wind turbine faults: Modeling and savings. Applied Mathematical Modelling, 130, 160-174. Retrieved from: https://doi.org/10.1016/j.apm.2024.02.036.

Yaqub, R. Heidary, K. (2017). Autonomous Wind Turbine Blades Cleaning System. 2017 IEEE International Conference on Smart Energy Grid Engineering (SEGE). 394-399.

Yürüşen, N.Y., Rowley, P.N., Watson, S.J., Melero, J.J. (2020). Automated wind turbine maintenance scheduling. Reliability Engineering & System Safety, 200, 106965, Retrieved from: https://doi.org/10.1016/j.ress.2020.106965.

Lopez, C.J., Kolios, A. (2022). Risk-based maintenance strategy selection for wind turbine composite blades. Energy Reports, 8, 5541-5561. Retrieved from: https://doi.org/10.1016/j.egyr.2022.04.027.

Mishnaevsky, L. Hasager, C.B, Bak, C., Tilg, A.M., Bech, I.J. Doagou Rad, S., Fæster, S. (2021). Leading edge erosion of wind turbine blades: Understanding, prevention and protection. Renewable Energy, 169, 2021, Pages 953-969. Retrieved from: https://doi.org/10.1016/j.renene.2021.01.044.

Murgia, A. Verbeke, R. Tsiporkova, E. Terzi, L. Astolfi, D. (2023). Discussion on the Suitability of SCADA-Based Condition Monitoring for Wind Turnbine Fault Diagnosis through Temperature Data Analysis. Energies, 16(2), 620. Retrieved from: https://doi.org/10.3390/en16020620. 1-20.

Nurseda, Y. Rowlay, P. Watson, S. Melero, J. (2020) Automated wind turbine maintenance scheduling. Reliability Engineering & System Safety, 200, 106965. Retrieved from: https://doi.org/10.1016/j.ress.2020.106965.

Oh, S.Y., Joung, C., Lee, S., Shim, Y.B., Lee, D., Cho, G.E., Jang, J., Lee, I.Y., Park, Y. (2024). Bin Condition-Based Maintenance of Wind Turbine Structures: A State-of-the-Art Review. Renew. Sustain. Energy Rev. 204, 114799. Retrieved from: https://doi.org/10.1016/j.rser.2024.114799.

Papi, F., Balduzzi, F., Ferrara, G., Bianchini, A. (2021). Uncertainty quantification on the effects of rain-induced erosion on annual energy production and performance of a Multi-MW wind turbine. Renewable Energy, 165(1), 701-715. Retrieved from: https://doi.org/10.1016/j.renene.2020.11.071.

Saleh, A. Chiachío, M. Fernández Salas, J. Athanasios, K. (2023). Self-adaptive optimized maintenance of offshore wind turbines by intelligent Petri nets. Reliability Engineering & System Safety, 231, 109013. 1-20. Retrieved from: https://doi.org/10.1016/j.ress.2022.109013.

Zhao, Y. Dongsheng, L. Dong, A. Kang, D. Qin Lv. Shang, L. (2017). Fault Prediction and Diagnosis of Wind Turbine Generators Using SCADA Data. Energies 2017, 10(8). Retrieved from: https://doi.org/10.3390/en10081210. 1-17.

PANEVĖŽIO KOLEGIJA ISSN 2029-1280, eISSN 2669-0071. Taikomieji tyrimai studijose ir praktikoje – Applied Research in Studies and Practice, 2024, 20.

# ESSAY WRITING IN A FOREIGN LANGUAGE IN GLOBAL CONTEXTS: ANALYSIS OF PRE-POST INTERVENTION STUDY

***Anastasija BIKOVA[a], Jelena ZASCERINSKA[b]***

*[a] Hochschule Wismar, University of Applied Sciences: Technology, Business and Design, Germany*
*[b] Centre for Education and Innovation Research, Latvia*

**Abstract.** Essay writing in a foreign language is of a high demand in the labor market. Essay writing in a foreign language is intended for audiences – including online users - with diverse cultural background in different parts of the globe. the aim of this article is to analyze the effectiveness of techniques (digital tools, visual aids, and interactive activities) for essay writing in a foreign language via the study of the pre-post intervention. The evaluation study was implemented at Riga Ilguciema Elementary School in Riga, Latvia. The study took place in April 2024. 20 students took part in the quasi-experiment. The average percentage value regarding improvement or deterioration of the result during the experiment is 7.99%. This result is obtained using the average formula regarding the percentage of each student's result. This number indicates that the overall essay writing result among students in grade eight has improved at least by 8%. Thereby, the finding is that the leverage of three techniques – digital tools, visual aids, and interactive activities – are effective for the development of students' essay writing in a foreign language.

**Keywords**: digital tools in teaching essay writing, essay writing, foreign language, global context, interactive activities, mother tongue, visual aids

## INTRODUCTION

Essay writing in a foreign language is of a high demand in the labor market. Essay writing in a foreign language is becoming more complicated due to the pervasive spread of the Internet and online access to essay materials. Essay writing in a foreign language is intended for audiences – including online users - with diverse cultural background in different parts of the globe. Essay writing in a foreign language is getting more complicated as essay writer's mother tongue, that impacts his/her essay writing in a foreign language, can be different from the mother tongue of the essay's readers. Even a difference in a level of the mother tongue of the essay writer and reader might create misunderstanding between them. Figure 1 reflects the relationships between global context, essay writing in a foreign language, and mother tongue of the write and reader.

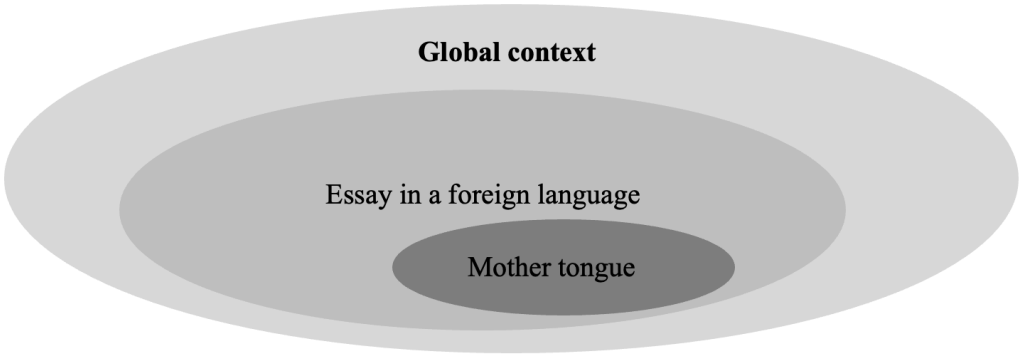



Figure 1. **Relationships between global context, essay writing in a foreign language, and mother tongue**

Essay writing in a foreign language can be enhanced through the leverage of techniques. Examination of the effectiveness of these techniques requires the study of the pre- and post-intervention. Therefore, the aim of this article is to analyze the effectiveness of techniques for essay writing in a foreign language via the study of the pre-post intervention.

## RESEARCH METHOD

The empirical study was motivated by the research question: What techniques are effectiveness for teaching essay writing in a foreign language?

The purpose of the empirical study was to evaluate the effectiveness of the intervention built on applied techniques for teaching essay writing in a foreign language. The intervention was built on the combination of three teaching techniques: 1.Integration of digital tools such as Kahoot, social media and others in teaching essay writing. 2.Incorporation of visual aids. 3.Use of interactive activities.

The evaluation study (Zaščerinska, 2010a) was implemented at Riga Ilguciema Elementary School in Riga, Latvia. The study took place in April 2024. 20 students took part in the quasi-experiment. English is a foreign language for the participating students. It should be also pointed that the educational process at Riga Ilguciema Elementary School

is implemented in the Latvian language. However, Latvian language is not the mother tongue for all the participating students. Figure 2 highlights the relationships between global context, essay writing in a foreign language, language of the educational process, and mother tongue of the write and reader.

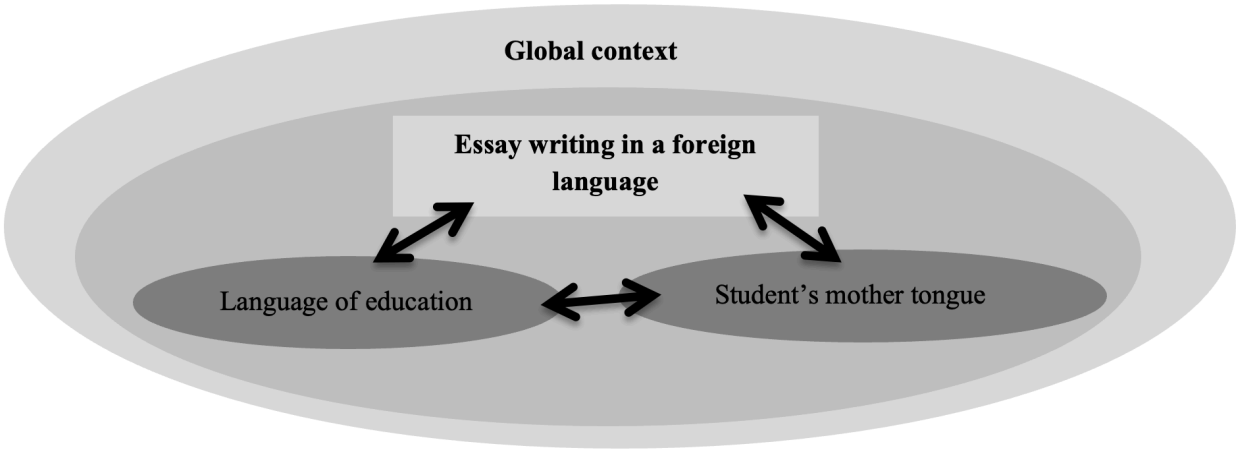



Figure 2. **The relationships between global context, essay writing in a foreign language, language of the educational process, and mother tongue**

All the languages interact with each other and impact each other (Zaščerinska, 2010a).

The data were collected via the pre- and post-test. The collected data were analyzed via a difference between the points in the student's pre- and post-test as well as percentage.

## RESULTS AND DISCUSSION

The main purpose of the quasi-experiment was to check the effectiveness of three techniques (digital tools, visual aids, and interactive activities) applied to teaching essay writing in a foreign language:

**Digital tools:** Using technology to teach essay writing increases student engagement and participation in writing instruction (Williams & Beam, 2019). With the help of digital technologies, teachers can motivate students to participate in the learning process, since digital technologies are considered popular and interesting among students (Williams & Beam, 2019). The use of technology in essay writing learning helps students focus on specific tasks and stay on the way to solve those problems (Williams & Beam, 2019). Also, digital technologies contribute to the expansion of interaction and cooperation between students, not only among peers, but also between students and the teacher. This is based on the connections that are made during learning how to use computer technology to teach writing (Williams & Beam, 2019).

Gamification including online gaming is an effective technology tool (Zaščerinskis, Zaščerinska, Gloņina, & Andreeva, 2013). Gamification is the use of technology, thinking and aesthetics to facilitate learning, engage and encourage people, as well for problem solving (Yunus, Hashim, Hashim, Yahya, Sabri, Nazeri, 2019). An example of a platform that includes gamification is Kahoot (Yunus, Hashim, Hashim, Yahya, Sabri, Nazeri, 2019). Kahoot is a game-based learning platform designed to engage students in the learning process. This platform can serve as an alternative media as by playing Kahoot games (such as answering questions), students better focus on the topic and learn the educational material faster, which motivates them to study. The use of Kahoot in teaching essay writing can be done by reinforcing the material being studied (for example, teacher can ask students to choose the correct order for the essay structure, introduction, body, conclusion, which will allow them to better remember the structure of the essay, etc.) or by testing students' knowledge of specific topic related to writing (Yunus, Hashim, Hashim, Yahya, Sabri & Nazeri, 2019).

Another powerful tool in the digital world for teaching English is social media (Lakhal, 2021). Social media have a huge impact on people today as they bring together a wide variety of people with some common interests, activities and experiences, allowing people to share ideas or make new discoveries with other people (Lakhal, 2021). Social media offer a variety of educational materials (texts, audio, video, etc.) and involve active learning among students Lakhal (2021). The use of social media in teaching essay writing increases student engagement in the learning process (Lakhal, 2021). Social media develops interactions between people through the transmission/reception of information (Mukminin, Habibi, Muhaimin, & Hidayat, 2023). In most cases, communication through social networks occurs through sending messages, assuming that a person will come up with a text, type it and send it to the recipient. Students perform similar actions in the process of writing an essay: they come up with an idea, analyze it, write it down on paper, reread it and correct it. Therefore, the use of social media in learning essay writing can have a positive impact on students' essay writing (Lakhal, 2021). One of the effective social networks for teaching English to students is YouTube (Prihatini, Prihatin & Sani, 2018). YouTube is a popular social network used to watch videos. The use of YouTube in the classroom can have a number of positive effects on students' essay writing learning (Prihatini, Prihatin & Sani, 2018). First, by watching relevant videos, students can discover new ideas and discuss them with peers. Since all people perceive information differently, the YouTube platform is suitable for everyone, since the videos contain audio and visual information (many

videos also have subtitles available in several languages), accordingly making it easier to perceive this information. Secondly, students can expand their vocabulary and learn how to construct sentences correctly. Thirdly, the use of YouTube in English lessons for teaching students essay writing can increase their interest and motivation to learn. An example of using YouTube would be using a video that explains educational material in a way that students can understand (Prihatini, Prihatin, & Sani, 2018).

**Visual aids:** Essay writing is an important language skill as it helps students better understand and learn the language. In the essay writing process, students have the task of expressing a specific idea using vocabulary and grammar appropriate to the topic. Teachers can have a great impact on students' learning to write because they can motivate students to write by creating the right conditions for generating ideas (Abdullah & Yunus, 2019). To enhance students' motivation in essay writing, apps, slides, and digital posters should be used, which has a positive impact on essay writing learning outcomes among eighth grade students (Muhamad, Lidiyatul, & Qondila, 2021). Visual aids such as pictures, presentation slides, posters, diagrams, photographs, etc. are valuable tools for teaching English foreign language (EFL). Visual materials greatly facilitate the memorization of information, which makes language learning effective (Abdullah & Yunus, 2019). When learning to write essays, visual aids can have a significant impact on students' results, since looking at pictures stimulates students' attention and helps them develop ideas, which subsequently affects the construction of sentences in essays (Abdullah & Yunus, 2019). The choice of visual aids is based on supporting students in essay writing by helping them to organize ideas, select appropriate vocabulary items, and combine them into sentences (Abdullah & Yunus, 2019). For example, one of the linguistic strategies for effective essay writing is discourse markers (Al-khazraji, 2019). Discourse markers are words and phrases that connect one section of a sequential text to another (Al-khazraji, 2019). They serve as important elements that make it easier for the reader to perceive the flow of the text (Al-khazraji, 2019). Discourse markers are particularly important in essay writing because they can help students learn text coherence, which is essential in essay writing (Al-khazraji, 2019). Discourse markers can be presented in pictures, tables or slides as visual aids that attract students' attention and allow them to easily remember the material and subsequently use it when writing an essay (Al-khazraji, 2019). Another visual aid is the visual effects used in presentations. Pictures and color effects in the presentation, which are associated with real life, attract the attention of most students (Patesan, Balagiu, & Alibec, 2018). Providing students with the opportunity to refer to visual material (pictures, effects) and compare it with their own real-life experiences or known experiences of others increases understanding of topics and students' involvement in the learning process (Patesan, Balagiu, & Alibec, 2018). Posters are an effective means of allowing students to absorb a large amount of information in a short period of time (Alsalihi, 2020). Posters are sheets that display any information. Posters are considered visual aids because they help explain words and phrases, convey information about events, and visually demonstrate differences between something (Alsalihi, 2020).

**Interactive activities**: Interactive writing activity can be defined as the collaborative efforts of students and teacher in the process of exchanging experiences and ideas to create a piece of writing (Lumbantoruan, Sihotang, & Situmeang, 2022). Interactive activities involve the creation of comfortable conditions for students so that they can successfully develop and acquire the necessary knowledge and skills. Interactive activities involve students collaborative work on a task (Brito, 2019). Interactive activities (Senthamarai, 2018) include 1.Think, pair, share strategy. 2.Brainstorming is a process aimed to bring students together to generate creative ideas and thoughts. 3.Live session when students gather in groups and express their ideas/thoughts on a specific topic. 4.Questions and Answers Session. 5.Incident Process. When initiating an incident process, the teacher divides students into groups, provides them with details of a real-life situation, and asks students to find an effective solution for the situation.

The quasi-experiment states that introducing structured essay writing techniques that include digital tools, visual aids and interactive activities will positively improve eighth graders' writing skills in English classes, then at the beginning and at the end of the experiment the teacher tested the students.

Pre-testing of students took place in the first week, after students were familiarized with the topic of essay writing, the structure and types of essays. Before the pre-test, the teacher conducted an interactive lesson, during which the students had the opportunity to discuss and express their opinions on various topics, working in pairs. The main task of the pre-test was to write an opinion essay on one of these topics. The students pulled a ticket to get the topic they would write about.

Table 1

**Points and requirements for the assessment criterion of the content and execution of the task**

| **Assessment criteria: Content and execution of the task** | | | | |
|---|---|---|---|---|
| ***PERFORMANCE DESCRIPTION, POINTS:*** | | | | |
| An attempt to write about the topic, the text of the task has been rewritten. | Text content that partially corresponds to the conditions of the task and reflects information from the task. | Mainly text content that corresponds to the conditions of the task; repetitions or deviations from the conditions of the task are possible. | The content of the text corresponds to the conditions of the task, whereby the opinion is supported with individual examples. | The content of the text fully corresponds to the conditions of the task and the communication situation and justifies the opinion with relevant examples. |
| **1 point** | **2 points** | **3 points** | **4 points** | **5 points** |

The results of the pre-test were assessed in relation to these criteria: content, organization, grammar and accuracy. The maximum number of points that students could score on each criterion was 5 points. Table 1 demonstrates

essay performance descriptions for obtaining a certain number of points on the assessment criterion of content and execution of the task.

A student can receive the least number of points if he/she only rewrote the terms of the assignment (has added one topic sentence in the essay). The largest number of points is assigned if the content of the essay fully corresponds to the topic and substantiates the author's opinion with logical examples/situations.

Table 2 demonstrates essay performance descriptions for obtaining a certain number of points on the assessment criterion of the organization and text formation.

Table 2

**Points and requirements for the assessment criterion of the organization and text formation**

| **Assessment criteria: Organization and text formation** | | | | |
|---|---|---|---|---|
| ***PERFORMANCE DESCRIPTION, POINTS:*** | | | | |
| The text contains several coherent sentences and some structural elements. The direction of the thoughts is barely recognisable. | The structure of the text only partially corresponds to the task. The combination of words and paragraphs only partially corresponds to the principles of text structure and content presentation. | The presentation of the text corresponds as far as possible to the task at hand. Predominantly coherent text; connecting words and paragraphs correspond in part to the principles of text structure and content presentation. | Formatting of the text according to the task. Coherent text; connecting words and paragraphs are more in line with the principles of text structure and presentation of content. | Formatting of the text according to the task. Clear and coherent text; connecting words and paragraphs fully comply with the principles of text structure and content presentation. |
| **1 point** | **2 points** | **3 points** | **4 points** | **5 points** |

Inconsistency with the structure of the essay (introduction, main part, conclusion) and lack of coherence of thoughts in the essay are assessed with the least number of points. A student can receive the greatest number of points if he/she writes a coherent text that matches the structure of the essay.

Table 3 demonstrates essay performance descriptions for obtaining a certain number of points on the assessment criterion of the variety of linguistic means (lexical and grammatical structures).

Table 3

**Points and requirements for the assessment criterion of the variety of linguistic means (lexical and grammatical structures)**

| **Assessment criteria: Variety of linguistic means (lexical and grammatical structures)** | | | | |
|---|---|---|---|---|
| ***PERFORMANCE DESCRIPTION, POINTS:*** | | | | |
| The linguistic means are very limited, the use of simple, memorized phrases. | Limited vocabulary, use of memorized phrases and simple grammatical structures that are often repeated. | Sufficient vocabulary to express thoughts simply using basic grammatical structures. | Sufficiently copious vocabulary and grammatical structures used predominantly in accordance with the context appropriate to the task and communication. | Appropriate vocabulary and grammatical structures to complete tasks effectively and communicate clearly. |
| **1 point** | **2 points** | **3 points** | **4 points** | **5 points** |

Limited vocabulary and memorized simple phrases, as well as many grammatical errors, are scored with the least number of points. A student can get the greatest number of points through the effective use of expanded vocabulary and grammatical structures in an essay.

Table 4 demonstrates essay performance descriptions for obtaining a certain number of points on the assessment criterion of the correctness and accuracy of language use (vocabulary, grammar and spelling).

A student can receive the least number of points if the essay contains many errors, which make it difficult to understand. To get the greatest number of points, the student must write a clear and accurate essay, without errors.

Table 4

**Points and requirements for the assessment criterion of the correctness and accuracy of language use (vocabulary, grammar and spelling)**

| **Assessment criteria: Correctness and accuracy of language use (vocabulary, grammar and spelling)** | | | | |
|---|---|---|---|---|
| ***PERFORMANCE DESCRIPTION, POINTS:*** | | | | |
| The use of language is mostly incorrect and only partially comprehensible. | The use of language is often incorrect and sometimes disturbs the perception of thoughts. | The use of language is mostly clear, although there are sentences or words that are incorrect. | The use of language is generally accurate; a few occasional errors do not affect the understanding of the text. | The use of language is generally accurate, with a few errors in more complex constructions not affecting the understanding of what is written. |
| **1 point** | **2 points** | **3 points** | **4 points** | **5 points** |

In total, students could score 20 points, which corresponded to a very high level. Table 5 illustrates points and their correspondence to the levels of assessment of essay writing.

Table 5

**Points and their correspondence to the levels of assessment of essay writing**

| **Assessment points** | 0-4 points | 4-8 points | 8-12 points | 12-16 points | 16-20 points |
|---|---|---|---|---|---|
| **Assessment levels** | Very low | Low | Average | High | Very high |

According to the results of the pre-test, most of the students' errors were related to grammar and accuracy. Some students had difficulties organizing the essay (students didn't follow the basic essay structure - introduction, main part, conclusion). However, almost all students coped well with the content of the essay (students expressed their opinions on the topic of the essay, supporting it with generally accepted facts and situations from real life).

After analyzing these results, the teacher concluded that more attention should be paid to grammar, accuracy and organization when teaching eight grade students how to write essays. Therefore, throughout the three weeks of experiment, the teacher tried different interactive methods and also used visual tools to improve essay writing among eighth graders.

In the last week of the experiment, the teacher administered a post-test. During post-testing, students wrote opinion essay on the topic of a healthy lifestyle. Previously, the teacher conducted a lesson on this topic, during which the students expanded their vocabulary, discussed good and bad human habits, as well as played Kahoot for the material revision. When preparing the topic for the last essay, the teacher wrote three clauses on the topic that the essay should include. Since students often wonder what to write about in an essay despite being given a specific topic, these clauses help students to better organize their thoughts and ideas and write specifically on the topic.

The post-test assessment was carried out using the same criteria that were selected for the pre-test assessment, in order to compare the results and determine the changes that occurred with the students during the period of essay writing learning.

Figure 3 shows the students' pre-test and post-test results in essay wring in the foreign language, namely English.

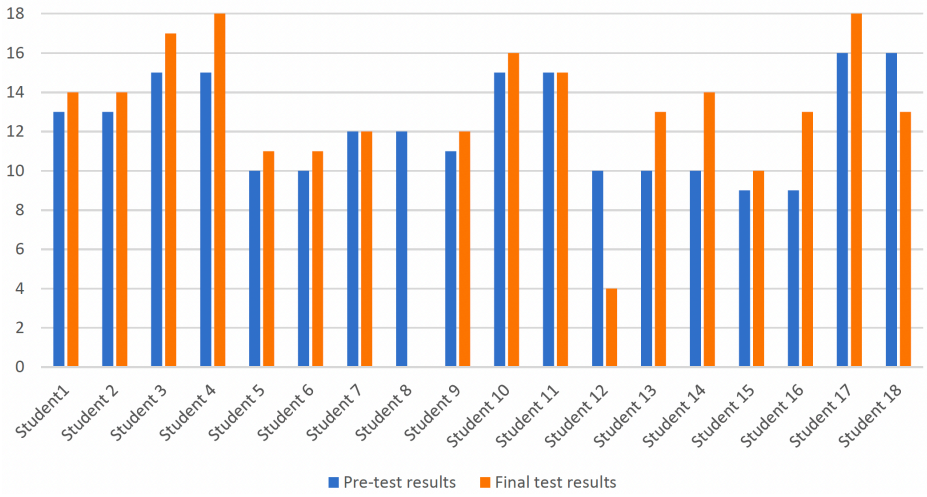



Figure 3. **The students' pre-test and post-test results in essay wring in English**

Table 6 demonstrates the differences in the students' pre-test and post-test points, levels as well as the percentage changes in the students' scores.

Table 6

**Students' results in the pre- and post-test**

| **Student** | **Pre-test assessment results (in points)** | **Pre-test assessment levels** | **Post-test assessment results (in points)** | **Post-test assessment results** | **Percentage changes in students' pre-test and post-test scores** |
|---|---|---|---|---|---|
| Student 1 | 13 | High | 14 | High | 7,69 |
| Student 2 | 13 | High | 14 | High | 7,69 |
| Student 3 | 15 | High | 17 | Very high | 13,33 |
| Student 4 | 15 | High | 18 | Very high | 20,00 |
| Student 5 | 10 | Average | 11 | Average | 10,00 |
| Student 6 | 10 | Average | 11 | Average | 10,00 |
| Student 7 | 12 | Average | 12 | High | 0,00 |
| Student 8 | 12 | Average | - | - | 0,00 |
| Student 9 | 11 | Average | 12 | High | 9,09 |
| Student 10 | 15 | High | 16 | Very high | 6,67 |
| Student 11 | 15 | High | 15 | High | 0,00 |

| | | | | | |
|---|---|---|---|---|---|
| Student 12 | 10 | Average | 4 | Low | -60,00 |
| Student 13 | 10 | Average | 13 | High | 30,00 |
| Student 14 | 10 | Average | 14 | High | 40,00 |
| Student 15 | 9 | Average | 10 | Average | 11,11 |
| Student 16 | 9 | Average | 13 | High | 44,44 |
| Student 17 | 16 | High | 18 | Very high | 12,50 |
| Student 18 | 16 | High | 13 | High | -18,75 |
| Student 19 | - | - | - | - | - |
| Student 20 | - | - | 12 | Average | - |

The first column displays the number of students who took part in the pre-test and post-test. The second column discloses the results of the students' pre-test assessment in points. A total of 18 students participated in the pre-test. The third column presents the students' post-test assessment results in points. 18 students took part in the post-test, too. Table 1 emphasizes that the two students who did not take part in the pre-test and post-test in one case is the same student, and in the second case, these are two different students.

The pre-test results showed that the class scored 12 points out of 20 on average, which corresponds to the average level of knowledge in essay writing in English. The largest number of points was 16, which corresponds to a high level; only two students showed this result. While the lowest number of points was 9, which corresponds to the average level, this result was achieved by only two students.

The post-test results showed that the class averaged 13 points out of 20, which corresponds to a high level. The highest number of points was 18, which corresponds to a very high level. Only 2 students showed this result. Whereas the lowest number of points was 4, which corresponds to a very low level. Only one student had this result.

The average percentage value regarding improvement of the result during the experiment is 7.99%. This result is obtained using the average formula regarding the percentage of each student's result. This number indicates that the overall essay writing result among students in grade eight has improved at least by 8%. Thereby, the finding is that the leverage of three techniques – digital tools, visual aids, and interactive activities – are effective for the development of students' essay writing in a foreign language.

## CONCLUSIONS

The theoretical analysis allows finding the interconnections between the global context, essay writing in a foreign language, language of the educational process, and mother tongue of the write and reader. Another theoretical finding is that languages as an individual unity are linked and impact each other. Student's mother tongue influences student's essay writing in a foreign language, and vice versa.

The empirical study reveals that the combination of three techniques – digital tools, visual aids, and interactive activities – is effective for the development of students' essay writing in a foreign language. The pre- and post-test results show the improvement in the students' essay writing in a foreign language.

The empirical study has a limitation in a number of study participants. Another limitation is the quasi-experiment that was carried out only in one grade, namely eighth grade. Implementation of the quasi-experiment is limited by taking place only in one country, namely Latvia.

Future research will widen the engagement of the quasi-experiment participants of different educational levels, grades, educational institutions, and countries.

## REFERENCES

Abdullah, Y. L., & Yunus, M. M. (2019). The Use of Pictures in Improving Students' Writing. Modern Journal of Language Teaching Methods, 1-8.

Al-khazraji, A. (2019). Analysis of Discourse Markers in Essays Writing in ESL Classroom. International Journal of Instruction, XII(2), 559-572.

Lakhal, M. (2021). Social Media use and its Effects on writing Ability among Moroccan University EFL Students. International Journal of English Literature and Social Sciences, 6(3), 132-143.

Muhamad, S. H., Lidiyatul, I., & Qondila, P. (2021). Teaching Writing Through Canva Application to Enhance Students' Writing Performance. Journal of Languages and Language Teaching, 9(2), 228-235.

Mukminin, A., Habibi, A., Muhaimin, M., & Hidayae, M. (2023). Social media use for English writing (SMU-EW): Preservice English teachers. Ampersand, 10, 100-112.

Patesan, M., Balagiu, A., & Alibec, C. (2018). Visual aids in language education. International Conference Knowledge-based organization, XXIV(2), 356-361. Retrieved May 7, 2024

Prihatini, F., Prihatin, Y., & Sani, N. (2018). The Use of Youtube Videos to Develop Students' Writing Skill in Narrative Text. English Focus: Journal of English Language Education, 2(1), 60-69.

Senthamarai, S. (2018). Interactive teaching strategies. Journal of Applied and Advanced Research, 3(1), 36-38. doi:https://dx.doi.org/10.21839/jaar.2018.v3S1.166

Williams, C., & Beam, S. (2019). Technology and writing: Review of research. Computers & education, 128, 227-242. doi:https://doi.org/10.1016/j.compedu.2018.09.024

Yunus, M. M., Harwati, H., Haida Umiera, H., Zaidatul Shima, Y., Farah Sabrina, S., & Adriana Nasuha, N. (2019). Kahoot!: Engaging and Active Learning Environment in ESL Writing Classrooms. International Journal of Innovation, Creativity and Change, 5(6), 141-152.

Zaščerinska, J. (2010a). Designing a Qualitative Research for Evaluation of English for Academic Purposes Activity in Teacher Education. Proceedings of the Teacher Education Policy in Europe (TEPE) Conference 2010 Developing Quality Cultures in Teacher Education: Expanding horizons in relation to quality assurance, 30th September- 2nd October 2010, pp. 33-44. Tallinn University, Estonia. http://tepe.files.wordpress.com/2011/01/tepe-2010-conference-proceedings.pdf.

Zaščerinska, J. (2010b). Professional Language in Language Education. Proceedings of 5th International scientific conference Theory for Practice in the Education of Contemporary Society of Riga Teacher Training and Educational Management Academy, 25 - 27 March 2010, pp. 403-408. Riga: Riga Teacher Training and Educational Management Academy. ISBN 978-9934-8060-5-6.

