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EDITORIAL

The 2025 edition of the *Journal of Education, Technology and Computer Science* is structured around three thematic sections addressing the integration of digital technologies into educational practice and research, with a particular emphasis on technology-mediated learning and teacher competencies in digital contexts.

The first section, *Selected Issues in Preschool Education*, explores early learning in digitally influenced environments. Contributions examine the relationship between foundational cognitive competencies–most notably spatial reasoning–and students' ability to process technical texts, as well as inquiry-based learning approaches implemented through exploratory play in preschool settings. The section concludes with a systematic synthesis of research on early childhood screen exposure (ages 0–3), drawing on empirical studies, meta-analyses, and international guidelines relevant to digital media use in early learning.

The second section, *Selected Issues in the Application of Information Technology in Education*, presents twelve articles focusing on emerging trends in digital culture and educational technology. Topics include the educational and social implications of influencer culture, analyses of high-risk online communities, and the challenges faced by youth in complex digital ecosystems. Several contributions address the role of artificial intelligence in educational media design, including user data analytics, speech synthesis, and computer vision technologies. The section concludes with studies on digital learning spaces and infrastructure in vocational IT education.

The third section, *Selected Issues in Teacher Education*, examines teacher preparation for digitally mediated learning environments. Contributions address cognitive load and multitasking in technology-rich learning contexts, comparative studies of teacher education models in Poland and Italy, and the use of quantitative and statistical methods in educational technology research. This section also presents a comparison of early childhood teacher education systems in Poland and Italy, using the University of Rzeszów and the Suor Orsola Benincasa University of Naples as case studies.

We encourage readers to engage in critical analysis and to prepare polemical texts in response to the diverse range of educational research topics presented in this quarterly journal.

PART ONE

SELECTED ISSUES IN PRESCHOOL EDUCATION

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PETER BEISETZER

Primary School Pupils' Comprehension of Technical Texts in the Context of Comprehension Level Research

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Abstract

The article addresses the issue of identifying and assessing the degree of connection between key competencies of primary school pupils, specifically spatial imagination and reading technical texts with comprehension. It provides a rationale for the chosen approach to the issue and outlines the strategic method used for processing the research data.

Keywords: spatial imagination, technical text, reading comprehension, research

Introduction

The issue of developing pupils' technical literacy is related to the question of why to pay special attention to reading comprehension within the teaching of the subject of Technology, if this area is already given attention through the development of reading competences. For example:

– teachers of Slovak language and literature – are responsible for the development of reading literacy and work directly with pupils on understanding various types of texts,

– researchers and experts in pedagogy and didactics – are engaged in the creation of methodologies, assessment and analysis of reading comprehension within the framework of national and international research (e.g. PIRLS, PISA).

The answer to this question lies in the fact that technical texts have specific characteristics that differ significantly from ordinary or literary texts. The main reasons are as follows:

1. Professional terminology – the text contains specific terms and symbols.
2. Precision – the text has the nature of a definition.

3. Logical structure – texts are organized step by step, with the sequence systematically following logic (instructions, procedures, calculations).

4. Text visualization – the text is linked with visual elements (diagrams, tables, charts, drawings) that need to be interpreted and connected with the text.

5. Practical application – solving technical tasks depends on understanding the text (technological processes, design activities, adherence to safety instructions).

6. Development of technical literacy – the ability to read and understand technical texts is part of technical literacy, which is important for performing technical professions as well as for everyday life.

7. Difficulty level – pupils who generally struggle with text comprehension need targeted support to understand technical content.

Understanding technical texts requires not only the ability to decode specialized terms and follow the logical structure of information but often also a well-developed spatial imagination. Technical texts commonly describe objects, processes, or mechanisms that are not immediately visible or accessible to sensory perception – for example, drawings, diagrams, assembly instructions for constructions, or technological procedures. Therefore, the pupils must not only verbally understand the text, but also visualize the spatial arrangement of elements, their shapes, dimensions and mutual relationships. Insufficient spatial imagination can significantly hinder the understanding of even well-formulated text. The assessment of the degree of correlation between spatial imagination and understanding of technical texts has become the subject of our interest within the framework of research activities supported by the VEGA 1/0055/24 Research of specific abilities and skills for reading comprehension in the subject of technology, taking into account the connection with the level of geometric and spatial imagination of elementary school pupils.

Characteristics and Justification of the Research

Based on the strategic intent, pupils' reactions to the differences between geometric and spatial imagination, as well as between educational and technical texts, will not be observed or evaluated. As a result, the research focus is simplified to concentrate on the relationship between spatial imagination and comprehension of technical texts. The defined research focus provided a basis for formulating research questions and hypotheses regarding a possible connection – specifically, the relationship between two cognitive abilities: spatial imagination (i.e., the ability to mentally manipulate geometric shapes and understand their spatial properties) and reading comprehension (i.e., the ability to understand and analyse the content of a text). The main research question is: How is the existing connection manifested – what is the degree of correlation between spatial imagination and the ability to read technical texts with comprehension? In defining the

research problem aimed at examining the degree of this correlation, the following key aspects are identified (specification of the research problem):

1. The relationship between cognitive abilities, i.e., to what extent spatial imagination as a specific cognitive skill is related to the ability to comprehend technical texts. (Does a higher level of spatial imagination contribute to more efficient processing of information in technical texts?)
2. Technical thinking requires the ability to read with comprehension, process spatial information, and logically integrate it. (To what extent does spatial imagination influence the ability to interpret and analyse technical texts and concepts?)
3. Correlation analysis (Can the level of spatial imagination predict or influence the level of text comprehension?)
4. Practical implications for education (The research findings may impact didactic approaches to teaching the subject of Technology). The research problem focuses not only on the quantitative analysis of the correlation between these abilities but also on the practical implications for education and the development of pupils' technical literacy.

The aim of the research is to analyse the relationship between spatial imagination and comprehension of technical texts among primary school pupils through correlation measurement. The formulation of hypotheses is based on the assumption that empirical verification will reveal the degree of correlation between spatial imagination and understanding of technical texts. It is assumed that spatial imagination positively influences the ability to comprehend technical texts – i.e., that Pearson's correlation coefficient (r) will indicate a strong positive correlation for both boys and girls. Based on this assumption, the following research tasks are derived:

1. To determine the level of spatial imagination while considering gender differences (boys vs. girls), and to evaluate the results statistically. We assume that no more than 60% of students will achieve a score higher than 60% on the spatial imagination test. Furthermore, we expect that boys will perform statistically significantly better than girls.
2. To assess the level of technical text comprehension while taking gender differences into account, and to analyse the results statistically. We assume that no more than 60% of students will score above 60% on the technical text comprehension test. We also expect boys to outperform girls with statistically significant results.
3. To determine the correlation between spatial imagination and technical text comprehension, taking gender differences into consideration, and to evaluate the correlation statistically. We hypothesize that the correlation will be positive, and we expect Pearson's correlation coefficient (r) to reach or exceed 0.5.

Correlation and Regression Analysis

After measuring the levels of spatial imagination and comprehension of technical texts (within a quantitative research framework), the results of these tests are paired – i.e., each pupils completes both tests in order to enable statistical analysis focused on:

A. Correlation coefficient – In correlation analysis, the variables spatial imagination and text comprehension are treated as equal, with no assumed direction of influence.

B. Regression analysis – In a simple linear regression model, the relationship is specified as follows:

a) Dependent variable (Y) = comprehension of technical text;

b) Independent variable (X) = spatial imagination.

Note: While there may appear to be a contradiction between correlation and regression, the difference lies only in the interpretation of the relationship between variables:

1. Correlation examines the relationship between two variables without implying causality. In correlation analysis, both variables are treated equally–i.e., we do not claim that one influences the other, only that a relationship exists between them.

2. Regression models the relationship between variables by using one variable (X) to predict the other (Y). The choice of independent and dependent variables is based on the hypothesis or practical interpretation. That is:

a) Our hypothesis is that spatial imagination may influence the ability to comprehend technical texts.

b) While regression does not establish causality, it allows us to predict how changes in spatial imagination might relate to changes in text comprehension.

c) Reversing the model (X = text comprehension, Y = spatial imagination) would not be logically meaningful in the context of our hypothesis.

If a causal relationship were to be examined (e.g., through experimental methods), spatial imagination would be treated as the independent variable and text comprehension as the dependent variable. Therefore, in a correlational study, it is methodologically appropriate to refer to two variables in a correlation analysis, rather than "dependent variables." The core research activities include the following:

1. Visualization of the relationship – data (scatter plot). Verifying the relationship between variables.

2. Calculation of the correlation coefficient (e.g., Pearson or Spearman coefficient):

a) Correlation represents a relationship between two variables (without distinguishing between dependent and independent variables), we do not label the correlation coefficient itself as a "traditional" variable (independent or dependent).

b) We determine the degree of relationship between spatial visualization and reading of technical texts.

c) We compare the results of boys and girls (analysis of differences between different pupils groups).

d) Possible conclusion: Pearson correlation coefficient $r = 0.65$ ($p < 0.001$), which indicates a moderately strong and positive correlation between spatial visualization and understanding of technical text.

To evaluate the interrelation between these two variables, the following approach is implemented:

1. The variables are treated as equivalent, i.e., one variable is not dependent on the other; they are considered equal in status (correlation does not imply causation).

2. Measurement of linear correlation between two interval or ratio variables – the use of Pearson's correlation coefficient (r). The value ranges from –1 to +1, where:

a) Strong positive correlation – as spatial imagination increases, reading comprehension also increases, i.e., $r \approx 1$ (the correlation value (r) is close to +1). There is a strong positive relationship between the level of spatial imagination and the ability to understand technical texts, i.e., pupils with better spatial imagination tend to have a better understanding of technical texts. This result supports the assumption that a higher level of spatial imagination is associated with better comprehension of technical texts.

b) Strong negative correlation – as spatial imagination increases, reading comprehension decreases, i.e., $r \approx -1$ (the correlation value is close to –1). A negative correlation may suggest that pupils with higher spatial imagination have poorer understanding of technical texts. Such a result requires further clarification through the analysis of additional variables.

c) No correlation – there is no linear relationship between the two variables, i.e., $r \approx 0$ (the correlation value r is close to 0). There is no strong linear relationship between these two variables. Comprehension of technical texts may be influenced by factors other than spatial imagination, such as prior experience. Therefore, it is necessary to examine additional factors and variables that may play an important role in text comprehension.

3. The data are non-parametric – the value ranges from –1 to +1; hence, Spearman's correlation coefficient is used (applied similarly to Pearson's).

4. Relationship – Correlation analysis indicates a relationship but not causality (to confirm causality, experimental methods must be used).

The evaluation of the correlation between spatial imagination and comprehension of technical texts represents a statistical analysis of the relationship between the results of two tests – the spatial imagination test and the technical text

comprehension test. Within the chosen analytical approach, the following hypotheses are tested through correlation analysis:

a) The correlation between spatial imagination and comprehension of technical texts will be positive, with the expectation that Pearson's correlation coefficient (r) will reach or exceed a value of 0.5.

b) As the level of spatial imagination decreases, the level of comprehension of technical texts will also decrease, and this trend is expected to occur in both boys and girls.

We evaluate the correlation (statistical data analysis) using Pearson's correlation coefficient for the following reasons:

- the processed variables are quantitative,
- there is a linear relationship between the variables,
- the evaluated data are on an interval scale,
- the analysed variables follow a normal distribution.

By calculating Pearson's correlation coefficient, we determine the degree of the relationship between spatial imagination and reading technical texts. The interpretation of the correlation coefficient values (values below zero are interpreted analogously for negative correlation) is as follows:

- 0.9 to 1.0: Very strong positive correlation,
- 0.7 to 0.9: Strong positive correlation,
- 0.5 to 0.7: Moderate positive correlation,
- 0.3 to 0.5: Weak positive correlation,
- 0 to 0.3: Very weak or no correlation.

3. Regression analysis – regression model ($Y = \beta_0 + \beta_1 X + \varepsilon$). This allows us to examine the predictive relationship between variables (spatial visualization and reading comprehension). We determine to what extent and how one ability predicts the other. This is a simple linear regression (spatial visualization and understanding of technical text). Regarding the selection of the regression model (simple linear regression), we note the following:

a) We examine to what extent one ability (e.g., spatial visualization) predicts the other (understanding of technical text).

b) Multiple regression will not be conducted, i.e., other factors that may influence text comprehension (e.g., language skills, prior experience, etc.) will not be taken into account.

c) Interpretation of results – results will be explained through:

- Regression coefficient (β) – indicates the strength and direction of the relationship between variables:
  - β_0 = intercept (the value of Y when X = 0);
  - β_1 = regression coefficient (how much Y changes when X increases by one unit);
  - ε = error term of the model.

- Coefficient of determination (R^2) – expresses the percentage of variability in one variable that can be explained by the other (explained variability).
- Statistical significance of the relationship – p-value.

d) Possible conclusions:

- If the β coefficient is positive and statistically significant, it means that higher spatial visualization likely leads to better understanding of technical text.
- If β is close to zero or not statistically significant, it indicates that the relationship is weak or nonexistent.
- Regression model: each 1-point increase in spatial visualization increases technical text comprehension by 0.58 points.
- R^2 value = 0.42, which means that 42% of the variability in text comprehension is explained by spatial visualization.

Conclusion

The direction and purpose of the research are determined by the research strategy and clearly defined objectives. The strategy was designed to ensure the following:

1. Logical consistency of the research process, i.e., systematic progression and coherence across the individual phases.
2. Adaptive flexibility, allowing for adjustments to the approach based on ongoing empirical findings.
3. Optimal utilization of available resources – including material, human, and temporal resources.

Reading technical texts with comprehension represents a key component of technical literacy, and its importance is growing in the context of several current educational challenges:

1. Lifelong learning – the ability to independently search for, interpret, and apply information is a fundamental prerequisite for success in both further education and practical life. The absence of this competence significantly limits an individual's developmental potential.
2. Development of critical thinking – text comprehension goes beyond basic decoding and includes interpretation, analysis, and evaluation of content. These processes directly support the development of cognitive abilities that underlie critical thinking, including the ability to ask questions and verify information.
3. Development of cross-curricular competencies – reading comprehension is a transversal skill applicable across various educational domains, contributing to pupils' overall educational success.
4. Prevention of academic failure – early diagnosis and targeted development of the ability to understand technical texts are crucial for ensuring balanced cognitive development and successful educational progress in pupils.

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Analysis of Inquiry-Based Activities in Pre-Primary Education

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Abstract

The study focuses on the analysis of inquiry-based activities in pre-primary education, with an emphasis on working with small materials. The theoretical part defines the objectives of the inquiry-based approach, the metacognitive development of the child, and the teacher's role in inquiry-based teaching. Children's inquiry activities and their cognitive development are analyzed by an observer. Specific inquiry-based activities were carried out using small materials in a selected kindergarten.

Keywords: technical education, inquiry-based approach, pre-primary education

Introduction

Building on the insights of both domestic and international scholars, as well as findings from scientific studies (Droščák, Fuchsová, Rochovská, 2024; Gunčaga, Severini, Totkovičová, 2024; Dostál, Kožuchová, 2016; Pavelka et al., 2019; Stebila et al., 2022; Stebila, Hatvanyi, 2022), it has been confirmed that any effort to foster interest in technical education should be grounded in the natural curiosity of children and their specific learning needs. Technical education should be contextualized within everyday situations and closely interconnected with other subject areas through an interdisciplinary approach. Children should learn primarily through observation, experimentation, and hands-on inquiry. Technical education provides an effective learning environment that enables teaching and

learning processes to adapt to the current needs of society. Education systems must remain flexible and capable of responding to rapid advances in science and technology, which necessitates the continual search for innovative instructional methods and forms. For these reasons, it is essential to determine what kind of technical education today's younger generations should receive.

This study focuses primarily on addressing current challenges related to the implementation of an inquiry-based approach in technical education. The essence of the "scientific method" in education lies in teaching that is inquiry oriented. In pre-primary education, it is grounded in the principle of relatively independent exploration of reality by children through active engagement in learning activities. Among the main objectives of the inquiry-based approach in early childhood education are the development of foundational critical thinking and metacognitive skills.

Metacognition refers to the capacity to be aware of and reflect upon one's thinking – essentially, "thinking about thinking" (Zelina, 2019). In the context of inquiry-based learning, metacognitive development plays a pivotal role because it encourages children to become aware of their cognitive processes and learning strategies, and to regulate and refine them actively. An inquiry-based approach particularly supports the development of skills essential for planning and monitoring one's learning – skills that are closely tied to both metacognitive awareness and critical thinking (Hlásna, 2018).

All processes within inquiry-based learning are inherently linked to the development of creative thinking, as creativity is intertwined with inquiry. When children become aware of their thought processes, they are better able to generate new ideas and explore unconventional solutions. Additionally, inquiry-based learning promotes the growth of communication skills. Children learn to clearly articulate their ideas, justify their reasoning, and persuade others during collaborative group activities, since inquiry-based learning is typically conducted in a team setting. Similar to what we can observe when applying role-playing games. (Wouters, Van Nimwegen, Van Oostendorp, Van Der Spek, 2013). Metacognitive development within the inquiry-based approach aims to empower children for autonomous learning and effective adaptation to life's challenges now and their future (Pintrich, 2002).

The aim of this qualitative study is to explore how inquiry-based activities using small materials support the development of children's metacognitive, creative, and critical thinking skills in pre-primary education. Specifically, the research seeks to analyze how children plan, test, and reflect on their learning during hands-on inquiry tasks in a kindergarten setting.

Research Methodology and Tools

In our research, we employed a qualitative case study approach (Yin, 2018) with elements of action research (Kemmis, McTaggart, Nixon, 2014), focusing on the observation and analysis of inquiry-based activities carried out in a pre-primary classroom. The methodological design was based on naturalistic and participant observation (Creswell, Poth, 2018; MacNaughton, Rolfe, Siraj-Blatchford, 2010), combined with the use of documentation tools, e.g., child worksheets and observers' notes (Denzin, 1978). Children's verbal expressions and behaviors were analyzed to identify evidence of critical thinking, creativity, and metacognitive processes (Schraw, Dennison, 1994; Whitebread, Coltman, Jameson, Lander, 2009). The educator's reflective analysis also contributed to the methodological triangulation of findings (Zeichner, Liston, 2014).

A preschool teacher in the Slovak town of Budimír implemented the inquiry-based activities. The specific activities were designed in alignment with the national curriculum for the educational area *Human and the World of Work*. The observations were conducted in November 2024. The inquiry-based sessions were typically carried out with a group of ten children aged 5 to 6 years.

Inquiry-Based Activities in Classroom Practice

In the proposed set of activities, the focus was placed on the preparation and implementation of paper-based tasks, which represent an effective means of developing children's practical skills. These activities aim to enhance fine motor skills and hand-eye coordination. In addition, working with paper fosters the development of creativity, imagination, and spatial awareness in young children. Through various paper manipulation tasks, children also learn about the properties of this material and its diverse applications in everyday life.

Activity 1: "Pinwheel"

This activity aimed to select a suitable small material and use it to create a functioning pinwheel, drawing on children's prior experience (they had previously made a paper pinwheel). The objective was to compare and evaluate which material would be more suitable for constructing a pinwheel. Children were encouraged to apply their creative thinking without being provided with a predetermined procedure. Subsequently, they tested their designs in the school yard to observe under which conditions the pinwheel would spin or remain still, and to explore the circumstances that influenced its motion.

Activity procedure

The teacher's individual questions, along with selected responses from the children, were systematically arranged in tabular form.

Table 1. Introduction to the activity

T*: “Look at the table, children. What do you see on it?”	Ch*1: “A bottle cork, wire.” Ch9: “A string and beads.” Ch3: “All kinds of stuff — beads, feathers…” Ch5: “There are two big sticks, too.”

* T – teacher; Ch – Child

From the observer’s notes:

The children’s responses reflect their current level of knowledge. The children attempt to name as many materials as possible. Child Ch3 demonstrates this by using the expression “all kinds of stuff,” indicating a desire to identify a wide range of items. Child Ch5 notices two thicker sticks on the table and perceives their potential use in the upcoming activity. The children observe the materials, touch and examine the objects on the table, and begin to reflect on what they might create from them.

Table 2. Open-ended (generative) question

T*: “What could we use these materials for?”	Ch*1: “Beads for a necklace.” Ch10: “The wire for something we wanna stick on… like to a stick.” Ch7: “Flowers for decoration.”
T: “And what could we use feathers for?"	Ch8: "For a carnival mask." Ch10: "For an Indian headdress." Ch7: "For dream catchers."

* T – teacher; Ch – Child

From the observer’s notes:

These responses indirectly indicate the children’s ability to formulate hypotheses and consider alternative possibilities. The children’s creative suggestions surprised even the teacher, particularly their ideas involving colorful feathers. The mention of a “dreamcatcher” was the most unexpected response; however, Child Ch7 later explained that they have a dreamcatcher made of colorful feathers at home, as her mother believes that peacock feathers help capture pleasant dreams. Six-year-old children exhibit a high level of creativity, often linked to their ability to integrate information from diverse sources.

Table 3. Inquiry-based reasoning question

T*: “Can we make a pinwheel like the one we made before with all these things?”	Ch*1: "No, because we made the pinwheel from paper." Ch7: "And we drew on it." Ch6: "Probably just some of it.”

* T – teacher; Ch – Child

From the observer's notes:

The children recalled a paper pinwheel they had previously decorated with colored pencils. They did not consider the materials on the table suitable for making a wind pinwheel. Child Ch5 remembered that there were two thicker sticks and a piece of wire. To help the children evaluate the suitability of the available materials for building a pinwheel, the teacher distributed worksheets. The children were asked to reflect on whether each material could be used to construct a functioning pinwheel. Their assumptions were recorded on the worksheet: if they believed a material was suitable, they marked a circle in the box with a smiling face; if they thought the material was unsuitable, they circled the box with a sad face.

Table 4. Guiding questions

T*: "How do we begin making a pinwheel?"	Ch*10: "We'll put the stick and the wire together."
T: "How do we put together them? "	Ch4: "We'll wrap the wire around the stick and leave one end sticking out."
T: "What will our next step be? "	Ch5: "Let's poke the cork onto the wire." Ch2: "Let's poke the feathers into the cork."

* T – teacher; Ch – Child

From the observer's notes:

Children at the age of six are already capable of developing a sequence of steps necessary to achieve a specific goal. In this case, they followed the suggestion provided by Child Ch10. The child focused on the basic components of the construction and understood that connecting these two elements was essential for creating the pinwheel. Child Ch4 began offering more specific instructions and recognized that the wire needed to be attached to the stick in a particular way to serve as the pinwheel's axis. Child Ch5 understood that the cork was another important structural element and demonstrated awareness of where it should be placed. Child Ch2 reflected on the functionality of the individual components and recognized that the feathers were necessary for the pinwheel to spin. With the help of the teacher's guiding questions, the children were able to break down a complex task into more straightforward steps and identify the required materials. They formed a mental image of the final product and were able to anticipate how the different parts would work together. The teacher allowed the children to test their ideas in practice. Some children inserted the feathers into the cork, but when they tried to make the pinwheel spin, it got stuck and did not rotate properly.

Table 5. Problem-solving question

T*: "What could we do to help the pinwheel spin better?"	Ch*4: "I think that if we put a bead in there, it will spin better." Ch2: "I think so too. I had a plastic pinwheel, and there was a bead in it." Ch1: "I agree."

* T – teacher; Ch – Child

From the observer's notes:

The children added one bead in front of and one behind the cork stopper. They drew on their prior experience with making a paper pinwheel as well as their familiarity with a plastic toy version. Finally, Child Ch7 suggested twisting the wire to prevent the beads from falling off. This revealed that Ch7 has great technical thinking, but is also generous, as the suggestion was shared with the other children as well.

Table 6. Descriptive question

T*: "What's left on the table?"	Ch*1: "Flowers." Ch8: "Oh, the letters are still there."

* T – teacher; Ch – Child

From the observer's notes:

The children discussed how they could attach flowers and leaves to the pinwheel. Child Ch8 suggested gluing them onto the cork. At this point, Child Ch4 recalled that when feathers had previously been glued to the cork, the pinwheel had great difficulty spinning. Based on that earlier experience, the children began to consider an alternative solution. They concluded that attaching the flowers and leaves using wire would likely be more effective. The teacher intentionally included an item that was not necessary for constructing the pinwheel. The children correctly identified that the string did not belong. In the final phase, they recorded the verified materials needed for the pinwheel construction on their worksheets and compared these findings with their initial assumptions. Children whose predictions matched the outcome expressed great joy and a sense of accomplishment. Conversely, those whose assumptions were not confirmed felt disappointed and frustrated. The teacher reassured them by explaining that even scientists do not always get their predictions right – and that such experiences provide valuable lessons for further inquiry.

Outdoor Inquiry Activity: "Why Does It Spin or Not Spin?"

The children were eager to test their completed pinwheels in the schoolyard. During outdoor time, the teacher continued to pose additional questions.

Table 7.

T*: "What did we have to do to get the propeller spinning?"	Ch*10: "We had to blow on it." Ch9: "We ran with it!" Ch2: "It twisted when the wind blew."

* T – teacher; Ch – Child

From the observer's notes:

Child Ch10 was the first to recall that they had to blow on the pinwheel, as there was no wind outside. However, not all children chose to blow–some ran around the yard with the pinwheel, and their movement caused it to spin. Child Ch9 later recalled this observation. Ideally, when the wind is blowing, there is no need to blow on the pinwheel or move quickly; the air current alone makes it spin. That is why it is called a wind pinwheel.

Table 8.

T*: "Why does the propeller spin when the wind blows?"	Ch*3: "...because the wind is blowing on it." Ch6: "The wind blows into the pinwheel." Ch10: "The air is moving." Ch7: "Sometimes the wind blows hard, and then the pinwheel spins fast."

* T – teacher; Ch – Child

From the observer's notes:

The children's responses show that even six-year-olds can think about natural phenomena and come up with simple explanations. They start to grasp cause-and-effect relationships. In Child Ch3's reaction, we see an emerging awareness of the link between wind and the movement of the pinwheel, even though the child cannot yet explain how the wind makes it turn. Child Ch6's answer is a bit more detailed, hinting at an emerging understanding that wind is basically moving air.

Table 9.

T*: "Have you seen such a large wind propeller anywhere?"	Ch*1: "Yeah, when we were in Austria, they were super tall and spinning around." Ch7: "I saw it in the fairy tale Perinbaba."

* T – teacher; Ch – Child

From the observer's notes:

Child Ch1 recalls a real-life experience involving a large wind turbine and links it to a specific location (Austria), which shows developing concepts of space and time. Child Ch7 talks about a fairy tale. It's important to understand that at this age, children may not fully distinguish between reality and fantasy. They are actively trying to understand the world around them and build mental models of how it works. The teacher explained to the children that wind energy can be used for various practical purposes.

Educational strategies

From the observer's notes:

The educational strategies, aligned with the learning objectives and the nature of the activity, included guided conversation through questioning

techniques, the use of individual recording sheets, collaborative work on a product combined with critical evaluation, as well as observation and experimentation with a pinwheel (focused on the conditions under which the pinwheel spins).

Teacher's Reflection

The length of the learning activity matched a typical lesson; however, it needed more flexibility during its execution. Building the wind pinwheel took place both indoors and outdoors, as the children tested and observed its rotation in real conditions. They experimented and explored different ways to make the pinwheel spin. The activity was not only fun for the children but also offered meaningful learning opportunities through their critical thinking, hands-on involvement, and direct experience. In the future, it could be beneficial to visit the only preserved windmill in Slovakia, located in Holíč (Trnava District).

Reflective Evaluation by the Observer

Difficulty and Level of Activities: The selected activities were suitable for the children's age and prior experience. Although the children had previously made paper pinwheels, this activity challenged them to build a pinwheel using various small materials. At first, their assumptions were imprecise; however, as the activity went on, their hypotheses became more accurate and more closely matched reality. This gradual change shows the activity's effectiveness in encouraging inquiry-based thinking skills.

Motivation and Interest in the Activities: The children demonstrated strong engagement with the task of constructing a pinwheel from materials other than paper. The colorful feathers sparked great interest, as most of the children had never encountered them before. They expressed a desire to use all the materials provided and were disappointed when a piece of string remained unused. Some suggested wrapping it around the stick to include it in the design. When the pinwheel did not function as expected, the children experienced disappointment, yet they actively explored solutions to improve the design (e.g., adjusting how feathers were attached to the cork), which they eventually achieved. The children showed exceptional interest in experimenting with the conditions that affected the pinwheel's motion outdoors. These moments aroused their curiosity and encouraged further exploration.

Educational Strategies: The cognitive development of six-year-old children is active, characterized by emerging abilities in critical thinking, curiosity, and understanding cause-and-effect. The teacher effectively used a variety of teaching methods, including observation, guided discussion, and alignment with the learning goals. The children were prompted to observe closely, which boosted their

critical thinking skills and experimentation. The activity and assessment also promoted teamwork, as children shared ideas and discussed their findings. Using individual recording sheets further improved their communication and analytical skills by helping them question their assumptions and reflect on what they observed.

Time Allocation

The inquiry-based activity was well suited to the available timeframe and was successfully finished within 40 minutes. This duration was selected based on the children's developmental stage and attention span (ages 5–6), ensuring consistent engagement and reducing fatigue – both of which helped the activity succeed.

Discussion

The inquiry-based approach has a significant impact on the metacognitive development of children, as it actively engages them in thinking about their cognitive processes. Throughout the activities, children are consistently encouraged to plan their steps, monitor their progress, and reflect on what they have learned. For example, when experimenting with the rotation of a pinwheel, they are guided to formulate predictions before the investigation and later compare those with actual outcomes. This process helps them become aware of how their thinking and learning evolve.

Inquiry activities directly foster the development of critical thinking, as children are required to analyze, evaluate, and synthesize information gathered through experimentation. For instance, when comparing the motion of the pinwheel under different conditions, they must critically assess the factors influencing its rotation – such as fast movement, twisting, or the effect of wind force. These discoveries are connected to broader theoretical frameworks. Through this process, children not only receive information but also learn to question, verify, and explore logical relationships between ideas.

Working with small and varied materials in inquiry-based activities also stimulates children's creativity. They learn to manipulate materials with different properties and experiment with their use, which enhances their ability to think beyond conventional frameworks, search for alternative solutions, and generate innovative ideas. In such activities, children identify problems (e.g., why the pinwheel fails to spin under certain conditions) and explore ways to resolve them.