Zaščerinskis M., Zaščerinska, J., Gloņina, O., Andreeva, N. (2013). Application of Game Theory in the Educational Process. In: Abstracts of the International Research and Practical Conference „Youth in Science and Practice" for Undergraduates, Master and Doctoral Students, p. 30-32. Jelgava: Latvia University of Agriculture.

PANEVĖŽIO KOLEGIJA ISSN 2029-1280, eISSN 2669-0071. Taikomieji tyrimai studijose ir praktikoje – Applied Research in Studies and Practice, 2024, 20.

# DISCOVERING GROUP PROJECTS TO IMPART TECHNICAL SKILLS TO UNDERGRADUARE ENGINEERING STUDENTS

***Parulkumari P. BHATI[a], Jelena ZASCERINSKA[b]***

*[a] Nirma University, India*
*[b] Centre for Education and Innovation Research, Latvia*

**Abstract.** Group projects in higher engineering education are considered as an effective method for imparting technical skills to undergraduate engineering students. The research aim is to analyse engineering students' self-evaluation of their participation in group projects during their undergraduate studies. The empirical study was carried out in January-February 2024. 211 undergraduate engineering students from India took part in the online survey questionnaire. For data analysis, the frequency and percentage of respondents' answers was investigated. The obtained findings were interpreted, and the study results were summarized. The empirical study allowed for finding out that the respondents' time management skills, team work skills, academic writing and academic presentation essential for the success of group projects' implementation need to be advanced. The conclusion is that the respondents are aware of the importance and relevance of the group projects' method for the imparting technical skills to undergraduate students. The empirical study allows for a conclusion that team work skills of engineering students have to be increased as the majority of the respondents expressed their wish to act as the group manager, and not as a group member. The implications on the organization and implementation of group projects are formulated.

**Keywords**: dyads, group composition, group project, technical skills, triads, digital tools in teaching essay writing, essay writing, foreign language, global context, interactive activities, mother tongue, visual aids

## INTRODUCTION

Technical skills are in TOP 10 skills essential in contemporary employment. It should be noted that modern employment - being either paid employment, entrepreneurship, or to full-time self-employment (Ahrens, Zascerinska, & Markussen, 2022) - is rooted in project work (Zascerinska, Aleksejeva, Zascerinskis, Gukovica, & Aleksejeva, 2020). A project aims to contribute to the formation of a system of knowledge and skills embodied in the final intellectual product; to promote autonomy, the ability to think logically, define problems and make decisions, receive and use information, plan, develop literacy and more (Khatamova, Ismailova, & Akbarova, 2019).

Diverse technical skills in almost every field and industry, from IT and business administration to health care and education are on a high demand (Coursera staff, 2024). By technical skills, specialized knowledge and expertise required to perform specific tasks and use specific tools and programs in real-world situations are meant (Coursera staff, 2024). Technical skills can be divided into basic technical skills and more advanced technical skills (Coursera staff, 2024). Table 1 presents sub-skills belonging to basic technical skills and more advanced technical skills.

Table 1

**Basic and advanced technical skills** (by authors)

| **Type of technical skills** | **Basic technical skills** | **Advanced technical skills** |
|---|---|---|
| **Sub-skills** | -cloud computing in Google Drive<br>-navigating social media platforms | -programming languages,<br>-technical writing, or<br>-data analysis |

Unlike workplace skills, also called soft skills, such as communication and time management, technical skills often need specific education and training to acquire (Coursera staff, 2024). For these purposes, higher education aimed at workforce preparation promotes students' enrichment of their technical skills by different methods.

Group projects in higher engineering education are considered as an effective method for imparting technical skills to undergraduate engineering students. It should be pointed that group project have a positive effect on students' soft skills, too (Zascerinska, Aleksejeva, Zascerinskis, Gukovica, & Aleksejeva, 2020). Due to the positive effect of group project in engineering students' technical and soft skills, the last few decades have seen a growing emphasis on group projects as part of engineering education programmes (Crawley, Malmqvist, Ostlund, Brodeur, Edstrom, 2014).

The aim of the present research is to analyze the organizational aspects of group projects in order to propose implications for higher education sector.

## RESEARCH METHOD

The empirical study was initiated to answer the research question: How to organize group projects for the enrichment of undergraduate engineering students' technical skills?

The purpose of the empirical study was to analyze engineering students' self-evaluation of their participation in group projects during their undergraduate studies.

The empirical study refers to the exploratory type. Table 2 created on the basis of our previous work (Ahrens, Zascerinska, Bhati, Zascerinskis, & Aleksejeva, 2021; Ahrens, Foerster, Zaščerinska, & Wasser, 2020) explains the ground of the selection of the exploratory study.

Table 2

**Reasons for the selection of the exploratory study**

| Reasons | A short explanation |
|---|---|
| Under-explored topic | -Only few works are published,<br>-The outset of either research or study on a topic |
| Flexibility | Researchers are supposed to discover new meanings, elements, links, factors, etc. if compared to explanatory or descriptive studies |
| Non-structure | Exploratory study is not limited by a formal structure. Researchers have a freedom to build their own structure |
| Scope identification | Exploratory study aim to outline "the boundaries" of the analysed phenomenon. |

The empirical study was carried out in January-February 2024. 211 undergraduate engineering students from India took part in the online survey questionnaire. It should be noted that the respondents could select more than one option when answering the survey questionnaire questions. Table 3 describes the engineering students' computer programmes skills.

Table 3

**Respondents' computer programmes skills**

| Computer programmes and software skills | Number of replies |
|---|---|
| Programming languages (HTML, CSS, JavaScript, Python, etc) | 185 |
| Cloud computing | 52 |
| Front-End Development | 63 |
| Back-End Development | 63 |
| Cybersecurity | 76 |

Table 3 shows that the majority of the respondents is skillful in programming languages.

Table 4 reflects the engineering students' digital skills.

Table 4

**Respondents' digital skills**

| Digital skills | Number of replies |
|---|---|
| User Experience (UX) | 132 |
| Wireframing | 30 |
| Responsive Design | 74 |
| Branding | 68 |
| Visual Design (Color Theory, Typography, etc.) | 92 |

Table 4 highlights that the majority of the respondents has developed their skills in user experience.

Table 5 emphasizes the engineering students' copyright skills.

Table 5

**Respondents' copyright skills**

| Copyright skills | Number of replies |
|---|---|
| Search Engine Optimization | 123 |
| Content Creation | 121 |
| Landing Page Copy | 38 |
| Headline Writing | 70 |
| Topical and Keyword Research | 71 |

Table 5 highlights that the majority of the respondents is able to use search engine optimization and content creation skills.

Table 6 presents the engineering students' software skills.

Table 6

**Respondents' software skills**

| Copyright skills | Number of replies |
|---|---|
| Adobe Software (Photoshop, InDesign, Illustrator, etc.) | 109 |
| Microsoft Office (Word, Excel, Powerpoint, etc.) | 160 |
| Point of Sale Systems (Harbortouch, Clover, etc.) | 19 |
| QuickBooks or Other Accounting Software | 27 |
| CAD or Other Engineering Programs | 111 |

Table 6 illustrates that the respondents' majority is keen to use Microsoft Office (Word, Excel, Powerpoint), CAD or other engineering programs, and Adobe Software (Photoshop, InDesign, Illustrator, etc).

The survey questionnaire results demonstrate that the respondents obtain advanced technical skills.

For data analysis, the frequency of respondents' answers was investigated. The obtained findings were interpreted, and the study results were summarized.

## STUDY RESULTS

Each of survey questionnaire questions was based on the 10-point scale. 1 point meant the lowest value, and 10 points – the highest value.

Table 7 gives an overview of the engineering students' answers in regards to their willingness to work in a group project.

Table 7

**Respondents' willingness to work in a group project**

| Points of the 10 point scale | Number of replies | Percentage |
|---|---|---|
| 1 | 5 | 2.4% |
| 2 | 8 | 3.8% |
| 3 | 13 | 6.2% |
| 4 | 26 | 12.3% |
| 5 | 28 | 13.3% |
| 6 | 8 | 3.8% |
| 7 | 19 | 9.0% |
| 8 | 33 | 15.6% |
| 9 | 18 | 8.5% |
| 10 | 53 | 25.1% |
| Total | 211 | 100% |

Table 7 reveals that the majority of the respondents have a high interest in working in a group project.

Table 8 gives an overview of the engineering students' answers in regards to their willingness to work in a group project.

Table 8

**Respondents' answers about their role in a group project**

| Role | Number of replies | Percentage |
|---|---|---|
| Group leader | 65 | 30.8% |
| Group manager | 63 | 29.9% |
| Group member | 83 | 39.3% |
| Total | 211 | 100% |

Table 8 points out that the majority of the respondents prefers to be a group member in a group project.

Table 9 reveals that the engineering students' answers in regards to the means of group project.

Table 9

**Respondents' answers about the means of group project**

| Role | Number of replies | Percentage |
|---|---|---|
| Face-to-face | 100 | 47.2% |
| Hybrid | 92 | 43.3% |
| Online | 18 | 18.5% |
| Total | 211 | 100% |

Table 9 discloses that the majority of the respondents prefers face-to-face or hybrid work in a group project.

Table 10 emphasizes the engineering students' time management skills in accordance to their answer to the survey questionnaire.

Table 10

**Respondents' answers about their time management skills**

| Role | Number of replies | Percentage |
|---|---|---|
| 1 | 6 | 2.8% |
| 2 | 5 | 2.4% |
| 3 | 5 | 2.4% |
| 4 | 7 | 3.3% |
| 5 | 26 | 12.3% |
| 6 | 14 | 6.6% |
| 7 | 40 | 18.9% |
| 8 | 52 | 24.7% |
| 9 | 31 | 14.7% |
| 10 | 25 | 11.9% |
| Total | 211 | 100% |

Table 10 allows finding that the majority of the respondents developed good time management skills.

Table 11 emphasizes the engineering students' team work skills in accordance to their answer to the survey questionnaire.

Table 11

**Respondents' answers about their team work skills**

| Role | Number of replies | Percentage |
|---|---|---|
| 1 | 5 | 2.0% |
| 2 | 13 | 6.0% |
| 3 | 7 | 3.0% |
| 4 | 2 | 0.9% |
| 5 | 17 | 8.0% |
| 6 | 7 | 3.0% |
| 7 | 24 | 11.0% |
| 8 | 55 | 26.1% |
| 9 | 50 | 23.0% |
| 10 | 37 | 17.0% |
| Total | 211 | 100% |

Table 11 reveals that the majority of the respondents developed good time management skills.

Table 12 emphasizes the engineering students' self-evaluation of writing skills in accordance to their answer to the survey questionnaire.

Table 12

**Respondents' answers about their writing skills**

| Role | Number of replies | Percentage |
|---|---|---|
| 1 | 5 | 2.4% |
| 2 | 5 | 2.4% |
| 3 | 5 | 2.4% |
| 4 | 7 | 3.3% |
| 5 | 17 | 8.0% |
| 6 | 22 | 10.4% |
| 7 | 49 | 23.3% |
| 8 | 43 | 20.3% |
| 9 | 35 | 16.6% |
| 10 | 23 | 10.9% |
| Total | 211 | 100% |

Table 12 reveals that the majority of the respondents leverage good writing skills.

Table 13 emphasizes the engineering students' presentation skills in accordance to their answer to the survey questionnaire.

Table 13

**Respondents' answers about their presentation skills**

| Role | Number of replies | Percentage |
|---|---|---|
| 1 | 5 | 2.4% |
| 2 | 8 | 3.7% |
| 3 | 8 | 3.7% |
| 4 | 12 | 5.7% |
| 5 | 18 | 8.6% |
| 6 | 26 | 12.4% |
| 7 | 38 | 18.0% |
| 8 | 38 | 18.0% |
| 9 | 33 | 15.6% |
| 10 | 25 | 11.9% |
| Total | 211 | 100% |

Table 13 reveals that the majority of the respondents developed good presentation skills.

Our finding is that the respondents evaluate their advance technical skills positively and express their willingness to work in group projects.

## DISCUSSION

The search for scientific literature on group project shows that this topic is under-explored. Only few publications were found via google search. The focus of these three publications was put on

- A structured approach to group project work (Powell, Hicks, Green, Truscott, van Silfhout, & Canavan, 2005),
- Group formation and learning for project-oriented student work (Cronholm & Melin, 2006), and
- Challenges and learning experiences in undergraduate group projects (Isaac &Tormey, 2015).

The other publications found via google search refer to project method, project work, group work, and similar. Publications with the key words - that did not contain "group project" - were excluded from further analysis.

Another finding is that the significance of group project in engineering education is growing. However, the topic of group project in scientific literature is not widely discussed. Our search revealed that the latest work on the topic of group project was published in 2015 by Isaac &Tormey.

In our study, the majority of the respondents evaluated their time management skills as good. However, meeting the timeframe when implementing group project remains an issue for students as studied by Isaac &Tormey (2015).

Formation of groups is another problem in group projects as a way of forming groups affects students' learning (Cronholm & Melin, 2006) in the group project. Forming project groups should be based on a reflected choice and the categories (Cronholm & Melin, 2006) of

- Perspectives and dynamic,
- Motivation,
- Pedagogy,
- Social relations,
- Heterogeneity and
- Coordination.

The researchers acknowledge that every group project is context-dependent (Cronholm & Melin, 2006). Therefore, some of the above presented categories can be more relevant than others in different contexts (Cronholm & Melin, 2006).

Two methods of group formation are identified in scientific literature:

- By student themselves (Cronholm & Melin, 2006), and
- By the instructor (Feichtner & Davis, 1984).

Formation of groups by students themselves is often based on friendship (Cronholm & Melin, 2006). However, this approach of group formation based on students' choice is difficult and unlikely to be effective (Cronholm & Melin, 2006).

Interestingly, students report more positive group experiences when the instructor forms the groups (Feichtner & Davis, 1984; Surikova, 2007).

In regard to a number group project members, the researchers Cronholm & Melin (2006) formed groups of six members. Opposite the proposed group structure of six members, the formation of a microgroup composed of two (so called dyads) - three (so called triads) members was found effective (Surikova, 2007). This finding on a group composed of three members is also supported by our study. The respondents of our study were offered to select a role of the three choices they would play in group projects:

- Group leader,
- Group manager, and
- Group member.

The majority of the respondents in our study preferred to be a group member in a group project. Along with this, there is nearly an equal choice of the respondents who would be a group leader or group manager.

The means of group project also plays an important role for reaching the project objectives. It was found by Isaac &Tormey (2015) that most students reported tensions within their group during their online work. This finding is also supported by the results of our study that discloses that the majority of the respondents prefers face-to-face or hybrid work in a group project.

Conventionally, a project aims at knowledge development (Khatamova, Ismailova, & Akbarova, 2019). Knowledge enrichment along with the project implementation proceed from existing knowledge through knowledge variety to new knowledge (Zaščerinska, 2011).

## CONCLUSIONS

The implemented theoretical analysis helps establish the links between the development of students' technical skills and group project: group project intends to be effective for the enhancement of students' technical skills. Group project is also found useful for the enhancement of students' soft skills.

The results of the empirical study reveal that undergraduate engineering students are highly interested in the development of their technical skills. The most important technical skills for undergraduate engineering students are programming languages skills, user experience skills, social media marketing skills, consumer analytics skills, search engine optimization and content creation skills, and, finally, Microsoft Office skills. The respondents expressed their positive attitude to their participation in group projects for the enrichment of their technical skills. The majority of the engineering students are keen to be project group manager. The students prefer face-to-face format for the implementation of group projects. The empirical study allowed for finding out that the respondents' time management skills, team work skills, academic writing and academic presentation essential for the success of group projects' implementation need to be advanced.

Based on the study results as well as the analysis of other researchers' works, the implications for organisation and implementation of a successful group project propose that

- A group for the successful implementation of a project should be formed by an instructor.

- Each group of students should be a micro-group composed of three-five members.
- Each group member is assigned a role of either group leader, or group manager, or group member.
- Each group member during a group project changes his/her role, e.g. from group leader, to group manager and, later, to group member.
- Group member role allows monitoring the progress in the process of the group project implementation.
- Group project has to be organised face-to-face or at least in a hybrid manner.
- Group project evaluation is product oriented.
- Group project proceeds in three key phases, namely from existing knowledge through knowledge variety to new knowledge.
- Group project evaluation should also include student self-evaluation.

The empirical study has a limitation: the study was carried out only in one country, namely India. Literature analysis was limited by the scientific publications available via google search. If other scientific works on the topic of group project had been available, other research results would have been reached.

Future research intends to include more respondents from different educational areas as well as educational institutions, and countries. Further work could be devoted to the analysis of knowledge development within a group project.

## REFERENCES

Ahrens, A., Foerster, M., Zaščerinska, J., & Wasser, I. (2020). European Accreditation Agency's View on Kazakhstan's Engineering and Information Technology Higher Education. SOCIETY. INTEGRATION. EDUCATION Proceedings of the International Scientific Conference. Volume V, May 22nd -23rd, 2020. pp. 15-25. DOI: http://dx.doi.org/10.17770/sie2020vol1.4861.

Ahrens, A., Zascerinska, J., Markussen, I.D.G. (2022). Development of Adult Learners' 21st Century Skills in Greenland: Field Work Analysis. Education Reform: Education Content Research and Implementation Problems, Volume 2 (2022), pp. 4-16. DOI: https://doi.org/10.17770/er2022.2.6964, http://journals.rta.lv/index.php/ER/article/view/6964/5885

Coursera staff. (16 September 2024). What are technical skills? Retrieved from https://www.coursera.org/articles/what-are-technical-skills

Crawley, EF, Malmqvist J, Ostlund S, Brodeur DR, Edstrom K. (2014). Rethinking Engineering Education, the CDIO approach. 2nd Edition. Cham: Springer; 2014.

Cronholm, Stefan, & Melin, Ulf. (2006). Project Oriented Student Work: Group Formation and Learning, 2006, The Proceedings of the Information Systems Education Conference 2006. From the Information Systems Educators Conference ISECON 2006, Dallas, TX. Postprint available at: Linköping University Electronic Press, http://urn.kb.se/resolve?urn=urn:nbn:se:liu:diva-95448

Feichtner S, Davis E. (1984). Why Some Groups Fail: a Survey of Students' Experiences with Learning Groups. Journal of Management Education. 1984;9(4):58–73.

Isaac S, & Tormey R. (2015). Undergraduate group projects: Challenges and learning experiences, QScience Proceedings (Engineering Leaders Conference 2014) 2015:19. http://dx.doi.org/10.5339/qproc.2015.elc2014.19

Khatamova, Ziyoda G`ulomovna, Ismailova, Hilola Inomovna, & Akbarova Marziyakhon Akbarjon qizi. (2019). Project Method in Teaching English. European Journal of Research and Reflection in Educational Sciences Vol. 7 No. 12, 2019, pp. 230-234. Progressive Academic Publishing, UK. ISSN 2056-5852. www.idpublications.org

Powell, Norman J., Hicks, Peter J., Green, Peter R., Truscott, William S., van Silfhout, Roelof, & Canavan, Brian. (2005). Preparation for Group Project Work – A Structured Approach. The University of Manchester. Retrieved from https://www.researchgate.net/publication/290047448_Preparation_for_group_project_work_-_A_structured_approach

Surikova, S. (2007). Organisation of Microgroups' Activity for Promoting Pupils' Social Competence. Doctoral Thesis. Riga: University of Latvia. Retrieved from https://dspace.lu.lv/dspace/handle/7/4747

Zaščerinska, J. (2011). Teaching Content: Development the System of External and Internal Perspectives. The Proceedings of Riga Teacher Training and Educational Management Academy's 6th Young Scientist Conference, December 2nd, 2010 (2010), pp. 221-229. Riga: Riga Teacher Training and Educational Management Academy, Riga, Latvia, 243.

Zascerinska, J., Aleksejeva, L., Zascerinskis, M., Gukovica, O., & Aleksejeva, A. (2020). The Impact of COVID-19 on the Improvement of Teaching Skills on Problem-Solving Learning. International Journal for 21st Century Education (IJ21CE) Volumen 7, Número 1 (2020), pp. 42-59. DOI: 0.21071/ij21ce.v7i1.13074. https://www.uco.es/ucopress/ojs/index.php/ij21ce/article/view/13074/12073

Zaščerinskis M., Zaščerinska, J., Gloņina, O., Andreeva, N. (2013). Application of Game Theory in the Educational Process. In: Abstracts of the International Research and Practical Conference „Youth in Science and Practice" for Undergraduates, Master and Doctoral Students, p. 30-32. Jelgava: Latvia University of Agriculture.

PANEVĖŽIO KOLEGIJA ISSN 2029-1280, eISSN 2669-0071. Taikomieji tyrimai studijose ir praktikoje – Applied Research in Studies and Practice, 2024, 20.

# INTERNATIONAL ASPECTS OF THE PROTECTION OF CHILDREN'S RIGHTS IN THE CONDITIONS OF WAR IN A GLOBALIZED WORLD

***Maryna TOPORKOVA***

*Utena University of Applied Sciences, Lithuania*

**Abstract.** In the modern functioning and development of the world community, the problem of protecting the rights of victims during the war does not lose its relevance. At the same time, the issue of protecting the rights of the child is particularly acute, which requires close attention from lawyers, the development of new approaches and ensuring the practical application of existing legal norms designed to protect the child. The problem of the legal status of the child during armed conflicts is complex and combines a number of separate aspects related to individual categories of children who have become participants in the conflict. The aim of the research is to analyse and highlight some of the main regulatory and legal documents of an international nature in the field of protection children's rights. The following methods are used in the work: a search in the available methodological and scientific literature with an analysis of the material found, induction and deduction, clarification of cause-and-effect relationships, systematization, abstraction and concretization, analysis of documentation. The analysis of this article shows that it is necessary to develop international norms that will regulate the issue of eliminating the involvement of children in armed conflicts and to create an established system of monitoring compliance with international legal norms on the protection of children's rights during armed conflicts.

**Keywords**: children's rights, protection rights, armed conflicts, international law

## INTRODUCTION

Modern society cannot ignore the problem of protecting children's rights, especially in the context of war. Preservation and protection of the rights of children is an integral part of humanitarian efforts and a task that requires deep analysis, scientific validity and high ethics.

War is one of the most destructive and negative phenomena of human civilization. Its impact on society as a whole and, on children in particular is unpredictable and multifaceted. Children are the most vulnerable category of war conditions; they feel its consequences most deeply and tragically. There is a violation of their physical, psychological, social and emotional rights, which is accompanied by a negative impact on their further lives.

In the context of war, children face numerous threats to their lives and health. They may become victims of direct military action, suffer from hunger, insufficient medical care and poor sanitation. Constant stress, lack of normal living conditions, and loss of loved ones – all this strongly affects the psychological state of children, leading to psychological injuries and long-term psychosocial maladjustment.

So, the problem of protecting children's rights in wartime is urgent and difficult. It requires an integrated approach based on scientific research, international standards and ethical principles. Understanding the impact of war on children's lives and developing effective mechanisms to protect them are key to ensuring a more humane and fair society.

**The object of the research –** international protection children's rights.

**The aim of the research –** to analyse and highlight some of the main regulatory and legal documents of an international nature in the field of protection children's rights.

**Methodology of the research:** a search in the available methodological and scientific literature with an analysis of the material found, induction and deduction, clarification of cause-and-effect relationships, systematization, abstraction and concretization, analysis of documentation.

## FORMATION OF CHILDREN'S RIGHTS PROTECTION AT THE INTERNATIONAL LEVEL

The issue of separating children's rights from general human rights arose relatively recently. The disastrous consequences of the World War I for the civilian population and the growing interest in the problem of protecting children's rights in most countries of Europe and North America necessitated the League of Nations, which was founded in 1919, to create a committee whose purpose was to develop cooperation between nations and guarantee peace and security. This body was called the Child Welfare Committee. Its activities were aimed at providing assistance to homeless children, that is, activities related to children who were in a socially dangerous situation. It should also be noted that an important role in the development of social standards for the protection of children's rights was played by non-governmental organizations, in particular, the International Save the Children Union, which was founded after the end of the First World War by the British teacher and human rights activist Eglantyne Jebb. She formulated the Declaration of the Rights of the Child, which was adopted by the General Assembly of the League of Nations on September 24, 1924, and became popularly known as the Geneva Declaration of the Rights of the Child. It was the first international legal document in the field of protecting the rights and interests of the child.

The Declaration enshrined 5 principles that shaped the goals of international legal protection of children, and also emphasized that caring for and protecting children is the exclusive responsibility of all humanity, and not just the family and a separate state. These five principles include:

1) The child must be given the means requisite for its normal development, both materially and spiritually.

2) The child that is hungry must be fed; the child that is sick must be nursed; the child that is backward must be helped; the delinquent child must be reclaimed; and the orphan and the waif must be sheltered and succoured.

3) The child must be the first to receive relief in times of distress.

4) The child must be put in a position to earn a livelihood, and must be protected against every form of exploitation.

5) The child must be brought up in the consciousness that its talents must be devoted to the service of fellow men. (Geneva Declaration of the Rights of the Child, 1924)

This document was valid until the collapse of the League of Nations in 1946.

However, the system of international protection of children's rights as a component of human rights was finally established after World War II within the framework of the United Nations, one of the fundamental principles of which was the proclamation of respect for human rights and freedoms without any forms of discrimination.

Appropriate and detailed development of means of protection of children's rights, due to the fact that the child, due to his physical and moral immaturity, required the allocation of international protection of children's rights in a special direction. For this purpose, in 1946 the UN created an emergency fund for children, UNICEF, which was later called the UN Children's Fund. The United Nations Children's Fund (UNICEF) believes that ensuring the rights of the child and caring for children around the world is the basis of human development. Working in more than 190 countries, UNICEF uses its global authority to cooperate with partners at all levels, trying to ensure the most optimal start in life for all children and their prosperity in conditions free from poverty, injustice, discrimination and disease (UNICEF: The United Nations Children's Fund, 1946). Since then, the problem of protecting children's rights has reached the international level and has taken real forms. Currently, UNICEF is the main mechanism for international assistance to children in difficult living conditions.

Consequently, a number of international documents aimed at regulating the protection of children's rights were adopted at the international level. Children's rights are enshrined in universal conventions and declarations on human rights, such as the Universal Declaration of Human Rights of 1948 Universal Declaration of Human Rights of 1948, International Covenant on Civil and Political Rights of 1966, and the International Covenant on Economic, Social and Cultural Rights. The Universal Declaration of Human Rights of 1948 emphasized: "that the child, by reason of his physical and mental immaturity, needs special safeguards and care, including appropriate legal protection, before as well as after birth" (Universal Declaration of Human Rights, 1948). These Covenants establish the right of the child to protection by the family, the State and society, the right to a name, nationality and protection in the event of family breakdown, and they also establish the prohibition of discrimination against children. Article 24, paragraph 1, of the Covenant on Civil and Political Rights states: " Every child shall have, without any discrimination as to race, colour, sex, language, religion, national or social origin, property or birth, the right to such measures of protection as are required by his status as a minor, on the part of his family, society and the State." In the Convention for the Protection of Human Rights and Fundamental Freedoms of 1950, as well as in the Geneva Declaration of the Rights of the Child of 1924, the Declaration of the Rights of the Child of 1959, the Convention on the Rights of the Child and the three Optional Protocols of 1989, which have become the main legal acts regulating human rights issues and constitute a universal international instrument for the protection of children's rights, applicable to all children and in all circumstances.

The Declaration of the Rights of the Child of 1959 included ten articles that proclaimed social and legal principles aimed at protecting and safeguarding children's rights, both at the national and international levels. Article 1 states: "that the protection and safeguarding of children's rights shall be carried out without distinction or discrimination on account of race, colour, sex, language, religion, political or other opinion, national or social origin, property, birth or other status, whether of himself or of his family". The greatest significance of this document is considered to be that it showed the true situation of children in the world and for the first time sharply posed to the world community the problem of protecting children's rights, ensuring their survival and decent development. The Declaration drew attention to the problems of child protection by states and posed them with the need to create an international legal mechanism for regulating the protection of children. Later, it influenced the change in the policy of many states regarding the protection of the rights and freedoms of children, as the most vulnerable category.

The Convention on the Rights of the Child of 1989 was a logical continuation of the Declaration of the Rights of the Child, significantly expanding and specifying its principles, which were recommended by nature. It brought together into one international document the rights of the child, which, perhaps, had previously been found only by studying a large number of documents that regulated various features and sectoral rights and covered almost all spheres of the child's life.

The Convention on the Rights of the Child put forward a new concept that recognized that: "a child is a human being who is an independent subject of law; a child is not the property of his or her parents; a child is a person who possesses the full range of rights established by law. "A great advantage of this Convention is that it has created mechanisms for protecting children and ensuring their rights, taking into account the national, cultural, economic, social and political conditions of development of different countries. This allows states to fulfil their obligations under the Convention without violating their national law. The role of this Convention at the historical level is determined by the

fact that it has united in one document everything that has been developed over many years in the field of children's rights and has become the main document in the field of protecting children's rights.

## PROTECTION OF CHILDREN'S RIGHTS DURING ARMED CONFLICT

One of the biggest problems that arise in the event of an armed conflict is the protection of the civilian population, including children. Despite the fact that the protection of the civilian population is universally recognized in the international arena, this problem has become acutely relevant. Now more and more types of conflicts and wars are emerging, where the boundaries between combatants and the civilian population, as objects and subjects of war, are blurred, and more and more new types of weapons are used. As a result of modern armed conflicts, the main losses are the civilian population, including children, as its most vulnerable part.

International humanitarian law provides a wide range of measures to protect children. In the event of armed conflict – international or non-international – children benefit from the general protection afforded to civilians not taking part in armed conflict. Civilians who are not combatants are guaranteed humane treatment.

There were several main problems with the protection of children during armed conflicts. Firstly, children, as the most vulnerable category, have the right to special protection, but this principle was not clearly stated in any of the articles of the Geneva Convention IV. Secondly, the issue of the participation of children in armed conflicts became acute. That is why two Additional Protocols to the Geneva Conventions of 1949 were adopted: Protocol I concerning the protection of victims of international armed conflicts and Protocol II concerning the protection of victims of non-international armed conflicts.

Additional Protocol I for the first time clearly formulated the principle of special protection of children during international armed conflicts: "Children shall enjoy special respect and shall be protected against all indecent assaults. The Parties to the conflict shall ensure such protection and assistance as they may require by reason of their age or for any other reason". The participation of minor children in total war, especially in occupied territory, is unfortunately a fact that has long since taken place. Therefore, Protocol I obliges the parties to the conflict to take all possible measures to ensure that children who have not reached the age of fifteen do not take a direct part in armed conflicts. If this does happen and such children fall into the power of the opposing party, they continue to enjoy special protection, regardless of whether they are prisoners of war or not. In the event of arrest, detention or internment for reasons related to armed conflict, children shall be held in separate accommodation from adults unless they can be accommodated with their families. In the case of persons who were under the age of eighteen at the time of the commission of the offence, the death penalty for offences related to armed conflict shall not be carried out. The legal provisions governing the conduct of hostilities shall apply to them. Taking into account the particular vulnerability of children, the Geneva Conventions of 1949 and their Additional Protocols of 1977 establish a number of specific rules granting children special protection. Children who take a direct part in armed conflicts do not lose this protection. The Additional Protocols, the Convention on the Rights of the Child of 1989 and the recently adopted Optional Protocol to it establish limitations on the involvement of children in armed conflicts (Legal Protection of Children in Armed Conflict – ICRC).