Moreover, the inquiry-based approach fosters interdisciplinary learning. Over time, children develop a deeper understanding of the connections between various fields, such as science, technology, mathematics, and the arts. These links significantly enhance their overall development through interdisciplinary integration.

Conclusions

Children's responses to teachers' questions offered a fascinating insight into their thinking processes and demonstrated that even at the pre-primary level, they are capable of complex and analytical reasoning. Their ability to break down a task into individual steps, plan sequences of actions, and verbalize their thinking represents a foundational element for further cognitive development (Whitebread et al., 2009).

Implementing inquiry-based learning (IBL) in early childhood education presents both challenges and significant opportunities. Research suggests that the successful implementation of IBL requires the systematic development of teacher competencies already during pre-service teacher education (MacNaughton et al., 2010). This includes not only theoretical knowledge but also practical experience in applying inquiry-based methods in real educational settings (Harlen, 2013).

The effective use of inquiry-based activities depends on creating supportive learning conditions, including smaller group sizes and access to adequate materials and time (Larkin, 2012). Curricula for early childhood education should fully embrace the inquiry-based approach as a central element, rather than treating it as optional enrichment. When properly implemented, IBL allows children to explore and understand the world more deeply and holistically (OECD, 2017).

Inquiry-based learning has a profound impact on the development of metacognition, as it encourages children to reflect on their thinking processes, plan their actions, monitor their learning, and evaluate outcomes (Schraw, Dennison, 1994). For instance, when experimenting with the construction and motion of a pinwheel, children were guided to formulate predictions, test them, and reflect on the outcomes, thus strengthening their self-regulation and planning strategies (Veenman, Van Hout-Wolters, Afflerbach, 2006).

IBL also directly supports the development of critical thinking. As children compare results under different conditions and search for causal explanations, they learn to question assumptions, evaluate evidence, and identify patterns. These activities train them to draw conclusions based on logical reasoning and evidence, which are key aspects of critical thinking (Facione, 2011).

Moreover, working with varied materials in inquiry-based tasks stimulates creativity. Children experiment with different textures, properties, and tools, and learn to generate original ideas and innovative solutions beyond conventional expectations (Craft, 2005). They learn to identify problems and explore multiple solutions – skills essential for success in future learning and life.

Importantly, IBL promotes autonomy and responsibility for learning. Children keep records of their hypotheses and results, develop organizational skills, and engage in collaborative decision-making – all of which support their academic and personal growth (Kuhn, 2000). Even fine motor development, often the focus of early technical education, can be nurtured through inquiry-based work with

small materials, promoting hand–eye coordination necessary for writing and other school tasks (Cameron et al., 2012).

Finally, inquiry-based learning encourages interdisciplinary thinking by connecting science, technology, engineering, arts, and mathematics (STEAM). Through integrated activities, children begin to recognize meaningful links between subjects and learn to apply knowledge across various domains, fostering a more comprehensive understanding of the world.

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Physical and Musical Activity of Preschool Children and Its Benefits for Their Development

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Abstract

Physical and musical activities are key determinants supporting the holistic development of preschool-aged children. Regular physical activity promotes balanced somatic, intellectual, emotional, and social growth, positively influencing the functioning of the nervous, circulatory, respiratory, and immune systems. Movement-based play and exercises enhance coordination, perseverance, independence, self-efficacy, and social integration. Musical activity – including singing, dancing, and rhythmic play – supports emotional, social, and cognitive development by improving memory, attention, auditory perception, and motor skills. The integration of movement and music in musical–movement activities intensifies cognitive processes, fosters imagination and creativity, and prepares children for school learning. Both forms of activity also perform preventive and therapeutic functions, promoting mental and physical health and shaping pro-social and pro-health attitudes.

Keywords: physical activity, musical activity, child development, preschool age, dance, musical–movement activities, coordination, emotions, cognitive development, preschool education

Introduction

Contemporary preschool education places strong emphasis on the comprehensive development of the child, encompassing physical, emotional, social, and cognitive domains. Among the most significant factors supporting this development are physical and musical activities, which naturally form part of a preschool child's everyday life. Both movement and music serve as fundamental means of self-expression, while simultaneously stimulating somatic, intellectual, and emotional growth.

Physical activity contributes to the proper functioning of the body by strengthening the muscular, skeletal, and circulatory systems, and by shaping both physical and mental resilience. Participation in movement-based play fosters social development through cooperation, adherence to rules, and the formation of positive self-esteem. Musical activity, which includes singing, dancing, and playing instruments, plays an equally important educational and therapeutic role. It stimulates cognitive processes, develops memory, attention, imagination, and linguistic abilities, and supports the acquisition of social competence.

The integration of movement and music in musical–movement activities enables the child to develop physically and mentally in a harmonious way, while cultivating emotional sensitivity and creativity. This article aims to highlight the importance of these two forms of activity in the context of preschool development and to identify the developmental benefits that arise from their implementation in early childhood education.

Subject of research

Physical activity has a significant and multidirectional impact on human health and quality of life. Primarily, it prevents postural defects in children, supports maintaining an appropriate body weight, aids in the reduction of adipose tissue in cases of overweight, and protects the body from numerous civilization-related diseases. Regular physical activity performed outdoors further strengthens immunity, promotes hardening of the body, and supports adaptive processes.

Motor activity contributes to reducing psychological tension and stress, improves emotional well-being, and in childhood serves as a kind of "energy reservoir" that the body draws from in later stages of development. It supports the proper functioning of internal organs and the circulatory, respiratory, nervous, and musculoskeletal systems. Furthermore, it shapes character, enhances psychological resilience, and strengthens the child's emotional competence (Maszorek-Szymala, 2010).

Regarding the aforementioned systems, movement increases joint mobility, flexibility, and elasticity of joint capsules and ligaments, promotes bone mineralization, strengthens tendons, and enhances lung vital capacity. Physical activity is also an essential factor supporting children's preparation for learning to read and write, as it improves visuomotor coordination and manual dexterity (Leżańska, Płóciennik, 2021).

Lack of physical activity leads to numerous negative health consequences, including reduced immunity, pulmonary efficiency, and overall adaptive capacity, as well as increased susceptibility to somatic diseases. Sleep disorders, digestive problems, and weakened cardiovascular function may also occur. Physical activity underpins proper cognitive development, enables school readiness, and facilitates adaptation to the educational environment.

During movement games and exercises, children integrate with peers, and by observing their capabilities, they form realistic self-assessment, influencing personality development. As physical fitness improves, the child gains confidence in their abilities, becomes more independent and self-reliant, and experiences joy, satisfaction, and a sense of accomplishment. Physical activity increases self--confidence, reduces fear and emotional tension, and also serves a preventive function by protecting against obesity and other chronic diseases (Maszorek--Szymala, 2010).

Alongside a balanced diet, physical activity is a fundamental component of obesity therapy, as it increases energy expenditure. The type and intensity of exercises should be adjusted to the individual capabilities and fitness levels of the child (Kubica, 2008).

Motor activity influences the development of:

– Somatic system – stimulates muscle development, ensures proper body mass gains, and guarantees harmonious physical growth;
– Intellectual system – enables problem-solving and supports understanding of phenomena and environmental elements;
– Psychological system – teaches experiencing success and failure, coping with stress and fatigue, and regulating emotions;
– Social system – fosters interpersonal relationships, adherence to rules, self-control, and respect for others (Trzcionka-Wieczorek, 2019).

Motor fitness also significantly affects the development of mathematical skills, as these develop during spatial activity. Preschool children with higher motor fitness "probably have greater abilities to process more complex concepts, including letters and numbers" (Witkowska, Gut, 2018, p. 141).

Movement games enhance the child's overall psychophysical fitness, with key benefits including:

– fulfilling the natural need for movement and creating a joyful atmosphere;
– strengthening immunity and physical efficiency;
– developing courage, independence, and creativity;
– fostering confidence in one's abilities and stimulating imagination;
– teaching cooperation and adherence to social norms;
– improving spatial orientation, direction and distance assessment;
– developing observation skills, logical and strategic thinking (Wlaźnik, 1996).

Walks and excursions as forms of physical activity combine learning and play, satisfying children's cognitive needs, allowing observation and experience, and enriching emotional experiences. They also foster cooperation, empathy, respect for nature, and independent thinking (Karbowniczek, Kwaśniewska, Surma, 2011).

Research published in 2006 in the *Journals of Gerontology Series A: Biological and Medical Sciences* demonstrated that physical activity stimulates neurons, leading to denser neural networks, which is crucial for cognitive development. Learning and memory processes are more efficient with a greater variety of physical activities (Koprowiak, 2020).

Dance, which can be classified as both a physical and musical activity, has particularly beneficial effects on the psychophysical development of children. It enhances overall motor fitness, strengthens muscles, develops the nervous system, and improves motor coordination. Dancing also increases endorphin levels, enhancing mood, reducing emotional tension, and generating feelings of joy.

Children who dance, clap, stomp, or sing consolidate kinesthetic-motor patterns, supporting motor memory development and sensory integration. Dance shapes character traits such as patience, perseverance, resistance to fatigue, and enhances memory, imagination, attention, and perceptiveness (Górniok-Naglik, 2000).

Music-movement activities serve two main functions: musical education and general development. They foster a sense of rhythm and musicality while stimulating cognitive processes, promoting abstract thinking, attention, and language competence (Ławrowska, 2003).

Music is a crucial factor supporting child development–it enhances concentration, memory, problem-solving, and teaches emotional regulation. Since rhythms in music correspond to life rhythms (e.g., day-night cycles, seasonal changes, daily rituals), musical and rhythmic play positively affects children's mental and physical health.

Music allows emotional expression, reduces tension, and strengthens positive emotional experiences (Podolska, 2008). This is especially evident during dance, playing instruments, or singing, which combine movement, expression, and play.

Musical activity develops visuomotor and auditory-motor coordination, preparing the child for reading and writing. Depending on the type of music, it may have a stimulating or relaxing effect – calm music promotes focus and relaxation, while rhythmic and dynamic music activates the nervous system and cognitive processes.

During dance and singing, the child's nervous system and muscles are strengthened, and breathing efficiency improves (Leżańska, Płóciennik, 2021). Singing activities support memory and rhythm development, whereas movement to music enhances imagination, coordination, and motor memory (Gandziel, 2015).

Broadly understood, musical activity promotes holistic child development. Singing improves respiratory and vocal apparatus functioning, while various musical activities enhance motor fitness.

Rhythmic and dance activities using large muscle groups develop coordination, movement fluidity, and motor planning abilities. Activities involving

clapping, snapping fingers, or playing simple instruments develop fine motor skills, while rhythmic-motor exercises enhance strength, endurance, and flexibility (Ławrowska, 2003).

Music strongly affects the child's emotional sphere. Early contact with music may create a lifelong need for engagement with music.

Musical activity supports the development of social and moral attitudes, teaches cooperation, empathy, and respect for others, and fosters responsibility for shared group achievements (Wojtanowska-Janusz, 2014). Music develops listening skills, cultural and social understanding, and verbal expression (Górniok-Naglik, 2000).

Music activities support group integration, allow emotional release, and are particularly valuable for shy or withdrawn children, facilitating social interaction, and for hyperactive children, helping them calm and relax (Sienkiewicz-Wilowska, 2012).

During collective musical activities, children learn to understand others' emotions, recognize diversity in experiences and perspectives, and engage in creative musical improvisation using props like ribbons or scarves (Woźniczka, 2010).

Musical activity requires differentiating sounds, enhancing auditory perception while also improving physical fitness, as music-based activities demand responses to tempo, rhythm, and dynamics.

Playing instruments reduces motor clumsiness, and singing or playing wind instruments strengthens the respiratory system and improves speech organs. Dance develops the body, increases flexibility, speed, strength, and endurance.

Music stimulates imagination, enriches the child's inner life, and refines perceptual abilities. Consequently, memory, attention, and concentration improve. Music education affects all developmental areas and serves a preventive function, reducing risks of social competence deficits (Wojtanowska-Janusz, 2014).

Learning songs expands vocabulary, develops phonological awareness, teaches rhythmization, and proper articulation, supporting reading and writing skills. Moreover, musical activity strengthens mathematical competencies by developing understanding of rhythm, time, sequence, order, and classification of objects (Majzner, 2015).

Conclusion

Physical and musical activities are integral to the holistic development of preschool children. Their role extends beyond recreation – they perform educational, preventive, and therapeutic functions that contribute to the child's overall well-being. Regular physical activity promotes proper somatic development, enhances body efficiency and coordination, and helps establish health-promoting habits. Musical activity, in turn, enriches auditory perception, stimulates cognitive

processes, and nurtures emotional and aesthetic sensitivity. Combining movement and music in daily preschool practice generates numerous benefits in emotional, social, and intellectual domains. Through such activities, children learn cooperation, self-control, empathy, and creative expression, which are essential for their balanced growth. Both forms of activity thus serve as powerful tools for supporting the child's holistic development and preparing them for further education and social life.

In conclusion, physical and musical activities should be considered indispensable components of preschool curricula, as they not only enhance motor skills and cognitive abilities but also foster pro-health, social, and emotional attitudes essential for lifelong development.

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KATARZYNA KOŁODZIEJCZYK

Implementation of Technical Education in Early Primary School: Analysis Based on Empirical Research

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Abstract

This article presents an analysis of key aspects of technical education in grades 1–3 of primary school in Poland, based on a study conducted among teachers and students in early primary education. The findings indicate that although children generally enjoy technical classes, such lessons are often held infrequently. The results also show that teachers attempt to meet the requirements of the core curriculum, yet they encounter obstacles arising from insufficient preparation, limited resources, or inadequate facilities. The article is based on the master's thesis: Kołodziejczyk (2024). The implementation of technical education in grades 1–3 of primary school in the light of own research University of Rzeszów.

Keywords: technical education, early childhood education, teacher preparation, student engagement, core curriculum, primary school

Introduction

The modern world is developing at a rapid pace, and many changes that seemed unattainable only a decade ago have become part of everyday life. Artificial intelligence, once associated exclusively with theoretical considerations and science fiction, is now widely applied in fields such as medicine, design, special effects, and data analysis (Patrzyk, Woźniacka, 2022).

The appearance of the 21st-century world is largely shaped by technological development. This era is characterized by dynamic progress, which creates the need for individuals to learn about technology from an early age – beginning in preschool and early school education. Teachers at these stages are obligated to implement the core curriculum, which requires them to teach technology using

methods appropriate to children's developmental needs. Although the idea is correct, practical experience suggests that it is not always implemented effectively, which motivated the present research.

In 2024, I conducted a study subjected to both quantitative and qualitative analysis. Its aim was to examine what technical education looks like in practice in grades 1–3 of primary school. Research tools were designed to obtain the most precise data. The procedures, results, and conclusions are presented in this article.

Subject of Research

The subject of the study was the implementation of technical education in grades 1–3 of primary school. The theoretical and cognitive aim was to determine how teachers apply the core curriculum and whether their training equips them with the skills necessary to conduct classes adapted to students' needs and the rapidly changing world. The practical aim was to examine the actual state of technical education in early primary grades and identify methods of supporting teachers (Palka, 2010).

Methodology and Study Group Characteristics

The research used the diagnostic survey method and a questionnaire (Sztumski, 2005). A total of 108 female teachers from various regions of Poland participated. They differed in workplace location, professional experience, and grade level taught.

Research was also conducted among primary school students. Diagnostic surveys and observations were applied. Student participation across research stages is shown in Table 1. The participants were pupils from several schools in the Podkarpacie region.

Table 1. Summary of the number of students participating in each stage

	Grade	Number of children	Total
Interview	1	5	20
	2	7	
	3	8	
Drawing	1	2	15
	2	6	
	3	8	
Observation	1	5	19
	2	6	
	3	8	

Analysis of Survey Results

The teacher questionnaire consisted of 13 closed and semi-open questions addressing: 1) implementation of the core curriculum in grades 1–3; 2) teachers'

preparation for teaching technical education; 3) obstacles encountered during instruction; and 4) sources of ideas for technical classes.

Analysis showed considerable variation in curriculum implementation. Most teachers conduct at least one hour of technical classes per week, using methods suited to their students. However, 68.5% reported obstacles – most commonly safety concerns during practical activities.

A discrepancy appeared in responses regarding teacher preparation: some believed that university studies did not prepare them for technical education, while others stated the opposite. Many develop their skills through online courses and webinars, though a significant number do not. This raises concerns about burnout or systemic issues. Pedagogy requires continuous learning because curricula and teaching methods evolve constantly.

Teachers face challenges such as time-consuming preparation, insufficient facilities, and limited materials. Most obtain ideas for classes from the Internet, which facilitates planning but may reduce creativity and blur the boundary between art and technology. Technical classes should emphasize solving practical, technical problems rather than artistic tasks.

Students' Perceptions of Technical Education

Interviews revealed that students enjoy technical classes and remember the projects they created.

Examples of responses:

Table 2. Examples of answers to question 1 of the interview:
What are technology classes like, what do you do during them?

Child's response	Child's name	Grade
"My teacher has many great ideas. Recently, we made hovercraft models. It was easy. We inflated a balloon, attached it to a bottle cap, and then to a board. The teacher prepared everything in advance."	Martyna	3
"In technology class, we do experiments. Recently, we mixed water and salt in a jar, tied a string to a pencil, and now we have to wait a week."	Kalina	2

1. Martyna (Grade 3): "My teacher has many great ideas. Recently, we made hovercraft models. It was easy. We inflated a balloon, attached it to a bottle cap, and then to a board. The teacher prepared everything in advance."
2. Kalina (Grade 2): "In technology class, we do experiments. Recently, we mixed water and salt in a jar, tied a string to a pencil, and now we have to wait a week."

Students appreciated their teacher's creativity and clearly distinguished technical classes from other types of lessons. Drawings and descriptions of their favorite projects were also collected.

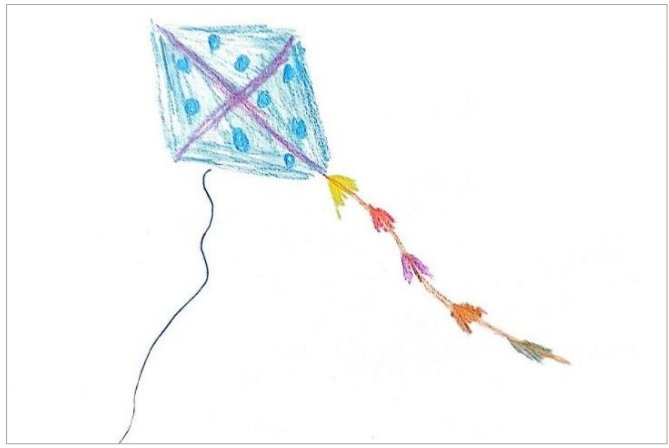

Figure 1. A kite made during class by Edyta (grade 3)

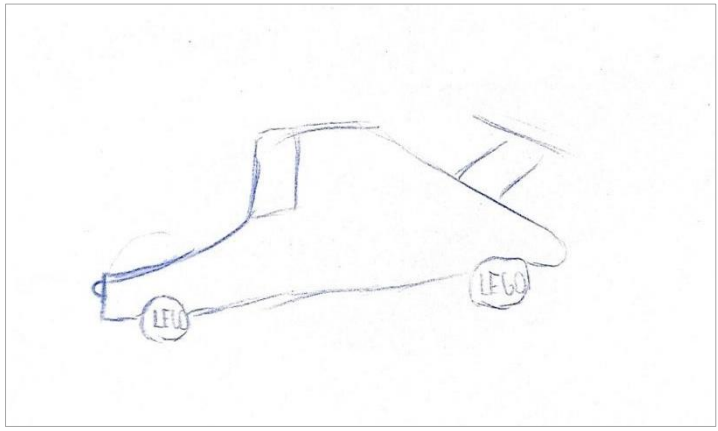

Figure 2. Formula I. Lego model design by Igor (grade 3)

However, the unfortunate reality is that many students rarely participate in such classes, and some do not have access to them at all. This issue became evident during the student interviews. Consequently, the quality of children's education deteriorates, and teachers are unable to adequately fulfill their professional responsibilities. Further large-scale research would be valuable in order to gain a more comprehensive understanding of this problem.

Observation Results

In the final stage, students folded a paper airplane according to instructions. The observation categories included workspace preparation, task initiation, adherence to steps, problem-solving, pace, and emotions.

Half prepared their workspace. Most began confidently. Eight completed the task without mistakes; others made errors but completed the work. Two needed teacher support due to low self-confidence.

Work pace varied, and emotions ranged from enthusiasm to frustration. All students, however, completed their airplanes and expressed satisfaction when testing them.

Technical activities proved highly motivating, even for initially reluctant participants.

Conclusions

The study examined the implementation of technical education in grades 1–3. Although teachers are required to provide at least one hour of technical education per week, only slightly more than half fulfill this obligation. Many students were unfamiliar with technical classes, indicating irregular implementation.

Those who did participate expressed strong interest, recalling their projects enthusiastically. Practical activities proved especially engaging.

Teachers encounter barriers such as insufficient resources, inadequate facilities, and safety concerns. Many lack essential materials and must rely on personal funds or parental support. Effective technical education requires proper resources, clear and developmentally appropriate instructions, and teacher preparation aligned with contemporary educational demands.

Technology plays a key role in the 21st century across medicine, education, and everyday life. Strengthening technical education from the earliest stages is crucial for Poland's continued development.

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EWA ŻYTKA-RYDOSZ

The Impact of Television and Mobile Device Screens on the Development of Children Aged 0 to 3 Years Students

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Abstract

In the digital era, infants and toddlers are frequently exposed to screen media. This article evaluates effects of screen exposure on children aged 0–3 years. A narrative integrative review synthesising empirical studies, meta-analyses, international and national guidelines, and recent reports, with focus on exposure measurement and contextual moderators (content quality, caregiver mediation, socioeconomic factors).

Excessive, unmediated screen exposure is associated with delayed expressive language, reduced contingent face-to-face interaction, poorer sleep quality and delayed sleep onset (notably with evening use), lower spontaneous physical activity, and challenges in behavioural self-regulation. Conditional benefits – such as video-calls and targeted educational or therapeutic apps – emerge mainly when media are age-appropriate and used with active caregiver engagement. Heterogeneity of measures and predominance of cross-sectional studies limit causal inference.

Recommend minimizing non-interactive screen time for under-3s, avoiding screens before bedtime, promoting caregiver-mediated uses and family media plans, and prioritizing longitudinal and intervention research.

Keywords: child development, digital media, television, smartphone, language development, emotional development

Introduction

Modern children grow up in a reality saturated with technology. From the earliest months of life, they are surrounded by screens–smartphones, tablets, computers, and televisions. In many families, these devices are an inseparable part of daily life. Infants and toddlers watch cartoons, listen to music, use educational apps, and engage in video calls. For many parents, screens have become a helpful tool in childcare – used to occupy, calm, or distract a child temporarily.

Meanwhile, children aged 0 to 3 go through a period of exceptionally intense biological and psychological development. During this time, brain structures responsible for speech, emotions, executive functioning, attention, and social relationships are forming rapidly (Shonkoff, Phillips, 2000). The environment–family, physical surroundings, and how time is spent–plays a critical role in shaping foundational competencies.

This article focuses on the impact of digital screens on the development of children in early childhood. It analyzes both direct consequences (e.g., speech delays, sleep disturbances) and indirect consequences (e.g., reduced social interaction, limited physical activity). Particular attention is paid to the recommendations of organizations such as the American Academy of Pediatrics (AAP), the World Health Organization (WHO), Zero to Three, and current research in developmental neuropsychology.

The goal of this article is to provide a comprehensive, evidence-based overview of how screen exposure affects children's early development and to offer practical strategies for parents, caregivers, and professionals to navigate media use responsibly in the first years of life.

Subject of research

The subject of this article is an analysis of the impact of exposure to screen-based images and content (television, smartphones, tablets, computers) on the multidimensional development of children from birth to 3 years of age. The study focuses on five key developmental areas: language acquisition and communication skills, socio-emotional development (including the quality of attachments and emotion regulation abilities), sleep quality and circadian rhythms, motor skills, and the potential use of technology as a supportive tool (e.g., educational apps, video calls, assistive technologies for children with disabilities). The article incorporates both empirical evidence from international literature and national data and reports relevant to Poland. The timeframe of the analysis covers contemporary research and the latest recommendations from international and national organizations, and the approach is synthetic and critical – the goal is to identify patterns of relationships between screen exposure and selected developmental indicators, and to formulate practical conclusions and recommendations.

Methodology

The article is of a review and integrative nature: a review of scientific literature, reports from international organizations (including the AAP and WHO), and available national studies and analyses (Polish reports and studies) was conducted, followed by a synthetic thematic analysis. The source selection criteria included: 1) empirical studies concerning the 0–3 age group; 2) review papers and meta-

analyses related to the impact of screen media on child development; 3) official guidelines and positions of pediatric and public health organizations; 4) national reports describing the scale of the phenomenon (descriptive and statistical data). The analysis was conducted multidimensionally – by identifying and comparing evidence pertaining to each developmental area: linguistic, socio-emotional, sleep and circadian rhythm, motor skills, and potential therapeutic/educational benefits.

The methods included: systematic literature searches in scientific databases (primary works and reviews), critical appraisal of study quality (particularly regarding study design, control of confounding variables, and types of designs – cross-sectional vs. longitudinal), and a narrative synthesis of results highlighting areas with stronger and weaker empirical support. Significant limitations of the sources were also indicated – in particular, the predominance of correlational over experimental studies and the problem of heterogeneity in measuring screen exposure and developmental outcomes. Ethical aspects refer to data protection standards and participant consent in primary studies, and in the case of reports – to the transparency of data sources.

Development of Children Aged 0–3: Mechanisms and Needs

The period from birth to age three is marked by rapid maturation of brain structures and the emergence of core cognitive functions. The infant brain exhibits extraordinary neuroplasticity – hundreds of thousands of new synaptic connections are formed daily (Gopnik, 1999). The quality of a child's early experiences– sensory, emotional, social, and physical – plays a fundamental role in shaping the developing nervous system. Through interaction with caregivers and exploration of their surroundings, children learn how the world works and begin to form their self-concept.

During this time, several key developmental domains evolve:

- Language acquisition (babbling, first words, sentence formation),
- Emotional regulation (expressing needs, responding to others),
- Social bonding (trust, attachment, non-verbal communication),
- Motor development (crawling, walking, manipulating objects),
- Executive functioning (working memory, attention, problem-solving).

Disturbances in any of these domains may have long-term effects on overall development. Researchers are increasingly interested in the role of digital media in this process – specifically, how the quantity and quality of screen exposure may support or interfere with typical development (Christakis, 2014, pp. 399–400).

Face-to-face interaction with caregivers, physical activity, and real-world sensory experiences are not optional extras – they are prerequisites for healthy development during this critical stage.

The Scale of the Phenomenon – Data from Poland and Worldwide

Reports from American and European organizations show that up to 90% of children under the age of two are regularly exposed to screen media (Rideout, Robb, 2020). The 2020 *Common Sense Media* report revealed that the average American infant spends more than one hour daily consuming screen content (Zimmerman, Christakis, Meltzoff, 2007, pp. 473–479). In Poland, a study conducted by the Empowering Children Foundation (Fundacja Dajemy Dzieciom Siłę) found that 63% of children aged 6 to 36 months use screens daily, with average exposure exceeding 90 minutes per day (Fundacja Dajemy Dzieciom Siłę, 2023).

This phenomenon intensified during the COVID-19 pandemic, when the closure of childcare institutions and remote working conditions for parents increased reliance on screens as a form of childcare (Radesky, Zuckerman, 2019, pp. 1070–1071). Many parents admit to using screen devices to:

- Calm the child during tantrums or fatigue,
- Provide entertainment while they attend to household tasks or work,
- Introduce educational content or language stimulation.

However, what is often perceived as harmless or even beneficial may, in reality, displace critical developmental experiences—such as verbal exchanges, eye contact, touch, and physical movement. The increasing reliance on screens among infants and toddlers poses a significant public health concern and calls for widespread education and preventive strategies.

The Impact of Screens on Language and Speech Development

Language and speech development is one of the most important indicators of a child's cognitive and social progress. During the first three years of life, children acquire essential communication skills – not only vocabulary and grammar, but also the ability to understand, respond, interpret, and express emotions through language. This process is fundamentally dependent on social interaction, particularly face-to-face communication with caregivers.

Language learning in early childhood relies on the active engagement of neural networks responsible for speech perception, phoneme production, and auditory categorization. Neuroimaging studies show that by 6 months of age, infants activate brain regions associated with language processing, but only in real-life, socially interactive contexts (Kuhl, Tsao, Liu, 2003, pp. 9096–9101).

Simply listening to language, such as from television or an app, is insufficient. Infants acquire language through dialogue, intonation, gestures, facial expressions, and shared attention – elements that are missing in screen-based interactions.

Research shows that children who learn language solely from screens acquire significantly fewer new words than children who engage in real conversations with adults. For example, a study by Kuhl et al. (2003) found that infants who were exposed to a foreign language in person could distinguish phonemes of that

language, while infants exposed to the same material via video could not (Christakis, Zimmerman, DiGiuseppe, McCarty, 2004, pp. 708–713).

Similarly, Christakis and Zimmerman (2007) demonstrated that each additional hour of television per day in children aged 8 to 16 months was associated with a 6–8% reduction in vocabulary size (Chonchaiya, Pruksananonda, 2008, pp. 977–982).

Globally, speech and language delays are increasingly diagnosed in children under age three. One of the contributing factors is excessive screen time, which replaces direct interaction with caregivers. A study by the Canadian Pediatric Society found that 18-month-old children who were exposed to screens for more than 1 hour per day were twice as likely to exhibit delayed expressive speech (Madigan, Browne, Racine, Mori, Tough, 2019, pp. 244–250).

Additional symptoms observed by speech-language pathologists include:

- Echolalia (repetitive speech),
- Flat intonation,
- Poor pragmatic language use (e.g., not asking questions or commenting),
- Impaired narrative skills and symbolic communication.

In many homes, children now spend more time interacting with screens than with adults. This shift results in screens acting as the "language source" – with cartoons serving as narrators and apps replacing dialogue. Although technology can be a developmental tool for older children, it cannot replicate the richness of real-time, emotionally responsive human communication during early childhood.

A study by Hirsh-Pasek, Zosh, and Golinkoff, (2015, pp. 3–34) showed that preschool-aged children learned better from educational apps only when an adult was present to interpret and discuss the content. Children left to interact with the screen alone showed minimal language transfer from the digital environment to the real world.