Additional Protocol II is devoted to the issues of providing children with the necessary care and assistance. These include, in particular, promoting the reunification of temporarily separated families, prohibiting the recruitment of children under the age of fifteen into armed forces or groups, special protection for such children if they nevertheless participated in armed conflicts and were taken prisoner, and the temporary evacuation of children from the area of hostilities. The rights of persons deprived of their liberty for reasons related to the armed conflict, regardless of whether they are interned, detained or subject to criminal prosecution, are not restricted by Protocol II.

It is also worth mentioning the Optional Protocol of 2000 to the Convention on the Rights of the Child on the involvement of children in armed conflict. It certainly strengthens the Convention in a number of ways, but it should also be noted that it cannot be considered entirely satisfactory.

Although the minimum age for voluntary participation of children in armed conflict has been raised, the relevant obligation imposed on States Parties is limited to the need to take "all feasible measures" – a formulation that largely coincides with that already enshrined in Additional Protocol I of 1977. Furthermore, another fact that should be noted is that this obligation applies only to direct participation in armed conflict, and in this statement, it is even weaker than the obligation established in Additional Protocol II, which deals with participation in armed conflict in general. Thus, the Optional Protocol does not protect children from indirect participation in armed conflict, most forms of which are no less dangerous than direct participation. However, one of the great advantages of the protocol is the increase in the minimum age of compulsory conscription, since similar provisions of the Convention on the Rights of the Child and Additional Protocol I to the Geneva Conventions only state that States parties "shall endeavour to give preference to persons of older age". Despite a number of shortcomings present in the Optional Protocol to the Convention on the Rights of the Child, it is an important step towards ensuring that children are not involved in armed conflicts. This protocol obliges States not only to ensure the effective implementation of its provisions, but also to ensure the demobilisation of children, as well as their rehabilitation and integration into society, and to cooperate with each other for these purposes. As for monitoring the implementation of these obligations, it is entrusted to the Committee on the Rights of the Child, which is the supervisory body in relation to the Convention on the Rights of the Child itself.

Another equally important international document concerning the protection of the population, including children, is the Convention (IV) relative to the Protection of Civilian Persons in Time of War, adopted on August 12,

1949 in Geneva. An analysis of this Convention shows that children, as part of the civilian population, are subject to all the provisions of this international document. The main provisions define the general principle of humane treatment of people, including respect for life, physical and psychological integrity, respect for human dignity, the prohibition of contempt and degrading treatment, the prohibition of condemnation and punishment without trial. Also, in relation to the civilian population, including children, torture, corporal punishment, medical and scientific experiments, collective punishment, reprisals, measures of intimidation or terrorism, taking hostages, unlawful deportation, etc. are prohibited. Article 14 of the Convention states that children under the age of 15 and mothers of children under the age of 7 are included in the category of the civilian population for whom special sanitary or safe zones may be established. They must also be evacuated from areas under occupation (Convention (IV) relative to the Protection of Civilian Persons in Time of War, 1949).

The Rome Statute of the International Criminal Court of July 18, 1998 defines as a war crime the recruitment or enlistment of children under the age of fifteen into armed forces or groups or their use for active participation in armed conflicts.

Over the past decades, the UN Security Council has adopted a number of resolutions on the protection of children caught in armed conflict. In terms of scope, all modern effective international legal mechanisms can be divided into two groups:

1. Before a military conflict. At this stage, the parties to the conflict are obliged to take preventive measures to remove persons under the age of eighteen from participating in armed conflicts. Such measures include:

– limitation of the conscription age;

– evacuation of children;

– inadmissibility of recruiting children.

2. After the military conflict. During this stage, children who have suffered during the armed conflict are protected and supported. This stage is extremely important, since the mental and physical trauma that children receive in conditions of armed conflict is very difficult to heal. Such measures include:

– ensuring the return of children to their families after the armed conflict;

– the right to protection and care after the armed conflict.

One of the most problematic issues has been and remains how to provide children with proper protection during armed conflict, when the probability of their rights and freedoms being violated is extremely high. Despite the fact that mechanisms exist to protect children's rights during active armed conflicts, their actual functioning and proper implementation are insufficient.

During the UN Security Council briefing on children and armed conflict of 2020, the UN Secretary-General noted: "Children are not participants in conflicts." However, as Graça Machel said in her 1996 report: "Millions of children are caught up in conflicts in which they are not merely bystanders, but targets." Children under the age of eighteen make up more than 50 percent of the population in most war-affected countries and are among the most vulnerable, unable to protect themselves from its consequences. These violations cause irreparable harm to children themselves, their communities and societies. They can fuel resentments and frustrations that lead to extremism, creating a cycle of tension and violence" (Secretary-General's remarks to Security Council Briefing on Children in Armed Conflict, 2020).

Against the backdrop of the war between Ukraine and the Russian Federation, the European Union has decided to strengthen the protection of children in armed conflict. In particular, it is about preventing child trafficking, their recruitment by military forces and separation from their families. This statement was made in light of the systematic and gross violations of children's rights by Russian military forces in Ukraine.

The European Council of the European Union calls on Member States to improve the protection of children in emergency situations, in particular by:

– establishing reception procedures that provide shelter adapted to the needs of the child, guarantee their physical and mental health and ensure their access to essential services;

– providing assistance to unaccompanied children, including through the rapid appointment of a legal guardian or an appropriate representative;

– strengthening policies to combat child trafficking, defining strategies to identify victims of trafficking and raising awareness among children and their families about the risk of exploitation;

– ensuring that emergencies are not used as a tool for child protection, and in particular that adoption does not take place during armed conflicts.

The conclusions also cover the EU strategy on the rights of the child more broadly. In particular, the Council calls on Member States to develop comprehensive policies to realise the rights of all children without any discrimination, to step up efforts to prevent and combat all forms of violence against children, to strengthen justice systems to ensure that they are responsive to children's rights, and to increase opportunities for children to be responsible and resilient members of the digital society (Council conclusions on the EU strategy on the rights of the child, 2022).

During the war in Ukraine, which was unleashed by the Russian Federation, a large number of children were forced to leave their homes in search of a safe place to stay. Therefore, the application of international humanitarian law in relation to refugee children is no less important. In accordance with the principles and norms of international humanitarian law, a displaced person enjoys protection as a civilian affected by hostilities (international or non-international), regardless of the reasons for the change of residence, whether persecution, armed conflict or internal unrest. The Geneva Convention relative to the Protection of Civilian Persons in Time of War and its Additional Protocols aim to

prevent or at least limit the impact of conflicts in which civilians may find themselves. Article 44 emphasizes: "refugees who do not in fact enjoy the protection of any government shall not be treated as enemy aliens who are nationals of an enemy solely by virtue of their legal affiliation with an enemy State." It also regulates guarantees of asylum in time of war. The Convention and its protocols oblige States participating in a conflict, as well as neutral States, to provide children with special protection from the effects of war, which usually results in a large influx of refugees. Article 24 of the Convention guarantees that "the Parties to the conflict shall take the necessary measures to ensure that children under fifteen, who are orphaned or are separated from their families as a result of the war, are not left to their own resources, and that their maintenance, the exercise of their religion and their education are facilitated in all circumstances, their maintenance, the exercise of their religious responsibilities and their education" (Children and war. Special brochure. ICRC, Geneva, 1994).

Among the norms of the Convention on the Rights of the Child, there are also norms that affect and regulate the rights of refugee children. First of all, this is the provision on ensuring the best interests of the child, which must be guided in all actions taken in relation to children. Another provision of the Convention concerns unaccompanied and separated refugee children, who have the right not to be separated from their parents, if this does not contradict the best interests of the child. In the case of determining the best interests of the child, it is necessary if the reason for forced migration is the cruel treatment of the child by the parents. Children also suffer from separation from their families during war. When a child loses his/her parents, not only the probability that he/she will not be able to survive on his/her own, find a safe place, and even more so a refugee camp, increases, but also the probability that he/she will take up arms and commit various other crimes. The protection of unaccompanied children therefore includes their identification, their temporary custody by any organization or institution that could take care of them, the provision of all necessary facilities, the tracing of their parents, the reestablishment of contact with relatives and the maintenance of contact with them until at least one of the parents is found. If a child is separated from one or both parents, the State Party shall respect the right of the child to maintain relations with both parents and to provide information on the whereabouts of the absent family member(s). Unaccompanied and separated refugee children, being deprived of their family environment, may, in accordance with the Convention, be entitled to special protection and assistance provided by the State.

## CONCLUSIONS

Child protection is the prevention of and response to abuse, neglect, exploitation and violence against children. The concept of child protection in situations of armed conflict covers a very wide range of issues that can vary depending on the specific context. Children are increasingly becoming one of the main victims of armed conflicts around the world. Unfortunately, according to estimates made by UNICEF, more than 250 million children are becoming victims of war today, which has not happened since the Second World War. Children are becoming refugees, losing their right to primary education, many schools have become objects of bombing or have ceased to exist, most children have been forced to leave their families and their homes.

Ensuring children's rights is one of the global and fundamental problems of our time that the international community faces and, in whose solution, the entire international community is interested. International protection of children's rights during armed conflicts is a system of mutually coordinated actions of states, international intergovernmental and non-governmental organizations aimed at developing and ensuring the rights of the child in order to form a full and harmoniously developed personality, to promote their consolidation in national legislation and to provide international assistance to children. International legal regulation provides for special protection of children as persons not participating in armed conflicts, and special protection as the most vulnerable persons. Moreover, children participating in armed conflicts are also subject to protection. During international armed conflicts, children are included in the category of persons protected by the Geneva Convention IV relative to the Protection of Civilian Persons in Time of War. This makes them subject to all provisions relating to the treatment of persons and establishes the fundamental principle of humane treatment of human beings, which includes respect for life, physical and mental integrity, and prohibits, among other things, coercion, punishment, torture, collective punishment and reprisals. As part of the civilian population, children are subject to all rules of international humanitarian law relevant to the conduct of war.

The protection of children's rights during armed conflicts cannot be ensured only by strengthening their legal autonomy. It consists of finding external mechanisms to protect the child's integrity from the encroachments of the family or public environment of which they are victims, and thus the protection of children places a direct responsibility on all participants in life, including the responsibility of representatives of humanitarian organizations in emergency situations.

During armed conflicts, international humanitarian law provides children with both the general protection provided for civilians not taking part in armed conflicts, and special protection, taking into account their particular vulnerability.

## REFERENCES

Children and war. Special brochure. ICRC, Geneva, 1994. P. 3–7.

Convention (IV) relative to the Protection of Civilian Persons in Time of War of 12 August, 1949. URL: https://ihl-databases.icrc.org/en/ihl-treaties/gciv-1949

Council conclusions on the EU strategy on the rights of the child. URL: https://data.consilium.europa.eu/doc/document/ST-10024-2022-INIT/en/pdf

Geneva Declaration of the Rights of the Child, 1924 URL: https://www.humanium.org/en/text-2/

International Covenant on Civil and Political Rights of 1966. URL: https://www.ohchr.org/en/instruments-mechanisms/instruments/international-covenant-civil-and-political-rights

International Covenant on Economic, Social and Cultural Rights of 1966. URL: https://www.ohchr.org/en/instruments-mechanisms/instruments/international-covenant-economic-social-and-cultural-rights

Legal Protection of Children in Armed Conflict – ICRC. URL: https://www.icrc.org/sites/default/files/document/file_list/children-legal-protection-factsheet.pdf

Optional Protocol to the Convention on the Rights of the Child on the involvement of children in armed conflict. URL: https://www.ohchr.org/en/instruments-mechanisms/instruments/optional-protocol-convention-rights-child-involvement-children

Protocol Additional to the Geneva Conventions of 12 August 1949, and Relating to the Protection of Victims of International Armed Conflicts (Protocol 1). URL: https://www.ohchr.org/en/instruments-mechanisms/instruments/protocol-additional-geneva-conventions-12-august-1949-and

Protocol Additional to the Geneva Conventions of 12 August 1949, and Relating to the Protection of Victims of Non-International Armed Conflicts (Protocol II). URL: https://www.ohchr.org/en/instruments-mechanisms/instruments/protocol-additional-geneva-conventions-12-august-1949-and-0

Secretary-General's remarks to Security Council Briefing on Children in Armed Conflict: Introducing Practical Guidance on the Integration of Child Protection Issues in Peace Processes [bilingual, as delivered; scroll down for all-English] of 2020. URL: https://www.un.org/sg/en/content/sg/statement/2020-02-12/secretary-generals-remarks-security-council-briefing-children-armed-conflict-introducing-practical-guidance-the-integration-of-child-protection-issues-peace-processes

UNICEF: The United Nations Children's Fund. URL: https://www.un.org/youthenvoy/2013/09/unicef-the-united-nations-childrens-fund/

Universal Declaration of Human Rights of 1948. URL: https://www.un.org/en/about-us/universal-declaration-of-human-rights

PANEVĖŽIO KOLEGIJA ISSN 2029-1280, eISSN 2669-0071. Taikomieji tyrimai studijose ir praktikoje – Applied Research in Studies and Practice, 2024, 20.

# THE CAUSES OF RESISTANCE TO CHANGE AMONG THE EMPLOYEES OF DIFFERENT GENERATIONS: THEORETICAL INSIGHTS

***Diana LIPINSKIENĖ[a], Renata ŽVIRELIENĖ[a], Jurgita MEŠKERIENĖ[b]***

*[a] Panevėžio kolegija/Panevėžys University of Applied Sciences, Lithuania*
*[b] Social partner, Lithuania*

**Abstract.** Today, managing the resistance to change among different generations of employees is a challenge for many organisations, as each generation has its own values, behaviours, working styles and expectations, which results in different reactions to change in the organisation. Therefore, identifying the reasons for resistance to change among different generations of employees becomes one of the keys to success for organisations to improve and remain competitive. This paper aims to provide theoretical insights into the causes of resistance to change among different generations of employees. The scientific literature analysis was used to achieve the paper's aim. The findings suggest grouping the reasons for employee resistance to change into two groups: first, situational reasons, which are described by changes in organizational culture, increased workload, lack of support during changes, and inadequate communication, and second, individual employee reasons, which are associated with the employee's characteristics, such as perceptions, needs, beliefs, and values. A significant variable that affects employee resistance to change is their age, therefore the reasons for employee resistance to change of different generations differ. An analysis of the scientific literature has shown that the main differences are that older generation employees seeking job security, passively resist change, while younger generation employees resist change when they do not see the benefits of change for themselves and the organization.

**Keywords**: generation, generations of employees, changes, resistance to change, reasons of resistance to change

## INTRODUCTION

In today's global world, where the economic, technological, political and other environments are changing rapidly, change is a given. Change is not limited to organisations where several generations are working simultaneously: Generations Z, Y, X and the baby boomers, and in some countries, the so-called silent generation - employees who are still working at the age of 78 or older (Perez, 2017). Each generation is distinguished by its values, behaviours, working styles and expectations, which results in their different reactions as employees to the changes implemented in the organisation.

Employee resistance to change is one of the main obstacles to the success of an organisation and one of the preconditions for negative working relationships. Therefore, to avoid and respond successfully to employee resistance to change, any organisational change must be managed through appropriate actions. One such action, according to Drejeris and Drejeriene (2021), is to identify the causes of employee resistance to change. According to the researchers, identifying the causes of employee resistance to change is relevant for every organisation, as the changes implemented enhance the company's competitiveness and distinctiveness and positively impact the organisation's success. However, different generations of employees have various reasons for their resistance to organisational innovation, as each generation has a different approach to work, interests and lifestyles (Rehman, Mahmood, Ibtasam, Murtaza, Iqbal & Molnár, 2021). Therefore, to be successful in implementing change in organisations, it is important to know and understand why the reactions of employees of different generations are different. This implies the *scientific problem* addressed in this article, which is formulated as the question: *what are the causes for the resistance of employees of different generations to change?*

The *object* of the paper: the causes of resistance to change among the employees of different generations. This paper *aims* to provide theoretical insights into the causes of resistance to change among different generations of employees.

The paper was prepared using the scientific literature analysis method.

## CLASSIFICATION OF GENERATIONS AND CHARACTERISTICS OF DIFFERENT GENERATIONS OF EMPLOYEES

In today's work environment, often work employees of different generations. These generations are characterized by different ways and forms of communication and collaboration. Each generation brings unique life experiences, attitudes, expectations and work styles; therefore, employees of different generations must be managed differently (Berisha, 2020; Carroll, 2020).

To reveal the characteristics of employees of different generations, it is appropriate to define the essence of the concept of generations. Valickas and Jakštaitė (2017), analyzing the concept of generation, present the definition of generation by sociologist Mannheim (1952), according to which a generation is a group of people of the same age which is united by some memorable historical event. Ryder (1965) also supports this idea of the scientist, stating that a generation

is a unit of individuals who are connected by the same events during the same period (Valickas and Jakštaitė, 2017). Kupperschmidt (2000) states that a generation is a group of people who are connected by their date of birth, position, and key events related to personality development. According to Valickas and Jakštaitė (2017), sociologists of the last decade of the 20th century introduced the new concept of "generation cohort" and defined a cohort as a group of people of the same or similar age, united by a common demographic event and/or historical experience, based on which a unique worldview is formed, distinguishing them from other similar formations.

However, most researchers (Ludviga & Senņikova, 2016; Valickas & Jakštaitė, 2017; Vraňaková, Babeľová & Chlpeková, 2021), considering the most important events of a certain period, divide people into generations simply - according to their date of birth. Such a generational classification was proposed by Strauss & Howe (1991), which is still used to categorize people and thus highlight the characteristics of their groups (Valickas & Jakštaitė, 2017) (see Table 1).

Table 1

**Generational classification (Valickas and Jakštaitė, 2017)**

| Generation | Date of birth |
|---|---|
| *Lost Generation* | 1883 – 1900 |
| *Greatest Generation* | 1901 – 1924 |
| *Silent Generation* | 1925 – 1942 |
| *Baby Boom Generation* | 1943 – 1960 |
| *Generation X* | 1961 – 1981 |
| *Y/Millennial Generation* | 1982 – 2001 |

Recently, representatives of another generation have been entering the labour market. They are described as the "iGeneration", "Gen Tech", "Internet Generation", "Postmillennials", "Facebook Generation", "Switcher Generation". Therefore, after such a generally accepted classification of generations, which is presented in Table 1, another one has appeared – Generation Z.

Čič and Žižek (2017), when examining the characteristics of employees of different generations, note that generational identities emerge in the workplace based on the collective memory of common events that occurred in the late formative years of each generation. This suggests that knowing the characteristics of different generations of employees would allow for the proper administration of the employee management process, which would ensure effective work.

*Baby boom generation*. Angeline (2011) describes the traditional baby boomer as a workaholic who rarely changes jobs. He is a dedicated, hardworking, motivated employee who expects to be promoted to positions based on his loyalty. Employees of this generation cherish the following values in their activities: optimism; risk-taking; orientation towards team goals; self-realization; hard work; the importance of personal growth and development; and equal rights and opportunities (Sarraf, 2019). According to Burke (2023), the added value of these employees to the organization is their wisdom, experience, and understanding of relationships, the ability to notice when people are lying, and the knowledge that ignoring one's values will cause harm.

Sarraf (2019) notes that this generation of employees prefers face-to-face communication over digital means. Kunze and Boehm (2013) argue that older employees are less motivated, less willing to learn, and less likely to engage in organizational change than their younger counterparts. Furthermore, according to Drejer and Drejerienė (2021), baby boomers may feel powerless due to their reluctance to acknowledge their skills gaps, and as a result resistance to change occurs. On the other hand, research has shown that older employees who believe that the organization they have worked for many years has always been open with them are more likely to trust it, which further strengthens their commitment and willingness to support change (Felix, Vhuramayi, Martin, & Nyasha, 2013). According to Kunze and Boehm (2013), baby boomers are generally associated with lower development potential (including learning new skills and tackling new challenges) and a higher degree of stability, and these features imply greater resistance to change among this generation. Furthermore, according to Felix et al. (2013), changes often occur so rapidly that employees of this generation feel unable to cope and adapt to them.

The characteristics discussed by baby boomers are particularly relevant when it comes to the features of employee communication and collaboration, performance appraisal, or resolving concerns. According to Carroll (2020), unlike younger generations who change jobs many times during their lives, baby boomers value job security, enjoy working in a team, and are helpful to younger generations. Managing baby boomers requires recognition of their hard work and utilization of their skills to make them feel valued and satisfied with their current roles, which will help retain them for many years (Carroll, 2020).

*Generation X employees,* according to Angeline (2011), are effective problem solvers but avoid extra work if possible. Compared to baby boomers, generation X employees are more pragmatic and sceptical. Generation X employees resent being constantly told and reminded what to do and that baby boomers are much harder workers than them. On the other hand, generation X representatives expect to be appreciated and rewarded as soon as they achieve the goals of the organization. When problems arise, they prefer to contact their managers directly so that they can quickly resolve them. Unlike baby boomers, generation X employees are not afraid to change jobs, as they are convinced that each new job will lead them to higher and better-paid positions.

Generation X representatives, according to Carroll (2020), are guided by the motto "work to live". Therefore, when managing employees of this generation, the organization should offer some benefits that support this motto of employees, for example, paying for employees to attend a gym. Generation X values independence, so Carroll (2020) believes that to motivate them to perform even better, employees of this generation should be given more autonomy.

When managing Generation X employees, it is necessary to pay attention to the fact that the following values are characteristic of employees of this generation: variety, thought, and global interest, self-reliant, technology literature, entrepreneurship, scepticism and distrust, lack of loyalty to the organization, belief in meritocracy, flexible and highly adaptable, happy, joyful and entertaining, independent and independent, Self-control and self-esteem, attention to informality (Sarraf, 2019).

When ensuring smooth management of Generation X employees in an organization, according to Kicheva (2017), it is necessary to consider that employees of this generation perceive work not as work for someone, but as work with someone. Therefore, they assume the greatest responsibility compared to employees of other generations. Representatives of Generation X can easily leave their job and then look for another. Sometimes their demands are not always realistic in terms of wages. This situation arises due to the labour market itself and the widespread imbalance of supply and demand, as Generation X employees have higher requirements and know their value as specialists. Generation X has an entrepreneurial spirit and, unlike the baby boomers, is ready to "accept" changes in the workplace. They are focused on career growth but pay more attention to the family. Representatives of this generation strive for a balance between personal life and work, therefore, one of the features of managing Generation X employees in the organization is the offer of flexible work schedules for them.

*Generation Y,* or millennials, particularly value interpersonal communication in both real and virtual environments. According to Angeline (2011), Generation Y workers are more technologically savvy, faster, more flexible, and more receptive than Generation X workers. However, Burke (2023) notes that many Generation Y workers face financial instability for a variety of reasons, from high student loans to housing debt.

According to the International Labour Office (2019), Generation Y workers entering the labour market face a variety of challenges, which are determined by several factors, including lower levels of physical, psychosocial, and emotional maturity, education, insufficient job skills, and/or work experience. Young workers also do not have the same bargaining power as more experienced workers; therefore, they may accept dangerous working conditions and tasks, or similar conditions associated with unsafe work. They are more likely to work under non-standard employment contracts or in the informal economy, are often unaware of their rights and obligations in the field of occupational health and safety and may be reluctant to report hazards or incidents they encounter in the workplace (International Labour Organization, 2019). Therefore, to ensure successful management of this generation of employees, the organization could consider how it could help solve these problems of Generation Y employees and thus ensure their greater commitment, retention or loyalty to the organization. For example, one of the solutions for managing Generation Y employees could be offering them competitive wages or salary increases after a certain period.

One of the key characteristics of Generation Y employees, according to Carroll (2020), is that millennials spend more time working and they work not only during work but also during their free time. When managing employees of this generation, it is necessary to consider that Generation Y holds the following values: civil duty, self-confidence, goodness, social ability, success and selfishness, realism, sentimentality, friendliness of participation, important state of affairs, quick feedback, very fond of recreation, friendliness (Sarraf, 2019).

Thus, Generation Y representatives are characterized by hard work, perseverance, goal-oriented work, and self-realization and recognition are important to them. Considering this, organizational leaders should ensure various career growth opportunities for employees of this generation, which would further increase Generation Y employees' motivation and involvement in the company's activities.

Generation Z, who saw the world in the first decade of the 21st century, is described as immersed in the digital world, mobile and is not afraid to change their choices: field of study or workplace. They do not like routine and desire personal freedom, strive for career, and personal development, and are described by a strong orientation towards themselves (Dolot, 2018). Benítez-Márquez et al. (2022) note that Generation Z can perfectly live and work in both the real and virtual worlds because they perceive them as complementary to each other. Generation Z uses various mobile devices, comments on reality, and the environment in which they live, expresses their opinion and point of view, and shares photos and videos. Generation Z not only consumes online content, but also creates and, in a way, controls it.

According to Carroll (2020), this generation is the most technologically savvy, which allows them to make creative decisions that other generations might not have thought of. Generation Z employees, when interacting with their managers, value a mentoring and coaching style rather than a top-down management style. They value collaborative relationships that help them grow and learn as they perform their duties. Generation Z employees are young, so to understand and manage them as best as possible, the organization should answer the question: are there ways that could help the organization to support Generation Z employees and retain them longer? This question should also be asked when managing employees of other generations, but it takes on special significance in the context of managing Generation Z employees. Although at first glance, Generation Y and Generation Z employees are similar, according to Sarraf (2019), there are significant differences between them. These differences become even more apparent in the workplace, especially when it comes to collaborating with employees of other generations, for example, sharing knowledge and transferring information. Generation Z, according to Berisha (2020), has little professional experience compared to other generations

but is concerned with social and ecological issues, values communication, and is innovative. Since Generation Z is still young, more detailed research on their characteristics as employees is expected in the future.

## REASONS FOR RESISTANCE TO CHANGE AMONG DIFFERENT GENERATIONS OF EMPLOYEES

Change is any change that occurs in the work environment and affects the performance of employees. Paulikas and Paulikienė (2022) define resistance to change as the negative behaviour of employees, by which they express resistance to implementing a change. Table 2 presents definitions of resistance to change proposed by different authors.

Table 2

**Definitions of resistance to change (Paulikas and Paulikienė, 2022)**

| Definition of resistance to change | Author, year |
|---|---|
| It is a consequence of cognitive, cultural, and structural approaches to transformation. | Senge, 1990 |
| It is a multifaceted negative attitude or hostile behaviour of employees, due to which the process of strategic change is unplanned delayed, expensive and unstable. | Waddel and Sohal, 1998 |
| It is a disagreement with the change process (sequence of actions), which the employee considers unpleasant, inconvenient or burdensome for personal or group reasons. | Giangreco and Pccei, 2005 |
| It is a natural and human element of organizational activity, a natural initial reaction of the employee, more often defined as a process, not an event. | Van Dijk and Van Dick, 2009 |
| It is a covert or overt expression of negative reactions, or a defence mechanism used to resist change management and the adoption of new practices. | Berna-Martinez and Macia-Perez, 2012 |
| It is a concept that managers use to explain, in their opinion, unpopular and undesirable behaviour and interaction of employees. What managers call resistance to change depends not on the observed behaviour of the employee but on the interpretation and judgments of the observers. | Barely and Rupert, 2018 |

Thus, it can be stated that resistance to change is a set of individual, interpersonal and organizational factors that cause employees to resist change (Cheraghi, Ebrahimi, Kheibar & Sahebihagh, 2023).

When implementing changes in any organization and aiming to mitigate employee resistance to change, it is appropriate to discuss the forms of employee resistance to change, and the reasons that determine them.

According to Damawan and Azizah (2020), the following forms of resistance to change are most often manifested among employees: boycott, decreased interest, concealment of information, opposing opinions, strikes, and demonstration of a negative attitude. Meanwhile, researchers Kuzhda (2016) and Karaxha (2019) distinguish the following forms of resistance to change:

1. Logical and rational resistance occurs when an employee lacks the time, skills, or resources to implement a proposed change. According to Damawan and Azizah (2020), resistance to change based on logical analysis and rationality indicates that the resources required to implement the change exceed the benefits of the change, and therefore employees are not interested in this change.

2. Psychological resistance is based on emotions and attitudes towards the change. Employees may fear the unknown, distrust management, or feel that their safety and ego are threatened.

3. Social resistance occurs when the well-being, values, or interests of the organization's employees are believed to be affected. Social resistance, according to Kuzhda (2016), manifests itself through employee coalitions, resistance to proposed values, and the maintenance of personal interests.

The reasons underlying employee resistance to change arise from *situational* circumstances, such as changes in organizational culture, increased workload, lack of support during change, inadequate communication, etc. (Tran, Pham, & Bui, 2020; Malhotra, Zietsma, Morris, & Smets, 2021) and *individual* employee characteristics, such as perceptions, beliefs, values, and needs (Damawan & Azizah, 2020).

Damawan and Azizah (2020) distinguish individual reasons for an employee's resistance to change:

- employees simply do not want to leave their comfort zone;
- lack of self-confidence;
- employees may resist change because they believe that they do not need change;
- increased stress. Stress may increase not because of the change itself, but because of the inconveniences that arise during the implementation of the change. For example, an employee may imagine that he will lose his status due to the change, and therefore, under the pressure of stress, may begin to resist the change;
- feelings of insecurity. This feeling arises when there is a lack of information about the intended change, so employees feel insecure about the future and the requirements of the change itself, which leads to the rejection of the change;
- habits. Employees' work is largely based on habits, and work tasks are implemented according to a certain professional routine. Organizational changes require changing these habits, which is why employees resist them;

- intolerance of change. Some employees have a personal characteristic of not tolerating change. Such employees always have a negative attitude towards any changes, because they see them as a threat, for example, to their salary. It is normal to expect that those employees who feel that they will lose part of their salary will resist change;
- fear of failure. Such a fear is experienced by pessimistic employees, they are afraid of personal failure. For example, an employee may fear that after implementing a change in the organization, he, as a professional, will not be able to learn new things necessary for his work after the change is implemented;
- fear of the unknown. Organizational changes in many cases cause uncertainty and a certain fear. When employees feel uncertainty in the process of change, and receive little or no information at all, in this case, they believe that the change is something dangerous. This uncertainty influences the members of the organization to resist the proposed changes;
- too weak emotional commitment. Employees with weak commitment to the organization lack psychological attachment and orientation to work and are not willing to stay in the organization voluntarily, in other words, employees do not care about the future of the organization and tend to resist change.

Researchers Pakdel (2016), Lomba-Portela et al. (2022) note that a significant variable affecting employees' resistance to change is their age. A study of teachers' attitudes towards change conducted by the latter researchers showed that age becomes a determining variable between positive and negative attitudes towards change among teachers, with negative attitudes being more associated with older workers, so it is important to be prepared to control any unwanted resistance. Therefore, to successfully reduce employees' resistance to change, it is necessary to know the reasons for employees' resistance to change of different generations. Scientific literature analysis (Ludviga & Senņikova, 2016; Vraňaková, Babeľová & Chlpeková, 2021) allows us to state that different generations of employees accept changes differently due to various reasons for resistance to change (see Table 3).

Table 3

**Reasons for resistance to change among employees of different generations (Ludviga & Senņikova, 2016; Vraňaková, Babeľová & Chlpeková, 2021)**

| Generation | Age | Reasons for resistance to change |
|---|---|---|
| Baby boom generation | 59 – 77 y. o. | This generation seeks job security and dislikes problems. Such employees may passively or not resist change, but they may enjoy it less than employees of other generations. |
| X generation | 43 – 58 y. o. | Generation X employees primarily want to know the benefits of change and how it will "help them," what they will gain if they adopt a new approach. Resistance occurs if employees of this generation believe that change will hinder their ability to achieve results. Some authors argue that Generation X representatives are very results-oriented and suggest involving them in the planning process. Generation X representatives need to see how changes can increase performance. In general, they adapt to change quite easily. |
| Y generation | 23 – 42 y. o. | Generation Y grew up in a world of constant change and rapid technological change, which makes them adaptable to a wide range of changes. Millennials expect organizational change to happen quickly and frequently. Resistance can arise if the initiative is driven by top-down management or if they do not see the significance and impact of change. They may be reluctant to follow a code of conduct in the workplace and have difficulty building relationships with their managers. Millennials value training and are generally positive about change. |
| Z generation | 17 – 22 y. o. | The youngest generation of workers cannot imagine life without new and modern technologies. They are characterized by frequent job changes, they are independent. Employees of this generation like to multitask and have good communication skills. Self-realization, achievements and identity are important for Generation Z, but work is also very important in their list of values. Due to their young age, this generation is still establishing itself in the labour market. Some representatives of this generation have already started their working careers while still students. |

The importance of analyzing the reasons for resistance to change related to individual employee characteristics is demonstrated by the fact that, when changes occur in an organization, employees naturally seek to understand the situation and adapt their expectations to the new experiences arising from the changes. In addition to the individual reasons for employees' resistance to change, researchers (Malhotra, Zietsma, Morris & Smets, 2021; Tran et al., 2020) also analyse contextual reasons for resistance to change, which include:

- the organizational environment before the changes occur, including culture, climate and trust in management;
- the change process: participation, communication, information and support from the manager during the changes;
- the perceived results and/or impact of the changes;
- changes that affect the organizational structure, strategy or possible systemic changes that cause stress, which can negatively affect employees' daily lives and personal well-being.

Knowing the reasons for employees' resistance to change allows managers to look for ways to reduce resistance to change, considering the reasons for employees' resistance to change of different generations, because the same change may be evaluated differently by employees of different generations. For example, the introduction of a new document task management program in an organization may cause support from Generation Z employees, while at the same time causing resistance from Baby Boomers. This is because Generation Z cannot imagine life without new and modern technologies, while the Baby Boomers are less technologically savvy.

Felix, Vhuramayi, Martin, and Nyasha (2013) argue that baby boomers who have already established careers are inflexible concerning various changes, they are more focused on the short-term perspective, and therefore are more resistant to change. Based on these arguments, it can be argued that older workers are generally associated with lower development potential (including learning new skills and solving new challenges) and a higher degree of stability, both of which imply greater resistance to change. In addition, changes in organizations often occur so quickly that older workers feel unable to cope and adapt to events. Baby boomers may be psychologically unable to accept radical changes. Older generations are generally more satisfied with their jobs and more committed to the organization, they pay less attention to extrinsic rewards and are more interested in intrinsic rewards, care more about the quality of their social relationships, are more emotionally stable, and value stability and routine at work more. Baby boomers change jobs less often, and they miss work less often but for longer periods due to health problems.

Paulikas and Paulikienė (2022) present providing clear and timely information about the change to employees as an important way to reduce resistance to change. According to the authors, by communicating the expected changes in a timely and clear manner, organizational managers can reduce excessive employee stress caused by fear of change. Employees should learn about the changes from their managers, and not from other sources, such as the media or rumours circulating in the organization. Information about the changes, the expected time and scope of the changes, as well as decision-making procedures and transition support mechanisms, should be sufficiently detailed and clear for employees of all generations of the organization. Employees' opinions about the change are influenced by the sufficiency, consistency and accuracy of the information provided, as well as the reliability and trust in the information source. According to Paulikas and Paulikienė (2022), organizations that provide employees with the opportunity to provide information and control its importance, structure and decision-making criteria can avoid resistance to change related to emotional stress for employees. To ensure a continuous flow of information, it is necessary to keep in mind that employees of different generations have different communication and information needs. By using various communication channels, such as e-mail, general organizational information systems, social networks and internal communication platforms, it is necessary to ensure several conditions: first, all employees can quickly receive the necessary information about the expected changes in the organization, second, they have to receive it in a way that meets their needs.

In summary, it can be stated that resistance to change occurs for reasons related to the individual characteristics of the employee, such as intolerance of change, stress, fear, selective information processing, etc. In addition, resistance to change can also occur for various situational (contextual) reasons: changes in organizational culture, increased workload, lack of support during change, inadequate communication, etc.

## CONCLUSIONS

1. Scientific literature analysis allows us to define a generation as a group of people of a certain age and a group that is connected by historical and social events that occurred during their lifetime. Experiences of this group shape its unique thinking, values, and attitudes towards work. Managers of organizations where employees of several different generations work at the same time have a difficult task, which is to manage employees of different generations, whose needs, experience, abilities, and attitudes towards innovations and changes differ.

2. Employee resistance to change is determined by situational and individual employee reasons. The latter reasons are associated with the employee's inherent and individual characteristics, such as perceptions, needs, beliefs, and values. A significant variable that affects employee resistance to change is their age, therefore the reasons for employee resistance to change of different generations differ:

- The resistance of baby boomers to change is usually caused by the following reasons: fear of losing their jobs, changes implemented quickly or unclear benefits of changes, and lack of feedback or communication.
- The resistance of Generation X employees is usually caused by the following reasons: hasty implementation of changes causing additional stress, insufficient involvement of managers when changes are imposed from above, unclear benefits of changes or unallocated responsibilities.
- The resistance of Generation Y and Z employees is usually caused by the following reasons: failure to listen to employees' opinions, limited opportunities for promotion and self-realization, and lack of financial and non-financial benefits.

## REFERENCES

Angeline, T. (2011). Managing generational diversity at the workplace: expectations and perceptions of different generations of employees. African Journal of Business Management, 5, 249–255.

Benitez-Marquez, M. D., Sanchez-Teba, E. M., Bermudez-Gonzalez, G., & Nunez-Rydman, E. S. (2022). Generation Z within the Workforce and in the Workplace: A Bibliometric Analysis. Frontiers in psychology, 12, 736820.

Berisha, B. (2020). Managing across generations: The case of Bibita group. Dynamic Relationships Management Journal, 9(1), 49–66.

Burke, M. (2023). Life at the Edge: Punctuated Time and Time Poverty. Feminist Philosophy Quarterly, 9(2).

Burke, S. & Collins, K. (2001). Gender differences in leadership styles and management skills. Women in Management Review, 16(5), 244–257.

Carroll, C. (2020). From Gen Z to Baby Boomers: Working with Multiple Generations. Management connection, 3, 6–10.

Cheraghi, R., Ebrahimi, H., Kheibar, N., & Sahebihagh, M. H. (2023). Reasons for resistance to change in nursing: an integrative review. BMC Nursing, 22(1), 310–319.

Čič, Ž. V., & Žižek, S. Š. (2017). Intergenerational Cooperation at the Workplace from the Management Perspective. Nase Gospodarstvo : NG, 63(3), 47–59.

Damawan, A., & Azizah, S. (2020). Resistance to change: causes and strategies as an organizational challenge. Advances in social science, education and humanities research, 395, 49–53.

Dolot, A. (2018). The characteristics of Generation Z. E-mentor, 74(2), 44–50.

Drejeris, R., & Drejeriene, E. (2021). Model for Causes Elimination of Staff Resistance to Innovative Change: evidence from Lithuanian Health Care Institutions. Preprints. https://doi.org/10.20944/preprints202101.0046.v1

Felix, C., Vhuramayi, C., Martin, C., & Nyasha, M. (2013). Impact of age on employee resistance to change. A case study cotton company (COTTCO). Greener journal of business and management studies, 3(9), 386–392.

International Labour Organization (2019). Safety and Health at the heart of the Future of Work: Building on 100 years of experience. https://www.ilo.org/safework/events/safeday/WCMS_686645/lang--en/index.htm

Karaxha, H. (2019). Methods for dealing with resistance to change. Baltic journal of real estate economics and construction management, 7, 290–299.

Kicheva, T. (2017). Management of Employees from Different Generations – Challenge for Bulgarian Managers and HR Professionals. Economic Alternatives, 1, 103–121.

Kunze, F., Boehm, S., Bruch, H., & Hertel, Béatrice I.J.M. van der Hei, Guido. (2013). Age, resistance to change, and job performance. Journal of Managerial Psychology, 28(7/8), 741–760.

Kupperschmidt, B. R. (2000). Multigeneration employees: strategies for effective management. The health care manager, 19(1), 65–76.

Kuzhda, T. (2016). Diagnosing resistance to change in the change management process. Economics, management and sustainability, 1(1), 49–59.

Lomba-Portela, L., Domínguez-Lloria, S., & Pino-Juste, M. R. (2022). Resistances to Educational Change: Teachers' Perceptions. Education Sciences, 12(5), 359.

Ludviga, I., & Senņikova, I. (2016). Organisational change: generational differences in reaction and commitment. Business and Management, 54, 1–10.

Malhotra, N., Zietsma, C., Morris, T., & Smets, M. (2021). Handling Resistance to Change When Societal and Workplace Logics Conflict. Administrative Science Quarterly, 66(2), 475–520.

Pakdel, A. (2016). An investigation of the difference in the impact of demographic variables on employees' resistance to organizational change in government organizations of Khorasan Razavi. Procedia – Social and Behavioral Sciences, 230, 439–446.

Paulikas, J., & Paulikienė, B. (2022). Impact of the communicated information content on employee resistance to change. Insights into Regional Development, 4(3), 61–75.

Perez, N. (2017). Five generations in the workplace: real world issues & solutions. Thought leaders solutions forum: Harnessing the Power of a Multigenerational Workforce, 13–14. https://www.shrm.org/content/dam/en/shrm/foundation/2017%20TL%20Executive%20Summary-FINAL.pdf

Rehman, N., Mahmood, A., Ibtasam, M., Murtaza, S., Iqbal, N., & Molnár, E. (2021). The psychology of resistance to change: the antidotal effect of organizational justice, support and leader-member exchange. Frontiers in psychology, 12, 1–15.

Sarraf, A. R. A. (2019). Managing Multigenerational Organizations. Economic Alternatives, 1, 93–105.

Tran, D., Pham, H.T., & Bui, V.T. (2020). The Effect of Contextual Factors on Resistance to Change in Lean Transformation. Journal of Asian Finance, Economics and Business, 7, 479–486.

Valickas, A., & Jakštaitė, K. (2017). Different generations' attitudes towards work and management in the business organizations. Human Resources Management & Ergonomics, 11, 108–119.

Vraňaková, N., Gyurák Babeľová, Z., & Chlpeková, A. (2021). Sustainable Human Resource Management and Generational Diversity: The Importance of the Age Management Pillars. Sustainability, 13(15), 8496.

PANEVĖŽIO KOLEGIJA ISSN 2029-1280, eISSN 2669-0071. Taikomieji tyrimai studijose ir praktikoje – Applied Research in Studies and Practice, 2024, 20.

# CONSUMER ATTITUDES TOWARDS THE APPLICATION OF GREEN LOGISTICS PRINCIPLES IN THE PARCEL DELIVERY SECTOR

***Kristina KAROSEVIČIENĖ, Daiva ČAPLIKIENĖ***

*Kolping Higher Education Institution, Lithuania*

**Abstract.** Currently, more and more attention is paid to environmental protection and efficient use of natural resources. The need to rethink approaches to the implementation of logistics functions in the presence of the need to protect the environment and increase social responsibility leads to the transformation of companies and the need to evaluate the consumer's attitude to the changing functions of companies and the creation of business strategies that would increase the value for the consumer. The object of the article is the users of the parcel delivery sector. The purpose of the article is to evaluate the consumer's attitude towards the application of green logistics principles in the parcel delivery sector. Objectives of the article: to reveal the benefits of applying the principles of green logistics to companies and the end user. To present the users' perspective on the application of green logistics principles. The article uses the analysis of scientific literature and quantitative research.

**Keywords**: green logistics, nature protection, parcel delivery, consumers

## INTRODUCTION

Companies are becoming more aware of their environmental impact. In order to turn environmental issues into business opportunities, many companies are beginning to consider how environmental or ecological aspects can be integrated into their service offerings (Isaksson and Huge-Brodin, 2013). The principles of green logistics are based on the triple principle, according to which the environmental, social and economic impact of logistics activities are taken into account, so the benefits accrue to the company, its suppliers and partners, customers and every member of society. Freight transport and business logistics can improve their environmental sustainability through energy efficiency, but the sector has only responded in 2018 by complying with European Union directives and the United Nations Sustainable Development Goals. The pursuit of energy efficiency as a means of achieving environmental sustainability, primarily by reducing the dependence of logistics operations and systems on fossil fuels, remains poorly understood (J. Wehner et al. 2021), but it must be recognized that the broad transport industry, which is greatly affected by emerging fuel prices, more efficient transport means not only a reduction in $CO^2$ emissions, but also economic savings. The intensified competitive environment and changed consumer expectations encourage companies to adopt green logistics strategies that would improve operational efficiency, profitability and reduce the carbon footprint. However, when companies make decisions to improve their operations, the quality of the service also changes in the short term, the delivery time of the parcel may increase, the delivery location may change, the price of the service may increase, so it is very important to assess the consumer's attitude as to how much we want and can contribute to the preservation of the nature around us.

**The object of the article** is services provided to users of the parcel delivery sector**.**

**The purpose of the article** is to evaluate the consumer's attitude towards the application of green logistics principles in the parcel delivery sector.

**The aims of the article:**

1. To reveal the benefits of applying the principles of green logistics to companies and the end user.
2. To present the users' approach to the application of green logistics principles.

**Research methods:** The article uses the analysis of scientific literature and quantitative research. The questionnaire survey method was used to perform the analysis of the quantitative assessment of consumer attitudes

## THE IMPORTANCE OF APPLYING THE PRINCIPLES OF GREEN LOGISTICS

Green logistics is a calculation and application concept to reduce the environmental impact of logistics activities, which has become an inevitable trend. If companies do not quickly implement the greening criteria of the sector, they may be pushed out of the competitive market in the future. Greening the logistics sector and implementing green logistics principles in business will help companies meet environmental criteria, increase competitiveness and achieve comprehensive and sustainable development and growth. Also, the implementation of these principles increases the image of the company, improves its name, and it should be mentioned that in this period environmental management is already an indicator of quality and reliability all over the world.

One of the main sources of environmental problems related to logistics is transportation and all operations related to the transportation process. This results in increased air pollution, fossil fuel consumption, increased risk of accidents and congestion on the road network in some regions. Transport accounts for 90 percent. logistics-related pollution in the greenhouse gas emission segment.

Globalization has led to fundamental changes in the way consumers and businesses operate, related to the facilitation of trade between different countries or the ability to buy products without leaving home. In fact, more and

more European consumers are adopting e-commerce every year. trade practice - 2021 74 percent of internet users shopped online (Silva, Amaral and Fontes, 2023). Lithuanian consumers did not stand out either. A study commissioned by Swedbank found that in 2021 even 85 percent population used e-commerce services.

According to the data of the official statistics portal in Lithuania in 2022. 38.9 percent of companies carried out by e. trade, i.e. i.e. sold goods or services over computer networks. 37 percent companies sold goods or services online and 5.2 percent. – using electronic data interchange. E-commerce was carried out by 58.9 percent. large companies, 46.6 percent. – average, 36.4 percent. - small ones. The largest part of the companies that carried out e. trade, there were companies engaged in trade activities, it accounted for 50.2 percent. (Official statistics portal, 2023).

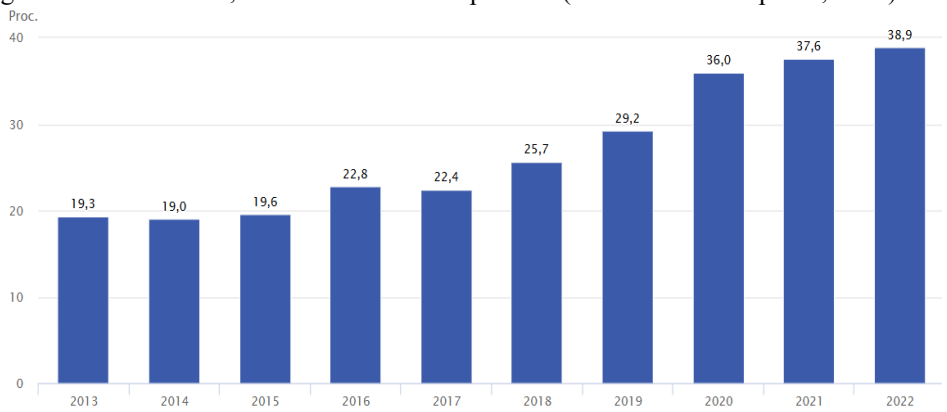



Figure 1. **Companies that sold goods or services (received orders) over computer networks, part of all orders. Source: Official statistics portal**

The impact of all these factors is reflected in logistics activities, especially the last mile, i.e. i.e. the last section of the parcel delivery service from the last logistics infrastructure to the recipient's destination, demand. It is also possible to formulate a definition that last mile logistics, i.e. i.e. the last step in the supply chain where goods are delivered from a warehouse or distribution center to a retail store or directly to the end consumer.

The last mile part of the supply chain is considered highly inefficient and expensive, accounting for 13-75%. of all supply chain costs. According to Bosona (2020), last mile logistics is the least efficient and complex part of the supply chain. And as expected, last mile operations also have social and environmental externalities such as air pollution, traffic accidents, congestion and stress, mobility barriers (possibility of not owning a car or not being able to drive).

Over the past two decades, the development of Internet infrastructure and the growth of e-commerce have significantly contributed to the increase in urban freight traffic, both in terms of freight volume and freight traffic (Bosona, 2020). in Lithuania in 2022 domestic cargo transportation by road transport amounted to 36.8 million tons of cargo and, compared to 2021, decreased by 19.5 percent (Official statistics portal, 2022).

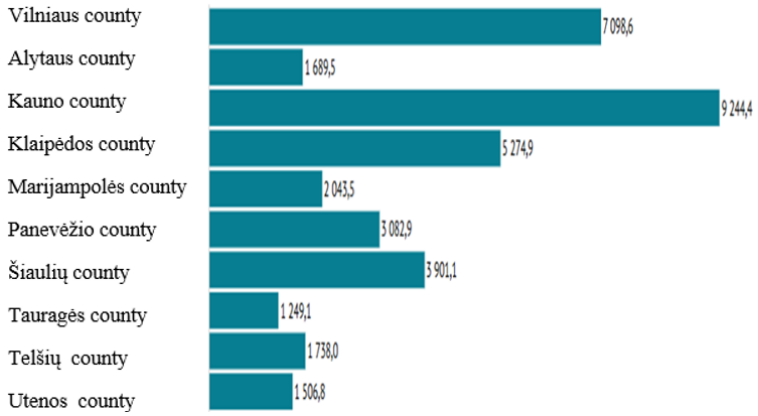



Figure 2. **Domestic freight transportation by road in 2022, thousand tons. Source: Official statistics portal.**

According to the data presented in the graph, the increase in last-mile logistics freight traffic is more noticeable in metropolitan areas, where the pressure is high and will continue to increase due to the increasing population and the resulting urbanization. Until 2030 about 60 percent of the world's population will live in cities. Today, the most popular Lithuanian parcel companies process from 65 mil. pieces of shipments.

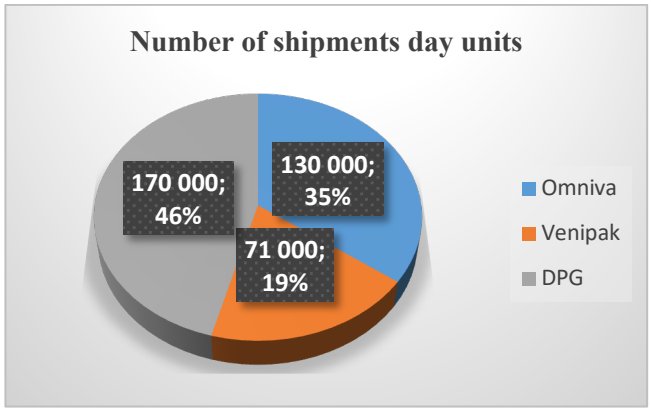



Figure 3. **The number of processed shipments per day, thousand units.**
**Source: Compiled by the author of the paper**

The last mile was and remains the most expensive and difficult to control part of the supply chain. This is partly because the last mile relies more on the human factor: the responsibility, courtesy and punctuality of the delivery driver or courier. However, beyond the human factor, there are other difficulties that companies face in implementing the principles of green logistics.

Green logistics is usually aimed at innovative solutions that include material processing, energy saving, air pollution control, environmental protection, renewable energy sources (Maymakova, 2023). The use of resource-saving technologies makes it possible to reduce material stocks by 40-60 percent, accelerate the turnover of working capital by 20-40 percent, and reduce loading and unloading and storage operations by 15 to 30 percent. On the other hand, the implementation of green logistics principles causes companies to also challenges are high costs of implementing innovative technologies and well-established traditions in waste sorting and reuse of materials. There is also a need to find effective, economically viable solutions to reduce the dependence of the parcel delivery sector on fossil fuels. Authorities currently regulate emission limits. However, a cross-sector agreement is needed to implement measures to build new facilities that meet the wishes of the entities involved in logistics activities. So, whether logistics operations are carried out in-house or outsourced, low rates and margins do not always allow thinking about investments in infrastructure, process automation or more efficient loading equipment.

In general, logistics is not sustainable because there is no customer. There is another problem: logistics is invisible to the customer and increasingly so. It is difficult to apply the principles of green logistics when the customer requires 24-hour delivery, which does not allow efficient consolidation of cargo or maximum utilization of traffic flows. In addition, logistics costs are often not included in the invoice or are negligible. This reduces their relevance and is one of the reasons why businesses do not invest in the sustainability of their environment.

Currently, service quality is the main concern of parcel delivery companies, surpassing issues such as profitability or lack of human resources. Customer satisfaction is defined as an individual's emotion or response, pleasant or unpleasant, resulting from comparing perceptions with expectations. More specifically, customer satisfaction is related to the quality of the service offered (Elnasras, Sobaihas and Saifas, 2023). Organizations have recognized that providing high-quality service to their customers creates a long-term competitive advantage. Service quality and customer satisfaction are critical aspects of corporate success, which ultimately affect market competitiveness, development, and growth (Tang et al., 2022).

The most important criterion when it comes to the quality of parcel delivery is delivery on time and fast. Companies promise fast delivery to meet the ever-increasing expectations of customers, but this is a difficult task for carriers. According to the classification of the dimensions of the SERVQUAL model, these criteria can be assigned to reliability and responsiveness. Responsiveness refers to the institution's ability to provide fast and quality services within the expected period. This requires reducing the waiting time for all interactions between the customer and the service provider (Zygiaris, Hameeds et al., 2021). Service speed is the target service time that can be performed within a specified time interval to satisfy customers (Akbar and Wadud, 2024). Reliability was assigned to the highest dimension of the SERVQUAL model. Reliability refers to the consistency and reliability of a product or service in delivering what is promised. Exact satisfaction of users' expectations creates the reliability of the service, which ensures a good name and competitiveness for the company. Customer satisfaction is greatly influenced by reliability as an aspect of service quality.

In order to reduce the environmental damage caused by last-mile logistics and meet these consumer needs, companies are forced to implement new technologies, automate operations, optimize routes and speed up the delivery of parcels to the consumer. Automating operations helps avoid problems with package damage or loss, and today's package delivery consumers expect accurate information about vehicle status, progress, delays, and sometimes even real-time tracking of the vehicle over the last mile. The implementation of secure monitoring systems increases the confidence of users and brings companies closer to the development of sustainable activities.

It is very important that customers are informed about the company's efforts to carry out sustainable activities and contribute to the implementation of the principles of green logistics.

## QUANTITATIVE RESEARCH RESULTS

The first group of questions was aimed at finding out the social situation of the respondents and which segment of consumers mostly uses the services of the parcel transportation sector.

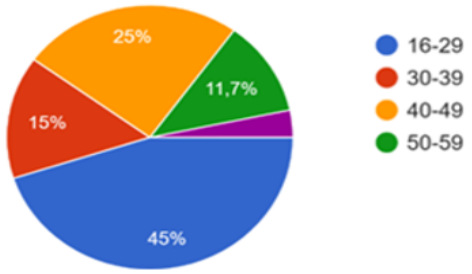



Figure 4. **Age of respondents**

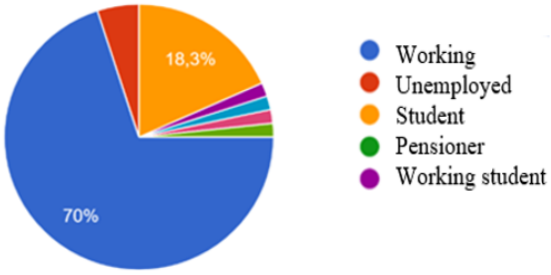



Figure 5. **Social status of the respondents**

In terms of the obtained results, it can be stated that the largest share of the services of the parcel transportation sector are used by working users, 70% of them indicated this. of those interviewed. The presented graph shows that 45 percent respondents are in the 16-29 age group and 25 percent fall in the 40-49 age group. We can say that the group of users of parcel transportation companies consists of young adults and middle-aged users with high employment.

Regarding the assessment of the benefits of applying the principles of green logistics, it is important to analyze the informativeness of the respondents on this topic, therefore, they were asked to answer whether the respondents have heard about the application of the principles of green logistics in the parcel delivery sector.

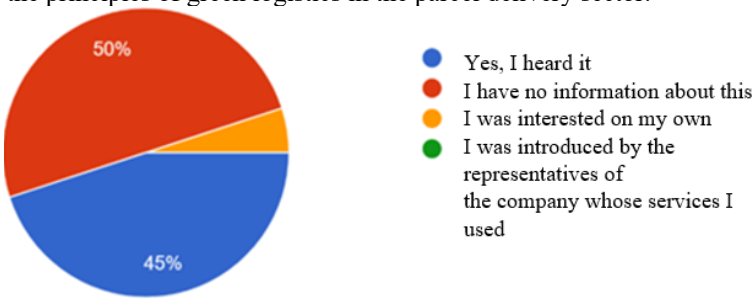



Figure 6. **Informativeness of respondents about the application of green logistics principles**

During the research, the following tendencies of respondents' opinions emerged: 50 percent. of the respondents stated that they do not have information about green logistics and applied principles, 45 percent. only 5% of the respondents said that they heard about it, were interested independently. respondents and none of the respondents were informed by company representatives about the benefits of applying the principles of green logistics.

In the literature analysis, it is described that the costs of the application of the principles and the deterioration of service quality fall on the shoulders of the company, but it is also seen that the companies do not inform the users about their set goals, the difficulties that have arisen, or the benefits of applying the principles of green logistics in the long term.

The second group of questions was aimed at finding out the benefits of green logistics provided by the respondents to the company and the benefits of the applied advanced technologies to the end user.

During the research, the respondents expressed their opinion about the benefits of green logistics principles for companies and 58.3 percent. respondents agree with the reduction of total costs and 41.7 percent. have no opinion or strongly disagree with this statement. 70 percent stated that it contributes to reducing fuel and energy costs, but 30% respondents answered that they had no opinion or completely disagreed with it. Contributing to the reduction of pollution, CO2 marked 73.4 percent. respondents and 56.6 percent. indicated that the application of green logistics principles increases the level of customer loyalty, but 35% respondents still have no opinion.

Also, the respondents were asked to express their opinion about the benefits of the applied advanced technologies for the end user. The conducted research made it possible to determine that 80% respondents agree that smart technologies such as tracking a shipment are useful for the consumer. 75 percent of respondents noted that transaction automation increases value for the end user. 68.4 percent approve the route optimization system. respondents and 61.6 percent confirms the use of non-polluting vehicles and the benefits they generate. We can say that the users of the parcel delivery sector support the implementation of technologies in companies and the benefits they generate.

As it was mentioned above in the article, the implementation of advanced technologies requires large investments and in the short term the quality of services may be disrupted, so the respondents were asked to provide their views on service quality disruptions in the implementation of green logistics principles.

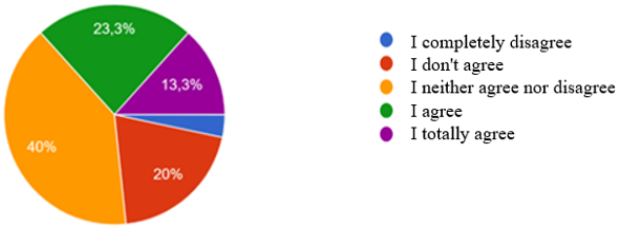



Figure 7. **Extended shipment delivery time**

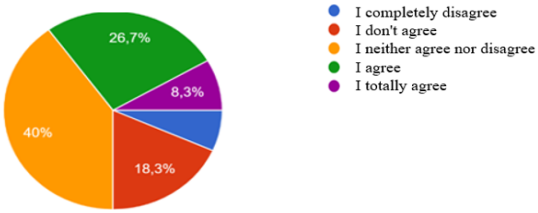



Figure 8. **The place of delivery is changing**

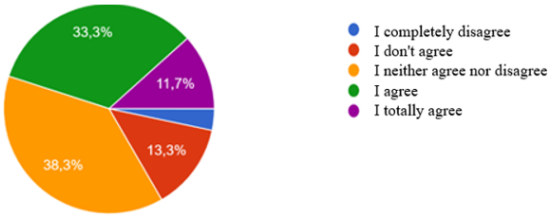



Figure 9. **Delivery time is subject to change**

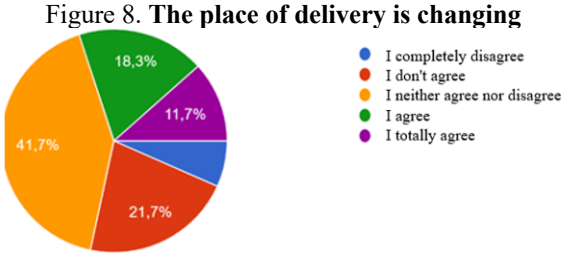



Figure 10. **The price of the service has increased**

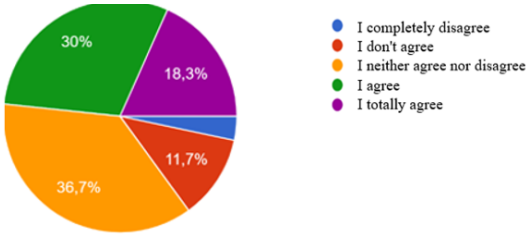



Figure 11. **Pick-up and delivery of parcels is carried out. only at postal machines**

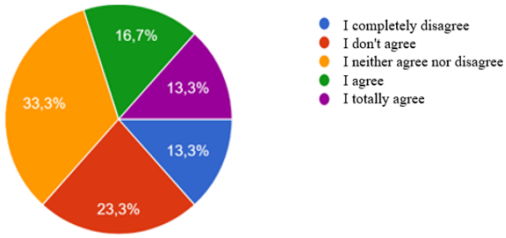



Figure 12. **Cancellation of the free return service**

In terms of the obtained results, it can be stated that 36.6 percent respondents would agree with the extended delivery time of the parcel. 35% would tolerate changing the place of delivery of the package. respondents and 45 percent respondents would agree to change the delivery time. Only 30 percent respondents agree with the increased price of the service. Also, picking up and delivering parcels is done only at post machines, 48.3 percent agree with that. respondents and 30 percent respondents would agree with the cancellation of the free return service. Thus, it can be seen that consumers do not have a positive attitude towards disruptions in the quality of services, even for a short period of time.