Emotional and Social Development and Digital Media

Emotional and social development in the first three years of life is rooted in the quality of early relationships, especially with primary caregivers. This is the time when children begin to form emotional security, trust, empathy, and the ability to self-regulate. Excessive screen exposure, especially when it dominates the child's daily experiences, can significantly disrupt these developmental processes. This section explores how digital media affect attachment, social engagement, and emotional growth in early childhood.

Bowlby's (1969) attachment theory emphasizes that a child's emotional development is built on predictable, responsive, and emotionally attuned interactions with a primary caregiver. From the first months of life, infants begin regulating their emotions through the facial expressions, voice, and physical presence of their

caregivers. These early exchanges help children understand emotional cues and develop trust.

When screens replace human interaction, the development of social synchrony – eye contact, turn-taking, shared attention – is compromised (Tronick, Cohn, Shea, 1986, pp. 349–371). A child who spends more time looking at a screen than at a caregiver's face misses critical moments of emotional learning.

Children exposed to high levels of screen time during early development often demonstrate:

- Poor facial expression recognition,
- Limited facial mimicry,
- Reduced social initiative,
- Avoidance of eye contact.

Heffler and Sienko (2020, pp. 420–426) found that toddlers aged 12–36 months who were exposed to screens for more than 2 hours per day showed a significantly higher incidence of autism-like behaviors, even if they did not meet formal diagnostic criteria. These behaviors are not necessarily signs of autism but may indicate a lack of social-emotional stimulation in early environments.

Empathy and emotional literacy are not innate – they develop through daily modeling by caregivers. A child learns to understand joy, anger, fear, and sadness by observing and participating in emotionally rich interactions. When screen content replaces this process, the child may struggle to recognize and regulate emotions in real-life social contexts.

A study by Nilsen, Zamani, and Lesaux (2019, pp. 781–789) showed that children with frequent screen exposure were less likely to initiate interactions with peers, had difficulty resolving conflicts, and showed delayed emotional self-regulation compared to their peers with lower screen time.

The term digital relational deprivation refers to the erosion of emotional connection caused by excessive digital media use in families. Even when a parent is physically present, if they are absorbed in their phone rather than engaging with the child, the child may experience a lack of being seen, heard, and emotionally validated (Radesky et al., 2014, pp. 843–849).

Tronick's "still-face" experiments demonstrated that infants as young as 3 months become visibly distressed when caregivers become unresponsive – even for a few seconds (Tronick, Als, Adamson, Wise, Brazelton, 1978, pp. 1–13). Similar reactions occur when the caregiver's attention is consistently directed at a device rather than at the child.

Digital content – especially apps and cartoons – is often hyperstimulating, with fast-paced visuals, bright colors, and loud sounds. These features can interfere with the development of self-soothing and attention regulation. Instead of learning to cope with boredom, frustration, or delay, children expect immediate gratification from screen-based entertainment.

Radesky et al. (2016) found that children who were frequently given screens to calm down were less likely to develop internal self-regulation skills and more likely to display impulsivity and tantrums in unfamiliar settings (Radesky, Schumacher, Zuckerman, 2015, s. 1–3).

Sleep, Circadian Rhythm, and Screen Use Before Bedtime

Sleep during the first three years of life plays a critical role in neurological, physical, and emotional development. It supports concentration, memory consolidation, emotional regulation, immune function, and overall mood. At the same time, infants and toddlers often experience irregular sleep patterns and require stable routines. Increasingly, researchers express concern about the negative effects of screen exposure on young children's sleep quality and rhythms.

Newborns and infants typically sleep 14–17 hours per day, though not in consolidated blocks. Around 6 months of age, the circadian rhythm begins to stabilize under the influence of melatonin – a hormone produced in response to darkness (Mindell, Owens, 2015). Establishing a consistent daily routine, dim lighting, and a calm environment is essential for healthy sleep development.

However, blue light emitted from screens (in the 460–480 nm range) inhibits melatonin production, delaying sleep onset and disrupting the sleep-wake cycle.

Electronic screens emit short-wavelength light that stimulates the suprachiasmatic nucleus of the hypothalamus – the brain's internal clock – leading to circadian rhythm disturbances. Hale and Guan (2015) found that children and adolescents who used screens in the evening experienced:

- Shorter total sleep time,
- Increased nighttime awakenings,
- Lower sleep quality (LeBourgeois, Hale, Chang, Akacem, 2017, pp. 92–96).

These effects are also observed in children under age 3, particularly when TVs or tablets are used during pre-sleep routines.

Sleep deprivation in toddlers does not always present as sleepiness. Instead, overtired children often become:

- Irritable,
- Hyperactive,
- Impulsive,
- Emotionally dysregulated.

A study by Cheung et al. (2017) showed that toddlers who slept fewer than 10 hours per night exhibited more frequent behavioral issues, including aggression and attention problems (Hale, Guan, 2015, s. 50–58). These children also struggled with social interaction and were less responsive to caregivers.

In many households, screens are incorporated into bedtime routines – "just one cartoon," a lullaby video, or a game on a tablet. Parents may believe these

tools help calm the child, but in reality, the sensory stimulation can lead to overarousal, delaying sleep and lowering sleep quality (Cheung et al., 2017).

Additionally, children may become dependent on screens to fall asleep, developing sleep associations that can interfere with self-soothing abilities.

Experts advise that children:

– Under 18 months should avoid screens altogether,
– Ages 2–3 should be limited to no more than 1 hour per day, with co-viewing (Nathanson, Alade, 2016, pp. 579–593).
– Avoid all screens at least 1 hour before bedtime.

Instead of screens, families can implement soothing bedtime rituals:

– Reading together,
– Gentle massage,
– Soft music or lullabies,
– Storytelling,
– Prayer or mindfulness for children.

These activities support melatonin production, emotional bonding, and relaxation, enhancing both the quantity and quality of sleep.

Motor and Sensory Development and Screen Devices

Motor and sensory development during infancy and early childhood lays the foundation for physical health, learning, and emotional regulation. Movement and sensory exploration help children develop body awareness, balance, coordination, and cognitive skills. Excessive screen exposure can interfere with these processes by reducing opportunities for active movement and multisensory experiences that are critical for sensory integration and neuromotor development.

Even before walking, infants engage in essential motor activities – kicking, rolling, reaching, crawling. These actions stimulate muscle development, bilateral coordination, and brain maturation. As the child grows, gross motor milestones like crawling and walking coincide with fine motor development such as grasping and manipulating objects (Zelazo et al., 2013, pp. 16–33).

These experiences not only build physical capacity but also contribute to executive functioning, spatial awareness, and emotional self-regulation. Children who are physically active are better able to focus, process stimuli, and manage emotions.

Screen-based activities typically involve static posture – sitting or lying down while watching videos or using a tablet. These prolonged periods of inactivity displace time that should be spent crawling, climbing, or playing. Even when children interact with touchscreens, the movement is limited to repetitive fine motor gestures, such as tapping or swiping.

Tremblay et al. (2017, p. 874) recommend that children aged 1–3 years engage in at least 180 minutes of physical activity daily, spread throughout the day, and that screen time be minimized or avoided. However, many parents unintentionally substitute screens for physical play, particularly in small indoor spaces or during bad weather.

Sensory integration is the brain's ability to organize information from various sensory systems (touch, sight, hearing, balance, proprioception) to produce appropriate behavioral and motor responses. This capacity is developed through diverse real-world sensory experiences – running, jumping, rolling, handling materials of different textures.

When children lack these opportunities due to prolonged screen use, symptoms may include:

- Delayed reflex integration,
- Poor hand-eye coordination,
- Increased sensitivity to touch or noise,
- Avoidance of physical activity,
- Balance and posture issues (Ayres, 2005).

Screens overstimulate visual and auditory pathways, while under-stimulating vestibular and tactile systems, leading to an imbalanced sensory profile.

Frequent use of screens in poor posture (e.g., "smartphone neck") is linked to muscle imbalances, curvature of the spine, and reduced core strength. Studies in Poland have shown that even preschool children display early signs of postural deviation, which correlates with screen time and lack of physical activity (Czaprowska, Nowotny, Pięta, 2018, pp. 108–114).

The child's developing musculoskeletal system is particularly vulnerable to habits such as slouching, prolonged sitting, and asymmetrical movements. These habits can persist into school age, affecting health, confidence, and classroom performance.

Young children need active, full-body movement that includes climbing, crawling, dancing, pushing, pulling, and jumping. These activities support:

- Motor planning,
- Bilateral integration,
- Proprioceptive awareness,
- Behavioral regulation.
- The World Health Organization recommends:
- No screen time under age 2,
- No more than 1 hour per day for ages 2–4, and only if balanced by 3 hours of daily physical activity (WHO, 2019a).

Encouraging outdoor play, exploration, and physical games is one of the most effective strategies to counteract the sedentary effects of screens and foster holistic development.

Potential Benefits of Digital Media (When Used Appropriately)

Despite the many risks associated with excessive and unregulated screen exposure, it is important not to overlook the developmental potential of digital media, provided they are used appropriately. When high-quality content is chosen, time is limited, and a caregiver is actively engaged, screen-based experiences can offer educational, emotional, and relational benefits – especially in specific contexts or for children with special needs.

One of the most clearly beneficial uses of digital media for young children is video calling with distant family members. Maintaining relationships with grandparents, siblings, or other relatives via video platforms helps foster emotional bonds, even across physical distances. Unlike passive video watching, video calls are interactive and socially responsive, which makes them more developmentally appropriate (McClure, Chentsova-Dutton, Barr, Heller, 2018, pp. 12–22).

A study by McClure, Chentsova-Dutton, Barr, and Heller (2018) showed that children aged 15–24 months responded with more engagement, facial expression, and verbal responses during live video calls than when watching pre-recorded videos (Myers, 2016).

Educational apps can support cognitive development when used in specific, controlled conditions:

- Content is age-appropriate and simple,
- Apps avoid overstimulation (e.g., no flashing lights or loud noises),
- The child uses the app with an adult, who interprets and expands on the experience,
- The app encourages active thinking, not passive consumption.

Hirsh-Pasek et al. (2015, pp. 3–34) demonstrated that children achieved better language comprehension and retention when an adult engaged with them during app use. In contrast, solo use led to minimal learning and poor transfer of knowledge to real-life contexts.

Some animated shows and educational video programs are created with input from child development experts and can serve as tools for learning empathy, emotional expression, or social problem-solving. However, these benefits are only realized when an adult co-watches and guides the experience.

Shared viewing enables:

- Talking about characters' emotions,
- Connecting the story to the child's real-life experiences,
- Expanding vocabulary and narrative skills.

Linebarger and Walker (2005) found that children who watched educational programming with a caregiver had significantly better language outcomes than those who watched random content alone (Linebarger, 2005, pp. 624–645).

In therapeutic contexts, digital tools can be especially helpful for children with developmental delays or disabilities. Examples include:

– Augmentative and alternative communication (AAC) apps for non-verbal children,

– Emotion recognition software for children with autism spectrum disorder (ASD),

– Interactive apps supporting fine motor skills or visual tracking.

Research by Ganz et al. (2012, pp. 60–74) supports the use of customized digital tools as part of a comprehensive intervention plan for children with autism and language impairments.

To ensure that digital media contributes positively to development, families should follow a set of evidence-based principles:

Table 1. Summary of Key Screen Time Guidelines for Young Children

Guideline	Description
Adult presence	The caregiver should talk, ask questions, and explain.
Time limits	No more than 1 hour/day for 2–3-year-olds (WHO, 2019b).
Quality content	Choose educational, age-appropriate, and non-violent content.
Balance	Screen time should never replace human interaction, movement, or outdoor play.
No screens before bedtime	At least 1 hour of screen-free time before sleep.

By using screens mindfully and sparingly, families can mitigate risks and harness digital tools for meaningful developmental support.

Recommendations for Parents and Professionals

In light of the growing concerns surrounding screen exposure in early childhood, leading medical and developmental organizations – alongside psychologists, speech therapists, and pediatricians – have formulated evidence-based guidelines. These recommendations are intended to minimize developmental risks and support families in creating healthy, screen-balanced environments during the formative years of life.

In its 2016 policy statement, the AAP outlined the following screen time recommendations for young children (American Academy of Pediatrics, 2016):

1. Children under 18 months: Avoid screen use entirely, except for video chatting.
2. Children 18–24 months: May be introduced to high-quality content, but only with an adult actively present and engaged.
3. Children 2–5 years: Limit to 1 hour per day, with co-viewing and discussion.
4. Avoid screens during meals, before bed, and in the child's bedroom.
5. Families are encouraged to create a media use plan and model healthy digital behavior.

In 2019, the WHO published strict recommendations focused on screen use, physical activity, and sleep for children under 5 (WHO, 2019c):

1. Under age 1: No screen time.
2. Ages 1–2: Screen time should still be avoided completely.
3. Ages 2–4: Screen time should not exceed 1 hour per day.
4. All children in this age group should engage in at least 180 minutes of physical activity daily, including moderate to vigorous play.
5. Children should receive 11–14 hours of quality sleep per day, including naps.

Many parents use digital media with the best of intentions, but lack awareness of the developmental consequences of early screen exposure. Therefore, professionals must take an active role in educating families:

1. In nurseries and preschools – through workshops, printed materials, and parent meetings.
2. In pediatric and psychological practices – by discussing screen habits during check-ups.
3. In media and public campaigns – using relatable messages like "Your face is the best screen for your baby."

Child development specialists (e.g., psychologists, speech therapists, pediatricians, occupational therapists) should incorporate screening for screen use into standard practice and offer guidance for alternatives to screens.

Everyday digital hygiene practices include:

1. Turning off screens during meals.
2. Putting away smartphones when the child seeks attention.
3. Setting limits on screen time (when, where, how long).
4. Having screen-free zones (e.g., bedrooms, dining rooms).
5. Avoiding screen use as a calming strategy during emotional outbursts.

Suggested alternatives to screen time:

1. Sensory play (e.g., playdough, water play, finger painting),
2. Reading books aloud, even to infants,
3. Physical activities like crawling, rolling, jumping, dancing,
4. Music and singing, to build rhythm and motor coordination,
5. Social play with other children or family members.

Organizations like AAP and UNICEF encourage families to create a Family Media Plan that outlines:

1. Who can use screens, and when?
2. Where are screens allowed or restricted?
3. Which apps, programs, or games are appropriate?
4. How is screen use balanced with sleep, meals, outdoor play, and social time?

Such plans help families stay consistent and empower children to develop healthy lifelong media habits.

Final conclusions

The first three years of a child's life are a critical window for neurological, emotional, linguistic, and physical development. It is during this time that the foundations of learning, self-regulation, communication, and social bonding are established. In this context, digital screens – television, smartphones, tablets – can be either supportive tools or developmental disruptors, depending on how they are used.

This review of current research and international guidelines clearly shows that excessive and unregulated screen exposure poses a significant risk to early development. Documented consequences include:

- Delays in speech and language development,
- Reduced emotional engagement and empathy,
- Disrupted sleep and circadian rhythm,
- Lower levels of physical activity and sensory input.

At the same time, well-curated, age-appropriate content – when used with adult participation – can provide educational value, support family connection, and assist children with specific developmental needs.

The most essential factor remains face-to-face interaction. Real human contact cannot be replaced by screen-based content. Caregivers, educators, and healthcare professionals should work together to promote media literacy, support digital balance, and reinforce the idea that the caregiver's face is the most powerful screen a child will ever need.

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PART TWO

SELECTED ISSUES IN THE APPLICATION OF INFORMATION TECHNOLOGY IN EDUCATION

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Influencerism and Its Impact on the Development of Digital Skills Among Upper Elementary School Students

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Abstract

The phenomenon of influencers has emerged from the dynamic development of social media, and their influence on society is continuously growing. These platforms provide a space for sharing personal attitudes, life experiences, and audiovisual content with a global audience. Certain demographic groups are particularly susceptible to influence, especially young people, older citizens, and people with limited ability to critically evaluate information. Our research initiative focused on analyzing the impact on upper elementary school students.

The primary aim of the research was to observe the growing influence of influencers in contemporary society and to deepen our understanding of this phenomenon. Our findings reveal the dual nature of this influence: on the one hand, influencers serve as a source of inspiration and a motivating force in shaping young people's personal identities, but on the other hand, they can create unrealistic standards and expectations that arise from the consumption of their often stylized content.

Keywords: social networks, influencers, impact, research survey

Introduction

Influence is a word borrowed from English, which means "impact" (Alboqami, 2023, etc.). The words "influence" and "impact" have been part of everyday communication since time immemorial, but these words began to take on their own meaning with the advent of social networks such as Facebook and Twitter (Hoang et al., 2023). Initially, users used these networks to communicate and share their lives without deliberately seeking fame or financial success (MacKenzie, Podsakoff, 2012). Over time, as social networks grew and gained more

users, a new opportunity arose to promote new products and services using the face of a user with a large reach and credibility (Zhou, Lei, 2024). In recent decades, these users have been associated with the words "influence," "influencer," and influencer marketing (McMullan, 2023).

According to Shaffer (2020), influencers can be defined as individuals who use their specific audience and followers to spread their messages, recommendations, or promote products and brands. They do this thanks to their ability to influence the opinions and decisions of others. They gain their popularity and audience through digital platforms, especially social networks, where they effectively build trust with their followers (Ki, Cuevas, Chong, Lim, 2020). According to him, the ability to gain trust is primarily based on pure human trust, because people trust those with whom they share their thoughts and attitudes and can easily identify with them. Gaining this trust between influencers and their audience is currently very easy thanks to social media, which has fundamentally changed communication between people (Franke, Groeppel-Klein, Müller, 2023). The internet and smartphones enable fast communication anywhere and anytime. Social media has significantly reduced the communication barrier between ordinary people, as it is very easy to share your life, create any content, and publish it (Cialdini, Goldstein, 2004). Thanks to this, almost anyone can become an influencer (Arsenyan, Mirowska, 2021). Influencer marketing is therefore about influencing others. This process involves influencers using various strategies to change the attitudes, opinions, and values of other people (Cheung, Leung, Aw, Koay, 2022).

Influencerism is not entirely new, as this phenomenon already appears in similar roles that focus on influence and popularity. Therefore, it is important to distinguish between very similar and closely related roles and not to confuse them directly with influencers (Ferraro, Sands, Zubcevic-Basic, Campbell, 2024). Celebrities, politicians, public figures, and experts have, to a certain extent, influence over the public and the ability to influence the opinions and behavior of others. Influencers are closest to celebrities and politicians. Not every influencer is a celebrity, and not every celebrity is necessarily an influencer. Celebrities gain more reputation by excelling in some area of the entertainment industry, and their fame depends on their success in sports, film, or music. Their audience is huge, but mainly diverse in terms of individuals, as they all have different backgrounds, interests, ages, and overall spending of time in their daily lives. Influencers try to engage and entertain their audience, share their everyday lives with them, and connect their experiences with certain products with the intention of selling them or gaining cooperation, all through social media. The difference between influencers and celebrities lies in their lifestyles and their impact on their audience. It is easier to connect with people with whom we have something in common

than with someone who, in most cases, lives a very comfortable life surrounded by luxury items (Ekşioğlu, 2021). Politicians and influencers have an impact on society, but the difference between these influences is their goal. Politicians focus on political processes and promoting change in an effort to benefit their political party, while influencers focus on their own brand or success (Jun, Yi, 2020).

Types of influencers

Influencers can be classified according to their audience size (Geyser, 2024), form (Kim, Park, 2023), and type of content (Leite, Baptista, 2021). According to the first of the above classification criteria, which is often cited as the most important and with the greatest potential impact (e.g., McMullan, 2023; Ozdemir, Kolfal, Messinger, Rizvi, 2022; O'Keefe, 2016), influencers can be divided into four groups based on their audience size.

1. Nano-influencers (1,000 to 10,000) – This type is specific to the beginnings of every influencer and focuses on small, specific groups. Compared to other groups, they can be a cheap solution for promoting a product to a specific and small group of people.
2. Micro-influencers (10,000 to 100,000) – The influence of these influencers lies mainly in their interaction with their followers. They are very selective when it comes to collaborations with different brands and products so as not to jeopardize their relationship with their audience. They are ordinary people who have made it big thanks to their personality, expertise, and content.
3. Macro-influencers (100,000 to 1 million) – These are highly successful individuals in their field of expertise. There are more of them than mega-influencers, so it is easier to seek their collaboration.
4. Mega-influencers (+1 million) – These influencers have a huge number of followers thanks to their work and established personalities. This massive number of followers allows them to reach a large audience. Collaboration with them is therefore sought after by large and well-known brands, which can increase sales and brand awareness through this promotion. The disadvantage of mega-influencers is their high financial costs.

There are many differences between these influencers. Each type is sought after by different brands and collaborations (Sánchez-Fernández, Jiménez-Castillo, 2021). Nano and micro-influencers have a relatively small reach, but collaborating with them is very affordable. Mega-influencers are sometimes labeled as expensive, commercial, and less trustworthy, but they have a huge reach. Macro-influencers are a more sought-after middle ground for collaboration than mega-influencers, thanks to their reach, credibility, and affordability (Shandrokha, 2023).

Identifying the influence of influencers on students

Influencers can, intentionally or unintentionally, use a large number of strategies to influence their followers (Thomas, Fowler, 2021). Social media makes it easy to influence a large number of users, as it is an effective means of disseminating content (Thorson, Rodgers, 2006). We all desire success or an amazing life, and when we see someone who is successful, it is quite common to strive for similar success. Influencers on social media can take advantage of these ideas and try to present themselves to others as ideal and successful versions of themselves that anyone can achieve by simply following in their footsteps. This psychology of identification and imitation is one of the key skills of influencers (Vinod, 2023).

Vinod also emphasizes the importance of parasocial relationships that influencers create with their followers through content viewing. This parasocial relationship represents a one-sided relationship between followers and influencers, in which followers, despite the lack of direct interaction, perceive the social connection with the influencers' content as sufficient and feel closeness and trust towards the influencers.

Students go through the development of identity, moral and social values, and the development of relationships with family and peers (Pugnerová, Kvintová, 2016). People are social beings with a need to fulfill their social needs. This need is fulfilled by students through normal interactions during the day and at school. According to Spitzer (2014), this social need can also be fulfilled through online activities. Bond (2016) mentions the possibility of replacing adolescents' social interactions with social media monitoring and the creation of parasocial relationships with media personalities, whereby such interactions can influence their attitudes and behavior. By following influencers' content, students can fulfill their social needs while being exposed to the influence of influencers. Considering the above-mentioned parasocial relationships and identification, we can conclude that influencers do indeed influence the development of students' identity, moral and social values, and behavior.

Psychological strategies used by influencers

Influencers use more strategies than just identification and parasocial relationships (e.g., Tsai, Bagozzi, 2014). These hidden psychological pressures on influencer followers can be classified into the following groups according to Kets de Vries (2023) and Leeba (2024).

1. The power of expertise and authority bias – In order for influencers to achieve a strong connection with their followers, they must demonstrate real knowledge. This expertise can distort the influencer's authority, and followers may automatically consider them experts.

2. Identification and social proof – The phenomenon of imitating others. When we see someone successful using a product, we tend to imagine that the product will help us achieve similar success to that of the influencer.

3. Trust through repeated exposure and familiarity – Regular and repeated posting of content on social media can attract followers. In this repetitive environment, trust and preference for information from influencers develops over preference for current information.

4. Information overload – A large amount of information and products can lead to confusion and clutter. Following influencers and their reviews can help us make decisions.

5. Social groups and the sheep effect – The phenomenon of following the crowd. Influencers exploit their followers' desire to belong to groups. Followers make better decisions based on how others decide, which is easier and more trustworthy for them.

6. Illusion of control – Traditional advertisements tend to be annoying and intrusive. Followers actively choose who they follow and, therefore, what advertisements they see. This phenomenon gives them a sense of control over the fact that viewing advertisements and promotions is their choice.

7. Attractiveness bias – This is a phenomenon where people tend to trust people who are physically attractive and automatically assume that they are also very intelligent.

8. Halo effect – This is the effect of generalizing characteristics as a whole. If an influencer has one positive characteristic, we can assume that they have other positive characteristics as well.

9. Scarcity illusion – This type of psychology and strategy is commonly used in everyday marketing. It involves creating a sense of scarcity of goods, which triggers the need for immediate purchase or use so that we do not miss out on this opportunity.

These hidden strategies and influences are very difficult to see and recognize. Research by the Faculty of Social Sciences at Charles University (2018) shows that out of a sample of 330 adolescents, only 11% can recognize embedded advertising or sponsored content. This was an embedded advertisement at the end of an influencer's video, where he promotes a drink by showing how to mix it correctly and flavor it with different flavors.

It is also important to take into account the level of critical thinking among students, as they encounter a large amount of information on the internet every day and do not consider its veracity. This is a problem where they automatically consider new information to be true. Developing critical thinking is a very good way to prevent the pitfalls of the internet and influencers (Woodroof, Howie, Syrdal, VanMeter, 2020). A related important skill for students is digital literacy,

which is the ability to use digital technologies effectively, search for information, and evaluate it critically. This literacy also includes privacy protection and safe behavior on the internet (Oliveira, Garcia, Vivacqua, 2021).

Research objectives and methodology

The main objective of this research was to analyze selected aspects of the influence of influencers on upper elementary school students, with an emphasis on their personal development. Specifically, they focused on questions related to what types of influencers these students follow, how influencer content affects them, and whether this influence has a positive or negative impact on upper elementary school students (Ragin, 2009).

Quantitative research (Chráska, 2016) was chosen as the research strategy and was conducted using a questionnaire. The reliability of the questionnaire was determined using Cronbach's alpha coefficient and was 0.91, which confirmed that the questionnaire was reliable. When designing the questionnaire, the basic requirements and characteristics specified by Chráska (2016, pp. 164–165) were taken into account. The questionnaire was distributed via email, which included an accompanying text message and a link that respondents could use to access the questionnaire. Completing the questionnaire was completely anonymous, but if respondents were interested in receiving the results, they could enter their email address at the end. Most of the questions in the questionnaire were set as mandatory, meaning that respondents had to answer them in order to continue filling out the questionnaire. Some of the questions had only one possible answer, but for others, it was possible to select multiple answers or enter your own answer. The questions were formulated in such a way as to be understandable to the target group of respondents, i.e., upper elementary school students.

A two-sample Student's t-test was chosen for the analyses described below. A two-sample Student's t-test is a statistical method used to compare the mean values of two independent data groups. Its purpose is to verify whether there is a statistically significant difference between the mean values of these two groups. The respondents' answers were quantified using a four-point scale, which we considered to be quasi-interval. Although the numerical values expressed order (ordinal character), the differences between the individual categories were interpreted as constant. A value of 1 represented the highest level of agreement (strong agreement) and a value of 4 represented the lowest level of agreement (strong disagreement). Subsequently, a null (H_0) and alternative (H_A) hypothesis were formulated for each question, and a series of two-sample t-tests were performed.

Although the scale is ordinal in nature, the t-test was applied due to its robustness to slight deviations from normality, especially with sufficient sample sizes. In the analyzed files, the size of each group was approximately 70 respondents,

which can be considered sufficient for the application of this test. However, it is necessary to take into account the limitations associated with the use of the t-test on quasi-interval data.

Description of the research sample

The questionnaire survey was conducted from January 2024 to March 2024, and during this period, a total of 145 respondents – primary school pupils in the Olomouc Region – took part. The schools included in the research sample (a total of three schools), or rather their pupils, were approached regardless of whether they tended to consume excessive amounts of influencer content or not. The structure of the research sample and its basic characteristics with regard to content consumption and attitudes towards influencers are presented in Table 1.

Table 1. Age and gender structure of the research sample, including the distribution of influencer following intensity

Gender and age distribution of respondents			
Gender	Frequency	Age category	Frequency
Boys	69 (48%)	6th and 7th grade	32 (22%)
		8th and 9th grade	37 (26%)
Girls	76 (52%)	6th and 7th grade	35 (24%)
		8th and 9th grade	41 (28%)
Distribution of intensity of influencer monitoring by respondents			
Viewing frequency	Frequency	scope of viewing	Frequency
Very often	54 (37%)	7 hours or more	5 (3%)
Often	40 (28%)	5–7 hours	8 (6%)
Sometimes	31 (21%)	3–5 hours	44 (30%)
Rarely	13 (9%)	1–3 hours	57 (39%)
Never	7 (5%)	0–1 hour	31 (21%)

As can be seen from the table above, the research sample did not show complete gender neutrality. However, both gender groups were represented by a representative number, which allowed for a reliable statistical evaluation, as influencers can influence the interests of different genders differently.

Furthermore, it can be inferred from the table that there are upper elementary school students who follow influencers for more than 7 hours a day, which can be considered a sign that these students may be suffering from addiction. Compared to some previous studies (e.g., Statista, 2020), the sample we analyzed, where 39% of upper elementary school students watch content for 1–3 hours, corresponds only to increased interest and not addiction. However, we can identify the sample of 30% of these students who watch influencers for more than 3 hours every day as a group with signs of addiction. Of this sample, 6% of upper elementary school students have a slightly increased addiction, and 3% of students can be said to be truly addicted, as they watch content for more than 7 hours a day. The research sample we used, in terms of the frequency of viewing influencer

content, corresponds to previously published results by other authors (e.g., Xie-Carson, Benckendorff, Hughes, 2023) and could therefore be used for further analysis.