It is said that customers can get answers to their questions without human assistance and this is beneficial on the one hand because it saves customers time and on the other hand it allows customers to have a positive and hassle-free experience with the company or brand. In addition, chatbots are increasingly being used to replace customer service personnel, as they can provide constant, always positive interactions and 24/7 support. The relatively low cost of deploying and using chatbots makes them attractive to many businesses. Therefore, respondents were asked for their views on the application of AI for more effective customer service in the parcel delivery sector:

* "Customer service must be performed by a person so that processes run smoothly and efficiently;
* "Will not ensure. Customers prefer real, live interaction to interaction with AI";
* "Artificial intelligence improves customer service, speeds up responses, enables 24/7 availability and personalizes services";
* "I think it will definitely not be ensured. Solving problems requires human input";
* "Currently, artificial intelligence is not developed enough to be convenient and easy to understand for the user. It just annoys users."

When we talk about ecology and the application of the principles of green logistics, it is important to understand that the planet earth is the home of people, so it is important to learn to protect it from pollution and irreversible consequences. In order to achieve these goals, the respondents were asked to give their opinion on whether they would agree to use an information program, with the help of which the resident would have the opportunity to deliver a small parcel to the post machine while on the way, thus contributing to the reduction of traffic flow, pollution, noise and nature preservation for future generations.

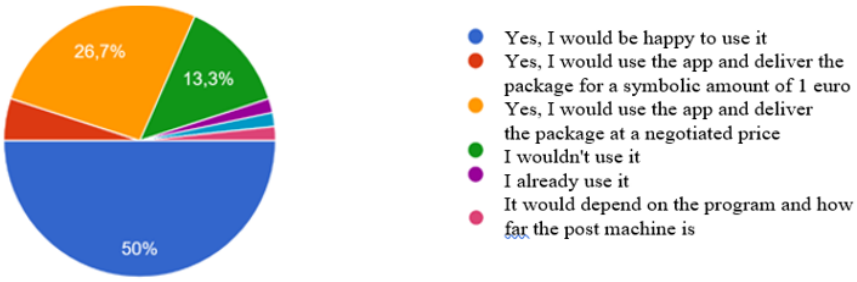



Figure 13. **The use of the small package delivery program, which provides an opportunity for residents to pick up small packages while on the way**

The conducted research made it possible to determine that 50% respondents would be happy to use such a program. 26.7 percent indicated, "yes, I would use and deliver the shipment at the agreed price"; 13.3 percent said they would not use it. and 10 percent of the respondents indicated that it depends on the convenience of the program and how efficiently the post machines are arranged.

After summarizing the research results, it is possible to formulate the conclusion that the respondents are not satisfied with the integration of artificial intelligence in the customer service process and the added value it creates. Also, consumers are not positive about service quality disruptions and increased prices. Thus, it would be worth paying more attention to improving the development of the transport system and involving the public in the process of implementing and disseminating the principles of green logistics, in order to achieve the common goal of preserving nature.

## CONCLUSIONS

1. The principles of green logistics are based on the triple principle, according to which the environmental, social and economic impact of logistics activities is taken into account, so the benefits accrue to the company, its suppliers and partners, customers and every member of society. Green logistics strategies improve operational efficiency, profitability, increase the company's competitiveness, reliability, help meet the growing needs of customers and reduce the carbon footprint.
2. In this period, logistics is increasingly invisible to the customer, which makes it difficult for companies to apply the principles of green logistics. According to the results of the conducted research, consumers do not look favorably on service quality disturbances due to the application of the principles. Only 36.6 percent agree to wait longer for the shipment. respondents, as well as only 30 percent. would agree to pay a higher price for the delivery of the package. It was also determined that consumers would not agree to refuse the free return service, even 69.9 percent indicated this. respondents. However, consumers would be happy to contribute to sustainable activities in other ways, such as carrying a small package while en route. It can be said that this system would be very useful in Lithuanian villages and small towns, where parcel delivery is not efficient. Also, the majority of respondents would refuse the service of home delivery of small parcels, which would help reduce vehicle traffic, pollution, and noise, especially in the big cities of Lithuania.

## REFERENCES

Akbar A. ir Wadud M. (2024). The Effect Of Speed And Reliability Of Service On Customer Satisfaction Mediated By Employee Performance In Using Agency Services At PT Bukit Prima Bahari. file:///C:/Users/Hp/Downloads/4974-Article%20Text-26014-2-10-20240504.pdf

Bosona T. (2020). Urban Freight Last Mile Logistics—Challenges and Opportunities to Improve Sustainability: A Literature Review.https://www.mdpi.com/2071-1050/12/21/8769

Elnasras A., Sobaihas E. ir Saifas A. (2023). Effects of Parcel Delivery Service on Customer Satisfaction in the Saudi Arabian Logistics Industry: Does the National Culture Make a Difference? https://www.mdpi.com/2305-6290/7/4/94

Isaksson K. ir Huge-Brodin M. (2013). Understanding efficiencies behind logistics service providers' green offerings. https://www.emerald.com/insight/content/doi/10.1108/01409171311306382/full/html

Tang R.,Tan Y.,Tan Z., Almawad M., Alosaimi A. (2022). A Study of Courier Service Quality and Customer Satisfaction. https://www.researchgate.net/publication/366151804_A_Study_of_Courier_Service_Quality_and_Customer_Satisfaction

Maymakova L., (2023). Environmental problems and ways to solve them in the development of transport and logistics services. http://rppe.ru/new/index.php/rppe/article/view/2122

Wehner J., Taghavi N., Deilami N., Altuntas C., Halldórsson A. (2021).Logistics service providers' energy efficiency initiatives for environmental sustainability. https://www.emerald.com/insight/content/doi/10.1108/IJLM-10-2019-0270/full/html

Oficialios statistikos portalas (2023). https://osp.stat.gov.lt/skaitmenine-ekonomika-ir-visuomene-lietuvoje-2023/e-komercija/e-prekyba-imonese

Oficialios statistikos portalas (2023). https://osp.stat.gov.lt/lietuvos-regionai-2023/aplinka/transportas#kroviniai

Silva V., Amaral A., ir Fontes T. (2023). Sustainable Urban Last-Mile Logistics: A Systematic Literature Review. https://www.mdpi.com/2071-1050/15/3/2285

Zygiaris S., Hameedas Z., Alsubaie M., Rehman S. (2021). Service Quality and Customer Satisfaction in the Post Pandemic World: A Study of Saudi Auto Care Industry.https://www.frontiersin.org/journals/psychology/articles/10.3389/fpsyg.2022.842141/full

PANEVĖŽIO KOLEGIJA ISSN 2029-1280, eISSN 2669-0071. Taikomieji tyrimai studijose ir praktikoje – Applied Research in Studies and Practice, 2024, 20.

# THE ASSESSMENT OF BALTIC STOCK MARKET FROM PERSPECTIVE OF DIVIDEND YIELD AND TOTAL SHAREHOLDER RETURN RATIOS

***Česlovas BARTKUS***

*Panevėžio kolegija / State Higher Education Institution,*

**Abstract.** Despite the integration of the Lithuanian, Latvian, and Estonian stock markets into the NASDAQ OMX Baltic exchange, the region continues to attract limited investment compared to its Nordic counterparts. This paper examines the growth and performance of the Baltic and Nordic stock markets from 2012 to 2024, focusing on Total Shareholder Return (TSR) and Dividend Yield (DY) as indicators of portfolio value. The findings show that long-term TSR is positive across all countries, with Scandinavian markets, particularly Denmark, outperforming the Baltics significantly. Denmark leads with an impressive TSR of 539% over the 12-year period, while Estonia, with only a 67.2% TSR, recorded the weakest performance. The study also highlights the positive recovery of markets following the downturn in 2022, driven by the impact of Russia's invasion of Ukraine. Short-term TSR and DY ratios indicate that Finland (9.5%) and Lithuania (5.2%) offered dividend yields surpassing the European Union's average annual inflation rate of 3.4%, positioning dividends as a hedge against inflation for investors. These results underline the importance of the Nordic markets for capital growth, while also offering insights into the Baltic market's potential for long-term wealth preservation.

**Keywords**: stock market, NASDAQ OMX Baltic, NASDAQ OMX Nordic, Total Shareholder Return, Dividend Yield

## INTRODUCTION

This article tries to compare the Baltic stock market to Scandinavian market which are close geographically but different historically. Mostly, the Lithuanian stock market is analyzed together with Latvian and Estonian stock markets as a part of joint Baltic stock market. Main reason of this is that all three Baltic countries belong to NASDAQ OMX Baltic market. The joint market was introduced in order to increase the trading volumes and market liquidity. Together the stock markets of three Baltic countries reflected in OMX Baltic Benchmark GI index. Separately, Lithuania stock market belongs to OMX Vilnius index, Latvia to OMX Riga and Estonia to OMX Tallinn. Worth mentioning, due to occupation of the Soviet Union, Baltic countries didn't develop stock markets and now they are in a chasing position compared to more developed stock markets. Studies from different periods explain the path Baltic stock markets managed to make. D. Klimasauskiene and V. Moscinskiene (1998) indentified that Lithuanian stock market shows weak form of efficiency. It was confirmed after 4 years by V. Kvedaras and O. Basdevant (2002) in investigation of all three Baltic stock markets. Lithuania and Estonia had weak form of efficiency. Meanwhile, Latvia had strong inefficiency in their stock market. But later, K. Kiete and G. Uloza (2005) found first sights of efficiency in Lithuania stock market after they measured daily trade data from 2001 till 2004. Meanwhile, Latvian stock market suggested a semi strong inefficiency. Authors have noticed that both countries markets reacted inefficiently on announcements of earnings, i.e. this phenomena was recognized as overreaction. In one of latest studies V. Aleknevičienė et al. (2018) concluded that Estonian stock market was the most efficient and Latvian – the least efficient. The reason for this is low liquidity. V. Deltuvaitė (2015) confirmed it with her study. The author concluded that global integration in the Baltic stock market is very low. Latvian stock market is more isolated at the global level than Lithuania and Estonia. The drivers of such trends were discovered by A. M. Pece (2015) from behavioral finance's point of view. In the case of Lithuania, there is no evidence of herding, which may be explained by the existence of an adequate quality of information on the market. In the case of Latvia, there are evidence of existence of less experienced investors that will adopt "follower strategies". The results in Estonia provide evidence of herding in the case of medium companies.

On the one hand, low liquidity shows small interest from worldwide investors. On the other hand, worldwide events affect the Baltic stock market. R. Rudzkis and R. Valkaviciene (2014) revealed that global stock exchange indicators have a significant impact on the Baltic stock market. EUR/USD exchange rate, money supply, the price of gold and oil influence the price of companies in Baltic countries. D. Pilinkus (2010), P. Dubinskas and S. Stunguriene (2010) researched correlations between Baltic stock and macroeconomic indexes: GDP; inflation rate; unemployment rate; state debt; export and import. The relationship between these indexes and the Baltic market index is very high in the longtime period. A. Pilvere-Javorsa et al. (2018) confirmed the shrinking of the market analyzed. They estimated the number of companies listed on Baltic stock market during period of 2008 – 2018. Only Estonia showed positive increase. Lithuania and Latvia showed a significant decrease. The positive thing, in terms of market capitalization, Lithuanian and Estonian companies showed substantial growth. While Latvia stock market's capitalization shrunk at twice. Estonian stock market, as a best in Baltic, was recognized in V. Vaišvilas et al. (2017) work where authors adapted MULTIMOORA method to collect best companies from Baltic stock market in 2016. Estonian companies were dominant on this list, while Lithuania was right behind and Latvia – the last.

Study of J. Nikkinen (2012) found Baltic and Nordic (Finland, Sweden and Denmark) stock exchanges have moved towards a harmonization of procedures and common ownership. While the results of this study demonstrate that the Baltic stock markets were apparently segmented before the crisis, they were highly integrated during the crisis. A. Struckas (2020) says that stock markets of these countries have similar cycles of fluctuations in the period from 2000 till 2020. Behavioral aspects were disclosed in paper of J. Grikietytė-Čebatavičienė (2016) where author has noticed sights of crowd effect behavior in both Baltic and Scandinavian stock markets. By cultural aspects the closest to Baltics is Finland. K. Harkmann (2020) identified long-run equilibrium relationship between Baltic and Swedish markets. Author‘s research discovered that the Baltic States are exposed to shocks from Sweden and the shifts in the Swedish market will bring adjustment in the Baltic stock market also. But Scandinavian and Baltic stock markets have very big differences: Baltic states started their operations only after the fall of Soviet Union. Meanwhile, Copenhagen Securities Exchange (Denmark) started its trading in year 1808 and Stockholm Securities Exchange (Sweden) in year 1863. The evidence of difference was found by A. Pilvere-Javorska and I. Pilvere (2020) within conclusion that Baltic States stock market listed companies might be undervalued or improperly valued by the market when compared to the Nordic countries stock market listed companies.

The goal of this paper is estimation of value of the Baltic stock market together with the comparison with Scandinavian stocks. The objectives to reach this goal are:

1. To determine Dividend Yield and Total Shareholder Return of Baltic and Scandinavian stock markets.
2. To compare Baltic and Scandinavian stock markets.

The article aims to analyze the growth and performance of the Baltic and Nordic stock markets between 2012 and 2024, using Total Shareholder Return (TSR) and Dividend Yield (DY) as key indicators to assess portfolio value. The study specifically examines how these markets, especially in the context of the Baltic states (Lithuania, Latvia, Estonia) and Nordic countries (Denmark, Finland, Sweden), performed in terms of long-term capital growth and short-term returns, with a particular focus on the effects of geopolitical events, such as the Russian invasion of Ukraine in 2022.

## METHODS OF RESEARCH

As the paper’s goal is to estimate the value of Baltic and Scandinavian stock markets, here was used Total Shareholder Return (TSR) formula. M. Čupič and M. Todorovic (2011), J. Lafont et al. (2020) describe the classical formula of TSR:

$$TSR = \frac{P\ final - P\ initial}{P\ initial} + \frac{DIV}{P\ initial} \quad (1)$$

Where, TSR – Total Shareholder Return;
P final – final stock price.
P initial – initial stock price.
DIV – dividend.

The article assumes that the period under observation lasts from 2012 till 2024 and lasts 12 years. Usually, TSR is being used to calculate each company separately. To get the data of all markets instead of one company, four models of TSR were calculated. The basis of the first two ratios were the share as the subject of investment and our calculations, i.e. one share of each company was added to the observed portfolio. The basis of the next two TSR ratios was the idea of investing 1 euro in each company. This point of view could show us a more realistic picture of the market observed. So, this article observes short-term and long term TSR from the point of view of TSR per share. And short-term and long term TSR from point of view of TSR per 1 euro.

The data of final stock price (P final) contains stock prices of each company on its ex-dividend day in 2024. In case, company has decided to not pay dividends, the final stock price contains prices of each company on its annual announcement day in 2024. All price data were obtained from NASDAQ OMX Baltic and NASDAQ OMX Nordic official websites.

The data of initial stock price (P initial) contains stock prices of each company on its ex-dividend day in 2023 for one-year TSR calculations and its ex-dividend day in 2012 for ten-year TSR calculations. All price data were obtained from NASDAQ OMX Baltic and NASDAQ OMX Nordic official websites.

The data about dividends (DIV) contains paid dividends to shareholders through observed period and were taken from official annual announcements of analyzed companies.

Another goal is to estimate Dividend Yield ratios for the same markets by formula described by A. Henne (2007):

$$DY = \frac{DIV}{P\ initial} \quad (2)$$

Where, DY – Dividend Yield.
P initial – initial stock price.
DIV – dividend.

The companies which got into our observation list are the biggest ones in Lithuania (13 companies), Latvia (3), Estonia (18), Finland (39), Sweden (156) and Denmark (46). The biggest Baltic companies were taken from Main

List of NASDAQ OMX Baltic market. The biggest Scandinavian companies were taken from Large Cap List of NASDAQ OMX Nordic market. Worth mentioning, Large Cap List companies have share values of over 1 billion euro. Meanwhile, Main List companies have a share value over 4 million euro only. Even this regulation could show us a big difference between these markets.

Dividend Yield ratio is an essential metric for evaluating investment opportunities, especially for those seeking income, protection against inflation, and long-term portfolio growth. It provides valuable insights into a company's financial health, stability, and ability to generate reliable returns for shareholders.

## THE RESULTS

During the observed period from 2012 till 2024 few global crises affected financial markets. Firstly, COVID-19 impact on financial markets should be mentioned. Early study of N. Sansa (2020) found significant positive relationship between COVID-19 confirmed cases and US, China financial markets. In case of Lithuania stock market, OMX Vilnius index fell more than 20% in first weeks of COVID-19 crisis. Secondly, the war started by Russia in February of 2022 negatively affected stock prices in all European finance markets.

This paper discusses two ratios and two periods, for reaching the main aim. Both ratios represent a possible return on portfolios made from a group of stocks. The analyzed periods are two: short term and long term. Short term contains data from 1 year from 2023 till 2024. Long term observes last 12 years from 2012 till 2024. Total Shareholders Return (TSR) and Dividend Yield (DY) ratios calculated by balanced 1 euros investment point of view. For example, each of 13 Lithuanian companies has 1/13 part in this ratio and each of Sweden 156 companies has 1/156 part in this ratio. In other words, ratios show how 1€ invested in stock market could change its value during some periods. Both ratios during the period from 2023 till 2024 are presented in Figure 1.

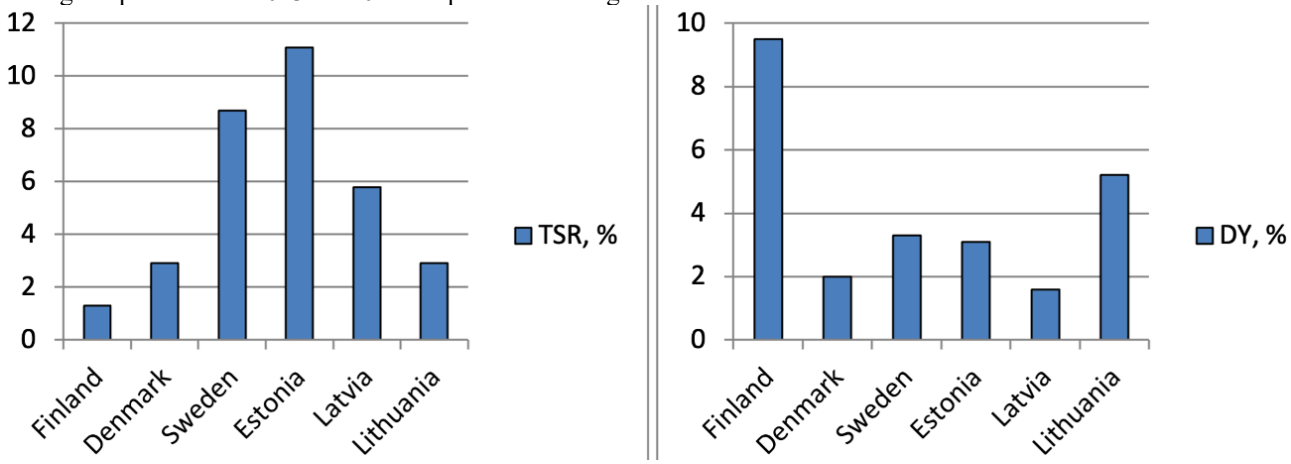



Figure 1. **TSR and DY during the period from 2023 till 2024**

Firstly, in the year 2022 (C. Bartkus, 2022) we noticed the signs of inefficiency of Baltic states stock market. That TSR was estimated after invasion in Ukraine and we had negative return for shareholder in Finland, Iceland, Denmark and Sweden. Meanwhile, results in Lithuania, Estonia and Latvia were positive. In the year 2024 financial markets around the Baltic Sea get used to the situation in the East and the year was positive for shareholders. As we see in Figure 1, the biggest annual changes in stock prices happened in Estonia (11.8%), Sweden (8.7%) and Latvia (5.8%). The biggest annual return from dividends calculated in Finland (9.5%) and Lithuania (5.2%). Two years ago, in the case of Sweden, we could assume that lost Russian market negatively affected Swedish giants as Volvo, Tele2 and etc. At year 2024 such companies as Volvo and Tele2 restored the shareholders trust with personal TSR of 5.6% and 7.8% accordingly.

One-year TSR and DY ratios (Figure 1) let us estimate sudden trends on stock markets affected by global shocks. However, individual or institutional investors are orientated to long-term investment much more. Even the above-mentioned research took the time horizon within 10 or more years. Therefore, the twelve-year ratios (Figure 2) open a more realistic view on Baltic and Nordic stock markets. Figure 2 specifies TSR ratio from 2012 ex-dividend day as initial price till 2024 ex-dividend day as final stock price. The observed period contains eight years of global rising trend and two years of global crisis. There is research, such as N. Sansa (2020) and C. Bartkus (2020), which confirmed the negative impact of COVID-19 crisis on financial markets. For example, in 2020 more than a half (8 from 14) of Lithuanian companies decided to do not pay dividends which are the part of TSR formula.

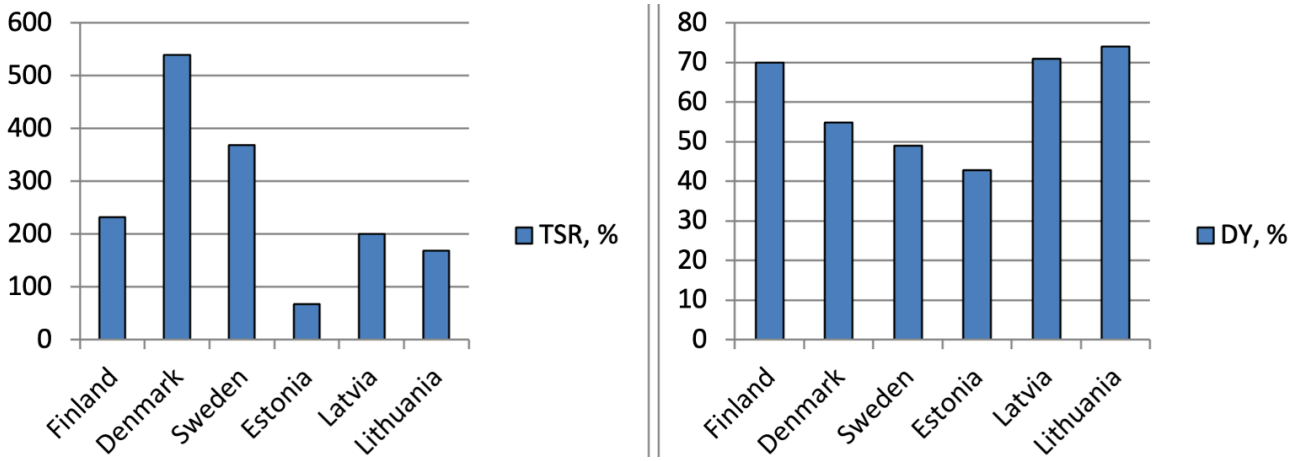



Figure 2. **TSR and DY during the period from 2012 till 2024**

In analysis of Figure 2, we can see the difference between returns for shareholders who have Scandinavian and Baltic companies in their portfolio. Especially, Denmark (539%) and Sweden (369%) are stand out with two or three times better TSR results if we compare them with the Baltic states. Probably, the Scandinavian financial market is still more attractive because of its longer financial history, bigger capitalization and stronger companies. Meanwhile, Dividend Yield per invested euro in each company shows Baltic markets as dividend attractive place to invest. There are no significant differences in times as we notice in TSR calculation. In case we ignore Latvia with only 3 representatives in Main List of Baltic market, we have Lithuania and Finland with highest Dividend Yield around 70%.

In future, such data from Baltic and Nordic stock markets should be compared with other European or Global stock markets. Also, the correlation between Total Shareholders Return and market capitalization should be explored to find reasons why return in Scandinavian market significantly better than Baltic one in long-term period. The introduction part of this article has revealed the leadership of Estonia in Baltic states stock market.

## CONCLUSIONS

1. Investing in Baltic and Nordic stock markets can protect wealth for investors from inflation and even ensure the growth of capital value in long-time period. Despite long-term ratios of return are positive in absolutely all observed countries, Scandinavian market TSR ratios are several times better than Baltic. The leader is Denmark with companies which gained 539% of TSR during period 2012-2024. In the same period Estonian companies gained 67.2% of TSR and it was the worst result.
2. Short-term TSR and DY ratios revealed positive impact in the securities markets following negative 2022 which were affected by Russia's invasion in Ukraine. If we consider dividends as "life jacket" to fight inflation, only Dividend Yield of Finland (9.5%) and Lithuania (5.2%) was over European Union annual inflation rate of 3.4%.

## REFERENCES

Alekneviciene, V., Kviedaratiene, L., Alekneviciute, E. (2018). Semi-Strong Form Efficiency in the Baltic Stock Markets under Changing Economic Situation. Engineering Economics, 29 (5), 495-506.

Bartkus, C. (2022). The Assessment Of Baltic Stock Market From Perspective Of Total Shareholder Return Ratio. Applied Research of Studies and Practice. 2022, 18.

Basdevant, O. & Kvedaras, V. (2002). Testing the Efficiency of Emerging Markets: the Case of the Baltic States. Working Papper of EestiPank, 9.

Čupič, M., Todorovic, M. (2011). Total Shareholder Return – decomposition, internal equivalent and alternatives. Problems of Competitiveness of Contemporary Economies, October 14, 2011.

Deltuvaite, V. (2015). An Empirical Investigation of the Baltic Stock Markets Global Integration. Procedia – Social and Behavioral Sciences, 213, 430-435.

Dubinskas, P. & Stunguriene, S. (2010). Alteration in the Financial Markets of the Baltic Countries and Russia in the Period of Economic Downturn. Technological and Economic Development of Economy, 16 (3), 502-515.

Grikietytė-Čebatavičienė, J. (2016). Kultūros psichologijos svarba minios efekto pasireiškimui Baltijos ir Skandinavijos šalių akcijų rinkose. Kauno technologijos universitetas.

Harkmann, K. (2020). Integration of the Baltic stock markets with developed European markets. Wiley, June, 2020.

Henne, A., Ostrowski, S., Reichling, P. (2007). Dividend Yield and Stability versus Performance at the Germany Stock Market. FEMM working paper No.17, July, 1-27.

Kiete, K. & Uloza, G. (2005). The Information Efficiency of Stock Exchanges in Lithuania and Latvia. Stockholm School of Economics in Riga, March 18.

Klimasauskiene, D. & Moscinskiene, V. (1998). Lietuvos kapitalo rinkos efektyvumo problema. Pinigų Studijos, 2, 25-34.

Nikkinen, J., Piljak, V., Aijo, J. (2012). Baltic Stock Markets and the Financial Crisis of 2008–2009. Research in International Business and Finance, 26 (3), 398-409.

Pece, A. (2015). The Gregarious Behavior Of Investors From Baltic Stock Markets. Annals of Faculty of Economics, University of Oradea, 1 (1), 905-911.

Pilinkus, D. (2010). Macroeconomic Indicators and Their Impact on Stock Market Performance in the Short and Long Runs: the Case of the Baltic States. Technological and Economic Development of Economy, 16 (2), 291-304.

Pilvere-Javorska, A., Pilvere, I., Rivza, B. (2018). Comparative Analysis of Post-Recession Stock Market Performance in the Baltic States. Science and Studies of Accounting and Finance: Problems and Perspectives, 12 (1), 37-46.

Pilvere-Javorska, A., Pilvere, I. (2020). European Nordic Countries Stock Market Listed Companies': Factor and Cluster Analysis Approach. Emerging Science Journal, 4 (6), 443-453.

Pynnonen, S., Knif, J. (1998). Common long-term and short-term price memory in two Scandinavian stock markets. Applied Financial Economics, 1998, 8, p. 257-265.

Rudzkis, R. &Valkaviciene, R. (2014). Econometric Models of the Impact of Macroeconomic Processes on the Stock Market in the Baltic Countries. Technological and Economic Development of Economy, 20 (4), 783-800.

Sansa, N. (2020). The Impact of Covid-19 on the Financial Markets: Evidence from China and USA. Electronic Research Journal of Social Sciences and Humanities, Vol. 2, Issue II.

Struckas, A. (2020). Sąsajų tarp ekonomikos ir akcijų rinkų ciklinių svyravimų Baltijos ir Skandinavijos šalyse tyrimas. Kauno technologijų universitetas.

Vaišvilas, V., Martinkute-Kauliene, R. (2017). Investment Portfolio Formation Using Multi-Criteria Evaluation Method Multimoora. Science – Future of Lithuania, 9 (2), 209-219.

PANEVĖŽIO KOLEGIJA ISSN 2029-1280, eISSN 2669-0071. Taikomieji tyrimai studijose ir praktikoje – Applied Research in Studies and Practice, 2024, 20.

# THE IMPACT OF THE CHOICE OF ASSET VALUATION TECHNIQUES ON THE VALUATION OF AGRICULTURAL ENTITIES: A CASE STUDY

***Lina PALIULIENĖ, Indrė KNYVIENĖ***

*Kauno kolegija / Higher Education Institution, Lithuania*

**Abstract**. Research aim is to analyse the impact of the choice of asset valuation methods on the financial performance of agricultural entities. Research problem: different methods can be used to value the assets of an agricultural entity in its financial statements. The choice of valuation method affects not only the accounting for all transactions relating to the use of assets, but also the financial position of the enterprise and its current and future performance. Therefore, there is a need to determine which valuation methodology reflects a more realistic representation of the financial position of the agricultural entity and provides users with true and fair information. In order to analyse the impact of asset valuation techniques on the financial performance of the enterprise, a simulation model was developed based on the data AC X. It was found that the valuation of fixed assets at revalued amount and of biological assets at fair value less point-of-sale costs has a significant impact on the financial performance of AC X. The application of fair value based methods results in an increase in the value of total assets, equity and liabilities on the company's balance sheet, and also increases the company's profits, which in turn leads to an increase in the profitability of sales. The return on assets and return on equity decrease. Indebtedness ratios are also reduced, making the company more attractive to creditors.

**Keywords**: asset valuation, historic cost, fair value, financial results

## INTRODUCTION

The actual financial position of an entity is critical to the correct decision-making of external and internal users of information and is linked to the presentation of true and fair information in the financial statements. To present true and fair information in the financial statements, it is important to make the appropriate choices and apply the required methods of measuring financial items, both in recording items at initial recognition and in preparing the financial statements. One of the elements of financial statements is assets. The consequences of an inaccurate valuation of an asset may be felt for several periods. The structure of the balance sheet, the income statement, the amount of depreciation expense and tax calculations will all depend on the valuation of assets. Therefore, the valuation of assets in corporate accounting needs to be given considerable attention.

**Research problem:** different methods can be used to value the assets of an agricultural entity in its financial statements. The choice of valuation method affects not only the accounting for all transactions related to the use of assets, but also the financial position of the enterprise and the current and future performance of the enterprise. Therefore, there is a need to determine which valuation methodology reflects a more realistic view of the financial position of the agricultural entity and provides users with true and fair information.

**The object of the study** is valuation methods.

**Research aim:** to analyse the impact of the choice of asset valuation methods on the financial performance of agricultural entities.

**Study objectives:**

1. Identify the advantages and disadvantages of the cost and fair value methods of valuing assets.
2. To determine the impact of cost and fair value measurement techniques on the financial position and performance of AC X.