Selected results of the research survey

The initial analysis focused on determining whether influencers can have a positive impact on the development of digital literacy among upper elementary school students – i.e., questionnaire item Q08. They usually do so directly or indirectly. Either they create content that focuses on the development of digital literacy, or it happens indirectly, when it is purely up to these students to think for themselves. They can assess whether the information from influencers is true or not. If an influencer recommends a product, it is important to consider whether they are recommending it from their own experience or whether they have been paid to promote it. Previous research has shown that following influencers, social networks, and their content can develop digital literacy and critical thinking in upper elementary school students (Oyolacarol, 2023; Modern Marketing, 2023). In accordance with the above methodology, the following research hypotheses were established:

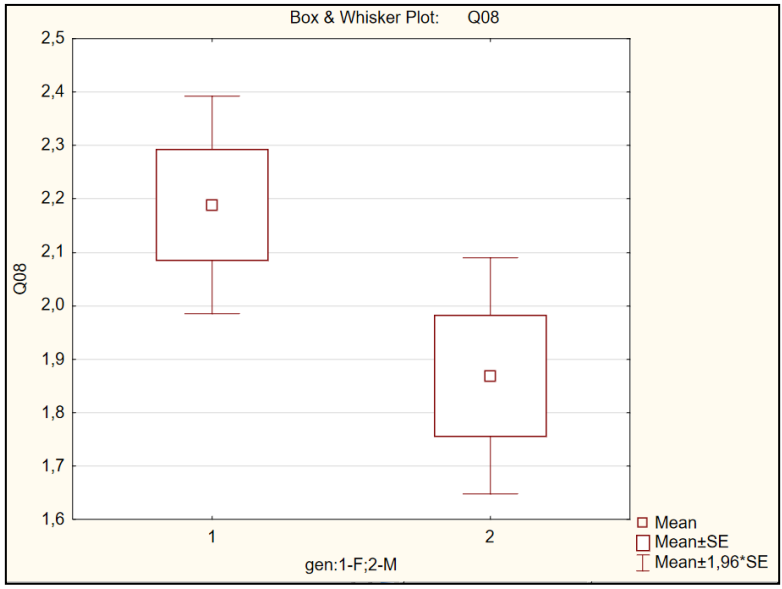
1. Null hypothesis ($HQ08_0$): There is no statistically significant difference between the average rating of influencers' motivation to develop digital literacy among girls and boys.
2. Alternative hypothesis ($HQ08_A$): There is a statistically significant difference between the average rating of influencers' motivation to develop digital literacy among girls and boys.

Table 2. Results of the t-test for digital literacy vs. gender

	t-test; grouped by gender, number of respondents – 145				
	Group 1 – girls	**Group 2 – boys**	**t-value**	**p**	**F-ratio**
Q08	2.188406	1.868421	2.072897	0.039977	1.303684

The results of the t-test ($t(143) = 2.073$, $p < 0.05$) show that boys exhibit a higher level of motivation than girls to develop digital literacy through influencers. For completeness, the results were also interpreted using the interquartile range (IQR) in the form of a box plot.

As shown in the graph, the average value of boys' responses ($M = 1.87$) is lower than that of girls ($M = 2.19$), which corresponds to a higher level of motivation among boys. The median, which is less sensitive to outliers, is also lower for boys, confirming the higher consistency of their responses. The interquartile range (IQR) for boys is slightly smaller than for girls, indicating lower variability in their responses. The range of typical values outside the IQR, represented by the length of the "whiskers" in the boxplot, is longer for girls, indicating a wider dispersion of responses in this group.



Graph 1. Interquartile range of digital literacy vs. gender

Based on the results of the t-test and visual analysis of graphical representations, it can be concluded that there is a statistically significant difference in the degree of motivation of influencers to develop digital literacy between boys and girls. With a p-value of 0.0399, at a significance level of 0.05 with 95% confidence, it can be said that there is a statistically significant difference between these groups, and it is therefore possible to accept the alternative hypothesis ($HQ08_A$): **there is a statistically significant difference between the average rating of influencers' motivation to develop digital literacy among girls and boys**.

Another area that was of interest to us was the acquisition of information for the further education of respondents – i.e., questionnaire item Q09. Education can be pursued in almost any field, so it is relatively easy to combine education with activities that are attractive to upper elementary school students. Influencers can create various types of content with educational potential and interesting execution. They can develop a topic and present it in an interesting way to appeal to upper elementary school students, such as financial literacy, English vocabulary, or programming. Therefore, influencers can be a valuable path to education and open up endless opportunities in life. In accordance with the above methodology, the following research hypotheses were established:

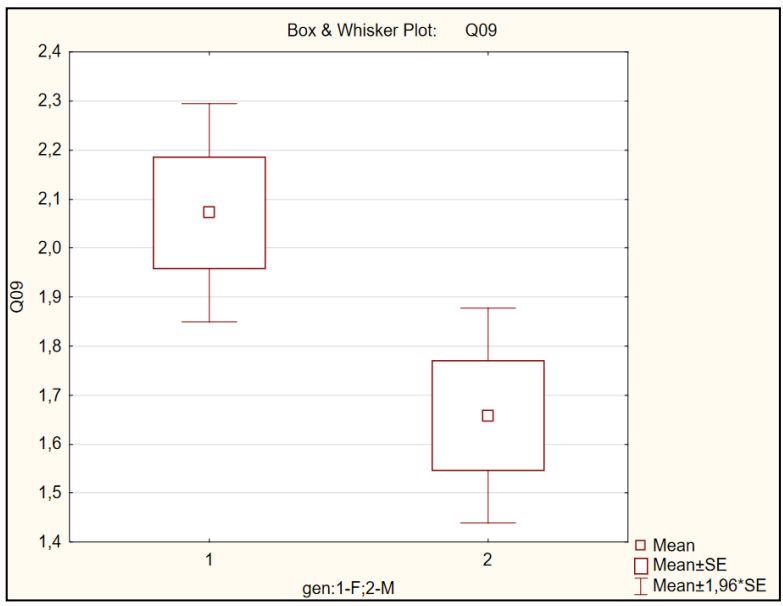
1. Null hypothesis ($HQ09_0$): There is no statistically significant difference between the average rating of the degree of acquisition of new knowledge and information by following influencers among girls and boys.

2. Alternative hypothesis ($HQ09_A$): There is a statistically significant difference between the average rating of the degree of acquiring new knowledge and information by following influencers among girls and boys.

Table 3. Results of the t-test for information gathering vs. gender

	t-test; grouped by gender, number of respondents – 145				
	Group 1 – girls	**Group 2 – boys**	**t-value**	**p**	**F-ratio**
Q09	2.072464	1.657895	2.597458	0.010374	1.063180

Based on the results of the t-test (t(143) = 2.597, p = 0.010374) and visual analysis of the Box & Whisker chart, it was found that there is a statistically significant difference between boys and girls in the extent to which they acquire new knowledge and information by following influencers.



Graph 2. Interquartile range of information acquisition vs. gender

The average value of boys' responses (M = 1.66) was lower than that of girls (M = 2.07), indicating a higher rate of acquiring new knowledge and information by following influencers among boys. The median values reflect a similar trend – the median for boys was lower than the median for girls. The interquartile range (IQR), representing the range between the 25th and 75th percentiles, was slightly narrower for boys than for girls, indicating greater consistency in responses among boys. The length of the "beards" in the graph revealed greater variability in responses among girls, indicating a wider range of individual

perceptions of the extent to which new knowledge and information is acquired by following influencers in this group. With a p-value of 0.01, we can therefore state with 95% confidence at a significance level of 0.05 that **boys show a higher degree of acquiring new knowledge and information by following influencers than girls**. We therefore accept the alternative hypothesis $HQ09_A$.

The last area presented here was research focused on whether influencers motivate respondents in the issue of validating acquired information – test item Q13. Education using only influencer content certainly does not replace schools, because the development of knowledge is only one step among many. It is still necessary to improve the development of thinking and skills that the school environment provides. In line with the above objectives and the chosen methodology, the following research hypotheses were established:

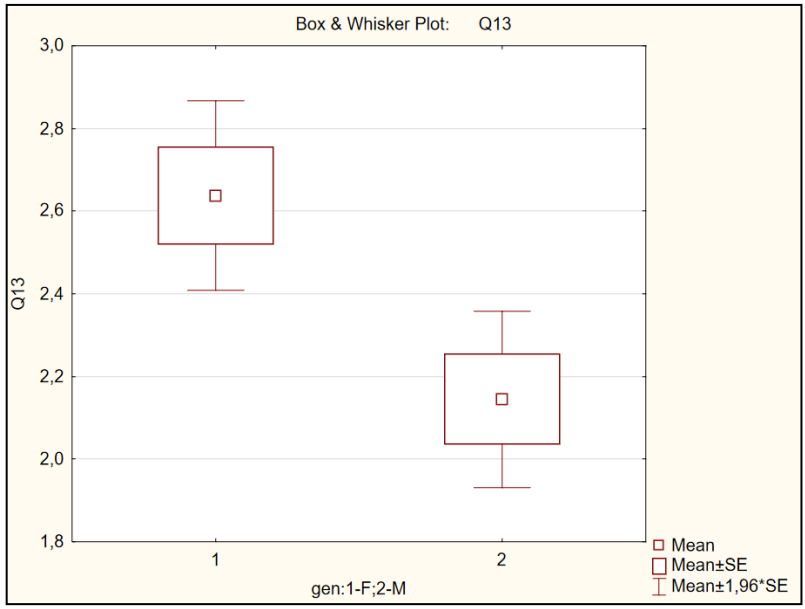
1. Null hypothesis ($HQ13_0$): There is no statistically significant difference between the average rating of the level of support from influencers for searching for and verifying information among girls and boys.
2. Alternative hypothesis ($HQ13_A$): There is a statistically significant difference between the average rating of the level of support from influencers for searching and verifying information among girls and boys.

Table 4. Results of the t-test for information gathering vs. gender

	t-test; grouped by gender, number of respondents – 145				
	Group 1 – girls	**Group 2 – boys**	**t-value**	**p**	**F-ratio**
Q13	2.637681	2.144737	3.093131	0.002382	1.046232

Based on the results of the t-test ($t(143) = 3.0931$ $p = 0.0023$) and visual analysis of the Box & Whisker chart, it was found that there is a statistically significant difference between boys and girls in the degree to which they perceive support from influencers in searching for and verifying information.

The average value of boys' responses ($M = 2.144$) was lower than that of girls ($M = 2.637$), indicating a higher level of perceived support among boys. The median values reflect a similar trend—the median for boys was lower than the median for girls. The interquartile range (IQR), representing the range between the 25th and 75th percentiles, was slightly narrower for boys than for girls, indicating greater consistency in responses among boys. The length of the "whiskers" in the graph revealed greater variability in responses among girls, indicating a wider range of individual perceptions of support in this group. With a p-value of 0.0023, we can state with 95% confidence at a significance level of 0.05 **that boys show a higher level of perception of support than girls**, thus accepting the alternative hypothesis $HQ13_A$.



Graph 3. Interquartile range of information gathering vs. gender

Discussion of results achieved

To compare our results, we selected previously conducted studies from the Czech environment, such as "Czech Children in Cyberspace" (2019), "EU Kids Online" (2020), and "Children and the Cult of Beauty in the Online World" (2022). Our results are current as of 2024, which allows us to evaluate changes in this area in the Czech Republic since 2019. According to previous studies conducted in 2019, 76% of adolescents in the Czech Republic used some form of social platform. In 2020, this number increased to 84%. According to our research, this figure reached 88%, showing a steadily increasing trend. The availability of the internet and mobile devices continues to grow, leading to an increase in communication via social networks. The social pressure that social media users exert on those who do not use it must also be taken into account. The most frequently used social media platforms are YouTube, Instagram, and TikTok. YouTube continues to be used by approximately 90% of Czech adolescents, and this figure remains stable, which also corresponds to our results. Instagram is used relatively steadily by 70% of adolescents. TikTok has seen the largest recent increase of all social platforms. In 2019, it was used by 29% of adolescents, and in 2022, this rose to 68%. However, in our 2024 research, this figure fell to just under 60%. Nevertheless, it can be concluded that TikTok's popularity remains significant and continues to grow.

The current negative influences of influencers are considered to be dangerous pranks and challenges. Comparing this with the research report "Dangerous Internet Challenges from the Perspective of Czech Children" (Kopecký, Szotkowski, Kubala, 2022), we find that in 2020, 86% of adolescents learned about these dangerous challenges, and 17% of them attempted to complete them. Based on our research on dangerous pranks, this figure reaches 29%. Therefore, we can conclude that there has been a significant increase in these dangerous challenges and pranks. Another negative aspect that emerges from the above studies is addiction and time spent on the internet. Most studies agree that Czech children are spending more and more time on the internet.

Unfortunately, there are no studies in the Czech Republic that directly focus on the positive effects of social media use. However, our research attempted to explore this area and found that influencers can have a positive impact on students' personal development. This is reflected, for example, in improved critical thinking, digital literacy, inspiration and motivation to develop hobbies, or acquiring knowledge, although these results often depend on the gender of the users.

Conclusion

Our research was conducted with the intention of contributing to the exploration and deeper understanding of the current trend of influencers, whose popularity is constantly growing, especially among upper elementary school students. These students are in an important developmental phase of adolescence, where they are forming their own identities. They are a sensitive group in terms of possible addiction to following influencers and their content. Based on the analyses carried out, which showed a clear gender difference in the perception of influencers among individual groups of respondents, we identified three basic categories that may explain the differences between the groups.

The first category is **a different relationship with influencers**, where boys may trust influencers more as a source of information, while girls may be more sceptical or prefer other information channels. It should be noted here that boys consider influencers to be trustworthy sources of information, while girls may perceive influencers more as inspiration in the areas of lifestyle, fashion, or cosmetics. Boys also more often follow influencers focused on technical fields, sports, or video games, where their influence may be more significant.

The second category is **different media habits**, where boys and girls may follow different types of influencers – boys may follow influencers focused on technology, science, or facts more, while girls may focus more on content focused on lifestyle or aesthetics. The fact that boys tend to prefer audiovisual learning through online videos, while girls may prefer other sources, such as text content or interpersonal interaction, may play a role here. Girls may also be more cautious

in admitting the influence of influencers on their interests for fear of social judgment or criticism.

The third and final category is **critical thinking and trust in information**, where girls may be more cautious in accepting information from influencers and rely more on traditional sources or personal experience. This fact can be supported by the opinion that boys are more influenced by peers who share an interest in influencers and their content, which can lead to greater acceptance of influencers as educational authorities. Boys may thus be more influenced by their peer group in terms of sharing interests and following the same type of content.

Here, we must point out that, given the total number of upper elementary school students, this is by no means a significantly representative research sample, but it does provide at least an indicative approximation of the issue under investigation. The subject of our further research efforts and activities is therefore to investigate addiction, dangerous imitation, unrealistic expectations, the spread of false information, restrictions on development, and the potential danger of pranks, which may pose a potential threat to students' personal development.

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Fake News in Social Media – Classification and Case Studies as an Important Guide for Media Education

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Abstract

The essence of this publication is an attempt to characterize the term of fake news in the social media environment. Social media platforms are commercial entities that are difficult to control and focused on user-generated content. Therefore, they constitute an effective space for spreading disinformation, both intentional and unintentional. The definitions of fake news, their types and examples were analyzed, and a case study was conducted in relation to two important events – both geopolitically and media-wise – the war in Ukraine and the presidential elections in the USA. The last chapter is a proposal of activities that will help you differentiate truth from false information and develop your own media competencies.

Keywords: disinformation, fake news, communication, media competencies, media, social media

Introduction

The intensive development of information technology, as well as the rise of social media, has meant that place and time – so important in face-to-face communication – no longer matter for the circulation of information. Distance, date and time in the transmission of news are no longer an obstacle. For a person connected to the network, the world is at his fingertips. Quick and easy access to publications coming from the other side of the world is a common phenomenon in our country today. Note that in 2021 more than 92% of Polish households had access to the Internet (GUS, 2021).

The media – both traditional and modern – affect society as a whole, as well as its individuals. Using the full range of their capabilities, they can perform many functions in human life:

– recreational – related to spending free time, leisure and entertainment,

– cultural – involving the culture of family, local, national and multicultural life,

– integrative – related to building cohesion and sustainability of society, both locally and globally,

– educational – presenting knowledge-enriching materials, conveying norms and behavioral patterns,

– informal social control – the so-called fourth power, tasked with monitoring the actions of the legislative, executive and judicial branches of government,

– the transmission of information and the co-creation of public opinion – concerning both the dissemination of news on politics, culture, sports, etc., but also influencing the opinions of audiences, shaping worldviews, dispelling or cementing prejudices (Ministerstwo Edukacji Narodowej).

According to the 'Digital 2022' report published by Canadian company Hootsuite, the main reason Poles use the Internet is to search for information – 72.8%, and to follow news and current events – 61.3%. Given the average time we spend online – 6 hours 39 minutes a day (Empemedia, 2022) we can assume that broadband connection is the main source from which we get information. And that's how it is in reality. The Institute for Internet and Social Media Studies (Instytut Badań Internetu i Mediów Społecznościowych – IBIMS) in partnership with the Institute for Market and Social Research (Instytut Badań Rynkowych I Społecznych – IBRIS) in 2021 conducted a survey twice, the results of which may be surprising to many. It turns out that the window to the world for the vast majority of Poles is not Polsat's 'Wydarzenia', TVN's 'Fakty' or TVP's 'Wiadomości'. In first place – 60.8% in January (Instytut Badań Internetu i Mediów Społecznościowych, 2021b) and 67% in April (Instytut Badań Internetu I Mediów Społecznościowych, 2021a) – are information web portals (Onet, Wirtualna Polska, etc.). Surprisingly, none of the popular TV news program came close to 50% of respondents' indications. In January, 38.8% of respondents indicated social media such as Facebook and Twitter as a source of up-to-date information about Poland and the world. There is a noticeable drop in April – 2 9.5%, which is still better than the indicators of the daily press, weekly newspapers, radio and some TV stations (IBIMS, 2021). Thus, there is no denying the statement that social media have a significant impact on our understanding of the world – they shape public opinion and determine the decisions we make.

Social media are making available to every citizen what was previously reserved for a small group of accredited reporters. Tik Tok briefly documents warfare across our eastern border (a meeting between the former US President and thirty popular Tik Tokers can attest to the power of this service, which was organized due to Russia's ongoing assault on Ukraine and the narrative created around this war (Wirtualnemedia, 2022a). Using the Facebook app, we were able to

follow the coverage of the refugee reception point, which was shared by a friend of ours acting as a volunteer. The X portal (formerly Twitter) gives us the opportunity to instantly read the current position of any diplomat from any corner of the world. Youtube opens up to us an abysmal collection of interviews and analysis, whose authors are recognized journalists, experts, but also passionate people who are anonymous to the wider public. Social media are part of our everyday life. They participate in it and shape it. However, it is important to note that their nature is significantly different from the specifics of traditional media we have known for decades. They are used both by the one of the crowd and by popular TV personalities across the country. Small local businesses and large corporations are present in them. Social media is where fans and football players, fans and artists, voters, editors and politicians contribute. This is where audiences become creators, and creators become audiences, who transmit, communicate, promote, endorse, criticize, and enter into discussions. *Within this type of structure based on relationships of a horizontal nature, in which the division between subordinate and superior disappears, human life is increasingly focused* (Rutka, 2014, pp. 145–166). Educators see a clear need and potential in using such platforms in educational activities but also educating about them.

Subject and methodology of the research

Threats in social media

The lack of geographic and time restrictions on access to knowledge and information make our daily lives much more convenient than years ago. The opportunities and possibilities offered to us by modern media are unquestionable. However, researchers point out that these tools (especially when used in an inappropriate and uncontrolled manner) can have a harmful effect on users. According to the Institute of Health Psychology of the Polish Psychological Association, the most important risks of being on social media include:

– cybercrime (installation of malware, phishing for personal data and passwords),

– cyberbullying (including sexual harassment) (Goetz, 2012). Staniuk-Rabenda (2014, pp. 113–114) elaborates on this concept by detailing such behaviors as teasing, stalking, denigration, humiliation, impersonation, exposure, deception, harassment, stalking, identity theft, making secrets public, cyberstalking, happy slapping, exclusion, and 'technical' aggression.

In addition to harming activities aimed at a specific user which are a digital extension of behaviors that have been occurring in social relations for centuries, recent years have also seen a flood of activities aimed at the mass audience, which are *an attempt to influence the results of elections, affect stock prices, deceive investors* (Newseria Biznes, 2017). We are talking about spreading disinfor-

mation, manipulating reality, sharing untrue messages that *increasingly play a political role* (…)*, can discredit politicians* (…)*, and influence important political events* (…) (Newseria Biznes, 2017). False narration (often from fake accounts) that is forwarded on by actual Twitter, Instagram or Facebook users without basic verification. **Fake news.** Researchers offer various definitions of this phenomenon. According to Rosińska (2021, pp. 31–32) they are *untrue media messages presented in the media as news but not real information. They can be intentionally created by the authors, or become fake news in the process of distribution through social media beyond the control of the original author. Fake news can also vary in the degree of falsity. They will be completely made-up news, partially made-up news, or news that is based on facts, but their arrangement, and therefore the message, is false*. The author notes the intentionality of the producers of false information, while allowing for the possibility of the evolution of information into fake news through social media users (an example of such evolution can be the detachment of information from the situational context, which changes its connotation). It also makes a distinction between fake news that is completely fictional and those that while based on real events manipulate them, creating messages that are far from the truth. Consulting agency Public Dialog in its report 'Fake news from the perspective of Polish journalists' offers a comprehensive definition of the phenomenon: *fake news is untrue information, the purpose of which is to mislead the recipient and thus evoke certain emotions and attitudes towards a given issue. Fake news is meant to shock and stir up controversy. Until now, it was considered that we qualify information as fake news only when it appears in the mass media. However, in the age of social media and universal access to the Internet, every user is a content generator. Any of us can create our own service or site and spread fake news. This leads to an exponential growth of this practice. Nowadays, the phenomenon of fake news is gaining momentum and is virtually unmeasurable on a global scale. Fake news is driven by emotions rather than facts, so it is often based on religious beliefs, values, views, stereotypes, prejudices, etc. In order for fake news to be effective as a tool of mass persuasion, it must refer to concepts that already exist in the consciousness of some social group* (…) (Public Dialog, 2018). Also in this case the intentionality of the sender and the purpose behind it is emphasized. The authors also note the scale of this practice. It is due to the specific nature of social media, in which every user becomes a mass sender. In addition, the role of emotions and personal beliefs in the process of spreading fake news was distinguished. They are much more important than facts when we talk about the formation of public opinion in the post-truth era (Public Dialog, 2018). Fake news must hit fertile ground, appeal to the viewer's worldview and evoke extreme emotions.

Characteristics of fake news

Classification and categorization of false information provided by the mass media is a topic of consideration for many researchers of the subject. Referring to the aforementioned report by the Public Dialog agency, we can adduce three basic types of them:

1. Completely untrue (false, contradictory, premeditated fabricated information is given), an example of such fake news could be a photo of Law and Justice MEPs holding crosses in the European Parliament:

Figure 1. A screenshot of a completely fake social media post "Strong group of exorcists already in action"

Source: http://www.facebook.com/RacjonalnaPL (15.05.2024).

The photomontage is quite obviously based on a dislike of the conservative Christian Democratic political party, portraying its members as overly attached to their religious symbols and negatively disposed to the institution in which they hold office. And while online political and worldview discussions are nothing new, what we have here is the proliferation of fiction – the crosses seen in the hands of MEPs have been added in a graphics editing program (Sawka, Czarnecka, 2019).

2. The truth is disputed (the viewer is misled, either by giving proper context to the facts or by presenting them in a selective manner), as exemplified by the politician's post about Donald Tusk's support for 'anti-EU Jobbik':

Figure 2. A screenshot showing selective facts presentation in social media "Donald Tusk went to Hungary and supported anti-EU Jobbik"

Source: http://www.facebook.com/DaszkowskiDamian (22.03.2023)

In fact, only an excerpt of the complex situation was presented. Firstly, the former European Council president admittedly visited Hungary and expressed his support, but not only for the Jobbik party, but for a whole coalition of Hungarian opposition parties that includes *the left-wing Democratic Coalition (DK) and the Hungarian Socialist Party (MSZP), the 'green' Dialogue for Hungary (PM) and LMP – Hungarian Green Party, the centrist Momentum, and the right-wing Jobbik* (Sadecki, 2021, p. 2). These groups have united to oust Fidesz, which has been in power since 2010 and headed by Viktor Orbán. The situation is therefore not as black and white as it might seem after a cursory review of the situation presented in this post. Secondly, the claim that Jobbik is an anti-EU party is simply outdated. According to the Centre for Eastern Studies: *after the 2014 elections, the party began to change its image and began to move toward the center.* (…) *Jobbik, formerly Eurosceptic, has accepted Hungary's membership in the EU, and on certain issues – such as joining the European Public Prosecutor's Office – it even favors deeper integration* (Sadecki, 2021, p. 3). The quoted entry, while based on a real event, completely distorts the tone of the event by relying on outdated and out of context information.

3. Quote manipulation (skillful placement of a person's statement in context, cutting out sentences that change the meaning of the statement and thus support a particular thesis). As an example, let's take the high-profile reports in certain circles about vaccinations and the plan to depopulate the world:

Figure 3. A screenshot showing quote manipulation on social media "Vaccines as a factor of depopulation"

Source: http://www.facebook.com/daszdasz (26.01.2023).

In the posted video Bill Gates addresses the issue of reducing carbon emissions. One of the factors that affects the amount of emissions is the number of people living on Earth. Thus, the Microsoft owner said that one way to deal with the climate crisis would be reducing population growth. And while at first glance this opinion may seem controversial, the full context of the statement is quite different. The idea is not to get rid of already living beings with deadly vaccines, but to curb birth rates in Third World countries. In poor areas the assurance of livelihood for the elderly is to have numerous offspring to support their parents. Less developed countries face a high infant mortality rate. Reducing this rate (through a modern preventive vaccination program) could lead to a situation in which people of childbearing age would more consciously plan for offspring. The idea is to lower the number of children born without the fear that some of them will die shortly after birth. This belief is based on an observation of demographics in rich and poor countries by the Bill & Melinda Gates Foundation (Jabłonowski, 2020). The commentary of the person sharing the video is also worth noting. He puts himself in the position of an enlightened person who understands more than the rest of society, in fact with a rather cursory knowledge of the issue.

Analysis of research results

Case study: the war in Ukraine

This article was inspired by the information warfare that accompanies Russian military aggression against Ukraine, so I would like to focus on fake news about refugees from Ukraine. The narrative created around the migration crisis

associated with the outbreak of war had a schematic framework from the beginning. When the first refugees appeared at our eastern border, social media began to publish comments reminiscent of the difficult Polish-Ukrainian history. Their purpose was to tone down the positive attitude of Poles towards their neighbors fleeing war (Wirtualnemedia, 2022b). However, this did not inhibit the aid carried by Polish society. Thus, the disinformation rhetoric changed and the emphasis was shifted to the threat that would be posed by dark-skinned men crossing the border and reaching Przemyśl (due to the general mobilization announced by President Volodymyr Zelensky, male citizens aged 18–60 were not allowed to cross the state border, but foreigners studying and working there were allowed to flee the military area). False information about the alleged aggression of these people spread by, among others, the Facebook page 'Podkarpaccy Kibice' (Subcarpathian Football Fans), contributed to the creation of a 'city cleansing action'. Nationwide media reported on the beating of three Indian citizens (Polsat news, 2022). This is a clear example of how disinformation spread on social media can affect public sentiment and the safety of people in an area. It is worth mentioning that reports of aggression by dark-skinned refugees have been continuously debunked by both the Subcarpathian Police (Podkarpacka Policja, 2022) and the city authorities (Miasto Przemyśl, 2022).

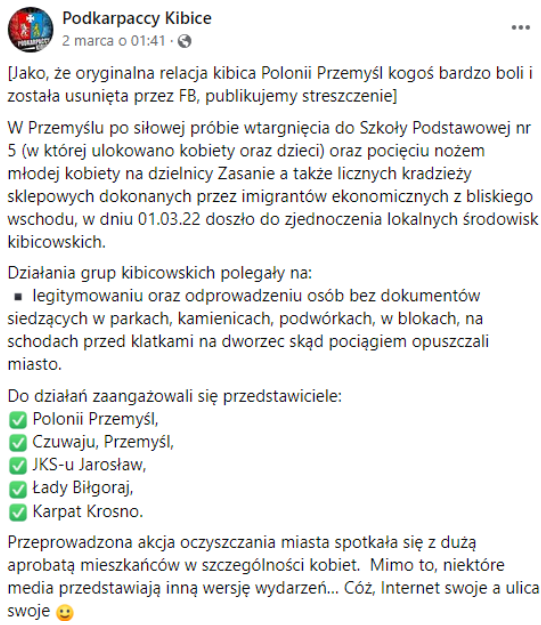

Figure 4. A screenshot showing disinformative social media post about crimes committed by refugees

Source: http://www.facebook.com/PodkarpaccyKibice (9.03.2022).

The next stage of the information war aimed at changing public attitudes were posts about the fictionalized dishonesty and demandingness of newcomers and special privileges granted by the authorities.

Figure 5. A screenshot showing false information about war refugee privileges

Source: http://www.twitter.com/Aiako2000 (15.04.2022).

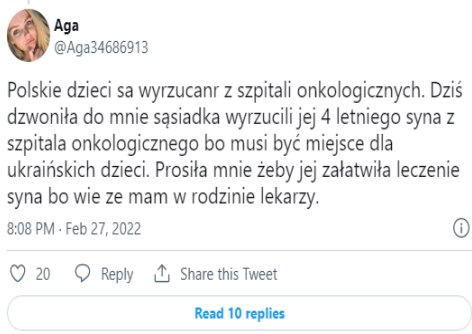

Figure 6. A screenshot showing false information about war refugee privileges

Source: https://twitter.com/aga34686913 (15.04.2022).

In the attached posts we learn about the situation of Polish students who were evicted from their dormitory and a neighbor's child who was discharged from the hospital to free up space for Ukrainian children. Both stories are building a narrative of unequal treatment of Polish and Ukrainian citizens within our country. Here, too, it is very easy to see the desire to pit Poles against the newcomers from a country ravaged by war. It is significant that we are not given to know which dormitory, which university, which hospital, or even which city the cited situations are supposed to refer to. We do not know who the neighbor is, we do not know the identity of the students. There is no way to verify these revelations. Researchers of the subject unanimously point to the source of such misinformation[1].

The cited examples perfectly show what fake news is and on what principle it works. We can note several important features, being their common denominator:

- intentionality,
- evoking extreme emotions (positive or negative),
- persuasion and polarization, which arouse the need to take sides,
- addressing current and controversial topics.

[1] I encourage you to read Polish articles about Russian bots and trolls: https://spidersweb.pl/2022/03/instagram-przypomnij-haslo-rosyjskie-trolle-jak-rozpoznac.html; https://www.telepolis.pl/wiadomosci/wydarzenia/rosyjskie-trolle-polska-dezinformacja-hejt, https://ibims.pl/komunikat-ws-prorosyjskich-atakow-informacyjnych-24-02-22/ (11.01.2025).

Figure 7. screenshot of false information and correction by the Polish Ministry of Health on social media

Source: http://www.twitter.com/MZ_GOV_PL (15.03.2023).

Case study: the U.S. presidential election – *If you do nothing,* (…) *Trump can win!* (Levy, 2022, p. 363)

While discussing the topic of fake news being used for political purposes, it is worth leaning into other important events in recent world history.

The outcome of the 2016 US presidential election was influenced by Russian manipulation, according to US journalist Steven Levy. These activities were carried out on popular social media.

Ned Moran, a Facebook threat intelligence analyst came across a lead on the activities of the Main Directorate of the General Staff of the Armed Forces of the Russian Federation (until 2004 the GRU, the Russian equivalent of the US CIA), in the Western world known colloquially as the Ministry of Propaganda. At issue are two units that have given themselves the names Fancy Bear and Cozy Bear. Before the presidential election, in which Hilary Clinton and Donald Trump were the main candidates, it turned out that accounts affiliated with the Ministry of Propaganda were highly active in seeking information on people from the Democratic community. The social network owned by Meta Platforms reported its concerns to the FBI, but there was no concrete response. Soon, Russian units launched an attack on the email inboxes of Democratic Party members. *One member of the Fancy Bear group* (…) *admitted that he had stolen the emails* (Levy, 2022, p. 350)". At the same time, efforts to activate Facebook users to share content planned by Russian services were detected. No one expected such a turn of events,

the social network was unable to react in any way. *Stamos was quick to point out that Facebook was unprepared for some of the problems that could have arisen in the 2016 elections* (Levy, 2022, p. 350). Around June 8, DCLeaks pages were launched on Facebook and Twitter, where the stolen content was published. Of course, we cannot call the content of the virtual correspondence fake news. However, the desire to influence the public by any means available is visible to the naked eye. At first, everything looked like the actions of people not connected with the former GRU – the site was founded by Alice Donovan, with Jason Scott and Richard Ginrey helping with the promotion – these are by no means Russian-sounding names. However, after careful analysis, the Facebook team discovered DCLeaks' ties to the Russian services. The portal unfortunately did not take immediate action. *WikiLeaks, a site that disseminates classified information from leaks, posted the stolen emails and the American press was able to draw from it at will, just as the Russians wanted* (Levy, 2022, s. 360). The site was only removed when it lost more relevance. Another of Facebook's shameful secrets is its focus on profit and its desire to please Republicans, who have attacked the Meta-Platforms authority time after time for alleged unfair treatment. After pressure from right-wing columnists and politicians, Facebook abandoned the selection of information in Trending Topics (until 2018 it was a box on the right side of the portal, showing popular news) by 'human hands' in favor of verification by algorithms. *Without human oversight, the algorithms promoted such posts that were successful on News Feed, and therefore attention-grabbing, but ignored questions of their veracity, intent and acceptability* (Levy, 2022, pp. 356–357). To make matters worse, links to articles were presented in the same way – trustworthy newspapers that had been verified over the years had the same visual value as a fake news site that had been created a few days ago. A huge step was taken towards tabloidization of a site with about 2 billion users. The problem was not only the manipulation of voter sentiment through leaked correspondence. The social media platform became an excellent source for distributing completely false information. In the last moment of the campaign, the number of fake news stories appearing on Facebook increased dramatically. *To avoid meddling in the election, Facebook basically gave the green light to sensationalized disinformation posts that were sure to influence the election* (Levy, 2022, p. 364). And the manipulators' modus operandi was clear:

- impersonating opinion-forming sources,
- fabricating stories about Hillary Clinton,
- posting links to fake stories on Facebook.

To show the scale of the problem, the author cites a story from November 5, when the Denver Guardian website (designed to pretend to be the real website The Denver Post), which had been prepared almost six months earlier, reported on the alleged suicide of an FBI agent suspected of leaking emails from Democratic

mailboxes. The headline of this fake news reached 15 million users and was shared 500,000 times.

Of course it is not only elections that have fallen victim to social media. The passive attitude of Mark Zuckerberg and his staff has affected many other areas of life, including health. (…) *when you searched for information about vaccines on Facebook, the search results were dominated by anti-vaccinationists with their made-up stories and conspiracy theories. They were a small minority in a huge country, but they set the tone of the debate* (Levy, 2022, p. 361). Therefore, it can be concluded that this huge platform had its (passive) share in the procedure of spreading disinformation on many important topics.

The stories mentioned concern events from almost a decade ago. Since then, Facebook has partnered with independent verifiers to check questionable content for credibility. However, observing the still ongoing flood of fake news concerning, among other things, Ukrainian refugees – the social media situation is far from optimal. In addition, given reports about the portal's resignation of fake news trackers, describing their actions as censorship of online content, we can't count on an improvement in standards (tvp.info, 2025).

Conclusions from the conducted research analyses – ways to deal with fake news

The development of information technology with all its advantages poses a huge challenge to society. There is no doubt that we are currently witnessing a never-before-seen crisis caused by a flood of information of questionable quality. Access to a multitude of (often polarized, worldview- and politically--charged) mass media can create a situation in which the recipient is unable to distinguish truth from manipulation.

It might seem that only half-truths and narratives built on the basis of events taken out of context are a problem. However, as the examples cited earlier show that also completely made-up reports by many social media users are treated as facts. So how can we deal with fake news? In an optimistic scenario, formal education from the youngest grades should be the answer to problems with understanding, verifying and interpreting data about the reality around us. However, counting on the panacea that would be the decisions of the Minister of National Education is wishful thinking. As Pęczkowski (2015, p. 42) notes – Polish schools are not keeping up with the dynamically developing world. This applies to every aspect of technological development of the reality around us). For many years, educators have been pointing to the need to introduce media education in Polish schools, but outside of academic centers, it is in vain to find such a subject in domestic educational institutions, and the content related to this topic is scattered (Drzewiecki, 2010; Łuc, 2018). And action should be taken here and now. This does not mean, of course, that the efforts of media researchers are meaningless.

Their presence in popular media provides an opportunity to capture the attention of the average audience, and the scientific publications they offer broaden the horizons of those already interested.

Given the tardiness of decision-makers (whether politicians, services or social network owners), it's worth introducing a few habits into your daily life that will help you develop your own media competence to distinguish manipulation from reality:

Don't stop at the headline, and if you don't have time – wait

We live in a time of information overload – there is no doubt about it. On the one hand, we are not limited in our access to news by time of day or distance. On the other hand, the time to thoroughly dig into each news item of interest is not unlimited. In such a situation, there is a tendency to superficially scan the text, or even to draw conclusions based on headlines alone. This is a mistake. The digital press is outdoing itself in editing more and more 'clickable' titles. It therefore becomes fundamental to thoroughly analyze the text you are reading – in its entirety and noting the situational or historical context. If a topic interests you, but you don't have the time to read it and understand the situation being described, hold off on making judgments and publishing them on social media. By failing to show restraint, you may unknowingly not only spread false information, but also become the author of it.

Use Internet resources, compare

As already mentioned, the multitude of online information sources can cause problems in understanding and interpreting the data presented. But with a little effort and good intentions, this disadvantage becomes a huge advantage. If a piece of information interests us enough that we want to pass it on (e.g., via social media), verify it in several sources. If we come across a screenshot of a controversial post by a politician on Facebook, let's visit the politician's profile and verify whether such a statement actually took place. This is the opportunity the World Wide Web gives us. Let's take advantage of it.

Verify accounts

Social media is teeming with bogus accounts trying to push their alternative vision of reality. The owners of large social media platforms are unable to control the misinformation spreading on them. Therefore, if we come across a post that evokes extreme emotions or its veracity is difficult to verify, let's take a look at the person who shared it. Let's check if the account isn't targeting a specific message. Using Google tools, let's verify the profile picture (using Google image search, we are able to determine if and when a photo has appeared on other sites, so we can find out if the avatar of a suspicious user is not simply copied from

another person's profile[2]). Let's find out if there is even a shadow of a chance that the information in question was published by a real person. As an example, let's take the twitter account 'Aga34686913' (https://twitter.com/aga34686913), whose post can be seen in photo 6. Aga, who presents herself as a conservative and Catholic, shares only controversial and polarizing content (mainly anti--vaccination and anti-Ukrainian). We are unable to determine her identity. In addition, she uses a photo of Annika Boron, an Instagram model from Toronto[3]. Is it worth trusting messages coming from such profiles and passing them on? It seems that the answer is simple. It is worth mentioning that unmasking a fake account is not always so simple. Manipulators often prepare profiles well in advance and publish content to make them look like normal users at first glance.

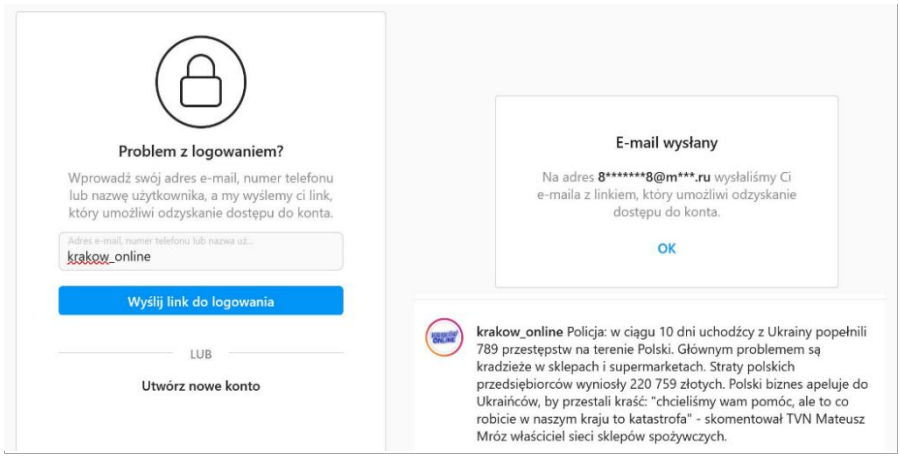

Figure 8. A screenshot of an entry from a disinformational profile registered with a Russian email address, impersonating local Krakow media

Source: https://x.com/gromotapl/ (19.04.2023).

Pay attention to spelling and punctuation

According to Giczan (2022)[4], a Belarusian opposition journalist and editor-in-chief of the Nexta website, much of the fake news is machine-translated from Russian. For a pro-Russian troll whose job is to torpedo the Western European Internet with fake news, the language barrier can be a big problem. Internet translators come to the rescue, which, as most of us probably realize, often cannot translate full sentences perfectly. While they do well with spelling, punctuation is

[2] Instructions on how to use this tool can be found at the link:https://support.google.com/ websearch/answer/1325808?hl=pl&co=GENIE.Platform%3DDesktop&oco=0 (3.01.2025).

[3] https://www.idolnetworth.com/annika-boron-net-worth-127659 (14.07.2024).

[4] An entry on this topic with examples is available at the link: https://twitter.com/TadeuszGiczan/status/1514208630610046989 (10.01.2025).

a problem for them. So if we come across a comment that seems controversial, and on top of that the flawless spelling is accompanied by commas placed in completely unexpected places, we can assume that it has been run through an automatic translator.

Separate your biases, expectations and emotions from reality

According to the principle of confirmation bias, we tend not to seek objective truth, but to surround ourselves with information that coincides with our worldview. We watch only that television whose optics are convenient for us. We buy only the press that nods to our views. On Facebook, we browse only those pages that do not shatter our vision of reality (and Facebook's algorithm 'learning' our interests, offers us more and more content that cements our beliefs). This leads to closing ourselves in a filter bubble. To prevent this from happening (or to get out of this bubble) it takes our commitment. Let's make the effort and read news and opinions that are not to our liking. This allows us to open ourselves to a different perspective, draw our own conclusions and get to the truth. Information does not become true just because it is convenient for us.

Start reading not from the news, but from the analysis of fake news

In order to sift real information from opinion and propaganda, it is worth considering whether the sources we use are definitely sources of information. For several years there have been fact-checking organizations in the Polish media market, that is organizations that track down and clarify false reports. They point out not only false news, but also news that is consistent with reality, additionally supplementing it with situational and historical context. Here are some examples of the sites which measure up to current fake news in a transparent, reliable and accessible way:

– fakenews.pl – an initiative that at first was intended to be a one-man blog, but became the reason for the creation of the 'Counteracting Disinformation' foundation. On the site we can find studies divided into categories: politics, society, technology, health and Ukraine. Importantly, we will also find information on the people involved in the project, sources of funding and fact-checking methodology;

1. sprawdzam.afp.com – Polish branch of the French news agency Agence France-Presse. The site is divided into 3 leading sections (main news, regions, topics) making it easier to find interesting articles. As of 2019, Facebook is (still) using AFP's analysis results in more than 30 countries. The site can be viewed in more than 20 available languages.

2. demagog.org.pl – a site until recently devoted mainly to verifying the statements of politicians (on a five-point scale: false, partial false, manipulated, true and unverifiable). Over time, the site has evolved. Today it publishes articles,

analyses and reports on news from the country and the world. The 'verified' tab lists all the politicians that have been screened, along with the quotes that have been analyzed.

3. fakehunter.pap.pl – a project of the Polish Press Agency and GovTech Poland, originally intended to expose fake news about the COVID-19 pandemic. Currently, the site features information on such topics as health, domestic and foreign policy divided into 3 categories: truth, fake news and unverifiable.

It is good practice to get verified news from transparent sources. In an age of information overload, troll farms and a crisis of authority, it is worth trusting those with the competence, knowledge and contacts to help review media reports. Perhaps, instead of reviewing news whose veracity we are unsure of, we should start by reviewing fake news whose falsity we can be sure of?

Alert

If a social media post seems suspicious to us, let's report it to the site administrator. Questionable content is reviewed. In the case of Facebook, they are not deleted, but marked as 'fake news'. They also have a link to the source of the post's rating. I evaluate this practice as beneficial – it allows me to see the lying content and confront it with reality.

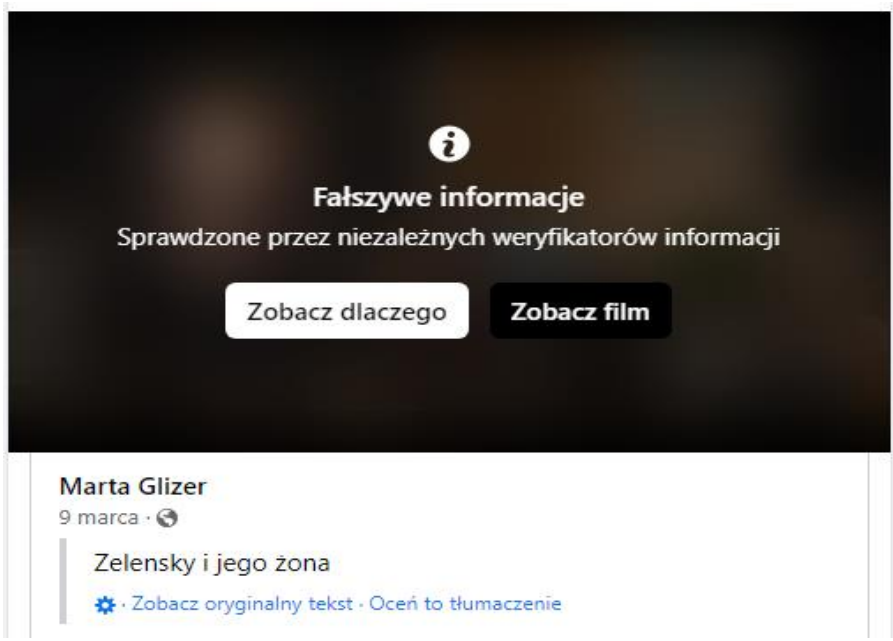

Figure 9. A screenshot of fake content verified by Facebook staff

Source: www.facebook.com/profile.php?id=100078846860078 (29.02.2023).

Conclusion

In the information society *information is treated as a product, as a commodity for sale (sometimes even as a raw material), which is becoming the main driving force of modern civilization* (Golka, 2005, p. 254). This is a huge threat. A commodity that can be sold and has a price is stripped of its ideas. Honesty and integrity often go by the wayside, benefits (economic or political) become more important to the sender. Truth builds an informed civil society, contributes to the development of a knowledge-based culture, preserving order in a rapidly changing world. Untrue information creates chaos, unrest and divides society. It is created for particular gain with the detriment of the public. It therefore becomes important to draw a clear line and distinguish between facts and harmful manipulation. However, it is difficult to put an individual before such a test without preparing him for it first. In conclusion – it is important that the drop of media education does not cease to wear away the stone of the traditional Polish school, permeating into our everyday life and providing inspiration for everyone.

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Suicide Forums in the Dark Web: Psychosocial Dimensions, Youth Vulnerability and Prevention Strategies in Cybersuicidal Greece and Slovakia

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Abstract

This essay examines the phenomenon of suicide forums in the dark web using material from recent studies published at the widely accessible part of the Internet (surface web). Namely, we clarify the terms "cybersuicide" and "Werther effect", examine the personality traits that are linked to suicidal tendencies, and analyse the differentiation between the terms "deep web", "dark net", and "dark web", which often get mixed up in everyday use. At the same time, we examine the way suicide is propagated to young people through the dark web forums, report on the basic conversation topics that take place there, study the profiles of the people who constitute them, the motives behind user participation, but also the possibilities for preventing young people's exposure to these websites. The aim of this essay is to achieve a critical understanding of the ominous but real phenomenon of online communities involved in the issue of suicide in Greece and Slovakia and to shed light on the dangers that lurk for young people who navigate the side of the Internet that hosts as much information as it does dangers.

Keywords: Suicide forums, Dark Web, Psychosocial dimensions, prevention strategies, cybersuicidal

Introduction

According to the World Health Organization (2025), suicide is the third leading cause of death worldwide for young people between 15 and 29 years old; 720,000 people take their own lives every year. For every successful suicide

attempt there are countless unsuccessful ones, which are potentially not even mentioned in the health databases. The Internet heavily influences the suicide percentages, as it is possible that in certain cases, it promotes and confers a "heroic" dimension on suicide (Murray, 2011). Thus, in the last few years, the term *Cybersuicide* has appeared, and is used to talk about online-assisted deaths from suicide (Fratini, Hemer, 2020). Usually, such deaths result from cyberbullying, prompting by unknown users in various communities, acquiring relevant information or the online purchase and use of equipment that facilitates suicide (Chang, Xing, Ho, Yip, 2019).

Moreover, since information funnelled in the Internet is not always checked, there have been several cases where people imitate the actions of others, ending up taking their own lives to get recognition in media outlets. This phenomenon is known in bibliography as *Werther effect* (Fahey, Matsubayashi, Ueda, 2018) and, despite WHO's warnings to journalists to not mention the method or location where each tragic event occurred, no one can impose this on the online communities (Fratini, Hermer, 2020).

Literature Review

Among the people that seek help from the Internet, there are quite often people who suffer from mental illnesses or have suicidal tendencies (Lester, 1998). Indeed, the degree of intensity of the suicidal ideation appears to be linked not only to neurotic and extroverted personality traits, but also to stress and depression (Stefa-Missagli et al., 2020). When a person with a neurotic personality (that is to say sensitivity to stress, worry, and negative sentiments) does not exhibit elements of depression, then there are greater chances of avoiding suicide. However, if the neurotic traits and the depression are present in a psychiatric patient, then the chances of suicide greatly increase (Stefa-Missagli et al., 2020). Additionally, studies show that people with high levels of neuroticism are in greater risk of been driven into suicidal thoughts or acts from the healthy population. This happens because people often face difficulties in their daily lives, such as separations (e.g. a divorce), lack of employment or lack of social support. These factors have also been linked to greater chances of suicide (Swickert, Hittner, Foster, 2010; Uysal, Pohlmeier, 2011).

All the above characteristics form the image of the more vulnerable users that visit suicide-themed forums in the dark web. The information that they receive during their stay there, potentially intensify the frustration symptoms they feel and amplify their self-destructing tendencies, trapping them in their negative experiences and leading them to suicide (Daine et al., 2013). However, since the Internet comprises communities that differ significantly from one another, it is worth noting here that Internet groups could prevent a user from taking their own life just as much as they can push them to this despicable act (Mokkenstorm et al., 2020).

In this essay, we will attempt to examine what happens within the groups that promote suicide, and reside "deep" in the Internet, while we will also talk about the available means to deal with cybersuicide.

Deep Web, Dark Net, and Dark Web

The term "*Deep Web"* was first used by Bergman (2001) to describe the part of the web that was not accessible by the conventional search engines. In particular, for Bergman deep web is:

1. Special databases accessible that could only be accessed within an organisation.
2. Websites wherein content is visible only after the user subscribes and pays a membership fee.
3. Websites in which content renews each time the user visits them.
4. Webpages that cannot be accessed unless the user searches for them within a specific website.
5. Emails and chat logs.

According to his essay, the deep web is 450 to 500 times larger than the surface web (the easily accessible part of the Internet), while the information it contains is of far better quality than that of the conventional Internet. As examples of deep web, he referenced the National Oceanic and Atmospheric Administration of the USA, the academic bibliography search engine JSTOR, the online commerce websites eBay and Amazon, as well as other webpages and online databases, that are still considered deep web today. However, due to the rapid technological progress, the deep web as defined by Bergman has gotten significantly smaller (Hatta, 2020).

Oftentimes in everyday speech, the deep web is confused with the term *Dark Net*. However, those two meanings are not synonyms. Biddle et al. (2003) define the dark net as a collection of networks and technologies that aim at distributing digital content anonymously (Biddle et al., 2003, page 155). The content could be distributed through CDs, USB sticks and/or from user to user through websites or networks the members of which know each other. The issue with these content distribution methods was that, in cases where the law needed to intervene (for example in cases of piracy), tracking the users was easy, since their IP addresses were known as they were not protected by any kind of encoding (Hatta, 2020).

On the other hand, the term *Dark Web* was probably used for the first time around 2009 (Becket, 2009) and significantly differs from the dark net and the deep web. The dark web is only but a small part of the deep web, which a special app or specialised browser is needed to access (Cohen-Almagor, 2017). The most common access method in this part of the Internet is possible through the software platform *TOR* (The Onion Router) (Volle, 2025). TOR is a user data encoding software, which effectively helps to browse the Internet anonymously by keeping

the user's IP address hidden under several layers of encoding. It was developed at the U.S. Naval Research Laboratory in the mid-1990s; a free version was made open source in 2003. According to data from the software itself, 2.6 million users connect to it daily. Even though TOR originally started with a benevolent goal, the circulation of sensitive information and the carrying out of police investigations, it gradually became a means for distributing malware, pornography, explicit, dangerous or forbidden content, laundering money, exchanging and selling illegal substances, material, guns, drugs, stolen data, and for numerous other malicious activities (Greengard, 2025). Among those activities is the creation of forums where means of taking a user's life are discussed and promoted.

The propagation of suicide tendencies to young people through the dark web

The increasingly worrying trend of teenagers' and young people's engagement with the "suicide subculture" raises reasonable concerns and sounds the alarm for the scientific society. The increase in the younger generation's interest on this subject seems to be tied to the Internet communities of the dark web and the prevalence of suicide challenges in the form of games, such as the Blue Whale Challenge (Surina, 2003). This particular "challenge" gradually drives participants to self-harm with a final task: suicide (Mukhra et al. 2019).

Teenagers are perhaps the most morally and psychologically vulnerable part of society, so its exposure to such dangers under the guise of trends is a major threat to their mental health, even to their life (Surina, 2023). By seeking to join teams both in the real world and online, people tend to come together in groups, the so-called *social networks,* within which they share data, engage with each other and form relationships (Tabassum, Pereira, Fernandes, Gama, 2018). Examples of such a social network are the online "death groups", found in the dark web. There, users share their thoughts and plans about suicide or promote it as a way to solve everyday life's problems. Some of these societies potentially promote suicide as a choice or a form of freedom (Surina, 2023). It is estimated that in Russia alone, 130 people took their own lives from November 2015 to April 2016, and their deaths are connected to "death group" activities (Yablokov, 2017).

In order to join these forums, an encoded connection, such as TOR, is needed. Accessing them is usually simple, allowing minors or mentally vulnerable people to participate. Post moderating is minimum or non-existent, while the anonymity mechanism promotes the lack of responsibility and empathy. For these reasons, communication within forums often includes explicit content. It has been observed that, although dark web forums record many more posts from active users compared to public discussion groups (200 posts per dark web forum user versus 15 posts per active public forum user), influential indivi-

duals are not often identified. In other words, dark forum users engage more with their personal issues or with telling their stories rather than participating in a common discussion under a post (Zamani, Rabbani, Horicsányi, Zafeiris, Vicsek, 2019).

Main thematic topics in the pro-suicide forums

Conversation topics in suicide forums usually revolve around the following categories:

1. Methods and practices of suicide: These include detailed descriptions or evaluations of various methods of suicide, frequently using classifications depending on the "effectiveness", the "certainty" or the pain. These types of forums strongly affect the user mentality as they don't leave a lot of room for critical thinking and decision making (Lewis, Seko, 2016).
2. Philosophical or existential subjects: In these forums, suicide is presented as the individual's choice or as a "release" from misery (Durkee, Hadlaczky, Westerlund, Carli, 2011).
3. Suicide stories: They include posts about completed suicides, sharing the experiences and reasons that led the users to that choice. Oftentimes, the communities of these forums comment approvingly to such posts (Durkee et al., 2011).
4. Toxic "support": While the community seems to what to support the users, gradually its positions become more and more irrevocable about the fact that pain is unavoidable in life and about suicide being the only solution (Park, Mahdy, Ammerman, 2021).

Exposure to any of the above categories of Internet forums may prove dangerous, even fatal, for a vulnerable user.

User typology in suicide forums

Fratini and Hemer (2020) in their studies on livestreamed online suicide note that the individuals who usually participate in relevant forums make up four categories. Firstly, there are the self-proclaimed "experts", who provide advice or comment on the method of suicide, often suggesting ways to improve or perform the act "correctly". Very close to this category, we find the so-called "trolls". Trolls actively encourage suicide, taking advantage of the individual's vulnerability, to cause turmoil or satisfy sadistic tendencies. On the other hand, there are the "life savers", who try to prevent people from taking their own life and encourage finding psychological support or, if needed, notify the relevant authorities themselves. Lastly, there is an ambiguous user category, who watch the stream without intervening or commenting, keeping a neutral stance. These users are called "the silent ones" and their motives remain relatively unknown. The researchers assume that behind such profiles are people moved by curiosity or people who found themselves in the platform by mistake.

All these user categories can be found in every kind of forum that promotes suicide and can strongly affect the decision of the individual who attempts to suicide. Acting as the audience, they applaud successful suicide attempts, while every person who finally escapes danger is forced to face their disapproval. Both the experts and the trolls don't easily let the individual change their mind and prevent their own death. According to French (2020), it is extremely difficult for the user who has publicly announced their suicide to retract on their suicidal intention when there is a live audience encouraging them to go through with it.

Causes for participation in suicide forums

Since, as previously mentioned, suicidal-themed forums are dangerous places, the question is: why would young users visit them? The bibliography indicates that most of them are seeking empathy and support from people going through similar psychological difficulties (Barak, Boniel-Nissim, Suler, 2008). The forums offer a sense of community and acceptance, which are usually missing from young people's real lives. Quite frequently, young people experience intense loneliness and helplessness, are socially disconnected, and believe they have lost their self-worth. They believe their internal gaps can be filled by participating in an online community. Young people could also experience stigma, consider themselves failures regarding achieving expectations or suffer from a mental illness, the existence of which clouds their judgement and overshadows their will to live (Ali, Gibson, 2019). Another equally important factor for turning to dark web forums is anonymity. Hiding one's real identity helps users seamlessly express their views, their thoughts, and their feelings (Oxford University, 2013), while they simultaneously have access to a wealth of information due to the lack of content moderation (Mars et al., 2015).

However, as previously mentioned, the prolonged stay in the Internet involves risks for users' mental and physical integrity, as the content in circulation might normalise and encourage self-harming behaviours and suicide (Sueki, 2015).

Research Methodology

Given that the present paper is theoretical in nature, the methodology followed does not involve quantitative or qualitative collection of primary data. Instead, it was based on a systematic and critical analysis of the existing scientific literature (Cooper, 2015). The main goal was the synthesis of knowledge from the broader framework of education and existing legislation in order to construct a comprehensive conceptual framework that examines the phenomenon of suicide forums on the Dark Web, with a special focus on the vulnerability of youth and prevention strategies in Greece and Slovakia.

Analysis-Results

One of the first discussion topics in the treatment of young people who suffer from mental disorders or harm themselves is the review of their relationship with the Internet (Lewis, Seko, 2015; Marchant et al., 2017). The research performed by Mörch et al. (2018) on dark web webpages about suicide brought to light the fact that there is a scarcity of webpages that engage in suicide prevention by discouraging the broad audience from proceeding with self-harming acts or by offering help to vulnerable users. By combining this data, we can extrapolate that young people browsing the dark web are more likely to come across content that promotes suicide rather than to find support for their troubles. It is thus understandable that protecting them from exposure on the dark web forums related to suicide is a dire need.

It is extremely important for young people to be educated early on the safe ways of surfing the web and to learn to identify dangerous webpages through critical evaluation of their content. They need to be able to tell dangerous or misleading content and steer clear of it (Georgieva et al., 2024).

Schools can contribute to prevent the search for information about suicide on the Internet by strengthening the mental health services they provide the students with. By collaborating with experts, teachers can create a safe environment that allows every student to express their feelings and receive the necessary support and help. Young people should be able to openly talk about their concerns, before they look for answers in dark Internet forums, and receive training that will help them deal with stress, social pressure, sadness, and other feelings they might be having difficulty with (Suicide Prevention Resource Centre, 2020). It is necessary to emphasize the education of adults (i.e. parents, teachers, etc.), so that they would be able to identify warning signs that underage Internet users might show when they are exposed to inappropriate content. The goal is to be able to intervene in time and help if necessary (Centre for Disease Control and Prevention, 2022).

Cyber-suicide prevention methods in Greece

Additionally, parents should stay informed by credible sources, such as the Ministry of Digital Governance and the Greek Police, about the dangers lurking in the Internet and about the methods they can use to mitigate them. Such methods are installing computer activity tracking software or malware and inappropriate content filtering software, as well as regularly checking the browsing history. Already there are several government apps that help parents check on their children's online activity, such as Kids Wallet and the parco.gov.gr platform, which contains clear guidelines on how to install parental control on the electronic devices used by minors. Moreover, it should be noted that open dialogue with the younger

generation, especially about such sensitive topics, is of paramount importance and could prevent great dangers (Ministry of Digital Governance et al., 2024).