**Research methods:** analysis of scientific literature, comparison, case study.

## THE ADVANTAGES AND DISADVANTAGES OF COST AND FAIR VALUE MEASUREMENT TECHNIQUES

Valuation is commonly understood in accounting as the process of determining the value at which items in the financial statements are presented in the financial statements. The laws on corporate financial reporting in the Republic of Lithuania outline the rules for the valuation of corporate assets. These laws require companies to value assets in their financial statements in accordance with generally accepted accounting principles and business accounting standards. Since 2007, Lithuanian companies can choose between International Accounting Standards (IAS) and Business Accounting Standards (BAS), except for listed companies, which have to prepare their financial statements in accordance with IAS. Both IAS and IAS provide a number of main options for the valuation of assets: historical cost and fair value.

According to Bužinskienė, Montrimiene (2023), (IAS 12, 2016), Arjunan (2022), Barker et al. (2022), Modria et al. (2022), the most common method of valuing assets in practice is the acquisition cost method. According to the Accounting Standards for Business Enterprises (IAS 12, 2016), and Bužinskienė, Montrimienė (2023), Rudžionienė, Lukošiūnaitė (2020) „*cost is the amount of cash or cash equivalents paid or payable, or the value of other assets given*

*or consumed in exchange, at the time of the asset's acquisition or construction*". Bužinskienė, Montrimienė (2023), Arjunan (2022), Barker et al. (2022), Modria et al. (2022), Rudžionienė, Lukošiūnaitė (2020), Candra et al. (2022), Li et al. (2024), Jang, Yehuda (2021) argue that the main purpose of this approach is to correctly value the asset by attributing to the value of the asset the full amount of the principal costs of acquiring and producing it. Kalčinskas, Kalčinskaitė-Klimaitienė (2017) state that „the basis for the valuation of tangible fixed assets should always be the actual cost of acquisition (in other words, the 'cost to oneself'), which is also referred to as the acquisition (production) value". However, it should be noted that, although the cost method is simple, widely used and labour-intensive, it does not always reflect the true value of an asset. Table 1 highlights the advantages and disadvantages of valuing assets at cost.

Table 1

**Advantages and disadvantages of the cost method** (compiled by the authors from Bužinskienė, Montrimienė (2023)

| **Benefits** | **Disadvantages** |
|---|---|
| Cost is easy to calculate. A simpler and more stable way | The fair value of assets, which changes over time as the business situation changes, is not reflected, resulting in a misstatement of the entity's financial results |
| An entity can reliably measure cost because the acquisition of an asset is evidenced by the relevant purchase or exchange transactions, which are the basis for measuring it. | |
| No additional cost, as the company's specialists can determine this value themselves from the acquisition documents | Making it harder to compare assets |

To summarise the data in Table 1, the cost method, although simple and labour-intensive, does not always reflect the true value of an asset. And it is very important for company managers to know not only how much it cost to acquire an asset, but how much it is worth now. Therefore, over time, it has become apparent that it is no longer sufficient to use double entry accounting, recording all transactions and events at cost, but that other methods must be used to give a true and fair view of the financial position and performance of the company and its cash flows. This becomes particularly important when everything around you is changing: resource prices, wage rates, interest rates, real estate and other commodity prices. The analysis of the academic literature shows that an increasing number of authors refer to the fair value approach in their articles. According to Rudžionienė and Lukošiūnaitė (2020) fair value accounting is based on market equilibrium with a perfect competitive environment. This theoretical ideal consists of the same expectations of all market participants, the availability of all commodities, the absence of transaction costs and taxes, and the same interest rates for money invested and borrowed in capital markets. Under these conditions, the fair value of an asset is its objective market value, and it is then easy to determine the fair value of an asset because it is simply the market price, which is independent of the individual conditions in a given company. However, such ideal conditions do not exist in reality - firms operate in markets that are not perfect and where neither market equilibrium nor objective market value exist. Therefore, it is argued that the determination of the fair value of an asset is quite complex and that fair value can only be defined as an approximation rather than a specific value. However, it should also be noted that the initial valuation of assets also distorts the true financial position and performance of an entity as prices change. Thus, the academic literature has shown a debate about which valuation method a company should choose to value its assets, and whether historical prices are better than certain varieties of present value.

According to Rudžionienė and Lukošiūnaitė (2020) „the choice of asset valuation method is particularly relevant for the valuation of long-lived assets, as valuation at historical cost usually leads to impairment of the asset's value, thereby reducing the availability of long-term credit. Valuing short-term assets at cost can lead to a reduction in costs and an increase in taxable profits". According to DeFond et al. (2020), the future financial reporting framework should include only fair value-based information, which will make the financial statements more informative and transparent.

Table 2

**Advantages and disadvantages of fair value measurement** (compiled by the authors based on Rudžionienė, Lukošiūnaitė (2020), Ahn et al. (2020), DeFond et al. (2020)

| **Benefits** | **Disadvantages** |
|---|---|
| Allows for an objective assessment of cash flows | Difficult to assess in the absence of active market share |
| Shows how efficiently assets are used | Indicates the notional value, which may nevertheless differ from the transaction price |
| Makes it easier to compare the value of assets, making it easier to assess and analyse | Requires additional costs and good professionals |
| Financial reporting reflects a more realistic view of the company's financial position | Because it is new and rarely used in practice, there is a lack of specialists and methodological information. There is no specific guidance in the Financial Accounting Regulations on how to reliably determine this value. |

Thus, according to all the authors who have analysed asset pricing issues, companies that use only historical prices in their accounting records are presenting in their financial statements a state of affairs and performance that is out

of line with market conditions rather than the true state of affairs. Therefore, in the opinion of the author of the study, today's management needs require timely information on the financial position of the company, which would nevertheless be better reflected by the use of current values. In the author's view, fair value can be defined as the amount for which assets or services can be exchanged. The fair value of an asset can be measured reliably if fluctuations in its fair value are insignificant or if the likelihood of the results of different valuations varying can be accurately determined or estimated.

Table 2 highlights the main advantages and disadvantages of the fair value option.

The analysis of cost and fair value approaches shows that there are advantages and disadvantages to both approaches, making it difficult for managers to decide which approach to use when valuing assets. An analysis of articles by various authors in this decade and the last decade on cost-based and fair value-based methods of valuing assets shows that almost all of the authors are of the same opinion, recommending that companies should choose the fair value method of valuing assets. According to Rudžionienė, Lukošiūnaitė (2020), Ahn J. et al. (2020), DeFond et al. (2020), Fukui et al. (2022) and other authors, the fair value approach is more promising as it allows for a more realistic value of assets and more reliable performance and financial indicators. It also simplifies accounting by eliminating the need to calculate the cost of all types of production. According to the authors, the fair value of assets reported in the balance sheet is consistent with the real value of the assets at the reporting date, and the fair value of assets is consistent with the accounting prudence principle and provides valuable feedback to users.

According to Rudžionienė and Lukošiūnaitė (2020), in order to increase the reliability of accounting and reporting data, it is necessary to abandon the tradition of valuing only at acquisition cost, as such valuation is in many cases biased. In his view, the fair value method should be used to value assets. The author also recommends this method for agricultural holdings with biological assets, as the fair value method provides a more reliable and realistic valuation of assets.Foreign authors also support the view that assets should be measured at fair value. Sharma et al. (2024) argue that applying the fair value approach internationally would increase the comparability of corporate financial information. DeFond et.al. (2020), Alharasis et al. (2022), Mahieux (2022) argue that fair value measurement is important for the decisions of creditors, investors as it reflects a company's true financial position. The cost method also influences decision-making as long as the carrying amount is reasonably consistent with fair value. When cost deviates from fair value, the influence of cost-based decision making decreases. According to Fukui, Saito (2022), the world needs to phase out the historical cost approach and adopt the fair value approach. According to him, fair value accounting provides more information for management functions. According to Blecher (2019), companies adopting the fair value measurement approach will generate greater social welfare, and a financial statement based on fair value is more useful in assessing the performance of the company in calculating financial ratios.

However, there are other opinions. Kalčinskas, Kalčinskaitė-Klimaitienė (2017) consider that the historical cost method is flawed because it focuses on the past, but reflects the costs actually spent to acquire the asset. The author argues that fair value does not indicate anything because it focuses on the real price of the asset, which can only be the case in one instance: at the time of sale-purchase. Cahyani, Firmansyah (2023), Nguven, Tran (2023) are also not very positive about the fair value method of valuation. They consider that fair value measurement is less objective and verifiable, and that the size of the entity affects the relevance and reliability of the fair value effect in financial statements. Alharasis et.al. (2022) argue that fair value measurement is more like a forecast than a reality. Zhang et al. (2020) also doubt that fair value measurement of assets provides any benefit. Blecher (2019) argues that the choice of valuation method depends on a variety of factors that influence the use of one or the other method. As companies can choose which valuation method to use, this author believes that the choice of valuation method may be influenced by factors such as the size of the company, the composition and durability of the assets held, the tax system of the country, etc.

In summary, one of the most pressing issues in corporate accounting is the choice of how to value assets, because the valuation of assets determines the reliability of information about the assets and financial position of an entity. IAS and IAS prescribe that assets should be measured at historical cost or fair value. Both methods have advantages and disadvantages, making it difficult for managers to decide which method is appropriate. The literature review shows that many authors favour the fair value approach and suggest it for companies that have a large number of fixed assets with a long useful life and a high degree of market volatility. They consider that the fair value of assets provides a more accurate assessment of financial ratios, such as the liquidity of the company and the profitability of assets. This information is particularly relevant for capital formation, bank borrowing and other purposes. For small, young companies that have no plans to borrow, are saving money and do not want to incur additional costs, the authors suggest that the cost approach should be used, as the costs of accounting for assets at fair value may exceed the benefits, thus violating the requirement of optimality. After analysing the advantages and disadvantages of valuation methods, the author proposes that companies should value assets at fair value. Although more complex and labour-intensive, this method provides a more accurate reflection of the company's financial position and performance, and more accurate financial ratios, which are essential for true and fair information.

## THE IMPACT OF ASSET VALUATION TECHNIQUES ON THE FINANCIAL PERFORMANCE OF AC X

Calculations have been carried out to justify that the use of fair value provides a more reliable and realistic financial valuation of the company. The author has selected the data from the financial statements of the agricultural

company X for the calculations. The calculations were based on the company's balance sheet, profit and loss account, accounting policies and information provided by the company's accountant. AC X was established in 2015 and its main activity is crop farming: cultivation of cereals (wheat, barley), storage and marketing of cereals. The company has 400 ha of cultivated land. The assets of AC X comprise fixed assets, biological assets and current assets. Fixed assets consist of tangible assets, biological assets consist of crops, agricultural produce consists of grain, and current assets consist of inventories, receivables within one year and cash equivalents. Inventories are stated at the lower of cost and subsequently cost or net realisable value when acquired; receivables and cash equivalents within one year are stated at cost. There are no alternatives to change the valuation methods for current assets and therefore the value of these assets remains the same in the following calculations.

The valuation of tangible assets in the financial statements may be based on the historical cost or revalued amount method. Many authors argue that it is appropriate to measure tangible assets on a fair value basis because these assets represent the largest proportion of a company's asset structure and, therefore, changes in the value of these assets have the greatest impact on the company's financial performance. For the purposes of the financial statements, AC X measures its property, plant and equipment at cost and applies the straight-line method of depreciation to these assets.

The revalued amount of the fixed assets of AC X was determined on the basis of the active market price. If there is no active market, the fair value is determined by reference to the market price of identical assets. If it is not possible to determine the market price of an identical asset, then the value of the asset is determined by reference to the market price of a similar asset. When the fair value of an asset cannot be determined in the market because it does not exist or because of significant improvements in technology, the asset is carried at cost.

## TANGIBLE ASSETS

The fixed tangible assets of AC X comprise: land, buildings and structures, equipment and vehicles. As already mentioned, the company owns 400 ha of arable land in Prienai district. The land was purchased in 2015 for EUR 400 000. As the land is not depreciated, the carrying amount at 31 December 2023 remains the same as at the date of purchase, i.e. EUR 400 000. In order to find out what the land is currently worth on the market and how it differs from the balance sheet, a market price analysis was carried out. The revalued value of the land according to the active market price was established on the basis of data from the agricultural land values map of the registry centre (http://www.registrucentras.lt/masvert/). According to the data of the Centre of Registers, the value of land in the Prienai district ranges from EUR 3801 to 4500/ha. The highest price of agricultural land, i.e. EUR 4 500/ha, as reported by the Register Centre, has been selected for the calculations (see Table 3).

Table 3

**Value of tangible fixed assets of AC X as at 31.12.2023**

| Tangible fixed assets | Carrying amount, EUR (estimated cost less depreciation) | Market value, EUR (revalued) | Difference between carrying amount and market value, EUR |
|---|---|---|---|
| Land (400 ha) | 400.000 | 1.800.000 | 1.400.000 |
| Building (900 m )$^2$ | 38.240 | 190.000 | 151.760 |
| Tractor Case magnum 310 | 1 | 32.700 | 32.699 |
| Harvester Massey Ferguson Cerea 7278 | 1 | 35.000 | 34.999 |
| Drill Kongskilde | 1 | 9.500 | 9.499 |
| Iveco 35c15 truck | 1 | 9.800 | 9.799 |
| **Total:** | **438.244** | **2.077.000** | **1.638.756** |

Table 3 shows that the revalued value of the agricultural land is as much as 4.5 times (EUR 1 400 000) higher than the carrying amount as at 31 December 2023, calculated on the basis of the cost method. As the difference in value between the balance sheet value and the revalued value of the land is sufficiently large, it is appropriate for the land to be revalued at the market price. AC X has one building which houses the company's administration and the company's ancillary facilities (200 $m^2$ ) and grain storage (700 $m^2$ ). The building was purchased in 2017 for EUR 71700. The depreciation standard for buildings in AC X is 15 years (Appendix 1 to the Law on Corporate Income tax). The revalued amount of the Company's buildings is based on the active market price of similar buildings offered for sale in similar locations on websites. The price of the building 900 $m^2$ is based on the price of a similar building found on skelbiu.lt (https://m.skelbiu.lt/skelbimai/parduodamos-gamybines-patalpos-prienu-rajone-patalpos-76840559.html).Table 3 shows that the carrying amount of the building at 31 December 2023, calculated at cost (less depreciation), is EUR 38240. The revalued value of the building is EUR 190000, which is EUR 151 760 higher than the carrying amount at 31 December 2023. As the difference between the revalued value of the building and the carrying amount calculated on the basis of the cost method is very significant, it is appropriate for the AC X to revalue the building on the basis of the market value. The revaluation of the building will allow a more realistic view of the value of the building in the company's financial statements. The group of machinery and equipment of AC X consists of: a Case magnum 310 tractor, a Massey Ferguson Cerea 7278 combine harvester, a Kongskilde Demeter Combiseed drill. The company's depreciation allowance for the tractor, combine harvester and seed drill is 5 years (Appendix 1 to the Law on Corporate Income tax). The agricultural

machinery was purchased by the company in 2015 and has a carrying amount of EUR 1 each as at 31 December 2023. The fair value of the tractor, combine harvester and drill can be estimated using active market prices. The price of a Case magnum 310 tractor (made in 2009) is calculated on the basis of the price of a similar tractor found on the website skelbiu.lt (https://m.skelbiu.lt/skelbimai/parduodu-traktoriu-case-magnum-310-76614327.html). The price of the Massey Ferguson Cerea 7278 harvester (made in 2008) is calculated on the basis of the price of a similar combine harvester found on the website autoplius.lt (https://autoplius.lt/skelbimai/fendt-8350-massey-ferguson-cerea-727-kombainai-17173857.html). The price of the Kongskilde Demeter Combiseed drill (made in 2006) is also calculated on the basis of the price of a similar drill found on the website autoplius.lt (https://autoplius.lt/skelbimai/kongskilde-demeter-combiseed-3-m-sejamosios-sodinamosios-25781384.html). As the difference between the revalued value and the carrying amount of agricultural machinery is very large, it is appropriate to revalue this machinery at market prices. The revaluation of the agricultural machinery will provide a more realistic view of the value of the company's machinery in the financial statements. X has an Iveco 35c15 truck (made in 2009). The depreciation standard for trucks is 4 years (Appendix 1 to the Law on Corporate Income tax). The market price of the truck is calculated on the basis of the price of a similar truck published on the autoplius.lt website (https://autoplius.lt/skelbimai/iveco-35c15-savivarciai-26780593.html).

As the difference between the revalued value and the carrying amount of the truck is significant, it is appropriate to revalue the asset at market prices in order to present a true and fair view in the financial statements.

In summary, the prices of real estate, agricultural machinery and vehicles can change significantly over time, depending on the economic situation of the country. As can be seen from the data in Table 3, the valuation of assets at cost does not always accurately reflect their true market value, and it is therefore appropriate to revalue assets periodically, especially those with a high value and a long useful life, as these assets are likely to have the most significant impact on the company's financial performance and the values of financial ratios.

## BIOLOGICAL ASSETS

The biological assets of the agricultural company X consist of crops and the agricultural production consists of cereals. The Company's accounting policy provides for the valuation of biological assets at acquisition (production) cost. In order to present a true and fair view in the financial statements, it is appropriate to measure biological assets at fair value less costs at point of sale. The fair value of the agricultural production (grain) of agricultural company X is determined by reference to the purchase prices of grain on 29-31 December 2023 (see https://www.linasagro.lt/matif-birzos-kainos), less costs at the point of sale.

The differences between the value of biological assets and agricultural production when valuing biological assets at cost and fair value less point-of-sale costs are shown in Table 4.

Table 4

**Value of biological assets and agricultural production at 31 December 2023**

| Assets | At cost, EUR | Fair value measurement, EUR |
|---|---|---|
| Agricultural production | 512.500 | 683.282 |
| Crops | 73.900 | 73.900 |
| Unfinished production | 43.600 | 43.600 |

Table 4 shows that the value of biological assets at cost is lower than their fair value less costs to sell. Although the differences in the value of the biological assets between the valuation methods shown in the table are small, the author considers that it is appropriate to value the biological assets at fair value less costs to sell.

In order to understand the impact on the financial position and performance of AC X of the valuation of fixed assets at acquisition cost and revalued amount, and of biological assets at cost and fair value less point-of-sale costs, a simulated balance sheet and profit and loss account has been developed (see Tables 5, 6).

Table 5

**Balance sheet of AC X at 31 December 2023**

| Article from | Assets measured at cost, EUR | Fixed assets at revalued amount; biological assets at fair value, EUR |
|---|---|---|
| **Fixed assets** | **512.144** | **2.150.900** |
| Tangible assets | 438.244 | 2.077.000 |
| Biological assets (crops) | 73.900 | 73.900 |
| **Short-term assets** | **621.172** | **791.954** |
| Stocks: | 556.100 | 726.882 |
| Agricultural production | 512.500 | 683.282 |
| Unfinished production | 43.600 | 43.600 |
| Receivables within one year | 51.232 | 51.232 |
| Cash and cash equivalents | 13.840 | 13.840 |
| **TOTAL ASSETS:** | **1.133.316** | **2.942.854** |
| **Shareholders' equity** | **495.166** | **2.033.273** |

| | | |
|---|---|---|
| Authorised or share capital | 200.000 | 200.000 |
| Revaluation reserve | 0 | 1.538.107 |
| Mandatory reserve | 25.445 | 25.445 |
| Retained earnings (losses) | 269.721 | 269.721 |
| **Provisions for income tax** | **0** | **271.431** |
| **Accounts payable within one year and current liabilities:** | **638.150** | **638.150** |
| Debts to suppliers | 303.050 | 303.050 |
| Income tax liabilities | 47.598 | 47.598 |
| Employment-related liabilities | 127.100 | 127.100 |
| Other payables and current liabilities | 160.402 | 160.402 |
| **TOTAL EQUITY AND TOTAL LIABILITIES:** | **1.133.316** | **2.942.854** |

Table 5 shows that the revaluation of property, plant and equipment at revalued amount and the valuation of biological assets at fair value less point-of-sale costs resulted in a significant increase in the value of all assets. The difference in the value of total assets on the balance sheet amounted to EUR 1 809 538 (160 %). The increase in the revalued assets resulted in a revaluation reserve in the balance sheet (EUR 1 538 107) which led to an increase in equity. The revaluation reserve is recorded at the amount resulting from the increase in the value of the assets resulting from the revaluation of the assets less the provision for income tax. The revaluation of the asset resulted in the carrying amount of the asset being higher than its tax base, giving rise to a taxable temporary difference which resulted in a deferred income tax liability. The provision for corporation tax (EUR 271,431) is calculated by multiplying the taxable difference by the corporation tax rate (15%). The deferred income tax liability has increased the company's total liabilities.

Table 6 shows an example of a simulated profit and loss account. As at 1 January 2023, the company's agricultural production balances had a balance sheet value of €184,800 and a fair value of €26,640. The carrying amount of crops at 1 January 2023 was EUR 45000 and the value of work in progress was EUR 20000.

Table 6

**Profit and loss account of AC X as at 31 December 2023**

| Indicator | Assets measured at cost, EUR | Fixed assets at revalued amount; biological assets at fair value, EUR |
|---|---|---|
| Sales revenue | 1.118.589 | 1.118.589 |
| Change in the value of agricultural production | 327.700 | 498.482 |
| Change in value of biological assets | 28.900 | 28.900 |
| Change in value of work in progress | 23.600 | 23.600 |
| Gross production | 1.498.789 | 1.669.571 |
| Variable and fixed costs | 1.181.470 | 1.181.470 |
| Profit from typical activities | 317.319 | 488.101 |
| Corporate income tax (15%) | 47.598 | 47.598 |
| Net profit | 269.721 | 440.503 |

Table 6 shows that the company's variable and fixed costs and income tax are unchanged as a result of the revaluation of the assets on 31.12.2023, and are the same as when the assets were valued at cost. However, it should be noted that next year, when depreciation will start to be calculated on the significantly higher value of the property, plant and equipment, the costs will increase. Net profit increased by EUR 170,782, i.e. 63.3%, as a result of the increase in gross production. The analysis shows that the fair value measurement of assets has a significant impact on the financial position and performance of AC X. The valuation of assets affects not only the level of assets, equity and profits, but also the financial ratios (see Table 7).

Table 7

**Financial indicators of AC X in 2023**

| Relative indicators | Assets measured at cost, EUR | Fixed assets at revalued amount; biological assets at fair value, EUR |
|---|---|---|
| **Profitability indicators** | | |
| Operating profitability, % (VP/PP*100) | 28,37 | 43,64 |
| Net profitability, % (GP/PP*100) | 24,11 | 39,38 |
| Return on assets, % (GP/T*100) | 23,8 | 14,97 |
| Return on equity, % (GP/NK*100) | 54,47 | 21,66 |
| **Liquidity (solvency) ratios** | | |
| Total liquidity ratio (TT/TL) | 0,97 | 1,24 |
| Critical liquidity ratio (TT-A)/ CI | 0,1 | 0,1 |
| Net working capital, EUR (TT-TOU) | -16.978 | 153.804 |

| | | |
|---|---|---|
| **Turnover rates** | | |
| Asset turnover ratio (PP/T) | 0,99 | 0,38 |
| **Indebtedness indicators** | | |
| Leverage (I/NK) | 1,29 | 0,45 |
| Indebtedness ratio (I/T) | 0,56 | 0,31 |

As can be seen from the data in Table 7, the financial ratios of AC X differ between the cost and the fair value methods of valuation. When fixed assets are valued at revalued amount and biological assets are valued at fair value less point-of-sale costs, the increase in the values of the profitability ratios is due to the increase in the company's profits. The return on assets and return on equity decreased, with a particularly significant decrease in the return on equity (-32,81 p.p.), due to the revaluation of assets resulting in a revaluation reserve in the company. It can therefore be concluded that the profitability indicators are affected by accounting differences. The analysis of the company's solvency situation shows that the fair valuation of assets increased the gross liquidity ratio and net working capital. The increase is due to an increase in current assets as a result of the revaluation of agricultural production at fair value. However, it should be noted that the company has a very low critical liquidity ratio. This situation indicates that the company has a large amount of inventories that will have to be sold. The asset turnover ratio decreased, due to a 160% increase in the value of the assets as a result of fair valuation. The gearing ratios of AC X at fair value also decreased. The lower these ratios, the better the company's situation. Creditors will always prefer low debt ratios. If a company has a high level of liabilities and little equity or assets, it will be less attractive to investors because of the investment risk.

The analysis shows that the application of the revalued amount method for fixed assets and the fair value less costs at point of sale method for biological assets will be continuously influenced by the market situation, as well as many other conditions. Such fluctuations in the value of assets affect the presentation of equity and the value of assets in the financial statements and, as a result of these fluctuations, users of the financial statements are able to see a truer and more accurate representation of the company's financial results.

## CONCLUSIONS

1. Assets may be accounted for in two main ways: based on historical cost or fair value. The literature review found that the authors prefer the fair value-based approach because the use of fair value provides a more reliable and realistic valuation of assets. Proponents of the cost approach argue that fair value-based valuation is unreliable because the real price of an asset can only be determined in one case: at the time of sale/purchase. Fair value proponents argue that fair value based valuation provides a more accurate representation of the value of the asset on the balance sheet at the reporting date, thereby providing users of financial statements with more realistic financial information about the entity.

2. The results of the simulation suggest that the valuation of fixed assets at revalued amount and biological assets at fair value less point-of-sale costs has a significant effect on the financial performance of AC X. The application of fair value based methods results in an increase in the value of total assets, equity and liabilities on the company's balance sheet and an increase in the company's profits, which in turn results in an increase in the profitability of sales. The return on assets and the return on equity decrease, with a particularly significant decrease in the return on equity, which is due to the revaluation of the company's assets resulting in a revaluation reserve. Indebtedness ratios also decrease, making the company more attractive to creditors.

## REFERENCES

Law on financial accounting. Official Gazette of the Republic of Lithuania, 2001, No. 99-3515. https://e-seimas.lrs.lt/portal/legalAct/lt/TAD/TAIS.154657/asr

Guidance Note on Accounting Standard 12 "Property, Plant and Equipment" (2016). Approved by Order No V2-22 of 28 December 2016 of the Director of the Audit, Accounting, Asset Valuation and Insolvency Management Authority under the Ministry of Finance of the Republic of Lithuania. https://www.avnt.lt/assets/Apskaita/Metodins-rekomendacijos-2020/12-VAS-MR.pdf

Ahn J., Hoitash R., Hoitash U. (2020). Auditor task-specific expertise: The case of Fair value accounting. The Accounting Review, 95 (3), p.1-32, https://doi.org/10.2308/accr-52599

Alharasis, E. E., Prokofieva, M., Clark, C. (2022). The moderating impact of auditor industry specialisation on the relationship between fair value disclosure and audit fees: empirical evidence from Jordan. Asian Review of Accounting Vol. 32(2), 227-255. https://doi.org/10.1108/ARA-03-2022-0050

Arjunan T. (2022). Building a Merging and Acquisition Simulator by Knapsack and Dynamic Algorithm. International Journal for research in Applied Science & Engineering Technology. Volume 10, https://doi.org./10.22214/ijraset.2022.46990

Barker R., Lennard A., Penman S. & Texeira A. (2022). Accounting for intangible assets: proposed solution. Accounting and Business Research. Volume 52, Issue 6. https://doi.org/10.1080/00014788.2021.1938963

Biljon, M, Van, Deon S. (2019). The importance of biological asset disclosures to the relevant user groups. AGREKON, Vol. 58(2), 244-252. ISSN:0303 - 1853(print) 20780400(online) https://doi.org/10.1080/03031853.2019.1570285

Blecher, Christian (2019). The influence of uncertainty on the standard-setting decision between fair value and historical cost accounting under asymmetric information. Rev Quant Finan Acc, Vol. 53, 47-72. https://doi.org/10.1007/s11156-018-0742-5

Bužinskienė R., Montrimienė M. Methodology of accounting for tangible fixed assets. Applied Scientific Research, 2023, 2(2), 73-86. DOI: https://doi.org/10.56131/tmt.2023.2.2.17

Cahyani, A. D., & Firmansyah, A. (2023). Managerial Ability, Earnings Management and Fair Value Accounting: Does Debt Policy Matter? Jurnal Dinamika Akuntansidan Bisnis, Vol. 10(1), 43- 60

Candra A., DS Priyarsono, Zulbainarni N.,Sembel R. (2021).Literature Review On Merger and Acquisition (Theories and Previous Studies). Vol. 39 No. 4 (2021): Special Issue: Managing Economic Growth in Post COVID Era: Obstacles and Prospects. https://doi.org/10.25115/eea.v39i4.4627

DeFond M., Hu J., Hung M., Li S. (2020) The effect of fair value accounting on the perfomance evaluation role of earning. Journal of Accounting and Economics, Volume 70, Issues 2-3. https://doi.org/10.1016/j.jacceco.2020.101341

Jang Y., Yehuda N. (2021). Resource Adjustment Costs, Cost Stickiness, and Value Creation in Mergers and Acquisitions. Contemporary Accounting Research. Volume 38, Issue 3 p. 2264-2301. https://doi.org/10.1111/1911-3846.12668

Jizi Li, Xiaodie Wang, Justin Z. Zhang, Longyu Li (2024). Optimal Information Acquisition and Sharing Decisions: Joint Reviews on Crowdsourcing Product Design. Journal of Database Management (JDM) 35(1). https://doi:10.4018/JDM.337971

Fukui Y., Saito S. (2022). Exploring the relevance and relatability of fair value accounting, Economics and Law, https://doi.org/10.1515/ael-2020-0086

Kalčinskas G., Kalčinskaitė-Klimaitienė R. (2017). Accounting. Vilnius: UAB "Pačiolis".

Mahieux, L. (2023). Fair value accounting, illiquid assets, and financial stability. Management Science. Volume 70, Issue 1. https://doi.org/10.1287/mnsc.2023.4692

Mondria J., Vives X., Yang L. (2022). Costly interpretation of asset price. Management Science 68 (1), 52-74. https://doi.org/10.1287.mnsc.20 20.3871

Nguyen, T. T. H., & Tran, N. H. (2023). Fair Value and Factors Impacting its Applicability in Vietnamese Enterprises. European Journal of Military Studies 13(1), 2344-235.

Pamungkas, P. A., Firmansyah, A., Qadri, R. A., Dinarjito, A. (2022). Tax Aggressiveness, Fair Value Accounting, Debt Maturity: Does Integrated Reporting Matter. JurnalAkuntansi, 26(1), 23-43.

Rudžionienė K., Lukošiūnaitė R. (2020). Science and studies of accounting and finance: problems and perspectives. Science & Studies of Accounting & Finance: Problems & Perspectives, 2020, Vol 14, Issue 1, p.12. https://DOI 10.15544/ssaf.2020.02

Sharma A., Vardia S., Soral G.(2024). Navigating value accounting researc: A bibliographic analysis. Pacific Business Review International, Volume 16, issue 10.

Zhang, L., Farooq, Q., Zhang, Y., Liu, X. & Hao, Y. (2020). Fair value and mispricing: how domestic earnings transparency of listed firms leads to global financial stability. European J. International Management, Vol. 14(1), 173-193.

PANEVĖŽIO KOLEGIJA ISSN 2029-1280, eISSN 2669-0071. Taikomieji tyrimai studijose ir praktikoje – Applied Research in Studies and Practice, 2024, 20.

# INNOVATIVE RESILIENCE: ASSESSING VACCINE PORTFOLIO PERFORMANCE DURING THE PANDEMIC THROUGH ALTERNATIVE DATA SOURCES

***Sandra ŽUKAUSKIENĖ[a], Tadas ŽUKAUSKAS[b]***

*[a] Panevėžio kolegija/State Higher Education Institution, Lithuania*
*[b] Lund University, Sweden*

**Abstract**. This study investigates the investment potential of vaccine-developing companies during the COVID-19 pandemic by comparing two portfolios: one weighted by public sentiment (via Google Trends data) and an equal-weighted portfolio. The study analyzes daily stock data from Pfizer, Johnson & Johnson, Moderna, AstraZeneca, and Novavax between 2020 and 2023, benchmarking performance against the S&P 500. Results show that the trends-informed portfolio achieved a 67.8% annualized return, significantly outperforming the market's 7.9%, though with higher volatility. The statistically significant difference in returns (p-value: 0.046) against the benchmark highlights the potential of sentiment-driven strategies. However, no significant difference in returns was found between the two vaccine portfolios (p-value: 0.331). These findings suggest that biomedical stocks demonstrate resilience during crises, and that alternative data, such as public interest, can enhance portfolio construction in times of heightened sector focus, but future research is required.

**Keywords**: Vaccine portfolio; COVID-19 pandemic; Google Trends; Alternative data

## INTRODUCTION

The global outbreak of the COVID-19 pandemic not only posed unprecedented challenges to public health systems but also significantly disrupted financial markets worldwide. Among the most critical responses to the crisis was the rapid development of vaccines, positioning the biomedical sector at the forefront of both public interest and investor attention. This study examines whether vaccine-developing companies exhibited superior market performance during the pandemic and evaluates whether a novel sentiment-based weighting mechanisms, such as Google Trends data, could enhance portfolio construction.

While prior studies have analyzed stock market volatility and sectoral shifts during economic downturns, there is limited empirical evidence on whether biomedical stocks, particularly those involved in vaccine development, provided sustained excess returns relative to the broader market. Additionally, while investor sentiment has been widely discussed in behavioral finance (Moat et al., 2013; Ahmed et al., 2017), its application in portfolio construction during financial crises remains underexplored.

The object of this research is the stock performance of vaccine-developing companies, while its purpose is twofold: to determine whether these stocks provided superior returns relative to the market during the COVID-19 pandemic and to assess whether sentiment-based portfolio construction could enhance investment outcomes. To address these questions, the study compares two vaccine-focused portfolios (an equal-weighted portfolio and a sentiment-weighted portfolio based on Google Trends data) against the S&P 500 benchmark.

The central research question guiding this study is: "Did vaccine-producing companies exhibit superior market performance during the COVID-19 pandemic, and can alternative data sources, such as Google Trends, enhance portfolio returns?" This study hypothesizes that vaccine-producing companies outperformed the broader market during the pandemic and that a sentiment-weighted portfolio would yield higher returns than an equal-weighted portfolio.

From a scientific perspective, this research contributes to the literature on financial market resilience during crises by analyzing a sector directly involved in global pandemic response. From a practical perspective, the findings provide insights for investors seeking sector-specific opportunities in times of market uncertainty, demonstrating the viability of vaccine stocks as an alternative crisis investment strategy and assessing the potential role of alternative portfolio construction.

By situating this analysis within the pandemic's context, the research sheds light on the unique investment landscape of the biomedical sector during a public health crisis, offering empirical insights into its potential for risk-adjusted returns and volatility considerations.

## SAMPLE AND METHODOLOGY

This research focuses on five companies engaged in vaccine development and production: Pfizer (PFE), Johnson & Johnson (JNJ), Moderna (MRNA), AstraZeneca (AZN), and Novavax (NVAX). Although there are currently 12 vaccines approved by the World Health Organization (WHO) from different companies, the sample is limited to these

five firms, as they are the only vaccine developers listed on U.S. stock exchanges. By restricting the sample to these companies, it ensured homogeneity across firms, making comparisons more reliable and relevant.

The study collects daily closing price data for these companies from Yahoo Finance, covering the period from January 30, 2020, to May 5, 2023. This timeframe aligns with the WHO's official declaration of a public health emergency of international concern, making it particularly relevant for studying the impact of the pandemic on vaccine-related stocks. Utilizing data from Yahoo Finance enhances the study's credibility, as it provides reliable, real-time financial data. Focusing specifically on daily closing prices allows for a consistent benchmark to evaluate the performance and fluctuations of each stock at the conclusion of each trading day, providing a clear view of price behavior over time. In analyzing portfolio performance, simple nominal annualized returns and simple nominal weekly returns are used. This approach provides an intuitive and straightforward representation of each investment's actual percentage gain or loss (Brown and Warner, 1985).

Table 1

**Descriptive statistics, weekly company returns**

| Variable | *Mean* | *Std. Dev.* | *Median* | *Min* | *Max* |
|---|---|---|---|---|---|
| Pfizer | 0.000 | 0.037 | 0.000 | -0.113 | 0.127 |
| Johnson & Johnson | 0.001 | 0.026 | 0.001 | -0.107 | 0.089 |
| Moderna | 0.012 | 0.114 | 0.007 | -0.313 | 0.515 |
| AstraZeneca | 0.003 | 0.036 | 0.003 | -0.127 | 0.137 |
| Novavax | 0.021 | 0.197 | -0.001 | -0.332 | 1.329 |

To assess the risk-adjusted performance of the portfolios, the Sharpe Ratio is calculated, which measures the excess return per unit of risk. The Sharpe Ratio considers the portfolio's return, standard deviation, and a risk-free rate (Sharpe, 1998). For this study, a constant risk-free rate of 4.73% is used, based on the 1-year U.S. Treasury bill rate at the end of the sample period (May 5, 2023), as a representation of the risk-free return available to investors during this timeframe. Google Trends data is incorporated to measure public interest and sentiment related to COVID-19 vaccines and drug development. Google Trends is a publicly accessible tool that provides indexed data on the relative popularity of search terms over time, which allowed us to capture the flow of public sentiment throughout the pandemic. This alternative data source enhances the understanding of market sentiment and its impact on investment strategies within the biomedical sector (Mavragani et al., 2018).

Google Trends does not give the absolute volume of searches but instead indexes the data to 100. Thus, after standardizing the trends data, portfolio weights are assigned to each company based on the level of public interest they attracted, with higher interest translating to a larger weight in the portfolio. Weight distribution depicted in Figure 1. To maintain consistency and robustness, all Google Trends queries were conducted within the same timeframe, region, and category, ensuring comparable data across companies.

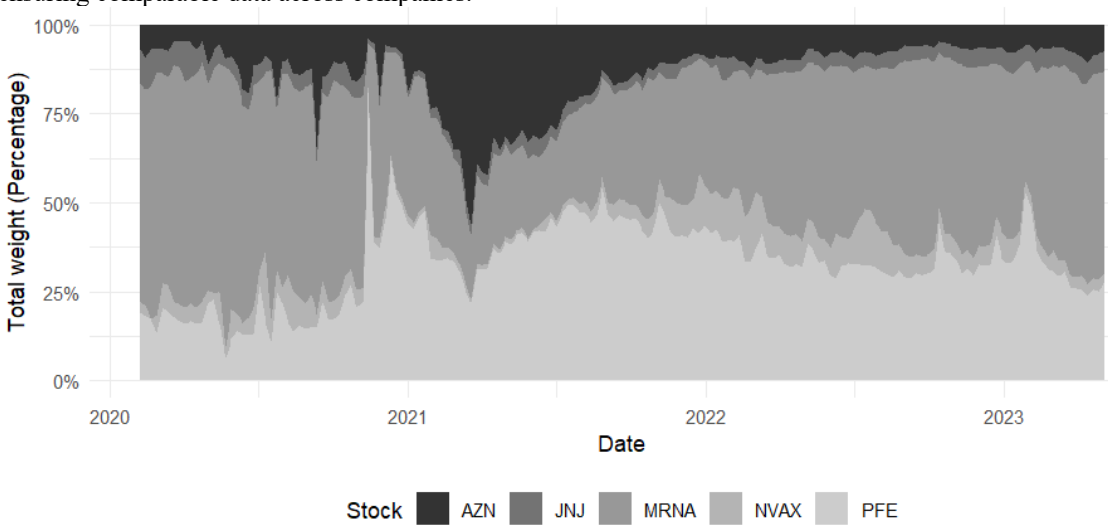



Figure 1. **Weight distribution**

The annualized returns of the vaccine portfolio are calculated as

$$R_{\text{annual}} = \left(\prod_{t=1}^{T}\left(1+\sum_{i=1}^{5} w_{i,t} \times R_{i,t}\right)\right)^{\frac{52}{T}} - 1;$$

where $w_{i,t}$ is the weight of stock i in the portfolio at week t, $R_{i,t}$ is the weekly return of stock i at week t, T is the total number of weeks in the analysis period.

An equal-weighted portfolio that assigns identical weights to each stock of the vaccine portfolio is used as a secondary portfolio (Windcliff and Boyle, 2004; Benartzi and Thaler, 2001). To benchmark the portfolios, the S&P 500 index is used as a standard market proxy (Indices, 2019).

## RESULTS/DISCUSSION

The impact of the COVID-19 pandemic on stock market performance, particularly among companies involved in developing vaccines, has garnered considerable attention. Prior research points to the potential for abnormal or positive returns in biomedical stocks and portfolios during pandemics and health crises (Zhang & Haskins, 2021; Ambelal & Sebastian, 2021; Oncu, 2021; Yacob & Abdullah, 2021; Pushpa et al., 2021; Mittal & Sharma, 2021; Ramos, 2023; Alberti et al., 2023). The analysis reveals similar trends, with the trends-portfolio of vaccine-producing firms yielding a 0.678 (67.8%) annualized return, significantly outperforming the market's return of (0.079) 7.9% over the same period. Consistent with prior literature, heightened volatility is observed in the portfolio, with a standard deviation of 0.550, which is considerably higher than the market's standard deviation of 0.232. This increased volatility likely reflects the amplified speculative interest and market sensitivity tied to vaccine development efforts. Although the volatility matches prior findings (Ambelal & Sebastian, 2021; Mason & Elkassabgi, 2022; Umar et al., 2021), it suggests that investors in vaccine stocks faced greater risk, introducing complexity to the portfolio's favorable returns. This dual nature of investing in vaccine-related stocks during a pandemic, potentially high returns paired with significant risk, offers insight into the dynamics at play during such periods. The portfolio's Sharpe ratio, at 1.147, is markedly higher than the market's ratio of 0.137, highlighting its strong risk-adjusted performance. This favorable ratio supports the portfolio's appeal for returns that sufficiently compensate for the associated risk.

To confirm the statistical significance of these observations, a one-sided Welch Two-Sample t-test was applied. This test indicates that the trends-informed vaccine portfolio's returns are statistically significantly greater than the market's at a 5% significance level (p-value: 0.046). The positive result from this t-test reinforces that the observed outperformance is not likely due to random variation but instead reflects a genuine difference in returns. These statistically significant findings underscore the distinctive impact that the COVID-19 pandemic had on the stock performance of vaccine-producing companies, suggesting that their observed outperformance is rooted in sector-specific factors rather than random variation. The Welch test is appropriate here given the higher volatility observed in the vaccine portfolio, which would violate the equal variances assumption required for a standard t-test. Moreover, it underlines the potential effectiveness of leveraging market sentiment and trends data in portfolio construction, especially during periods of market stress or heightened public interest in specific sectors, such as healthcare during a pandemic.

In contrast, the equal-weighted portfolio achieved an annualized return of 41%, with a standard deviation of 0.467 and a Sharpe ratio of 0.777. This time, the test fails to reject the null hypothesis of the weekly returns being greater than those of the benchmark (p-value: 0.092), indicating no statistically significant difference at the 5% significance level. Figure 2 illustrates these performance metrics, showing the contrast in risk-adjusted returns between the vaccine-focused and market portfolios.

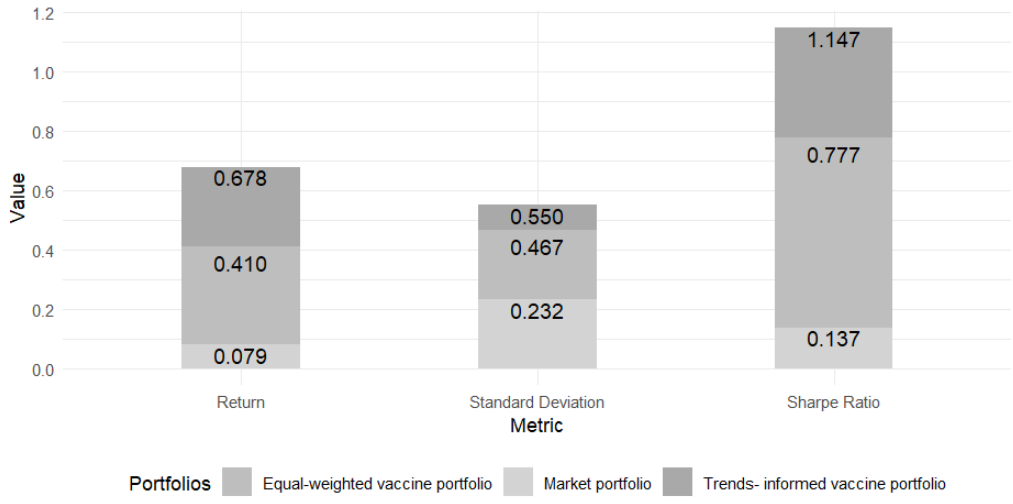



Figure 2. **Financial metrics**

By juxtaposing the results of the trends-informed and equal-weighted portfolios, it can be observed that the trends-informed strategy may offer a more effective approach for investors aiming for higher returns in this sector. However, the Welch test for the difference in mean returns between the trends-informed and equal-weighted portfolios fails to reject the null, specifically regarding the trends portfolio having a higher mean return (p-value: 0.331). This result indicates that the apparent return advantage of the trends-informed portfolio over the equal-weighted one may not be statistically significant. Therefore, unfortunately, it reduces the expected impact of using alternative data. Moreover, the

increased return potential in the trends-informed portfolio is accompanied by higher volatility, which may not suit all investors' risk tolerance levels.

## CONCLUSIONS

This study demonstrates that stocks of vaccine-developing companies displayed both resilience and potential for market outperformance during the COVID-19 pandemic. The Google Trends-informed vaccine portfolio achieved substantial annualized returns, significantly outperforming the S&P 500 benchmark. This result supports the hypothesis that vaccine-related stocks offered distinct market advantages during the pandemic.

By incorporating Google Trends data into portfolio construction, this research highlights the potential of alternative data sources in investment strategy. The findings suggest that investor sentiment, as reflected in search volumes, can serve as a valuable tool for weighing portfolios, especially during periods of heightened public focus on specific sectors. This approach provides actionable insights for investors, showing how real-time public interest data can capture trends that traditional financial metrics might overlook. Nevertheless, the trend portfolio failed to show statistically significant results compared to an equal-weighted portfolio. Therefore, future research could explore other alternative data sources and work to optimize the Google Trends approach. This refinement could unlock more robust ways to capture and utilize public interest data, further enhancing investment strategies.

Overall, this study underscores the dynamic role that vaccine-related stocks played during the COVID-19 pandemic, providing evidence that public sentiment can be a powerful factor in portfolio construction. The findings suggest that biomedical stocks and their portfolios have the ability to outperform the market and that trends-informed investing holds promise as a strategy for outperforming the market during crises, adding a valuable tool to the modern investor’s toolkit.

## REFERENCES

Ahmed, F., Asif, R., Hina, S., & Muzammil, M. (2017). Financial market prediction using Google Trends. International Journal of Advanced Computer Science and Applications, 8(7), 388–391.

Alberti, E., Herberger, T. A., & Ender, M. (2023). Short-term stock performance of healthcare companies in times of viral epidemics and pandemics. Atlantic Economic Journal, 51(2), 131–148.

Ambelal, M., & Sebastian, A. (2021). An analysis of the impact of a pandemic on the performance of pharmaceutical stocks. African Journal of Business & Economic Research, 16(4).

Benartzi, S., & Thaler, R. H. (2001). Naive diversification strategies in defined contribution saving plans. American Economic Review, 91(1), 79–98.

Brown, S. J., & Warner, J. B. (1985). Using daily stock returns: The case of event studies. Journal of Financial Economics, 14(1), 3–31.

Indices, S. D. J. (2019). S&P U.S. indices methodology.

Mason, A. N., & Elkassabgi, A. (2022). Evidence of abnormal trading on COVID-19 Pfizer vaccine development information. Journal of Risk and Financial Management, 15(7), 299.

Mavragani, A., Ochoa, G., & Tsagarakis, K. P. (2018). Assessing the methods, tools, and statistical approaches in Google Trends research: Systematic review. Journal of Medical Internet Research, 20(11), e270.

Mittal, S., & Sharma, D. (2021). The impact of COVID-19 on stock returns of the Indian healthcare and pharmaceutical sector. Australasian Accounting, Business and Finance Journal, 15(1), 5–21.

Moat, H. S., Curme, C., Avakian, A., Kenett, D. Y., Stanley, H. E., & Preis, T. (2013). Quantifying Wikipedia usage patterns before stock market moves. Scientific Reports, 3(1), 1801.

Oncu, E. (2021). The impact of COVID-19 on health sector stock returns. In Administrative, Economics and Social Sciences Theory, Current Researches and New Trends (pp. 109–121).

Pushpa, A., Raju, V., Jagadheesh, K., & Gaadha, B. (2021). Impact of COVID-19 on leading pharmaceutical companies' stock prices listed in BSE, India. Empirical Economics Letters, 20.

Ramos, R. F. D. (2023). El sector farmacéutico: eficiencia, rentabilidad y COVID-19 (PhD thesis, Universidad Nacional de Educación a Distancia).

Sharpe, W. F. (1998). The Sharpe ratio. Streetwise–The Best of the Journal of Portfolio Management, 3, 169–185.

Umar, Z., Adekoya, O. B., Oliyide, J. A., & Gubareva, M. (2021). Media sentiment and short stocks performance during a systemic crisis. International Review of Financial Analysis, 78, 101896.

Windcliff, H., & Boyle, P. P. (2004). The 1/n pension investment puzzle. North American Actuarial Journal, 8(3), 32–45.

Yacob, N., & Abdullah, S. M. M. (2021). Healthcare stocks: Defensive or speculative? Evidence from developed and emerging markets. International Journal of Accounting, 6(35), 26–41.

Zhang, N., & Haskins, M. (2021). Trends of industry-leading biotechnology stocks during COVID-19. Journal of Student Research, 10(3).

PANEVĖŽIO KOLEGIJA ISSN 2029-1280, eISSN 2669-0071. Taikomieji tyrimai studijose ir praktikoje – Applied Research in Studies and Practice, 2024, 20.

# REVIEW OF TECHNOLOGIES FOR STABILIZING ELECTRICAL NETWORKS THROUGH REACTIVE POWER COMPENSATION AS THE PENETRATION OF RENEWABLE ENERGY SOURCES INCREASES

***Rokas BAGOČIŪNAS[a], Daiva STANELYTĖ[ab]***

*[a] Klaipedos valstybine kolegija – Higher Education Institution, Lithuania*
*[b] Lithuanian Energy Institute, Lithuania*

**Abstract**. Technologies for generating electricity from renewable energy sources (RES) are becoming an integral and highly important part of the electricity generation market. The integration of these technologies into distribution networks is gaining momentum. However, alongside the benefits offered by these technologies, maintaining the stability of electric networks is becoming increasingly complex. This study analyses the impact of RES based power plants on the stability of network parameters and compares several technologies that are often the subject of scientific research to maintain their stability. The study found that RES plants have a negative impact on the stability of network parameters. The technologies most often considered in scientific research as alternatives for stabilizing network parameters are STATCOM, SVC and SC technologies. STATCOM technology is superior to SVC technology, which is a predecessor of the FACTS controller group, due to its characteristics. Comparing STATCOM and SC technologies is challenging due to the different operating principles and characteristics of these technologies. However, the choice between these three technologies should be based on the characteristics of the electrical network into which the technology will be integrated, as well as a cost-benefit analysis.

**Keywords**: reactive power compensation, Synchronous Condenser; Static Synchronous Compensator; Static Var Compensator

## INTRODUCTION

**Relevance**. The European Union's (EU) Renewable Energy Directive (REDIII) states that by 2030, the EU aims to reduce greenhouse gas ($CO_2$) emissions by 55% and by 2050, the EU will achieve the climate neutrality target set by the Intergovernmental Panel for Climate Change (IPCC). This target represents a balance between the amount of $CO_2$ emitted and the amount of $CO_2$ naturally removed from the atmosphere, allowing the EU to be considered a climate-neutral entity. In September 2023, the European Parliament supported an agreement with the EU Council, which states that renewable energy will account for 42.5% of the total electricity generated in the EU by 2030 (up from the previous target of 32%).

**Problem Statement.** The increasing share of electrical energy generated by RES in the distribution networks poses significant challenges to the stability, inertia, balance, and efficiency of electric networks. As the characteristics of electricity generated from RES differ from those of electricity generated from fossil fuels, this integration creates significant complications in the energy sector and needs to be balanced. The parameters affected by the penetration of RES into the electricity networks can be divided into two main groups: those related to frequency stability and those related to voltage stability. Both parameters are crucial for the further integration of RES into the distribution networks, and therefore both will be examined in this article. However, due to the broad scope of these parameters, the focus is on the analysis of voltage stability.

**Subject.** Integration of RES into distribution networks.

**The aim of the research:** To analyze methods of electric grid stabilization through reactive power (Q) compensation as RES penetration increases in distribution networks.

**The objectives of the research:**

1. Investigate the impact of RES penetration in distribution networks.
2. Analize methods for stabilizing electric network parameters.
3. Provide a comparison of methods for stabilizing electric network parameters and identify the most effective reactive power (Q) compensation method.

**Research methods:** analysis of scientific literature.

**Value of the Research:** Given the lack of scientific research specifically focused on the impact of RES on the stability of electric grids followed by the analysis and comparison of different technologies aimed at stabilizing this impact, the primary objective of this article is to fill this research gap.

## RESEARCH METHODOLOGY

This study employed a quantitative research method aimed at analyzing synthesized data from various primary studies. To analyze the negative impact of RES to the electrical network and technologies used to reduce it, a review of scientific literature sources was conducted. The reviewed sources included works by foreign authors, which allowed for

a detailed examination of the subject. Research data and theoretical reviews published in *Science Direct* and *IEEE* were analyzed. The suitability of scientific articles for analysis was assessed by reviewing titles, abstracts, and full texts. The literature search was methodical, thorough, as the most relevant databases were selected, where results of studies on the subject were published. A literature search was conducted, and all possible search terms describing the investigated concept were used. Based on the applied keyword combinations, 89,164 publications were identified. The results are presented in the table below.

Table 1

**Results of the literature search in scientific article databases**

| Key words | Science Direct | IEEE | Total |
|---|---|---|---|
| Synchronous Condenser | 5197 | 767 | 5964 |
| Static Var Compensator | 7586 | 5936 | 13522 |
| Static Synchronous Compensator | 7522 | 14067 | 21589 |
| Reactive power compensation | 11396 | 36693 | 48089 |
| **Total** | 31701 | 57436 | 89164 |

The study adheres to the principles of research ethics, as the information required for the study is accessible in scientific databases.

## ISSUES WITH THE INTEGRATION OF RES INTO ELECTRICAL GRID

Most researchers analyzing mechanisms to compensate the negative impact of RES power plants to the grid stability note that as the development of RES technologies accelerates, the negative impact of these technologies on electric grids also accelerates. The last few decades have seen unprecedented growth in two technologies, solar and wind, which now account for 13% of total electricity generation. The annual growth rate of electricity generated by solar power plants is 27% and that of wind power plants is 13% over the last five years (Sinsel et al., 2020). The integration of RES is a crucial tool for reducing emissions and mitigating the effects of climate change (Musau et al., 2017). As the amount of electricity generated from RES power plants increases, the share of electricity generated from fossil fuels is continuously decreasing, which is beneficial for emissions control (Wang et al., 2017). However, as the share of electricity generated from RES increases globally, its impact on power grids becomes more significant, which poses challenges in planning, development and ensuring stable grid operation (Yan et al., 2019).

The main reasons often cited are the variability of RES power plants and their different technological characteristics compared to conventional electric power plants. RES generators have several disadvantages: their generated output is variable as it depends directly on natural conditions, the amount of power generated can be predicted but not controlled (Ghosh et al., 2020). As a result, voltage regulation in distribution system becomes more complex (Knittel et al., 2020). Energy generated from RES has different static and dynamic characteristics than traditional energy generated by synchronous generators (Yan et al., 2019). Traditional synchronous generators can provide inertia and primary frequency response to the electric grid, which RES generators cannot provide because they are connected to the grid through inverters and usually operate in a mode of maximum power generation to the grid (Fanglei et al., 2020). Most of the scientific research published agrees about the impact that RES to the electric grid, as well as the reasons for this type of impact.

## ANALYSIS OF POWER GRID INERTIA AND FREQUENCY STABILITY

One of the most important parameters in electrical grids is the grid frequency and its stability. Frequency stability refers to the ability of the electric system to maintain a constant grid frequency when deviations from the normal operating mode occur, resulting in a significant imbalance between the power generated and consumed (Musau et al., 2017). The rapidly increasing integration of RES into distribution networks negatively affects the network inertia and the primary system response to frequency deviations (Qin et al., 2018). The inertia of a generator is described by its inertia constant H:

$$E = \frac{1}{2}J\omega^2; H = \frac{E}{S_B} = 1/2\frac{J\omega^2}{S_B} \quad (1)$$

where **E** - kinetic energy stored in the rotating mass, **ω** - angular frequency, **J** - moment of inertia, $\mathbf{S_B}$ generator's rated power, **H** - inertia constant (indicates how long the generator can supply the grid with nominal power solely from the stored kinetic energy) (Musau et al., 2017).

The graph below shows the response of a traditional generator with a given inertia constant to a frequency drop in the electrical network.

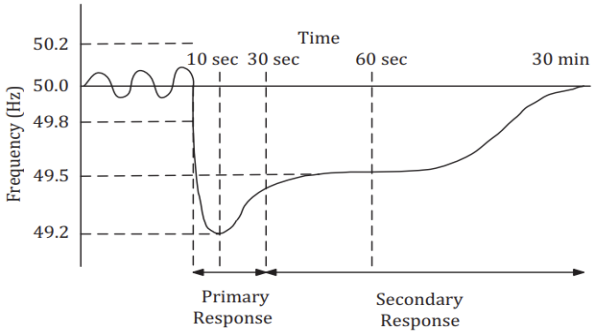



Figure 1. **Response of a traditional generator with a given inertia constant to a frequency drop in the system**

Low inertia levels may lead to large frequency swings under any circumstances, making it necessary to raise concerns about the security of power system (Huang et al., 2017).

The table below presents the inertia constants of different sources.

Table 2

**Inertia constants**

| Source of electrical energy | H(s) |
|---|---|
| Steam | 4-9 |
| Gas | 3-4 |
| Water | 2-4 |
| Wind | 2-5 |
| Solar | 0 |

As shown in the table above, RES have a lower inertia constant than other sources of energy.

## ANALYSIS OF POWER GRID VOLTAGE STABILITY

Grid voltage is another parameter affected by the integration of RES technologies into distribution grids. Researchers in analyzed studies identify the nature and characteristics of RES power plant technologies as the main reasons for this impact. Parameters related to voltage in the electrical system play an important role in evaluating the quality of electrical power. Quality refers to the absence of deviation from the ideal parameter - a sine wave of constant frequency and amplitude (Okoń et al., 2016). The integration of RES into distribution networks significantly changes the characteristics of the electric network, making it more static due to the power electronic devices used to connect RES power plants to the grid, which complicates the voltage stabilization in the electrical network (Li et al., 2017). Due to the instability of RES sources, their accelerated integration has a negative impact on maintaining grid stability (Li et al., 2020). One way to stabilize the voltage in the grid is through Q compensation (Okoń et al., 2016). Q compensation involves the regulation of the Q component to increase the efficiency of AC power generation in power grids (Zhou et al., 2018).

The equation describing the dependence of transmission line voltage on Q is:

$$\frac{\partial V_j}{\partial Q_{ij}} = \frac{X+\left(R^2+X^2\right)*\frac{Q_{ij}^{(r)}}{V_i^2}}{\sqrt{V_i^2+2\left(R*P_{ij}+X*Q_{ij}^{(r)}\right)+\left(R^2+X^2\right)*\frac{P_{ij}^2+Q_{ij}^{(r)2}}{V_i^2}}} \quad (2)$$

Where $\mathbf{V_i}$, $\mathbf{V_j}$ – voltages at different ends of the transmission line; $\mathbf{P_{ij}}$, $\mathbf{Q_{ij}}$ – active and reactive power **R**, **B, X** - transmission line branch parameters (Okoń et al., 2016).

The graph below presents the dependence of voltage at different ends of the transmission line from Q.

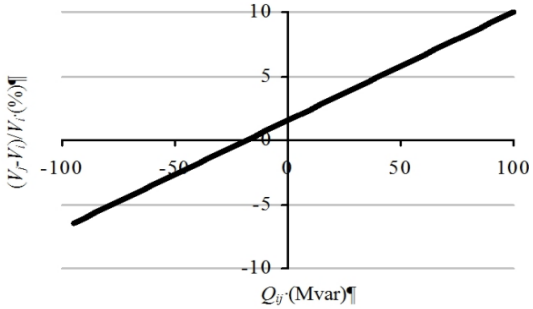



Figure 2. **the dependence of voltage at different ends of the transmission line on Q**

Q compensation can improve the network power factor, effectively stabilize the voltage and its fluctuations, and reduce transmission line power losses (Zhou et al., 2018). Compensation of Q is a widely used technology for stabilizing the voltage in electric network.

## METHODS FOR VOLTAGE STABILIZATION BY COMPENSATING Q STATIC VAR COMPENSATORS

It is observed that one of the most frequently analyzed technologies in scientific research for quality compensation and network parameter stabilization is the Static Var Compensator (SVC). SVC is a type of controller in the family of flexible AC transmission systems (FACTS), which is controlled by thyristors (hence called static) and can generate reactive power with lagging or leading power factor (Zhou et al., 2018). FACTS controllers are very fast acting power electronic devices that influence the characteristics of the electrical network (Bharti et al., 2016). This type of controller is designed to increase the efficiency of the electrical network by reducing losses in transmission lines (Qatamin et al., 2017).

A typical SVC controller schematic and its main components are shown below:

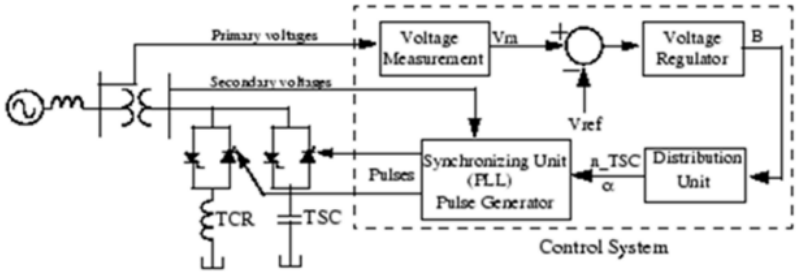



Figure 3. **Typical SVC controller schematic and its main components**

A typical SVC system consists of two main components: a thyristor-controlled reactor (TCR) and a thyristor switched capacitor (TSC) (Zhou et al., 2018). When the SVC system connects the TCR or TSC to the circuit, it generates reactive power with a lagging or leading power factor (Qatamin et al., 2017). Therefore, by connection of TCR or TSC a shift of the phase angle between the voltage and the current is achieved.