Naturally, the contribution of bigger organisations, such as social networking platforms and search engines, is also necessary. They, in turn, should work together with mental health organisms and show users supporttive content when they research topics like “how to kill myself” (Borge et al., 2021). Artificial intelligence could also be used through implementation of machine learning technologies to identify concerning behaviour or keywords in users’ online activity. Such an app is presented in Van Herk’s (2023) postgraduate essay.

The World Health Organization (2017) offers a full guide about suicide prevention, meant for mental health specialists. Among others, it mentions that it is important for experts to openly discuss the topic with their patients, educate them in methods of handling difficult emotions, provide psychological support and empowerment, but also advise them on where to find valid sources of information and support for the issues they are concerned about. Additionally, mental health specialists must be equipped to provide proper support to caretakers of people that experience suicidal ideation, so they can frame the issue correctly and achieve optimal therapy results.

Lastly, it is necessary for the state to take measures, such as the advocacy of legislative initiatives to protect minors on the Internet. Illegal webpages that circulate on the surface and in the dark web should be identified and taken down by the police authority responsible for online safety, the Cyber Crime Division (Hellenic Police, 2022).

In general, a coordinated multilevel effort from all the institutions is needed in order to limit and effectively deal with the risks of inappropriate content exposure, such as what is circulated in the dark web suicidal forums (Substance Abuse and Mental Health Services Administration, 2024).

Cyber-suicide prevention methods in Slovakia

Cyber suicides represent a serious societal and public health issue, particularly in relation to the growing influence of the digital environment on the mental health of young people. The aim of this paper is to identify and evaluate methods of cyber suicide prevention in Slovakia, with a focus on institutional strategies and interdisciplinary interventions.

The most significant pillar is online crisis support provided by organizations such as IPčko and the *Chcem sa zabiť* ("I want to die") project. These platforms operate continuously, offering anonymous and free assistance via chat, email, or telephone, and often intervene directly in online environments. (IPčko, 2025.; Chcemsazabit.sk, 2022). Additionally, IPčko carries out specialized online outreach

work aimed at identifying at-risk groups and intervening within online communities (IPčko, 2021).

Another crucial aspect is media awareness, which reflects the recommendations of the World Health Organization regarding responsible communication about suicide (NCZI, 2025). In the context of the World Suicide Prevention Day (September 10), awareness campaigns emphasize empathy, destigmatization, and the active search for help (TASR, 2024; SME, 2024).

The school environment also plays an irreplaceable role. Teachers are equipped with professional methodological guides that help them identify warning signs, strengthen students' mental health, and respond appropriately to crisis situations (Bertolote, 2007).

A comparative overview of the cyber-suicide prevention initiatives and policies implemented in Slovakia and Greece is presented in Table 1

Table 1. An overview of the cyber-suicide prevention initiatives and policies implemented in Slovakia and Greece

	Greece	Slovakia
Primary Focus	Parental control, legislative action, and source removal.	Online crisis intervention, outreach, and public awareness.
Key Actors	Ministry of Digital Governance, Greek Police (Cyber Crime Division), schools, parents.	NGOs (IPčko, "I want to die" project), media, schools.
Technological Approach	Use of government apps (Kids Wallet) and parental control software for monitoring and filtering.	Online chat/email support and specialized online outreach to at-risk users in their communities.
Educational & Media Role	Government platforms (parco.gov.gr) provide guidelines for parents. Emphasis on open dialogue within the family.	Media follows WHO guidelines for responsible reporting. Nationwide awareness campaigns (e.g., World Suicide Prevention Day).
Institutional & Legal Measures	Advocacy for laws to protect minors. Police action to identify and take down illegal websites on the surface and dark web.	Schools are equipped with methodological guides for teachers to identify warning signs and support students.
Overall Strategy	A model focusing on limiting exposure to harmful content through control and enforcement.	A model focusing on crisis intervention, outreach, and destigmatization through public engagement.

In conclusion, effective cyber suicide prevention requires technologically supported assistance, active media engagement with the topic, and a well-prepared educational environment. Moving forward, it is recommended that collaboration between state institutions, the education sector, and mental health professionals be further strengthened.

Discussion – conclusion

The cyber-suicide phenomenon, as showcased through the dark sides of the Internet and, more specifically, through the digital communities of the dark web, constitutes a complex, multifactored, and deeply concerning threat for modern

society. A particular concern rises when the threat in question turns against the most vulnerable population groups, notably teenagers and young adults. This essay attempted to investigate this phenomenon not only as an individual expression of mental discontent, but mostly as a product of a collective reinforcement in the context of a deregulated digital environment that allows and/or encourages the replication of suicidal ideas. As the analysis of suicidal forums of the dark web has indicated, the platforms in question function as hubs of anonymous, unmoderated interaction. The lack of institutional moderation and the lack of empathy that govern these communities render the distribution of pathological content extremely easy. More specifically, the prevailing discussion topics in these spaces reveal the users' psychological burdening, while a deeper cultural transposition, where suicide is portrayed as an alternative solution or as a form of personal liberation, is also perceived.

At the same time, the analysis of the participation motives in suicidal forums has demonstrated that people's need for social acceptance, communication, and psychological release often works deceptively. It is possible that, due to the deficiencies in the above domains, Internet users could be directed towards dangerous environments. Several times, the lack of psycho-societal support in the real world translates in a search for one's identity and for understanding in the digital world. When this fact is combined with vulnerable personalities, the potential for influence and manipulation from members of the suicidal communities is increased.

As such, it becomes clear that dealing with the phenomenon of cybersuicide cannot be limited to isolated efforts or individual interferences. On the contrary, forming a multifactored and cross-scientific prevention and interference framework is needed. Families, schools, the scientific community, the mental health institutions, and the state in its entirety must get mobilised and together contribute to the efforts of protecting mental health, and to young people's education. Advances in artificial intelligence have revolutionized the development of suicide screening tools and suicide risk detection systems. Thus, various types of AI systems, including text-based systems and social media, have been proposed to identify individuals at risk of suicide (Castillo-Sánchez et al., 2020; Parsapoor, Koudys, Ruocco, 2023). This way, the ultimate goal of protecting the younger generation's wellbeing could be achieved, thus securing the future of our society.

Despite differing implementation frameworks, Greece and Slovakia share common pillars in their fight against cyber-suicide: leveraging online platforms for support and awareness and integrating mental health principles into education. The primary distinction emerges in their operational focus. Slovakia has developed advanced psychosocial intervention models directly within digital environments, whereas Greece places greater emphasis on regulatory frameworks and technological tools for shielding minors. This juxtaposition suggests that an ideal model would synergize proactive support with preventative safeguards.

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Artificial Intelligence in Function of Multimedia Quality for Functional Learning

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Abstract

Artificial intelligence (AI) is transforming the quality of multimedia content, enabling personalized, interactive, and adaptive learning (AL). This paper explores how AI contributes to improving multimedia materials using methods such as user data analysis, speech synthesis, and image recognition. The focus is on functional learning (FL), where AI enhances student comprehension and engagement. The works of prominent researchers, including Mitchell, Goodfellow, and Russell, are analyzed. The results indicate that AI enhances accessibility, personalization, and efficiency of multimedia educational resources.

In addition, recent research 2020–2024 confirms that AI-supported multimedia significantly improves higher-order cognitive processes, problem-solving skills, and learning transfer, which are central components of FL (Zawacki-Richter, Marín, Bond, Gouverneur, 2020; Papamitsiou, Economides, 2021; Holmes, Tuomi, 2022; de Araujo, Dorça, Lima, Fernandes, 2023; Chen, Xie, Zou, 2024).

Keywords: artificial intelligence, multimedia, FL, AL, interactive systems

Introduction

The digital revolution has enabled the intensive use of multimedia technologies in education, leading to changes in how students approach learning and knowledge acquisition (Gaftandzhieva, Hussain, Hilčenko, Doneva, 2023). Multimedia content such as interactive simulations, video lectures, and adaptive educational games has become an integral part of modern teaching methods

(Hilčenko, 2006). However, despite their advantages, traditional multimedia educational resources often do not consider different learning styles, cognitive abilities, and prior knowledge of students, which can limit their effectiveness (Hilčenko, 2008).

Integrating AI into educational multimedia systems opens new opportunities for content personalization and adaptation to individual student needs. Using advanced machine learning algorithms and data analysis, AI enables real-time dynamic adjustment of educational materials, optimization of interactivity, and enhancement of student engagement (Hilčenko, 2009). Intelligent systems can analyze educational patterns, adjust task difficulty levels, and provide personalized feedback, thereby increasing motivation and learning efficiency (Mitchell, 1997; Hilčenko, 2015c).

In this paper, the concept of FL is defined as a process in which students acquire knowledge and skills that can be directly applied in practical, real-life, and problem-solving contexts. FL emphasizes transferability, active engagement, and meaningful application of learned concepts, distinguishing it from memorization--based learning. AI-enhanced multimedia supports this approach by enabling adaptive scaffolding, contextual simulations, and interactive problem-solving environments.

The aim of this paper is to explore how AI enhances the quality of multimedia content in FL, with a special focus on AL support systems, interactive educational platforms, and automated student progress analysis capabilities (Hilčenko, 2015a, 2015b). By analyzing existing research and practical examples, the paper will highlight the advantages and challenges of AI integration into multimedia educational resources, as well as its potential for further development of educational technologies (Hilčenko, 2019).

Furthermore, this study synthesizes recent findings (Zawacki-Richter et al., 2020; Holmes, Tuomi, 2022; Liu, Wang, Chen, 2023) to provide a more comprehensive understanding of AI's pedagogical value, addressing not only technological but also epistemological and cognitive dimensions of AI-mediated learning.

Problem Analysis

Personalization and Adaptivity

One of the key contributions of AI in multimedia education is personalized learning, which enables content to adapt to each student's specific needs (Hilčenko, Nikolić, 2023). Goodfellow, Bengio, and Courville (2016) emphasize that AI can analyze learning patterns and dynamically adjust educational material according to individual user characteristics, such as learning styles, comprehension speed, and prior knowledge (Hilčenko, Nikolić, 2024). This approach allows students to progress at their own pace, contributing to more efficient learning and better information retention.

Recent deep learning studies, such as those by LeCun, Bengio, and Hinton (2015), demonstrate how algorithms can segment students according to their learning styles. They can identify behavioral patterns not immediately apparent. Moreover, natural language models like BERT and GPT-3 (Devlin, Chang, Lee, Toutanova, 2019; Brown et al., 2020) enable advanced text content analysis. They facilitate the generation of customized educational materials and real-time content adaptation, significantly improving the learning experience.

Recent AL systems (Xiang, Li, Sun, 2021; Huang, Spector, Yang, 2024) further incorporate reinforcement learning and explainable AI, enabling transparent decision-making models that help educators understand why certain adaptations occur, thus bridging the gap between automated processes and pedagogical expertise.

Enhancement of Image and Sound Quality

Besides personalization, AI significantly improves multimedia content quality, particularly in image and sound processing. Advanced algorithms, as described by Russell and Norvig (2021), allow for better understanding and interaction with visual and auditory components of educational materials. These algorithms can automatically optimize image resolution and sound clarity, enhancing the accessibility and effectiveness of educational resources.

One of the most significant technological innovations in this field is Generative Adversarial Networks (GANs) (Goodfellow et al., 2016), which improve image and video quality by generating high-quality visual content from existing data. These models are especially useful for generating educational content in real-time, such as 3D visualizations or simulations.

Newer architectures, such as diffusion models (Moerland, Broekens, Jonker, 2022), provide even higher fidelity and are increasingly used in educational AR/VR systems, enabling immersive environments that support FL through experiential and situational simulations.

Data Analysis and Interactive Systems

AI also enables deep analysis of user data, allowing dynamic adjustment of educational content based on student progress. Bishop (2006) highlights that these tools can analyze educational data to identify knowledge gaps and provide personalized feedback. This allows educators to better understand student progress and optimize their teaching approaches.

Using deep neural networks (He, Zhang, Ren, Sun, 2016) and advanced architectures like Transformers (Vaswani et al., 2017) facilitates the development of interactive systems. These systems can analyze data, recognize linguistic structures, and understand contextual meanings. This improves student interaction with educational materials (Figure 1).

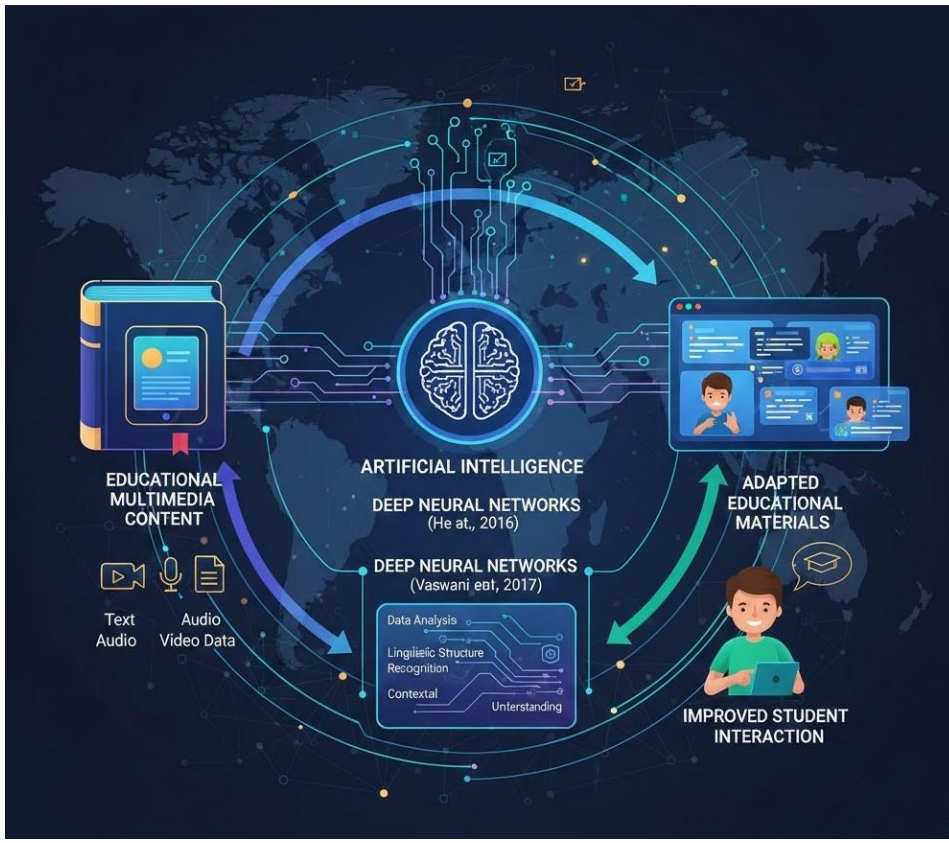

Figure 1. The process of adapting multimedia content using artificial intelligence. Note. Illustration adapted from authors' own design

Modern multimodal AI (Gupta, Sharma, 2022) combines text, audio, and visual input, enabling the creation of intelligent tutors capable of tracking cognitive load, emotional states, and engagement levels–key components for ensuring that FL truly occurs.

Discussion

Previous research highlights AI's significant potential in improving multimedia educational resources, particularly through content personalization and adaptivity, as well as enhancing interactivity and student engagement. However, despite AI's evident benefits in education, several challenges must be addressed for its effective and ethical implementation.

One of the key challenges is user privacy protection when processing data. Educational AI systems often collect vast amounts of sensitive student data. This includes learning habits, performance, and even biometric data. Without adequate

safeguards, the risk of data misuse or unauthorized access can jeopardize user trust and the integrity of the educational system (Radford et al., 2019).

A further challenge lies in ensuring pedagogical validity. AI-driven adaptations must align with instructional goals, not merely algorithmic optimization. Research from 2020–2024 warns that excessively automated systems may reduce learner autonomy, introduce algorithmic bias, or create over-dependence on adaptive scaffolding. Therefore, the integration of AI requires a balance between automation and human oversight (Zawacki-Richter et al., 2020; Papamitsiou, Economides, 2021; Holmes, Tuomi, 2022; de Araujo et al., 2023; Chen et al., 2024).

In addition, the concept of FL demands that AI tools promote deep understanding rather than superficial task completion. This requires careful design of multimedia resources to ensure that adaptive content leads to meaningful cognitive engagement and real-world applicability.

Moreover, AI systems must provide transparent decision-making processes. Recent adaptive learning frameworks use explainable AI to allow educators to understand why certain adaptations occur. This helps bridge the gap between automated processes and pedagogical expertise (Zawacki-Richter et al., 2020; Papamitsiou, Economides, 2021; Holmes, Tuomi, 2022; de Araujo et al., 2023; Chen et al., 2024).

Finally, the ethical implementation of AI in education also involves addressing equity and inclusivity. Adaptive systems should ensure that all students, including those with special needs or from disadvantaged backgrounds, benefit from AI-enhanced learning. Designers must consider universal design principles to make multimedia content fully accessible and flexible for diverse learners.

Conclusion

AI represents a crucial revolution in multimedia education, enabling personalized, interactive, and dynamic educational resources tailored to student needs. AI applications in FL have the potential to transform the education system by increasing student efficiency and engagement through automatic analysis of their learning styles, progress speed, and required support levels.

Despite AI's advantages in education, further research and innovation are necessary to overcome existing obstacles. Technical constraints, such as high computing power and infrastructure requirements, pose significant challenges, especially in resource-limited educational institutions. Additionally, ethical concerns regarding user data privacy must be addressed to ensure the responsible and secure implementation of AI in education.

Moreover, future work must deepen the theoretical integration of AI within FL frameworks, ensuring that adaptive multimedia supports transfer, autonomy, and problem-solving competencies. The development of explainable, multimodal, and context-aware AI systems will play a critical role in achieving these goals.

The next research steps should focus on developing scalable solutions that effectively integrate AI into various educational contexts, including those with limited technology access. Future studies should also explore how AI can enhance the inclusivity of education, offering learning opportunities to students with special needs or from socioeconomically disadvantaged backgrounds.

Special attention should be given to designing AI-driven multimedia that supports universal design for learning (UDL), enabling fully flexible and accessible educational experiences. In addition, recent research (2020–2024) confirms that AI-supported multimedia significantly improves higher-order cognitive processes, problem-solving skills, and learning transfer, which are central components of FL (Brown et al., 2020; Zawacki-Richter et al., 2020; Papamitsiou, Economides, 2021; Holmes, Tuomi, 2022; de Araujo et al., 2023; Chen et al., 2024).

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Enhancing IT Competencies Through Python-Based Computational Thinking Modules for Teachers

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Abstract

This study addresses the growing need for IT competency among educators in higher education by introducing Python-based computational thinking modules. Computational thinking – involving decomposition, pattern recognition, abstraction, and algorithm design – is a critical skill for navigating the digital era. Python, known for its simplicity and versatility, is an ideal language for enhancing these skills. This paper details the design of professional development programs tailored for higher education faculty, focusing on curriculum structures, practical exercises, and case studies of successful implementations. The findings demonstrate how such programs can empower educators to integrate computational thinking into their pedagogy, fostering a culture of innovation and technological fluency in academic environments. Furthermore, this study explores the role of artificial intelligence (AI) in enhancing Python's applicability, highlighting its potential to revolutionize education through tools like machine learning frameworks and intelligent tutoring systems.

Keywords: Computational Thinking, Python Programming, Higher Education, Teacher Training, Professional Development

Introduction

The integration of computational thinking into higher education is essential for preparing both educators and students for the demands of the modern digital world. Computational thinking, as defined by Wing (2006), is a problem-solving

methodology that involves decomposition, pattern recognition, abstraction, and algorithmic thinking. These skills are foundational for navigating not only computer science but also a broad range of academic disciplines and real-world challenges.

Python, a high-level programming language known for its readability and extensive library support, has gained popularity as a teaching tool in higher education. Its versatility makes it an effective medium for introducing computational thinking concepts to educators, allowing them to bridge theoretical knowledge with practical applications. Faculty equipped with Python skills can design innovative teaching strategies, create interdisciplinary connections, and improve student engagement in various courses.

Higher education institutions play a pivotal role in equipping faculty with these competencies. Educators require not only technical proficiency in Python but also pedagogical strategies tailored to adult learners. Professional development programs tailored for faculty members are crucial to achieving this dual goal. Such programs should focus on integrating computational thinking into existing curricula, fostering collaborative learning environments, and supporting continuous professional growth.

This paper outlines the framework for Python-based computational thinking training tailored to higher education faculty. It explores curriculum design principles, practical exercises to enhance IT competence, and case studies demonstrating the transformative impact of these programs. By empowering educators, higher education institutions can advance their mission of fostering innovation and preparing students for a technology-driven future.

Curriculum Design for Teacher Training in Computational Thinking

Learning Objectives:

1. Understanding Computational Thinking: Faculty members are introduced to core components of computational thinking, such as decomposition, pattern recognition, abstraction, and algorithm design. These skills are essential for structuring complex problems into manageable parts (Wing, 2006; Hilčenko, 2023).
2. Solving Real-World Problems: Educators learn to apply Python in modeling and solving problems relevant to their academic disciplines, such as data visualization or automating research workflows (Grover, Pea, 2013; Hilčenko, 2024).
3. Teaching Strategies: Training includes strategies for teaching computational thinking to university students, emphasizing interactive and student-centered approaches (Van Roy, 2009).

Module Structure:

1. Introductory Module: This module provides a foundational understanding of Python syntax, variables, and data types. These basics prepare faculty for more advanced topics and ensure all participants have a common starting point (Python.org., 2025).

2. Intermediate Module: Participants delve deeper into loops, conditionals, and functions. These skills are vital for developing structured and efficient code, which is critical for solving real-world problems (Code.org., 2025).

3. Advanced Module: Faculty work on real-world applications, such as automating repetitive tasks, analyzing datasets, and designing algorithms. This module bridges theoretical learning with practical application, fostering confidence in applying Python in diverse scenarios (Shute, Sun, Asbell-Clarke, 2017).

4. Pedagogical Module: This module equips educators with tools and strategies to integrate computational thinking into their teaching. Techniques such as project-based learning and flipped classrooms are explored to enhance student engagement (Sengupta, Kinnebrew, Basu, Biswas, Clark, 2013).

Resources and Tools:

1. Python IDEs: Tools such as Jupyter Notebook and Thonny are introduced for their user-friendly environments that support coding and visualization (Python.org., 2025).

2. Interactive Platforms: Platforms like Replit and Code.org provide opportunities for additional practice and collaboration, ensuring learning continues beyond structured sessions (Code.org., 2025).

3. Educational Libraries: Python libraries like Turtle Graphics for visualization and pandas for data analysis are integrated into the curriculum to demonstrate practical use cases (Wilson, Guzdial, 2013).

Practical Exercises to Boost IT Competence

Interactive Activities:

1. Programming Puzzles: These exercises are designed to reinforce foundational concepts like loops and conditionals. They encourage hands-on problem solving, helping participants bridge theory and practice (Grover, Pea, 2013).

2. Turtle Graphics Projects: Faculty use Python's Turtle library to create visual representations, such as geometric patterns. These activities foster creativity and logical reasoning, showcasing the versatility of Python in visual problem-solving (Wilson, Guzdial, 2013).

3. Data Manipulation Tasks: Using the pandas library, participants learn to clean and analyze simple datasets. These tasks provide a gateway to advanced data science concepts while remaining accessible to beginners (Resnick et al., 2009).

Collaborative Learning:

1. Pair Programming: Participants work in pairs to write and debug code, which promotes peer learning and fosters collaboration. This approach mirrors real-world programming practices and enhances problem-solving skills (Van Roy,

2009). Additionally, research highlights the importance of choosing beginner--friendly programming languages, such as Python, to ensure an inclusive and accessible learning experience. Python's simple syntax and wide applicability make it particularly effective for engaging educators in collaborative tasks (Viduka, Kraguljac, Ličina, 2021).

2. Group Projects: Teams of educators collaborate on developing small applications or simulations, such as grading systems or classroom management tools. These projects encourage interdisciplinary collaboration and practical application of skills (Lye, Koh, 2014).

Real-World Applications:

1. Automation: Faculty are trained to write Python scripts that automate repetitive tasks like grading assignments or managing datasets. This streamlines administrative workflows and demonstrates Python's practical utility (Shute, Sun, Asbell-Clarke, 2021). Additionally, the integration of Python with Raspberry Pi has proven particularly effective in small-scale production environments, enabling the automation of tasks such as product counting and packaging. Such applications highlight Python's capacity to combine affordability with powerful industrial solutions, as demonstrated in a case study of Raspberry Pi and Python optimizing workflows in manufacturing plants (Ličina, Viduka, Ilić, 2021).

2. Classroom Simulations: Python is used to model educational scenarios, such as simulating statistical experiments or visualizing complex mathematical concepts. These applications enhance teaching efficacy by making abstract concepts more tangible (Sengupta et al., 2013).

Case Studies of Successful Python Integration

Table 1 summarizes the key findings from three case studies that explore the integration of Python into professional development for higher education faculty. Each case study highlights different contexts and activities, showcasing the diversity and effectiveness of Python-based training programs:

Table 1. Three case studies that explore the integration of Python into professional development for higher education faculty

Case Study	Participants	Key Activities	Outcomes
Professional Development Workshops	50 faculty	Python scripting, administrative automation, Turtle Graphics	30% improvement in technical proficiency; increased confidence in pedagogy
Blended Learning Approach	100 faculty	Online lessons, live coding sessions, project design	20% increase in computational thinking integration; enhanced student engagement
Community-Driven Python Learning Circles	30 faculty	Workshops, collaborative projects, knowledge sharing	40% increase in interdisciplinary collaboration; repository of teaching materials

Case Study 1: Professional Development Workshops

A university conducted a series of workshops to introduce faculty members to Python and computational thinking. Each session combined theoretical discussions with practical activities, such as creating scripts to automate administrative workflows and developing visualizations using Turtle Graphics. Participants reported increased confidence in their ability to incorporate Python into teaching and research. Additionally, faculty who participated in the workshops reported a 30% improvement in their technical proficiency, enabling them to implement innovative teaching methods in their courses (Wilson, Guzdial, 2013).

These workshops emphasized hands-on learning, with participants engaging in activities such as scripting and administrative task automation using Python. The result was a significant improvement in technical skills and increased confidence among faculty in integrating computational thinking into their teaching.

Case Study 2: Blended Learning Approach in Teacher Training

An online professional development program was launched to train higher education faculty in computational thinking. The course featured asynchronous video lessons on Python fundamentals and live coding sessions for real-time problem-solving. Faculty were tasked with designing Python-based projects relevant to their disciplines, such as data visualization tools or interactive simulations. Post-course evaluations highlighted a marked improvement in participants' confidence and student engagement. Furthermore, educators reported a 20% increase in the integration of computational thinking activities into their curricula (Van Roy, 2009).

This approach combined asynchronous and synchronous learning to deliver Python training. Participants developed discipline-specific projects, such as data visualization tools, resulting in a marked increase in both student engagement and the adoption of computational thinking methodologies in classrooms.

Case Study 3: Community-Driven Python Learning Circles

In a peer-driven initiative, faculty members from diverse disciplines formed local learning circles to explore Python's applications in education. Monthly workshops included topics such as automating data collection, creating visual aids for lectures, and teaching computational concepts in non-technical fields. These meetings fostered a collaborative learning environment, allowing participants to share resources and best practices. Outcomes included the development of a shared repository of Python-based teaching materials, a 40% increase in interdisciplinary collaboration, and sustained engagement through quarterly hackathons (Resnick et al., 2009).

Faculty from various disciplines collaborated in local learning circles, sharing resources and developing Python-based teaching tools. This peer-driven initiative fostered interdisciplinary collaboration and the creation of a shared repository of educational materials.

Conclusion and recommendations

Python-based computational thinking modules provide an effective framework for enhancing IT competencies among higher education faculty. These programs equip educators with the skills needed to address modern educational challenges, fostering a generation of computationally literate students. By empowering educators with computational thinking skills, institutions can encourage innovation, critical thinking, and problem-solving in academic environments.

To ensure the success of such programs, institutions should:

1. Provide ongoing support through mentoring and resources to help faculty continuously refine their computational thinking skills.
2. Encourage collaboration among educators through communities of practice, promoting the sharing of knowledge, resources, and innovative teaching strategies.
3. Regularly update curriculum content to reflect technological advancements, ensuring that faculty stay ahead of emerging trends and applications.
4. Develop assessment metrics to evaluate the impact of computational thinking programs on teaching efficacy and student engagement.
5. Offer incentives for faculty participation in professional development programs, recognizing the importance of these efforts in advancing institutional goals.
6. Foster partnerships with industry and research organizations to create real-world applications and case studies for training modules.

The integration of artificial intelligence (AI) into Python programming introduces transformative opportunities for both educators and students. AI-powered tools and frameworks, such as TensorFlow and Scikit-learn, allow educators to explore machine learning concepts and their applications in problem--solving and data analysis. These advancements enable higher education faculty to incorporate cutting-edge AI techniques into their curricula, preparing students for careers in emerging technological fields. Furthermore, AI applications in education, including personalized learning platforms and intelligent tutoring systems, can be developed using Python, demonstrating its potential as a tool for innovation in pedagogy. By implementing these recommendations and embracing AI advancements, higher education institutions can establish a culture of continuous learning and technological adaptability. This proactive approach ensures that both educators and students are well-prepared for the demands of a rapidly evolving digital landscape.

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Learning Geometric Polyformisms in Mathematics Education

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Abstract

The renowned Russian mathematician, mathematics education methodologist, scientist, science popularizer, author of geometry textbooks, and lecturer at Moscow State University, Igor F. Sharygin, believed that geometry should primarily be *geometric*, rather than analytical or algebraic. The central character in this story should be the *figure*, with the triangle and circle dominating its surface, and the main means of learning should be the drawing and the image. Textbooks that focus on geometric content should not be limited to the development of geometric theories. The learning process of such content involves a wide variety of work formats, primarily through problem solving. A problem is not merely a skill exercise, but a component of knowledge. Students should become familiar with a sequence of sufficiently challenging geometric problems, following well-known models. Incidentally, this essentially constitutes the process of learning algebra as well.

Keywords: geometry, polyformism, geometric polyformisms in teaching

Introduction

We present students with methods and convey algorithms that are difficult, if not impossible, to discover independently. In geometry, unlike algebra, such algorithms are scarce or almost non-existent. Nearly every geometric problem is

non-standard. Therefore, in teaching, the importance of key problems increases – those that explain useful facts or illustrate a method (Sharygin, 2004). Drawing is the first step toward abstraction – essential properties are condensed, and non-essential ones are disregarded (Sharygin, 2004). When Rudolf Arnheim, one of the founders of the Gestalt school in psychology, wrote his seminal work *Visual Thinking* (the unity of image and concept) in the early 1930s, he based all his claims on geometric interpretations. In his article "Does Geometry Belong in 21st Century Schools?", Igor F. Sharygin emphasizes that we create geometric images in order to stabilize our internal representations. Visual thinking – thinking in images – has the property of comprehensiveness and is not easily transferable. Images, or icons, are carriers of information. That is why Sharygin (1937–2004), when speaking about "good geometry," puts a good problem – presented with a beautiful image and vivid language – at the center of the story. This "vivid language" makes visual thinking more transferable. The interpretation of a mathematical problem through geometric polyformism allows for a dynamic approach to the problem or phenomenon itself, resulting in comprehensive and profound understanding (Nikolić, 2021; Hilčenko, Nikolić, 2023, 2024).

When we say that mathematics teaching should be dominated by geometric polyformisms, we refer to instruction where mathematical problems are primarily solved and teaching phenomena are explained through various schematic representations–that is, through geometric reinterpretations of the same problem in multiple ways (Nikolić, Hilčenko, 2024).

Polyformism

The fundamental principles of polyformism are based on the dual or multiple applications of the law of the negation of the negation to the same phenomena–i.e., to initial problems or established theories. The interpretation of a mathematical problem that allows for polyformal geometric analysis enables a dynamic approach to the problem or the phenomenon itself, resulting in its comprehensive and profound understanding. The diversity dominated by geometric polyformisms represents the principle of polyformism, which is grounded in a finite number of logical conjunctions or principles (e.g., the laws of the negation of the negation, modus ponens, the principles of obviousness, permanence, etc.) (Marković, 2012). This diversity, when combined with arithmetic, algebraic, and methodological variation, constitutes a didactic principle of polyformism. At its core, this principle lies in the constant insistence on an integrative view of various evident – especially geometric – approaches to the understanding and conceptualization of taught mathematical notions (Nikolić, Hilčenko, 2024). In practice, this demands that the teacher possesses a deep knowledge of and the ability to apply a wide array of professional, didactic, and methodological strategies. At the same time, it

stimulates students' intensive intellectual activity, expressed through high-quality, self-directed work and enhanced motivation. Instruction, when viewed through the lens of such principled foundations, presupposes new, polyformal methodological approaches. Learning through self-cognitive polyformal heuristics – as a dominant method within the framework of polyformal principles of interactive teaching – implies that the content to be acquired by students is not presented in a ready-made form, but must instead be discovered, preferably in multiple ways (Nikolić, Đokić, Hilčenko, 2022). This significantly enhances students' intellectual capacity, motivation, and learning engagement, accompanied by a sense of satisfaction from the accomplished work. Learning through the method of self-cognitive polyformal heuristics yields greater outcomes in terms of acquiring conceptual knowledge, and especially procedural (i.e., applicable) knowledge, in accordance with modern taxonomies of knowledge. This occurs because the student invests individual effort to organize newly acquired information within their own cognitive system and to find the full range of necessary information. As a result, the student's ability to organize and structure data improves, through deductive and analytical-synthetic approaches and their application to various problem-solving and even real-life contexts. According to numerous researchers, modern education – which represents a fusion of principled and methodological "weaving," aided by the use of computers (often unrecognized or unacknowledged by traditionalist approaches) – introduces new qualities of diverse instructional practices. These enhance student engagement in the learning process, increase motivation, curiosity, initiative, creativity, and the applicability of acquired knowledge in everyday life, which are the core goals of contemporary mathematics education (Nikolić, 2021).

The Didactic Principle of Polyformism

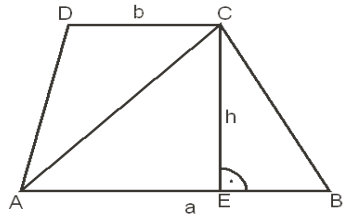
The effectiveness of the polyformism principle is based on an evident psychological fact: change and variety in instructional work refresh the teaching process, whereas monotony typically induces a decline in interest and results in passivity and boredom. Therefore, in mathematics education, the principle of polyformism should play a general role – one that is manifested through the enrichment of instruction by means of diverse content, tools, procedures, and methods. With regard to content, this refers to the selection of tasks that allow for multiple, varied approaches to problem-solving, including the use of visual and concrete teaching aids. However, organizing such lessons requires the appropriate application of diverse methodological forms and instructional variations within a single lesson. The methodological forms and specific teaching strategies planned and implemented by the teacher during instruction are grounded in the timely activation of didactic principles. This manifests as their simultaneous *polyformal-cohesive effect* – that is, their integral dialectical unity (Nikolić, Marković, 2016).

Development (Analysis of Research Results): Examples of Geometric Polyformism in Primary School Teaching

In primary and secondary school textbooks, as well as in various problem collections and mathematical handbooks, there is typically only one, or at most two to three, approaches to deriving a given formula. These proofs are generally based on theorems concerning decomposable or complementary equality of polygonal areas.

Proof 1

Let ABCD be a trapezoid with bases AB and CD of lengths a and b, respectively, and height h. By drawing the diagonal AC, the trapezoid is divided into two triangles: △ABC and △ACD The area of the trapezoid can thus be calculated as the sum of the areas of these two triangles, using the aforementioned theorem on decomposable equality of polygonal areas:



Slika 17a

Figure 1

$$P_{ABCD} = P_{\Delta ACD} + P_{\Delta ABC} = \frac{a \cdot h}{2} + \frac{b \cdot h}{2} = \frac{(a+b) \cdot h}{2},$$

which is the required result (see Figure 1).

Proof 2

Let GF be the midline (median) of trapezoid. Let point E denote the intersection of lines DF and AB, as shown in Figure 2. It is easy to demonstrate the congruence of triangles △DGF and △AFE based on the well-known SAS (side–angle–side) triangle congruence criterion. Consequently, their areas are equal:

$$P_{\Delta DFC} = P_{\Delta EFB}.$$

According to the theorems on decomposable and complementary equality of polygonal areas, the area of trapezoid ABCD is equal to the area of triangle △AED, i.e.,

$$P_{ABCD} = P_{ABFD} + P_{\Delta DFC} = P_{ABFD} + P_{\Delta EFB} = P_{\Delta AED} = \frac{(a+b) \cdot h}{2},$$

Which was to be demonstrated.

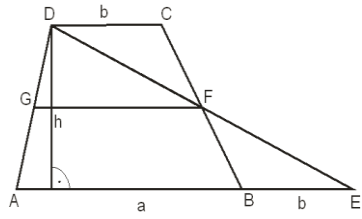


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Figure 2

Proof 3

Let the measures of the lengths of the bases of the trapezoid AB and DC be a and b, respectively, where, as in the previous cases, a > b, see Figure 3. Through vertex C, construct a line CE∥DA. It is easy to observe that the length of segment AE = b, as is EB = a – b.

The area of the trapezoid can then be decomposed into the sum of the area of the parallelogram AECD and the area of triangle △EBC, i.e.,

$$P_{ABCD} = P_{AECD} + P_{\Delta EBC} = b \cdot h + \frac{(a-b)\cdot h}{2} = \frac{(a+b)\cdot h}{2}.$$

During supplementary mathematics classes for upper elementary school students, we assigned a task in which the students were encouraged to independently discover additional algorithms for deriving the formula for the area of a trapezoid. We instructed them that they could use the stated theorems on decomposable and supplementary equality of polygonal areas, as well as other geometric principles – such as congruence, homothety, and similarity of geometric figures. With the help of semi-guided and independent heuristic approaches, the students arrived at the following polyform procedures.

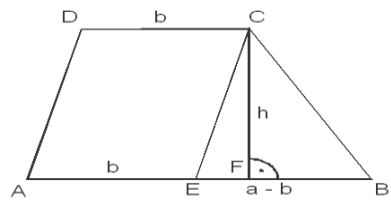

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Figure 3

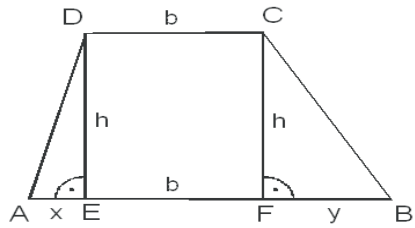
Proof 4

If we modify Figure 3 by removing the line segment CE and instead construct a new line CE perpendicular to AB, we obtain Figure 4. In this configuration, we have:

DE = CF = x, AE = x, FB = y, EF = b, AB = x + b + y = a.

The area of trapezoid ABCD can be decomposed into the sum of the areas of triangles △AED, △FBC, and the rectangle EFCD, that is:

$$P_{ABCD} = P_{\Delta AED} + P_{AFCD} + P_{\Delta FBC} = \frac{x \cdot h}{2} + b \cdot h + \frac{y \cdot h}{2} = \\ = \frac{(x + b + y) \cdot h}{2} + \frac{b \cdot h}{2} = \frac{(a + b) \cdot h}{2}$$



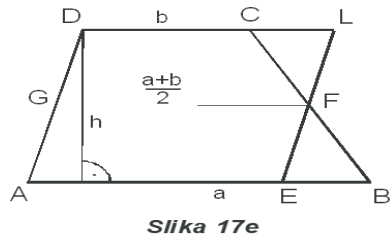
Slika 17d

Figure 4

Proof 5

Let FG be the midline of the trapezoid, and let the line FL be parallel to AD, such that point **E** is the intersection of lines AB and FL. It is easy to observe that the area of trapezoid ABCD is equal to the area of parallelogram AELD, which, based on the theorem of equidecomposability of polygonal areas, can be expressed as the sum of the areas of the pentagon AEFCD and triangle △FLC (see Figure 5), that is:

$$P_{ABCD} = P_{AEFCD} + P_{\Delta EBF} = P_{AEFCD} + P_{\Delta LCF} = P_{AELD} = \frac{(a + b) \cdot h}{2}$$



Slika 17e

Figure 5

since, by the SAS congruence criterion (side–angle–aide), the triangles are congruent. $\Delta EBF \cong \Delta LCF$. Now, let us examine two dynamic proofs.

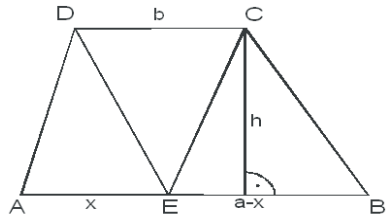


Figure 6

Proof 6

Let us choose an arbitrary point **E** on the base **AB** of trapezoid **ABCD**, and construct the segments accordingly (see Figure 6). Let **h** denote the height of the trapezoid. It is easy to observe that, based on the theorem of equidecomposability of polygonal areas, the area of trapezoid **ABCD** is equal to the sum of the areas of triangles △AED, △DCE and △EBC that is:

$$P_{ABCD} = P_{\Delta AED} + P_{\Delta DCE} + P_{\Delta EBC} = \frac{x \cdot h}{2} + \frac{b \cdot h}{2} + \frac{(a-x) \cdot h}{2} = \frac{(a+b) \cdot h}{2}.$$

Proof 7

If point E is chosen on the line AB such that the order of points is either A–B–E or E–A–B, two similar proofs can be constructed. Here is one of them, corresponding to the case where the order is A–B–E, as shown in Figure 7.

The area of the larger trapezoid **AECD** can be calculated in two different ways:

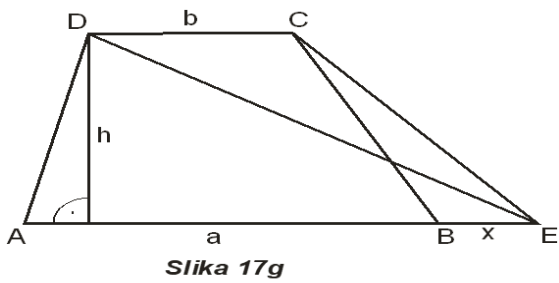


Figure 7

(1) $P_{AECD} = P_{ABCD} + P_{\Delta BEC}$ and

(2) $P_{AECD} = P_{\Delta AED} + P_{\Delta DCE}$,

from equations (1) and (2), it follows that

$$P_{ABCD} + P_{\Delta BEC} = P_{\Delta AED} + P_{\Delta DCE}\text{, i.e.}$$

$$P_{ABCD} = \frac{(a+x)\cdot h}{2} + \frac{b\cdot h}{2} - \frac{x\cdot h}{2} = \frac{(a+b)\cdot h}{2}.$$

Proof 8

Through vertex B in the plane of trapezoid ABCD, construct a line parallel to AD, i.e., let BE be such that BE∥AD. This line intersects the line containing the base **DC** at point **E** (see Figure 8).

The area of parallelogram **ABED** can be decomposed into the sum of the areas of trapezoid **ABCD** and triangle △ECB, that is: Area

$$P_{ABED} = P_{ABCD} + P_{\Delta ECB}$$

from which it follows:

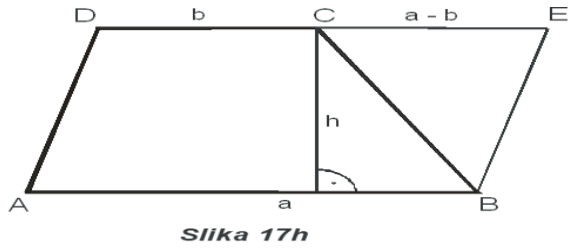


Figure 8

$$P_{ABCD} = P_{ABED} - P_{\Delta ECB} = a\cdot h - \frac{(a-b)\cdot h}{2} = \frac{(a+b)\cdot h}{2}$$

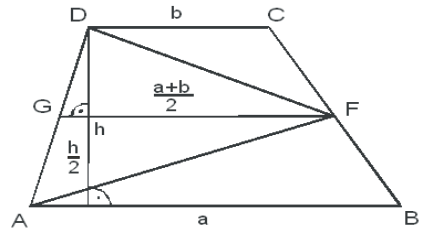
which was to be proven.

Proof 9

Here is another proof similar to Proof 2 (see Figure 9).

Let trapezoid ABCD be given. Construct its midline GF and the segments DF and AF, where AB = a and DC = b are the bases, and h is the height of the trapezoid. Using the theorem of equidecomposability of polygonal areas, the area of the trapezoid can be expressed as the sum of the areas of triangles △ABF, △GFA, △GFD and △DCF, that is:

$$\Rightarrow P_{ABCD} = \frac{a\cdot\frac{h}{2}}{2} + 2\cdot\frac{\frac{a+b}{2}\cdot\frac{h}{2}}{2} + \frac{b\cdot\frac{h}{2}}{2} = \frac{(a+b)\cdot h}{2},$$



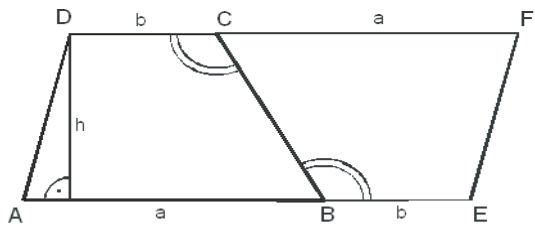
Slika 17i

Figure 9

which completes the proof.

Proof 10

Now, here is an interesting proof in which we calculate the area of a parallelogram that is twice the area of the required trapezoid. Construct trapezoid CFEB congruent to trapezoid ABCD, such that.



Slika 17j

Figure 10

Which is obtained by rotating trapezoid ABCD around the midpoint of leg BC by 180 degrees, as shown in Figure 10. It is easy to observe that the area of parallelogram ADEF is decomposable into the sum of the areas of the congruent trapezoids, that is: $P_{AEFD} = 2 \cdot P_{ABCD}$ therefore, it is

$$P_{ABCD} = \frac{P_{AEFD}}{2} = \frac{(a+b) \cdot h}{2}$$

which was to be proven.

Proof 11

This derivation, in addition to previously exploited theorems, is also based on the application of the properties of homothety, i.e., similarity. Let S denote the intersection of the lines containing the legs AD and BC of trapezoid ABCD, and let SE = h_1 denote the height of triangle $\triangle DCS$, and the height of the trapezoid

EF = h, with AB = a and DC = b being its bases, where a > b. Then, from the similarity of triangles (see Figure 11), it follows that:

$$\frac{h_1}{b} = \frac{h_1 + h}{a} \Rightarrow h_1 = \frac{h \cdot b}{a - b},$$

therefore, it is easy to observe the following relation:

$$P_{ABCD} = P_{\Delta ABS} - P_{\Delta DCS} = \frac{(h_1 + h) \cdot a}{2} + \frac{h_1 \cdot b}{2} = \frac{\left(\frac{h \cdot b}{a - b} + h\right) \cdot a}{2} - \frac{\frac{h \cdot b}{a - b} \cdot b}{2} =$$

$$= \frac{h}{2} \cdot \frac{b \cdot a + a^2 - a \cdot b - b^2}{a - b} = \frac{h \cdot (a^2 - b^2)}{a - b} = \frac{(a + b) \cdot h}{2}$$

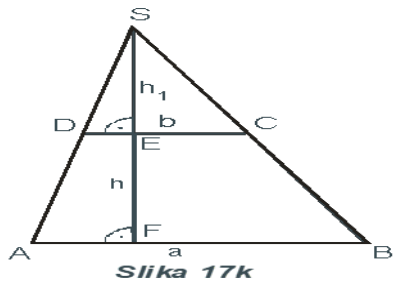


Figure 11

which completes the proof. Such polymorphic approaches to solving geometric problems enrich mathematics education, inducing greater activity and dynamism in students' work, as well as a more complete understanding of the given problems.

Advantages of Learning Through the Method of Self-Discovery Polyform Heuristics

The diversity dominated by geometric polyformism, in combination with arithmetic, algebraic, and methodological variability, represents a didactic principle of polyformity. This principle is grounded in a finite number of logical conjunctions or laws and principles (such as the law of double negation, modus ponens, the principles of obviousness, permanence, etc.).

The essence of this important instructional principle lies in a permanent insistence on an integral consideration of diverse, especially geometric, approaches to understanding and conceptualizing educational content. In practice, this requires teachers to possess thorough knowledge and skill in applying a wide range of

professional, didactic, and methodological strategies. It also stimulates intensive cognitive engagement among students, expressed through high-quality, self-directed work and increased motivation.

Instruction, when viewed through the lens of these principled foundations, necessarily entails new polyform methodological approaches. Within such an interactive teaching model, the method of self-discovery polyform heuristics becomes dominant. Here, the learning content is not presented in its final form; instead, it must be uncovered – preferably through various pathways (Nikolić, 2022). This process enhances students' intellectual capacities, motivation, and engagement, and it fosters a sense of satisfaction through accomplishment. Learning through the self-discovery polyform heuristic method produces stronger effects in acquiring not only substantive knowledge but especially procedural and applicable knowledge, as outlined in modern taxonomies of learning. In this process, students invest their own effort to organize newly acquired information within their personal cognitive frameworks and to seek out the entire spectrum of necessary knowledge. This, in turn, improves their ability to structure and manage data using deductive, analytic-synthetic approaches and to apply such methods in solving various academic and real-life problems. According to numerous researchers, modern teaching – conceived as a synthesis of principled and methodological "weaving", often supported by computer technology and unrecognized by traditionalist pedagogies – offers new qualities in diverse teaching practices. It enhances student engagement, improves knowledge acquisition, and fosters greater motivation, curiosity, initiative, creativity, and applicability of acquired knowledge in everyday life. These are among the fundamental goals of contemporary mathematics education (Marković, Veljić, 2015). Although such research is still rare in our region, it is increasingly relevant worldwide. The self-discovery heuristic method is precisely the approach that modern education needs – one that the school of the 21st century is bound to "discover" and affirm. We are convinced that, through its practical revelations and educational "resurrections", it will ultimately earn the status of universality.

Conclusion

The essence of this important didactic principle lies in the continual emphasis on an integrated view of diverse approaches to understanding and conceptualizing educational phenomena. Its application in practice requires teachers to possess a high level of expertise and skill in employing a wide range of professional, didactic, and methodological strategies. At the same time, it stimulates intensive cognitive engagement from students, expressed through quality self-directed effort and increased motivation. The effectiveness of the principle of polyformity is grounded in a well-established psychological fact: variation and change in instructional practice refresh the learning process, while monotony typically leads

to diminished interest, passivity, and boredom. For this reason, the principle of polyformity should play a universal role in mathematics education – enriching the learning process through diverse content, tools, techniques, and methods. Due to these characteristics, the principle of polyformity represents not only a didactic--methodological principle but also one whose epistemological foundation aligns with that of the principle of permanence and the law of the negation of negation. In this way, the principle of polyformity assumes the features of a dialectical law. As the principle of polyformity encompasses all existing didactic principles, it is elevated to the status of a universal principle in education.

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Fostering Spatial Comprehension in Solid Geometry: The Role of Augmented Reality and GeoGebra

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Abstract

Augmented reality (AR) represents an innovative digital technology capable of fostering a learning environment that enhances the understanding of spatial concepts, mathematical objects, and the relationships between them. This paper looks into the features of AR and its practical applications in mathematics, highlighting its transformative potential in classrooms. Addressing challenges in solid geometry, such as the visualization and representation of three-dimensional (3D) spaces, AR emerges as a powerful tool, offering a dynamic means to explore and interact with geometric objects within real-world contexts.

A particular focus is placed on the *GeoGebra 3D Calculator* and its integrated AR module. Through four carefully selected examples from solid geometry, we provide detailed demonstrations of how these tools can be used to solve complex problems, thereby bridging the gap between theoretical concepts and practical understanding. These examples illustrate the profound impact of AR technology on improving spatial comprehension and engaging learners in mathematics.

Keywords: Augmented reality, GeoGebra, 3D Calculator, Solid geometry, Spatial visualization

Introduction

The study of solid geometry presents challenges due to the abstract nature of 3D spatial reasoning. Unlike planar geometry, which can be easily visualized, solid geometry requires learners to mentally construct and manipulate objects in space, a skill that is not intuitive for many students.

To address these challenges, educational technologies, especially AR, have been developed to create dynamic learning environments. AR offers a revolutionary

method for visualizing geometric objects, making abstract concepts more tangible and comprehensible. Unlike static representations, AR integrates virtual objects into the physical environment, allowing learners to dynamically interact with them and view geometric elements from multiple perspectives, such as from the side, above, or below. This immersive approach fosters a deeper understanding of spatial relationships and geometric properties by enabling learners to explore these relationships in an intuitive, real-world context. (Bacca, Baldiris, Fabregat, Graf, 2014; Sekulic, Stojanov, 2023).

The *GeoGebra 3D Calculator*, with integrated AR functionality, provides a powerful platform for exploring solid geometry. It allows users to interact with 3D objects in augmented space, making abstract concepts more accessible (Widada et al., 2021). This paper examines the educational potential of AR in solid geometry, with a focus on the *GeoGebra 3D Calculator*, and demonstrates how AR can improve spatial comprehension through illustrative examples.

Teaching and Learning Solid Geometry in Computer Environment

Solid geometry presents challenges in teaching and learning, primarily due to the complexity of visualizing and representing 3D objects. Traditional methods relying on static diagrams often fail to fully convey the dynamic relationships of geometric structures. Computer technologies, like *GeoGebra* and AR, offer innovative solutions by enabling real-time interaction with 3D models in immersive environments (Petrov, Atanasova, 2020).

The *GeoGebra 3D Calculator* stands out for integrating AR, allowing learners to project geometric constructions into physical spaces and engage in hands-on exploration. Studies indicate that interactive tools enhance spatial reasoning and comprehension of solid geometry concepts (Sekulic et al., 2023). Additionally, these technologies support iterative learning and creative experimentation, reducing cognitive strain and enabling individual educational experiences.

The benefits of AR representations become particularly significant in the study of geometry, where understanding the interaction and spatial alignment of objects is crucial. By presenting objects as if they were part of the learner's real surroundings, AR bridges the gap between abstract mathematical constructs and their practical applications. For example, learners can manipulate virtual objects within their environment, observe their interactions, and analyze their spatial relationships from different angles. This interactive experience not only enhances engagement but also supports a more comprehensive understanding of mathematical principles, as noted in studies exploring AR's impact on education (Zulfiqar et al., 2023).

Despite the benefits, challenges like accessibility and technological proficiency remain barriers to adoption. Addressing these issues through professional development and limited access is crucial for broader implementation (Muhazir,

Retnawati, 2020). Integrating computer technologies into solid geometry teaching transforms learning, bridging theoretical concepts with practical understanding.

GeoGebra 3D Calculator and AR Module

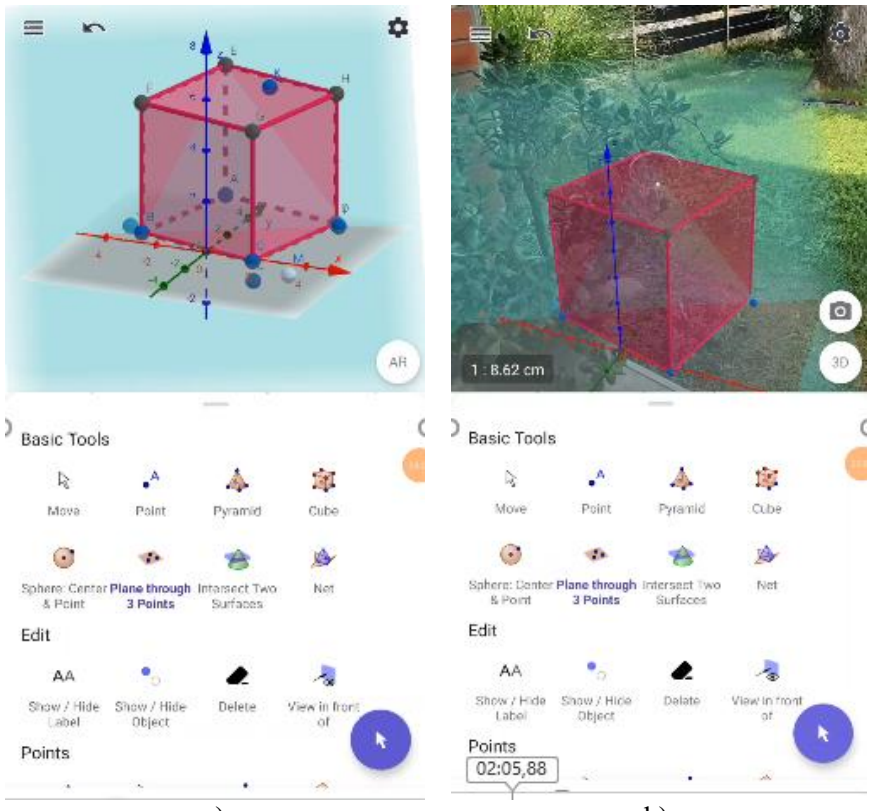
GeoGebra is a dynamic mathematics software designed for use in both mathematics and science education. As an open-source platform, it is freely available and offers a user-friendly interface, while still providing a powerful set of tools. *GeoGebra* includes several specialized modules, such as the *Graphing Calculator* (for plotting functions, exploring equations, and visualizing data), *Geometry* (for constructing figures, transformations, and measurements), *CAS Calculator* (for symbolic algebraic manipulations including solving equations, and computing derivatives and integrals), and the *3D Calculator* (for graphing and exploring three--dimensional objects and relationships). All these modules are accessible online or via download and are compatible with multiple platforms including Windows, iOS, Linux, and Android.

The *GeoGebra 3D Calculator* is particularly useful for teaching and learning topics in spatial geometry. It provides a wide range of tools for constructing 3D objects and conducting spatial investigations. Users can create planes (defined by three points, or parallel/perpendicular to a given object), intersect surfaces, and draw solids such as prisms, cones, cubes, and spheres. These tools are available to use within the *GeoGebra 3D Calculator* interface.

With the growing availability of mobile devices equipped with AR capabilities, AR has become increasingly accessible across platforms. For this reason, *GeoGebra's 3D Calculator with* AR module was selected for this study. It was chosen both for its cross-platform compatibility (e.g., Android and iOS) and because it is freely available. In this study, the Android platform was used, with a mobile phone serving as the device.

The *GeoGebra 3D Calculator* application for mobile phones can be easily downloaded from the *Play Store*. Once installed, it is ready for immediate use. The interface provides the familiar *GeoGebra* drawing space and standard *GeoGebra* tools, with the addition of buttons for switching between 3D and AR modes. When the 3D mode is selected, users can create and manipulate three--dimensional mathematical objects as usual, using *GeoGebra* tools, Figure 1a). However, selecting the AR mode integrates the virtual geometric content into the user's physical environment using the device's back camera, Figure 1b).

Once created, the object can be manipulated using a mobile phone, it can be observed from different angles, sides and positions in the environment chosen by the user. Precisely this possibility to manipulate and observe objects within the real environment is the key element which contributes to understanding spatial relations and to the learning process.



a) b)

Figure 1. 3D and AR representation of a cube in *GeoGebra 3D Calculator*

These features support dynamic, spatially contextualized learning experiences and illustrate the potential of integrating AR into mathematics education using accessible, free tools like *GeoGebra.*

Application of the AR Module of the GeoGebra 3D Calculator for Solving Problems in Solid Geometry

By utilizing the AR module in the *GeoGebra 3D Calculator*, the four examples that demonstrate its diverse capabilities will be presented. A standout feature of *GeoGebra 3D Calculator* is its ability to project geometric problems into the real-world environment through AR modules, enabling students to directly observe and interact with these problems as though they were physically present.

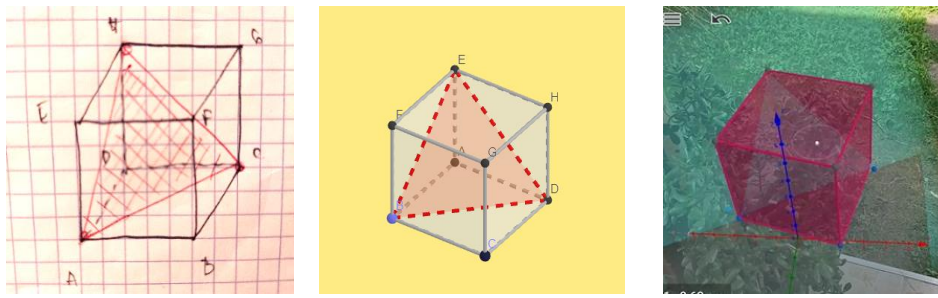
Each of the four examples illustrates how the AR experience enhances understanding, allowing students to explore relationships among objects in a real setting, view them from different perspectives, and grasp spatial con-

cepts more intuitively. The AR approach bridges theoretical knowledge and practical application, making it an indispensable tool for mastering spatial geometry.