## STATIC SYNCHRONOUS COMPENSATOR

The Static Synchronous Compensator (STATCOM) is another widely researched technology that is considered a superior and more modern modification of the SVC. STATCOM is a member of the FACTS controller's family, typically used in long-distance power transmission lines, substations, and industries where voltage stability is critical (Rijesh et al., 2017).

STATCOM generates variable Q for the electrical network by modulating the amplitude and phase angle of the current (Zhou et al., 2018).

A typical STATCOM controller schematic and its major components are shown below:

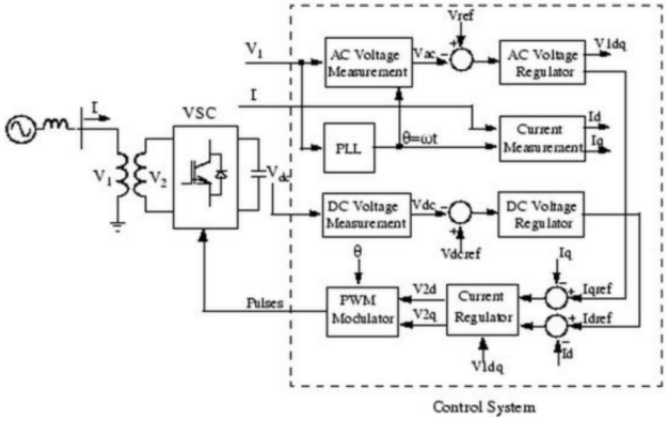



Figure 4. **Typical STATCOM controller schematic and its main components**

A typical STATCOM system: 3-phase voltage source converter (VSC) based on gate turn-off thyristors (GTO) or insulated gate bipolar transistors (IGBT), a step-down transformer, direct current (DC) capacitor, and a VSC controller (Bao et al., 2021). The controller changes the amplitude and phase angle of the modulated parameter through the VSC (Rijesh et al., 2017). STATCOM technology is widely used in compensation of Q.

## SYNCHRONOUS CONDENSER

Researchers claim that the technology of the synchronous condenser (SC) is a long-known and widely used technology in electrical networks, which is currently undergoing a revolution. It often becomes the subject of scientific research as one of the alternatives for Q compensation and electrical network stabilization. SC is a system that has played an important role in voltage regulation and reactive power compensation for more than 50 years (Zhou et al., 2018). The excitation system of an SC can be classified as DC or AC, depending on the nature of its power source (Bao et al., 2021). Below is an example of a SC DC excitation system.

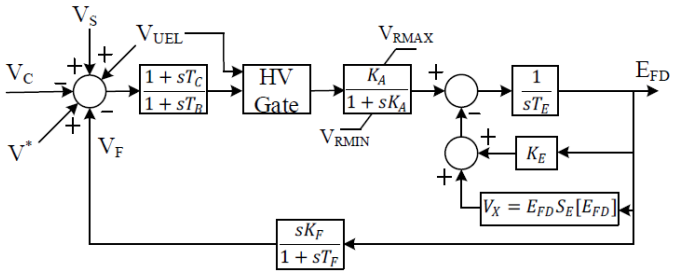



Figure 5. **Typical SC controller schematic and its main components**

Where $\mathbf{V_c}$ – input voltage, $\mathbf{V_s}$ – voltage obtained from the stabilizer, $\mathbf{V_{REF}}$ – reference voltage, $\mathbf{V_F}$ – output voltage, $\mathbf{T_A}$ and $\mathbf{T_B}$ – time constants of the voltage regulator. An SC is a rotating synchronous electric machine connected to the electric network without a mechanical load, controlled by a voltage regulator, and used for Q compensation (Huang et al., 2017). After the machine is connected to the electric network, by changing the excitation current of the machine, it generates Q with a leading or lagging power factor (Zhou et al., 2018). A synchronous machine with an excitation current control system can provide the electrical network with continuous Q compensation (Zhou et al., 2018). SC is a well-known and effective technology.

## COMPARISON OF DIFFERENT TECHNOLOGIES COMPARISON OF STATCOMC AND SVC SYSTEMS

At this point, there is no doubt that STATCOM is a superior FACTS controller technology for Q compensation. Numerous scientific studies, researchers, and practical applications confirm this, with the only cited drawback being the relatively higher cost of STATCOM systems. It is observed that when comparing the performance of SVC and STATCOM systems of the same rating in the electrical network, the STATCOM system is more effective during grid disturbances (Bharti et al., 2016). Currently, SVC technology is advanced and widely deployed. However, the influence and the importance of STATCOM (as a more advanced technology) in maintaining grid stability is growing. The only factor slowing down this growth is the relatively higher system cost (Zhou et al., 2018). The graph below shows the impact of FACTS devices on network voltage.

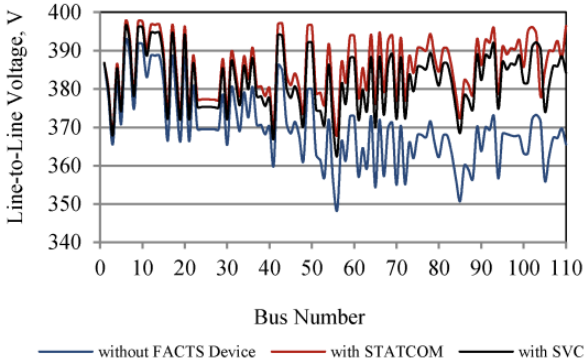



Figure 6. **The impact of FACTS devices on electrical network voltage**

As shown, the best measured voltage profile in the electrical network is achieved with STATCOM.

## COMPARISON OF STATCOM AND SC SYSTEMS

When comparing STATCOM with SC systems, the opinions of different researchers vary. Some of them state that SC systems are rarely used today due to their complex structure. These systems have a negative impact on short-circuit currents in electrical networks and cannot be controlled quickly enough to compensate for load changes (Zhou et al., 2018). The graphs below show the voltage fluctuations in the electrical network during a disturbance.

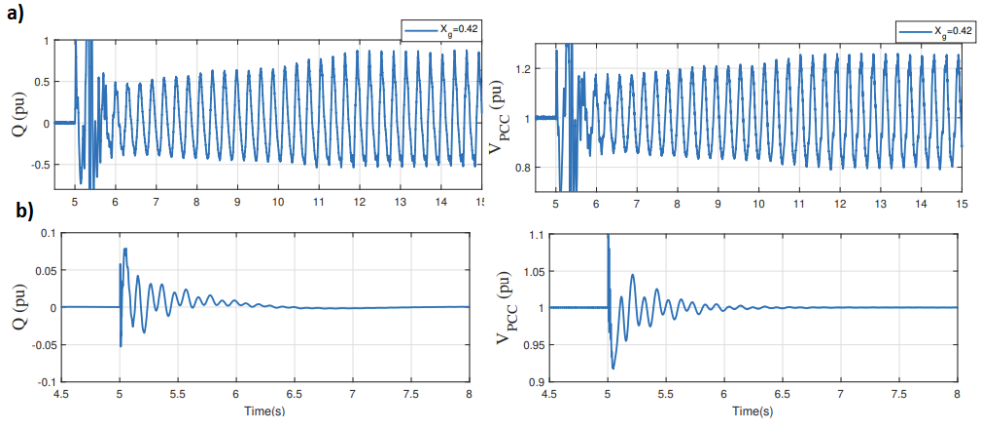



Figure 7. **Voltage fluctuations in the electrical network during a fault**

The graphs in the previous page indicate two scenarios of electric grid disturbance: a) disturbance of electric grid connected with STATCOM without compensation of Q. b) disturbance of electrical grid of the same magnitude connected with SC instead of STATCOM without compensation of Q. At the moment the disturbance occurs the electric system connected to STATCOM, and its parameters start to fluctuate greatly and become unstable, resulting in a system collapse. However, the electrical system connected to SC shows signs of grid stabilization even without Q compensation, only because of its stored inertia in the rotating mass. Therefore, according to other researchers, before mentioned disadvantages of SC systems are being questioned. As they state, it is observed that SC systems have several advantages compared to STATCOM and SVC: these systems positively affect the network inertia due to the energy stored in their rotating masses, thereby improving stability. In addition, they have a positive effect on the network's resistance to short-circuit currents during faults (Geis-Schroer et al., 2020). To continue, some of the authors state that, the losses in SC systems are high, and compared to STATCOM, these systems are more expensive (Zhou et al., 2018). However, other authors in their study publications provide examples of how the installation cost of these systems can be reduced. In many cases, decommissioned synchronous generators from traditional power plants can be converted to SC systems at minimal cost. For example, Siemens has implemented several such systems in Germany (Geis-Schroer et al., 2020).

According to some researchers, when comparing SVC, SC, and STATCOM technologies, the STATCOM system is the most advanced, has better dynamic characteristics, and will be the most widely used in the future (Zhou et al., 2018). However, the operating mechanisms of these systems are different, making direct comparison a complex task. The choice between one system or the other is not simple. The choice must consider the characteristics of the electrical network in which the device will be installed, which requires a more comprehensive study to evaluate these characteristics (Kynev et al., 2016). As stated before, the results of scientific research vary and the comparison of the two systems is complex.

## CONCLUSIONS

Technologies for generating electricity from renewable energy sources (RES) are becoming an integral and highly important part of the electricity generation market. The integration of these technologies into distribution networks is gaining momentum. However, alongside the benefits offered by these technologies, maintaining the stability of electricity networks is becoming increasingly complex. After analyzing the impact of RES based power plants on the stability of network parameters and comparison of several technologies that are often the subject of scientific research to maintain their stability, it is concluded that:

1. RES power plants have a negative impact on the stability of network parameters due to the characteristics of electricity generation from RES compared to electricity generated by conventional plants.
2. The most common subjects of scientific research as alternatives for stabilizing network parameters and minimizing the impact of RES to electric grids are: STATCOM, SVC, and SC technologies.
3. When comparing STATCOM and SVC technologies, STATCOM is undoubtedly the superior type of FACTS controller. However, the relatively high cost of these technologies necessitates a proper cost-benefit analysis of the electrical network into which the technology will be integrated to select the appropriate technology. On the other hand, STATCOM and SC technologies differ in their operating principles, making their comparison quite complex. Therefore, only a proper assessment of the characteristics of the electrical network into which the technology will be integrated and a conducted cost-benefit analysis can provide more information for technology selection.

Throughout this study it has been observed that the analyzed methods for voltage stabilization through Q compensation rely on reacting to events or disturbances in the electrical grid. Consequently, there is always a delay before corrective actions are taken in response to these events or disturbances. As the integration of RES into distribution networks continues, the impact on the electrical grid is likely to intensify. Therefore, to balance the integration of RES it might become necessary to develop prediction and forecast-based Q compensation and load control systems. The digitalization of electrical networks is likely to gain great importance. Furthermore, the rapid advancement of artificial

intelligence technology may play a crucial role in the development of such prediction-based control systems to achieve a controlled and balanced integration.

## REFERENCES


1. Bharti, S. Dewangan, S. Ram (2017). Performance of wind farm distribution system under balanced and unbalanced condition with SVC & STATCOM, 1-4. Retrieved from: https://doi.org/10.1109/IREC.2017.7926048.
2. Bao, L. Fan, L. Miao, Z. (2020). Comparison of Synchronous Condenser and STATCOM for Wind Farms in Weak Grids, 1-6, Retrieved from: https://doi.org/10.1109/NAPS50074.2021.9449775.
3. Fanglei, L. Fan, W. Jiaming, Y. Guoyi, X. Tianshu, B. (2020). Estimating Maximum Penetration Level of Renewable Energy Based on Frequency Stability Constrains in Power Grid, 607-611, Retrieved from: https://doi.org/10.1109/ACPEE48638.2020.9136471.
4. Geis-Schroer, J. Nair, A. R. Patel, S. Kamalasadan, S. (2020). Modeling and Analysis of Weak Grid Considering Phase Locked Loop and Synchronous Condenser Effect on Grid Stability, 1-6, Retrieved from: https://doi.org/10.1109/PESGRE45664.2020.9070728.
5. Ghosh, R. Tummuru, N. R. Rajpurohit, B. S. Monti, A. (2020). Virtual Inertia from Renewable Energy Sources: Mathematical Representation and Control Strategy, 1-6, Retrieved from: https://doi.org/10.1109/PESGRE45664.2020.9070733.
6. Huang, H. Chu, X. (2017). Improving rotational inertia of power system with variable speed synchronous condenser, 1-5, Retrieved from: https://doi.org/10.1109/PESGM.2017.8274191.
7. Knittel, M. Majumdar, N. Schneider, M. Thie, N. Moser, A. (2020). Voltage Control in Transmission Grids Considering Uncertainties of Renewable Energy Sources, 580-585, Retrieved from: https://doi.org/10.1109/ENERGYCon48941.2020.9236597.
8. Kynev, S. Pilz, G. Schmitt, H. (2016). Comparison of modern STATCOM and synchronous condenser for power transmission systems, 1-6, Retrieved from: https://doi.org/10.1109/EPEC.2016.7771769.
9. Li, Y. Chi, Y. Tian, X. Liu, C. Hu, J. Fan, Y. Fan, X. Xiao, Y. Wang, C. et al. (2020). Research on Capacity Planning of Renewable Energy Grid Integration Based on Effective Short Circuit Ratio, 622-627, Retrieved from: https://doi.org/10.1109/iSPEC50848.2020.9351108.
10. Li, Y. Tian, X. Liu, C. Su, Y. Li, L. Zhang, L. Sun, Y. Li, J. et al. (2017). Study on voltage control in distribution network with renewable energy integration, 1-5, Retrieved from: https://doi.org/10.1109/EI2.2017.8245755.
11. Musau, M. P. Chepkania, T. L. Odero, A. N. Wekesa, C. W. (2017). Effects of renewable energy on frequency stability: A proposed case study of the Kenyan grid, 12-15, Retrieved from: https://doi.org/10.1109/PowerAfrica.2017.7991192.
12. Okoń, T. Wilkosz, K. (2016). Impact of reactive-power optimization on voltages in a power system, 674-678, doi: 10.1109/ICHQP.2016.7783403.
13. Qatamin, A. Etawi, A. Safasfeh, G. Ajarmah, N. Al-Jufout, S. Drous, I. Wang, C. Soliman, A. H. (2017). SVC versus STATCOM for improving power system loadability: A case study, 1-4, Retrieved from: https://doi.org/10.1109/IREC.2017.7926048.
14. Qin, X. Su, L. Jiang, Y. Zhou, Q. Chen, J. Xu, X. Chi, Y. An, N. (2018). Study on Inertia Support Capability and Its Impact in Large Scale Power Grid with Increasing Penetration of Renewable Energy Sources, 1018-1024, Retrieved from: https://doi.org/10.1109/POWERCON.2018.8601687.
15. Rijesh, A. Chakraborty, S. (2017). Performance analysis of smart device — STATCOM for grid application, 1-5, Retrieved from: https://doi.org/10.1109/TENCONSpring.2017.8069999.
16. Sinsel, S. R., Rimkie, R. L., Hoffmann., V. H. (2020) Challenges and solution technologies for the integration of variable renewable energy sources – a review. Renewable Energy, 2271-2285, Retrieved from: https://doi.org/10.1016/j.renene.2019.06.147.
17. Wang, Z. Luo, D. Li, R. Zhang, L. Liu, C. Tian, X. Li, Y. Su, Y. He, J. (2017). Research on the active power coordination control system for wind/photovoltaic/energy storage, 1-5, Retrieved from: https://doi.org/101109/EI2.2017.8245403.
18. Yan L., Xiaohui Q., Yongning C., Xinshou T., Sujuan S., Shenglun Z., Xiangmei K., Lei S. (2019). Study on Requirement of Control and Stability with Renewable Energy Generation Grid Integration, 26-30. Retrieved from: https://doi.org/10.1109/APAP47170.2019.9224875.
19. Zhou, X. Wei, K. Ma, Y. Gao, Z. (2018). A Review of Reactive Power Compensation Devices, 2020-2024, Retrieved from: https://doi.org/10.1109/ICMA.2018.8484519.

# INFORMATION ABOUT THE AUTHORS

**Rima ADOMAITIENĖ:** *lecturer, Panevėžio kolegija/State Higher Education Institution, Lithuania*.
**Areas of scientific interests**: biomedical, dentistry, oral health
**E-mail:** rima.adomaitiene@panko.lt

**Domilė AUGULĖ:** *lecturer, Panevėžio kolegija/State Higher Education Institution, Lithuania*.
**Areas of scientific interests**:
**E-mail:** domile.augule@panko.lt

**Donatas AVIŽA:** *doctor of Technology Sciences, the Associated Professor of Panevėžio kolegija/State Higher Education Institution, Lithuania.*
**Areas of scientific interests**: Construction, Energy Saving in Buildings
**E-mail:** donatas.aviza@panko.lt

**Rokas BAGOČIŪNAS:** *student; Klaipedos valstybine kolegija / Higher Education Institution, Lithuania*.
**Areas of scientific interests**:
**E-mail:** rok.bagociunas@kvkedu.lt

**Donatas BALČIŪNAS:** *lecturer at Panevėžio kolegija/State Higher Education Institution, Lithuania*.
**Areas of scientific interests**:
**E-mail:** donatas.balciunas@panko.lt

**Marius BARANAUSKAS:** *lecturer at Panevėžio kolegija/State Higher Education Institution, Lithuania*.
**Areas of scientific interests**:
**E-mail:** baranauskas9@gmail.com

**Česlovas BARTKUS:** *lecturer at Panevėžio kolegija/State Higher Education Institution, Lithuania*.
**Areas of scientific interests**:
**E-mail:** ceslovas.bartkus@panko.lt

**Parulkumari P.BHATI:** *PhD in area of management, is a faculty member in HRM and OB at Nirma University in Gujarat, India.*
**Areas of scientific interests**:
**E-mail:** dr.parulbhati@gmail.com

**Ramunė BENAITYTĖ:** *student; Klaipedos valstybine kolegija / Higher Education Institution, Mechanical Engineering study program, Lithuania.*
**Areas of scientific interests**:
**E-mail:** ram.benaityte@kvkedu.lt

**Anastasija BIKOVA:** *master student; International Project Management programme, Hochschule Wismar, University of Applied Sciences: Technology, Business and Design, Germany.*
**Areas of scientific interests**: foreign language teaching and learning
**E-mail:** a.bikova@stu.hs-wismar.de

**Asta BUTKUVIENĖ:** *Master of Pediatrics; lecturer at Panevėžio kolegija/State Higher Education Institution, Lithuania*.
**Areas of scientific interests**: pediatrics, farmacology, cardiology, skin and sexually transmitted diseases
**E-mail:** asta.butkuviene@panko.lt

**Pınar ÇELİK ÇAYLAK:** *PhD and Assoc. Prof.; Akdeniz University, Serik Faculty of Business Administration, sustainable tourism, sustainability, Turkey*.
**Areas of scientific interests**:
**E-mail:** pinarcelik@akdeniz.edu.tr

**Justina CHANKINIENĖ:** *lecturer at Panevėžio kolegija/State Higher Education Institution, Lithuania*.
**Areas of scientific interests**:
**E-mail:** justina.chankiniene@panko.lt

**Dmitrij CHARUNOV:** *student; Klaipedos valstybine kolegija / Higher Education Institution, Electrical and Automation Engineering study program, Lithuania*.

**Areas of scientific interests**:
**E-mail:** dmi.charunov@kvkedu.lt

**Daiva ČAPLIKIENĖ:** *lecturer at Kolping Higher Education Institution, Lithuania.*
**Areas of scientific interests**:
**E-mail:** daivac981@gmail.com

**Miglė Eleonora ČERNIKOVAITĖ:** *lecturer, Vilniaus kolegija/ Higher Education Institution, Lithuania*.
**Areas of scientific interests**:
**E-mail:** migle.cernikovaite@panko.lt

**Aurimas ČESNULEVIČIUS:** *Assoc. Prof. Dr. at Panevėžio kolegija/State Higher Education Institution, Kaunas university of technology Panevėžys Faculty of Technologies and Business, Lithuania*.
**Areas of scientific interests**:
**E-mail:** aurimas.cesnulevicius@panko.lt

**Oğuzhan DALMAZ:** *master degree and Specialist; Kumluca Chamber of Commerce and Industry, Coordinator of International Relationship, sustainable tourism, sustainability, Turkey*.
**Areas of scientific interests**:
**E-mail:** oguzhan@kumlucatso.org.tr

**Iker DIAZ ELIPE:** *student; Universidad del País Vasco UPV/Euskal Herriko Unibertsitatea EHU & Klaipedos valstybine kolegija / Higher Education Institution, Lithuania.*
**Areas of scientific interests**:
**E-mail:** ger.noreikaite@kvkedu.lt

**Vida ELIJOŠAITIENĖ:** *lecturer at Panevėžio kolegija/State Higher Education Institution, Lithuania*.
**Areas of scientific interests**:
**E-mail:** vida.elijošaitiene@panko.lt

**Rasa GLINSKIENĖ:** *Assoc. Prof. Dr.; Panevėžio kolegija/State Higher Education Institution, Lithuania*.
**Areas of scientific interests**:
**E-mail:** rasa.glinskiene@panko.lt

**Danas GARUCKAS:** *Assoc. Prof.; of Panevėžio kolegija/State Higher Education Institution, Lithuania*.
**Areas of scientific interests**:
**E-mail:** danas.garuckas@panko.lt

**Daiva JANKAUSKAITĖ:** *lecturer at Panevėžio kolegija/State Higher Education Institution, Lithuania*.
**Areas of scientific interests**:
**E-mail:** daiva.jankauskaite@panko.lt

**Haritz Dominguez JARAMILLO:** *student; Universidad del País Vasco UPV/Euskal Herriko Unibertsitatea EHU & Klaipedos valstybine kolegija / Higher Education Institution, Lithuania*.
**Areas of scientific interests**:
**E-mail:** d.stanelyte@kvk.lt

**Mantas JAUGELAVIČIUS:** *student; Klaipedos valstybine kolegija / Higher Education Institution, Lithuania*.
**Areas of scientific interests**:
**E-mail:** man.jaugelavicius@kvkedu.lt

**Reda JONUŠAUSKIENĖ:** *lecturer at Panevėžio kolegija/State Higher Education Institution, Lithuania*.
**Areas of scientific interests**: Application of information and communication technologies (ICT) in education, studies on the need for education professionals
**E-mail:** reda.jonusauskiene@panko.lt

**Kristina KAROSEVIČIENĖ:** *Head of the economic and business center at Kolping Higher Education Institution, Lithuania.*
**Areas of scientific interests:**
**E-mail:** k.karoseviciene@gmail.com

**Jovita KAUPIENĖ:** *lecturer at Panevėžio kolegija/State Higher Education Institution, Lithuania*.

**Areas of scientific interests**:
**E-mail:** jovita.kaupiene@panko.lt

**Lina KAZOKIENĖ:** *lecturer at Panevėžio kolegija/State Higher Education Institution, Lithuania*.
**Areas of scientific interests**:
**E-mail:** lina.kazokiene@panko.lt

**Indrė KNYVIENĖ:** *lecturer at Kauno kolegija / Higher Education Institution, Lithuania*
**Areas of scientific interests**:
**E-mail:** indre.knyviene @go.kauko.lt

**Lilija KRYŽEVIČIENĖ:** *lecturer at Panevėžio kolegija/State Higher Education Institution, Lithuania*.
**Areas of scientific interests**:
**E-mail:** lilija.kryzeviciene@panko.lt

**Gustas KUNIGONIS:** *student at Panevėžio kolegija/State Higher Education Institution, Lithuania*.
**Areas of scientific interests**:
**E-mail:** gustas.kunigonis@panko.lt

**Ingrida KUPČIŪNAITĖ:** *lecturer at Panevėžio kolegija/State Higher Education Institution, Lithuania*.
**Areas of scientific interests**:
**E-mail:** ingrida.kupciunaite@panko.lt

**Sigitas LAURINAVIČIUS:** *lecturer at Panevėžio kolegija/State Higher Education Institution, Lithuania*.
**Areas of scientific interests**:
**E-mail:** sigitas.laurinavicius@panko.lt

**Jurgita LIEPONIENĖ:** *Assoc. Prof.; of Panevėžio kolegija/State Higher Education Institution, Lithuania*.
**Areas of scientific interests**: cloud computing, data mining, databases technologies
**E-mail:** jurgita.lieponiene@panko.lt

**Diana LIPINSKIENĖ:** *Assoc. Prof.; Panevėžio kolegija/State Higher Education Institution, Lithuania*.
**Areas of scientific interests**: human resource management and entrepreneurship
**E-mail:** diana.lipinskiene@panko.lt

**Jurgita MEŠKERIENĖ:** *social partner, Lithuania***.**
**Areas of scientific interests:**
**E-mail:**

**Diana MICEVIČIENĖ:** *assoc. Prof.; of Panevėžio kolegija/State Higher Education Institution, Lithuania*.
**Areas of scientific interests**: transport economy, sustainable transport and solutions for streaming logistic processes
**E-mail:** diana.miceviciene@panko.lt

**Gintarė MILČĖ:** *lecturer at Kolping Higher Education Institution, Lithuania***.**
**Areas of scientific interests:**
**E-mail:** gintare.milce@gmail.com

**Renata MILIŪNĖ:** *lecturer at Klaipedos valstybine kolegija / Higher Education Institution, Lithuania.*
**Areas of scientific interests:**
**E-mail:** renata.miliune@ktu.lt

**Robert MUSIAŁKIEWICZ:** *university professor*, *University of Applied Science in Wloclawek, Poland.*
**Areas of scientific interests:** education policy, public finance, higher education
**E-mail:** robert.musialkiewicz@pans.wloclawek.pl

**Gerda NOREIKAITĖ:** *student, Klaipedos valstybine kolegija / Higher Education Institution, Lithuania.*
**Areas of scientific interests:**
**E-mail:** ger.noreikaite@kvkedu.lt

**Oskaras PABRĖŽA:** *student, Klaipedos valstybine kolegija / Higher Education Institution, Lithuania.*
**Areas of scientific interests:**
**E-mail:** osk.pabreza@kvkedu.lt

**Rimanta PAGIRIENĖ:** *lecturer at Panevėžio kolegija/State Higher Education Institution, Lithuania*.
**Areas of scientific interests**:
**E-mail:** rimanta.pagiriene@panko.lt

**Lina PALIULIENĖ:** *lecturer at Kauno kolegija / Higher Education Institution, Lithuania*
**Areas of scientific interests**:
**E-mail:** lina.paliuliene@go.kauko.lt

**Alma PAUKŠTIENĖ:** *lecturer at Panevėžio kolegija/State Higher Education Institution, Lithuania*.
**Areas of scientific interests**:
**E-mail:** alma.paukstiene@panko.lt

**Kristupas PETRAUSKAS:** *student, Klaipedos valstybine kolegija / Higher Education Institution, Lithuania.*
**Areas of scientific interests:**
**E-mail:** kri.petrauskas@kvkedu.lt

**Danguolė PLUNGYTĖ:** *lecturer at Panevėžio kolegija/State Higher Education Institution, Lithuania*.
**Areas of scientific interests**:
**E-mail:** danguole.plungyte@panko.lt

**Birutė RAGALYTĖ:** *lecturer at Panevėžio kolegija/State Higher Education Institution, Lithuania*.
**Areas of scientific interests**:
**E-mail:** birute.ragalyte@panko.lt

**Aušra RUDŽIANSKIENĖ:** *lecturer at Klaipedos valstybine kolegija / Higher Education Institution, Lithuania.*
**Areas of scientific interests**:
**E-mail:** a.rudzianskiene@kvk.lt

**Gediminas SARGŪNAS:** *Assoc. Prof. Dr.; Director of Panevėžio kolegija/State Higher Education Institution, Lithuania*.
**Areas of scientific interests**: corporate social responsibility, stakeholder management, business processes and planning
**E-mail**: gediminas.sargunas@panko.lt

**Justina STALIORAITYTĖ:** *graduate of the Oral Hygiene Care study program of the Faculty of Health Science Klaipėdos valstybinė kolegija /Higher Education institution, Lithuania*.
**Areas of scientific interests:**
**E-mail:** stalioraityte@gmail.com

**Daiva STANELYTE:** *lecturer, Klaipedos valstybine kolegija / Higher Education Institution, Lithuanian Energy Institute, Lithuania.*
**Areas of scientific interests:**
**E-mail:** d.stanelyte@kvk.lt

**Sigita ŠIMBELYTĖ:** *Assoc. Prof.; of Panevėžio kolegija/State Higher Education Institution, Lithuania.*
**Areas of scientific interests**: administrative law
**E-mail:** sigita.simbelyte@panko.lt

**Karolis TOLEIKIS:** *student; Klaipedos valstybine kolegija / Higher Education Institution, Lithuania.*
**Areas of scientific interests**:
**E-mail:** kar.toleikis@kvkedu.lt

**Maryna TOPORKOVA:** *scientific researcher of Utenos kolegija/State Higher Education Institution, Lithuania.*
**Areas of scientific interests**: Protection of Human Rights
**E-mail:** m.toporkova77@gmail.com

**Dalia URBONIENĖ:** *lecturer at Panevėžio kolegija/State Higher Education Institution, Lithuania.*
**Areas of scientific interests**: Awareness of public opinion and interests, intercultural communication
**E-mail:** dalia.urboniene@panko.lt

**Dainius VAIČIULIS:** *doctor of Technology Sciences, the Associated Professor of Panevėžio kolegija/State Higher Education Institution, Kaunas university of technology Panevėžys Faculty of Technologies and Business, Lithuania*.
**Areas of scientific interests**:
**E-mail:** dainius.vaiciulis@panko.lt

**Jelena ZASCERINSKA:** *leading researcher at Centre for Education and Innovation Research, Riga, Latvia.*
**Areas of scientific interests**: educational research
**E-mail:** iizi.info@inbox.lv

**Vakaris ŽILINSKAS:** *student; Klaipedos valstybine kolegija / Higher Education Institution, Lithuania.*
**Areas of scientific interests**:
**E-mail:** vak.zilinskas@kvkedu.lt

**Sandra ŽUKAUSKIENĖ:** *lecturer at Panevėžio kolegija/State Higher Education Institution, Lithuania.*
**Areas of scientific interests**:
**E-mail:** sandra.zukauskiene@panko.lt

**Tadas ŽUKAUSKAS:** *master's student at Lund University, finance and financial economics, Sweden.*
**Areas of scientific interests**:
**E-mail:** ta4712zu-s@student.lu.se

**Renata ŽVIRELIENĖ:** *lecturer at Panevėžio kolegija/State Higher Education Institution, Lithuania.*
**Areas of scientific interests**: social sciences
**E-mail:** renata.zvireliene@panko.lt

**P A N E V Ė Ž I O  K O L E G I J A**

**T A I K O M I E J I  T Y R I M A I  S T U D I J O S E  I R  P R A K T I K O J E**
APPLIED RESEARCH IN STUDIES AND PRACTICE

**SCIENTIFIC JOURNAL**

**2024 No. 20**

ISSN 2029-1280
eISSN 2669-0071

Edition of 70 copies
Publisher
PANEVĖŽIO KOLEGIJA

Laisvės sq. 23, LT35200, Panevėžys, Lithuania
E-mail.: kolegija@panko.lt