Problem 1: *The given object is a cube* $ABCDA_1B_1C_1D_1$ *with edges of length* a*. Calculate the area of the intersection between the cube and the plane defined by vertices* A*,* C*, and* D_1*.*

Solution: $b = a\sqrt{2}$ *(diagonals of the faces of a cube),* ΔACD_1 *is equilateral, therefore:* $P = \frac{b^2\sqrt{3}}{4} = \frac{a^2\sqrt{3}}{2}$

Problem *1* is one classical geometry problem, which is often present within the school teaching and learning process. Considering the solving process of geometry problems, it is usual that the students are first instructed to make a sketch of the problem. This, for some students, can be an obstacle, because not all students are equipped with spatial reasoning and the ability to translate it on the twodimensional paper. Also, the graphical representation may not always be correct, and therefore can lead to wrong solving paths. By using *GeoGebra 3D Calculator*, from hand-drawn sketch (Figure 2a)), it can evolve into 3D representation (Figure 2b)), which can be further manipulated and viewed from different perspectives. Finally, using the AR module of the *GeoGebra 3D Calculator*, the problem can be exported in a real environment, and provided with even deeper insight, Figure 2c).



a) *b)* *c)*

Figure 2. Graphical, 3D and AR representation of Problem 1

The solving process enriched with the AR representation now becomes the process which transforms into more than just an application, it becomes an enriching experience or even an experiment, fostering deeper engagement and exploration, Figure 3. As a result, this approach not only enhances understanding but also leads to an effective solution of the problem at hand.

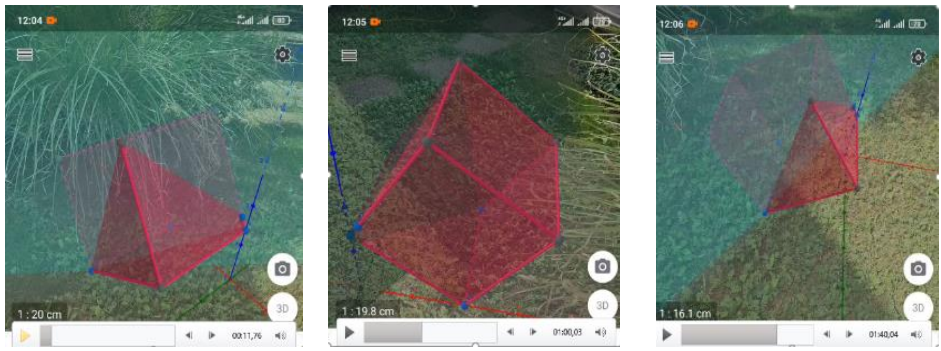


Figure 3. AR illustration of the solving process of Problem 1

Problem 2: *A cube with edge length* a *is given. Calculate the distance from one vertex to a spatial diagonal that does not pass through that vertex.*

Solution: *Let the desired distance be* d*, and let* x *and* y *be the segments into which the foot of the perpendicular divides the diagonal. From this:* $x + y = a\sqrt{3}$, $d^2 + x^2 = a^2$, $d^2 + y^2 = 2a^2$. *The desired distance can then be easily find as:* $d = \frac{a\sqrt{2}}{\sqrt{3}}$.

In Problem *2* the option of first creating a 3D representation of the problem is illustrated, and within it, the use of the possibility to extract some features which are an important part of the solution. This is especially important for this problem, considering that spatial diagonal is one part of it, and therefore, the hand-drawn sketch can be very challenging even for students having good spatial perception.

The *GeoGebra 3D Calculator* even offers this kind of option to switch on/off some parts of the 3D model, in order to enable better insight into the problem. Further use of the AR module places the created object into the real environment and by that offer deeper experience, Figure 4.

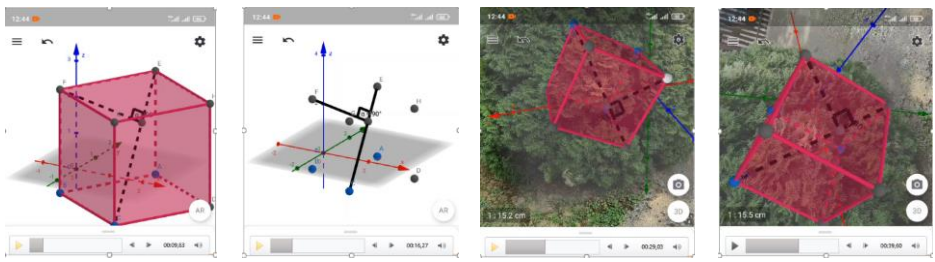


Figure 4. 3D and AR representation of Problem 2

Problem 3: *The edge of a regular tetrahedron has length a. Calculate the area of the cross-section of the tetrahedron with a plane that contains one edge of the tetrahedron and divides the opposite edge in a $2:1$ ratio.*

Solution: *Observe that the intersection of the tetrahedron and the given plane is an isosceles triangle with side length b and height h. By applying the law of cosine, we find that: $b = \frac{a\sqrt{7}}{3}$, and $h = \frac{a\sqrt{19}}{6}$. The area of the desired triangle is: $P = \frac{a \cdot h}{2} = \frac{a^2\sqrt{19}}{12}$.*

Similar to previously considered problem, Problem *3* requires insight into the internal structure, this time of the tetrahedron. Figure 5 illustrates the application of the 3D and AR representation of the tetrahedron.

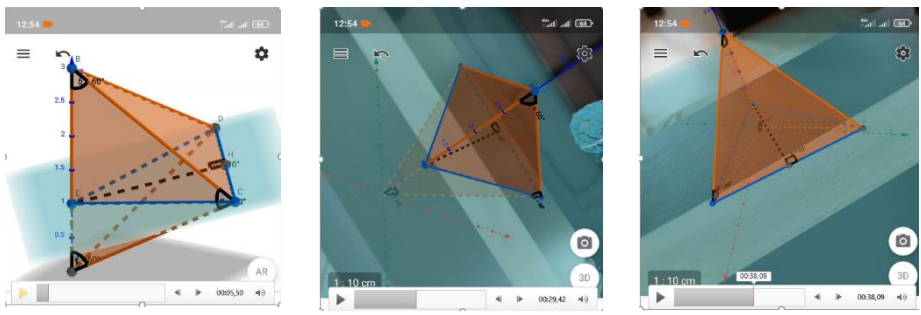


Figure 5. 3D and AR representation of Problem 3

Problem 4: *A sphere is circumscribed around a right circular cone whose slant height is equal to the diameter of the base. What is the ratio of the surface areas of the cone and the sphere?*

Solution: *We can observe that the radius of the sphere R is equal to $\frac{2}{3}$ of the height of the cone H.*

From this it follows: $\frac{P_K}{P_L} = \frac{\frac{a^2 \cdot \pi}{4} + \frac{a \cdot \pi \cdot a}{2}}{4\pi \cdot \frac{a^2 \cdot 3}{9}} = \frac{9}{16}$.

The cone circumscribed into the sphere, as presented in Problem *4*, refers to a group of geometry problems which students find the most challenging. The possibility to realistically represent these kinds of objects is of great importance for students, because they can gain insight into the relationships between two or more geometric objects. Particularly advantageous is the capability offered by *GeoGebra 3D Calculator* to isolate or exclude parts of the objects, as this allows for observing and determining the relationships among the objects, leading to the solution of the problem through further analysis, Figure 6.

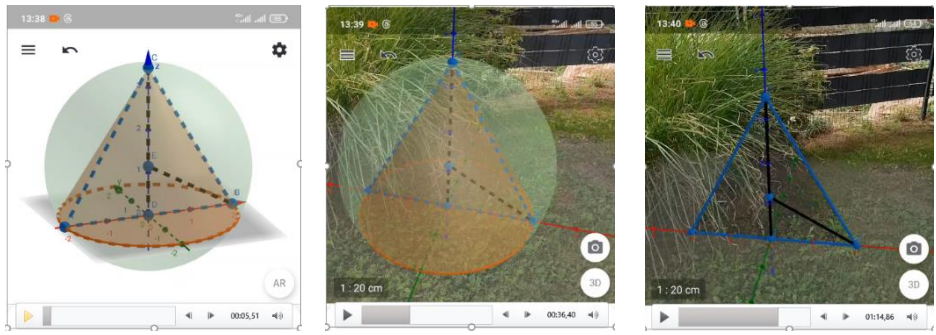


Figure 4. 3D and AR representation of Problem 4

Conclusions

The integration of AR into mathematics education, particularly through tools like the *GeoGebra 3D Calculator*, has the potential to significantly transform the teaching and learning of solid geometry. As demonstrated through the presented examples, AR technology enhances students' ability to visualize, interact with, and understand complex 3D objects and their relationships in space. By bridging the gap between abstract mathematical concepts and their real-life representations, AR fosters a more intuitive and engaging learning environment.

Traditional methods of teaching solid geometry often rely on two-dimensional sketches and static diagrams, which can be limiting for students who struggle with spatial reasoning. The *GeoGebra 3D Calculator* addresses this challenge by enabling dynamic construction, manipulation, and visualization of geometric figures. Furthermore, the AR module extends these capabilities by embedding these figures into the learner's physical environment, making the exploration of geometric properties a more meaningful experience.

The examples presented highlight how AR can enrich the problem-solving process by moving from conceptual sketches to interactive 3D models and finally to contextualized AR experiences. This transformation not only aids comprehension but also encourages experimentation, active learning, and deeper engagement with mathematical content.

In conclusion, AR enhanced learning experiences in solid geometry represent a powerful innovation. By making spatial relationships visible and manipulative within real-world contexts, AR helps students develop critical mathematical competencies and fosters a deeper appreciation for the structure and beauty of geometry. These findings highlight AR's potential as a powerful educational tool, capable of transforming how mathematical and spatial concepts are taught and understood (Hilčenko, Nikolić, 2023, 2024). Incorporating AR technology into mathematical education aligns with the evolving needs of modern learners, providing innovative ways to make learning engaging and effective.

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Cultural Reflections on the use of Technology in Education in the Case of Serbia: Does National Culture Limit the Expansion of Digital Education?

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Abstract

Intensive changes in the implementation of information and communication technology in education bring numerous opportunities for learning. Although current discussions on the potential of digital education within academic and expert circles tend to support the thesis that it will take precedence over traditional forms of education, its development and expansion are influenced by various factors—one of the most significant being national culture. The primary aim of this paper is to explore the issue of further development and use of digital technology in education from a cultural perspective. The main premise of this work is that the development of digital education should not be viewed solely through the lens of technological advancement and its application, but also in the context of culturally conditioned structures of need. Technology changes the way we learn, access knowledge, share and apply it; however, on the other hand, culture influences how and to what extent these new technologies are accepted and used. Therefore, the central goal of this paper is to reflect on the interdependence between national culture and the application of digital technologies in education in Serbia.

Keywords: technologies, digital education, digital learning, national culture, values, motives, preferences

Introduction

Digital education is transforming the traditional approach to learning and teaching by enriching it through the application and use of new technologies (e-learning, applications, artificial intelligence, virtual classrooms, online educa-

tional institutions, etc.), which offer previously unimaginable possibilities, as well as their own requirements regarding the organization, design, and implementation of the learning process. One important indicator of an individual's ability to use digital technology in formal education to enhance the quality of their education (in addition to the adequacy of the educational content itself) is the level of digital maturity. This includes the readiness and motivation to improve digital competencies and to use technologies for acquiring and applying knowledge in practice.

The main focus of this paper is to highlight the influence of national culture on the application and use of modern technology in education, and the level of digital maturity. Culture, as a set of values, beliefs, and behavioral patterns that a group (such as a national community) has adopted as acceptable and useful for solving the problems of its survival, exerts a strong social influence on individual behavior and on life choices and decisions. Through values, culture determines the motivational structure that influences the direction and intensity of human activities (Janićijević, 2008). This, of course, also applies to digital learning and education.

Based on the understanding that the expansion of digital education depends not only on the development and implementation of technology but also on dominant national values and characteristics of national culture which influence how and to what extent these technologies are used in learning this paper focuses on analyzing the interdependence between national culture and digital education in the case of Serbia, specifically addressing the question of whether there are cultural barriers to the development of digital education.

Digital Education

A major challenge for the world of modern education is the need to more rapidly adapt to the demands of the digital economy by reducing the gap between job requirements and formal education (Đorđević, 2007). The digital economy requires new knowledge and a new approach to learning. In previous periods, regardless of profession, it was important for people to be literate and to possess basic knowledge of natural sciences. Today, they must be digitally literate that is, capable of using computers. In this sense, it can be confidently stated that one of the main tasks of education is digital literacy, or raising the level of digital maturity (Hilčenko, Nikolić, 2023).

Traditional teaching tools (chalk and blackboard) are being replaced by a new generation of teaching aids through an e-learning system that, in practice, takes the form of modern technologies: learning via mobile phone applications, mobile learning (M-Learning), learning based on web technologies (Web-Based Learning), Distributed Learning, Distance Learning, Remote Learning, Online Learning, Virtual Classrooms, Virtual Laboratories, etc. (Bazić, 2017).

Technology has become so applicable that every aspect of our lives and functioning now depends on it. Through the use of information and communication technologies, knowledge becomes more accessible and easier to acquire for everyone. The boundary between knowledge and ignorance is narrowing, providing everyone the opportunity to access and use necessary information in a simpler, faster, and more efficient way (Hilčenko, Nikolić, 2024). On the other hand, knowledge spreads more rapidly, but it also becomes outdated more quickly, creating a constant need for the generation of new and innovative knowledge. From this arises the need to enhance learning through digital technology, as traditional learning methods are becoming a less acceptable link between knowledge and the application of knowledge (Hasić, Zejnelagić, 2022). By introducing digital technologies into education, the barriers and shortcomings of traditional learning are overcome. The roles of teachers and students change students shift from being passive recipients of knowledge (where the teacher is the main authority and knowledge is simply transferred and reproduced) to becoming active participants who construct their own knowledge, with the teacher acting as a guide and support. The introduction of technology into the classroom also changes relationships and interactions. In the teacher–student dynamic, technology becomes an equal participant in the educational process. The teacher still supervises and evaluates the learning process, but now does so with the assistance of technology, receiving feedback both from the digital tools used and from the students themselves. It is precisely from this shared responsibility for the learning process that the need arises to develop collaborative relationships between teachers and students, emphasizing the role of the teacher as a mentor who empowers students to approach modern technologies critically (Danilović, 1996).

E-readiness and Motivation for the Use of Digital Technologies in Education

In the literature, a large number of studies can be found on the changes brought about by the implementation of technology in education. Despite the evident positive effects of applying digital technology in education, some authors still emphasize that technologies alone will not improve the quality of education; however, when used appropriately, they certainly contribute to positive results in specific areas of educational work (Stojanović, Delić, Ilić, 2021). In a paper analyzing the most common misconceptions about information and communication technologies in education, author Pešikan (2016) highlights several fallacies: it is not enough to simply equip schools with technology – teachers, students, and pupils must also be trained to use that technology; it is not true that today's children, often referred to as the Google generation, possess innate digital skills and competencies – they are merely more interested in technology, which does not mean they are adequately digitally literate; everything necessary can be found on the Internet, and artificial intelligence can answer all our questions – students enjoy

searching for information online and using AI, but acquiring certain knowledge requires understanding and the ability to critically interpret and select what is found online; and finally, the misconception that technology will replace teachers – technology alone cannot teach without a teacher, but it can greatly assist in delivering lessons and provide students with an inexhaustible source of information. The biggest challenge in digital education is to stimulate students to use technology as a means of acquiring knowledge and to participate actively. The vast amount of available content and information can demotivate students, making it harder for them to navigate meaningfully through such abundance. They often stray from the assigned topic and use technologies for non-educational purposes. In the early stages of applying digital technology in education, the dropout rate was over 60% (Hasić, Zejnelagić, 2022). There are numerous reasons for such a high dropout rate, and one significant issue is the cultural specificity of motivation for using digital technology.

As one of the strongest determinants of behavior, motivation is among the most extensively studied phenomena in the field of human behavior. The need for knowledge, learning, and development is certainly one of the most important human needs. However, at the core of learning, other significant needs are often present, such as social needs, the need for achievement, and the need for security. These needs trigger specific motivational structures and determine the choice of a learning model that best suits the dominant need. It is well known that merely having a need is not enough to initiate a motivational process–expectations that a certain activity will fulfill the need, as well as the perceived value of the outcome, are equally important. Values, however, are one of the key cultural elements, meaning that learning, motivation, and culture are in constant interaction (Vemić, Đurković, Jotić, Lovre, 2012).

Motivation and digital maturity are often linked to individual needs. Maslow's hierarchy of needs, Alderfer's ERG model of needs, and Herzberg's two-factor theory of motivation identify and explain the key needs that influence individuals to behave in certain ways. The reasons for insufficient engagement and lack of motivation to use digital technologies in education – taking into account the main assumptions of these motivational theories – can be sought in the answer to the question: to what extent can digital education meet the needs for achievement and personal development?

Achievement motivation is based on the need for excellence, prestige, and the challenge posed by the tasks themselves. It relies on the individual's desire to demonstrate knowledge, receive positive feedback, and earn praise. On the other hand, the needs for achievement and development require a high level of commitment, self-discipline, and persistence in goal attainment. Since digital technologies provide vast access to information and content, individuals often struggle to maintain focus and self-discipline. The use of digital technologies frequently involves working independently, which does not favor the need to showcase success

or receive public praise. Traditional education, in contrast, offers more opportunities in this regard – from more frequent testing to teacher support and encouragement. Group learning allows for mutual respect and acknowledgment, which can enhance self-esteem and the sense of achievement.

National Culture, Motivation, and Digital Technologies in Education in Serbia

Globalization of the world economy, the opening of borders and networking and business through the Internet, the flow of information, people, ideas, and products, increasing diversity in the environment, increasing workforce diversity, rapid dissemination of knowledge but also its obsolescence, and a paradigm shift in education driven by the rise of the digital economy represent key factors for the growing interest in researching the influence of national culture on behavior, education, and business. Numerous authors have addressed national culture and its characteristics (Hofstede, 1984; Venaik, Brewer, 2015; Gnoth, Zins, 2013; Strese, Adams, Flatten, Brettel, 2016; Ferreira, Serra, Pinto, 2014; Hallale, 2013; Hackert, Krumwiede, Tokle, Vokurka, 2012, etc.), explaining its significance in shaping the opinions and attitudes of individuals, social groups, and society as a whole. National culture is the collective programming of the mind that distinguishes the members of one nation from those of another. Hofstede (Hofstede, Hofstede, Minkov, 2010) is known for his theory of cultural dimensions and believes that national culture influences the behavior, thinking, and values of people in a given country. Janićijević (2008) defines national culture as a set of assumptions, beliefs, and values shared by members of a national community that significantly determines their understanding of the world and their behavior in it.

The influence of national culture on motivation plays a key role in education and the work environment. The way people are motivated to achieve goals, learn, or work depends on their cultural values, norms, and social expectations. It has been established that each culture may vary across dimensions that affect the behavior of its members. In this regard, the dimensions of national cultures can indicate universal characteristics or aspects of a given culture that can be measured and compared (Hofstede et al., 2010). These dimensions are also suitable for analyzing cultural barriers to the application of digital technologies in education in Serbia, as they provide insight into individual differences that may determine the perception and behavior of members of a particular culture, which can serve as the basis for designing digital education in accordance with the needs and values of Serbian culture. Hofstede defined dimensions by which cultures can differ. According to him, four dimensions applicable to cultures worldwide were conceptualized: power distance (the extent to which a society accepts inequalities among people); collectivism versus individualism (the extent to which a society functions more as a group than as individuals); masculine versus feminine values (whether masculine or feminine values are more prevalent in a society);

uncertainty avoidance (the extent to which a society tolerates risk and uncertainty) (Hofstede, 1984).

These dimensions serve as an analytical framework for the cultural reflection on the application of digital technologies in education in Serbia. Hofstede's research included many countries, including the Republic of Serbia. The results show that Serbian citizens score high on the power distance dimension, with a score of 86/100, indicating that unequal distribution of power is accepted as natural. Decision-making centralization is preferred, people respect authority and expect to be told exactly what to do. Serbian national culture is notably collectivist, scoring 75/100. Loyalty and self-sacrifice for the collective good are emphasized, best reflected in the well-known saying: "All for one, one for all." Serbian citizens are also more reflective of feminine values than masculine ones, which means equality, solidarity, family life quality, and a friendly work atmosphere are valued, while free time is a significant motivator. The highest-rated dimension in Serbia is uncertainty avoidance, with a score of 92/100. Serbian citizens have a pronounced aversion to risk, stick to written rules and standards, and feel a strong need to work hard (even when unnecessary) to be perceived as diligent and committed. For them, security is the most important source of motivation (Vasilić, Brković, 2017).

High power distance, as a feature of Serbian national culture, is not a favorable foundation for developing digital education. This type of culture is characterized by strict hierarchies between teachers and students, with teachers' authority rarely questioned and regarded as the primary source of knowledge. Student initiative is limited, and they are expected to follow instructions rather than explore independently. Teachers in high power distance cultures may avoid digital technologies out of fear of losing control or that students will surpass their knowledge. Digital education requires open communication (discussions, forums, feedback), which is difficult in systems that do not encourage opinion exchange between teachers and students. In traditional education, students interact with well-established teachers whose names often guarantee the quality of learning. In digital education, the teacher's role is significantly depersonalized, and teaching must be highly structured. In Serbia, as a society characterized by high power distance, the name and reputation of the teacher and the possibility of personal interaction remain important in education choices.

Collectivism, as a characteristic of Serbia's national culture, is not conducive to the expansion and development of digital technologies in education. It emphasizes group belonging, harmony, and shared values over personal goals and individuality. In collectivist societies, individuals rely on the group for work and learning, and personal initiative is often suppressed in favor of group unity. Changes introduced from outside, such as new digital technologies, may be seen as a threat to tradition. Students may avoid using digital tools if the rest of the

group does not, not wanting to stand out or appear overly ambitious. People in collectivist environments often wait for group consensus or approval from an authority figure before accepting changes, which slows the adoption of new technologies. Digital tools often require individual initiative, independent research, and personalized learning, which may clash with group-oriented learning approaches. Digital transformation can be perceived as something that disrupts traditional educational values. If the group views it negatively, individuals will avoid participating.

According to Hofstede's theory, masculine and feminine values represent societal priorities. In Serbian culture, feminine values dominate, emphasizing modesty, cooperation, equality, and care for others, with less focus on competition and personal achievements. Social harmony is more valued than individual success. Digital technologies often promote personal advancement, independent learning, and self-promotion through online competitions, rankings, and rewards. In cultures with strong feminine values, competition can be undesirable. In digital learning, if someone advances quickly and uses tools others do not, it may create discomfort or a sense of unfairness in the group. Students may consciously slow their progress to maintain group balance. In feminine cultures, interpersonal relationships are more important than technical knowledge and innovation. Technology may be seen as cold, distant, and irrelevant for social progress. Digital education often involves individualization and personalization, which may conflict with the desire for collective advancement.

Uncertainty avoidance reflects how uncomfortable people feel with the unknown, unclear, and unpredictable situations. In cultures like Serbia's, which score high on this dimension, people prefer rules, routines, and security. Change is often perceived as a threat rather than an opportunity, and ambiguity and experimentation cause stress and resistance. Digital technologies often require experimenting, exploring, and accepting mistakes. In high uncertainty avoidance cultures, mistakes are viewed as failures rather than part of the learning process. Digital tools introduce new learning methods, such as online platforms, self-directed learning, and video lessons. People in these cultures tend to stick with familiar methods (books, classrooms, chalkboards). If digital environments lack clearly defined rules and instructions, students and teachers may lose motivation and feel insecure. Technology-assisted learning often involves testing new solutions, which can be stressful in cultures that value stability and the familiar.

Conclusion

In order to properly utilize the potential of digital technologies in education and ensure a path for their further development, it is necessary to view them from multiple perspectives, among which culture plays an important role. Therefore, the main significance and contribution of this work lies in analyzing the possibilities for using and further developing digital technologies in education from

a cultural perspective. The answer to the question – does national culture limit the expansion of digital education in Serbia – is provided in the work through an analysis of the impact of key characteristics (dimensions) of national culture on motivation to use and develop digital technology.

The main conclusion of the analysis is that the key features of Serbian national culture largely represent barriers to the expansion of digital education. In cultures with high power distance, digital education may face resistance and lower motivation, as it involves: greater independence for students, reduced control by teachers, open communication, and the exchange of ideas. In collectivist cultures, motivation to use digital technologies may be reduced because students do not want to stand out from the group, wait for group approval, and seek to preserve harmony and tradition, even if it means delaying the acceptance of innovations. In cultures that nurture feminine values, motivation to use digital technologies may be reduced due to the avoidance of individual distinction, the desire for social equality, the focus on relationships rather than technology, and the rejection of competitive and personalized aspects of digital learning. In cultures with strong uncertainty avoidance, motivation to use digital technologies may be reduced due to fear of mistakes and failure, resistance to change, the need for structure and rules, and unwillingness to experiment.

However, it would be wrong to speak of the dimensions of national culture as something permanent and unchanging. Although culture has a constant tendency to preserve the existing state, it is subject to changes influenced by numerous factors such as experience, technology, and the social and economic system. This means that the dominant motivational structure in a society is also subject to change. The significance of this reflection lies in emphasizing that the interdependence of national culture and digital education requires the adapted introduction of technologies to preserve values, because for digital education to develop successfully, its development must align with primary national values and needs. For digital education to be successful in cultures with high power distance, such as Serbian national culture, gradual changes in educational values are necessary, support for teachers, and the encouragement of independent learning among students. In collectivist national cultures, it is essential to involve the entire community (students, teachers, parents) in digital changes and promote technology as a group benefit rather than a personal initiative. In Serbian national culture, which nurtures feminine values, it is also important to design technology that encourages collaboration, sharing, and support, which aligns with feminine values. Avoidance of uncertainty, as a cultural dimension of Serbia's national culture, largely represents an obstacle to the development of digital education, and a solution could lie in the gradual introduction of technology, with clear rules, training, and support, to create a safe and predictable environment for students and teachers.

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Digital Technologies in School – Opportunity or Threat? An Analysis of the Phenomenon in the Opinion of Pedagogy Students*

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Abstract

This article summarizes the opportunities and threats arising from the use of digital technologies in schools. It sheds light on their proper application in the education system, supporting young people in their transition into the modern world. It also demonstrates how inappropriate and excessive use of mass media can have lasting negative consequences, significantly undermining the potential for integrating them in a way that supports student development. The goal is to adapt the stimuli that naturally reach students and maintain the process of proper socialization while simultaneously integrating modern opportunities that offer a wide range of educational opportunities.

Keywords: digital technologies, e-education, educational strategy, educational opportunities, educational threats

Introduction

This article discusses the opportunities and threats arising from the use of digital technologies in grades 1–3 of primary school. This is an extremely interesting and timely topic, and one that should be of interest to all students of preschool and early childhood education, as we, as future teachers, care about the proper development of our students. Below, we present the results of our research and analyze what we consider to be opportunities and threats.

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In the 21st century, technology has become an inseparable part of our daily lives – shopping, official matters, communication with the outside world. It has also found its place in the education system. The COVID-19 pandemic significantly accelerated the implementation of modern technologies in teaching. This was essential for effectively implementing the core curriculum. When the opportunity, yet also the necessity, of remote work and distance learning arose, many people argued that it was a way of keeping up with the times, facilitating and enabling individuals to self-develop and perform their duties from the comfort of their homes. It didn't take long for us to notice the first problems – loneliness, lack of motivation to learn, a lack of will to live. However, in the realm of online education, problems began to stem, among other things, from teachers' lack of appropriate digital skills to work in such conditions. Constantly sitting in front of a computer had negative health consequences, especially for children, both mentally and physically.

Despite so many alarming signals, despite the consequences and forgetting the negative impact of distance learning, society has begun to implement various technologies in schools. Learning platforms, interactive whiteboards, tablets, phone apps, and so on, are becoming increasingly popular. Their intuitiveness, ease of use, and the time savings encourage both teachers and students to use them. Learning in a technologically-driven environment, using quizzes, competitions, rankings, and games, makes children more willing to participate, and they begin to associate learning with positive associations. Teachers have recognized this as a chance to break the bad reputation of boring school learning. Technologies have become a significant opportunity for teachers – ready-made question databases, games, and learning platforms create incredible opportunities and save time, and educators don't have to sacrifice time outside of work to prepare for classes. It's also a chance to utilize and respect their private lives. Children are eager to use digital technologies both at home and at school. They become immersed in the virtual world, forgetting the real world, which can lead to problems with everyday functioning and long-term health consequences. The philosopher John Locke once compared a child's mind to a blank slate filled with experiences. He contrasted this with modern neuroscience research, which demonstrates that the most important neural connections in the brain are formed during the early years of life. Let's consider how digital technologies will impact the filling of this "slate". If a child doesn't develop these neural connections through appropriate stimulation – sensory, motor, etc. – during this period, they will never be able to recreate them in their entirety. True simulation, real, active contact with a stimulus is necessary, while passively receiving these stimuli through being the recipient of an image or completing a task by swiping a finger across a screen cannot provide this. This blank slate cannot be completely filled in for the child, because by doing so, we are introducing irreversible changes that could prove catastrophic for all of humanity in the future.

Opportunities and Threats of Using Digital Technologies in Education

Many experts believed that digital technologies could introduce a modern education system, increase teaching effectiveness, and help prepare students for life in the modern world. They began to be recognized as opportunities to individualize teaching, equalize educational opportunities, develop digital competencies in schools, and increase student engagement through modern, engaging, and interactive forms of learning. Modern solutions also provided teachers with all the tools they needed, addressing the possibilities and quality of their duties in organizing work and managing schools, students, and their education. Thanks to rapid development, technology in the 21st century has become an indispensable element of everyday life, including in educational systems.

The most frequently mentioned digital technologies used in schools include:

1. Tablets and laptops are used directly by students during lessons. They are particularly useful for engaging educational opportunities. Each student, equipped with a tablet/laptop, can complete tasks recommended by the teacher to enhance their knowledge of a given topic, search for information related to the lesson topic, use programs, learn coding, and practice safe online habits.
2. Interactive whiteboards, in particular, allow teachers to present/display content for the entire team. As the name suggests, interactive whiteboards allow for interaction between both teachers and students, especially when it comes to assignments, allowing each student to approach and complete the task individually. They also offer creative feedback, for example, by displaying a thermometer so each student can mark how engaging the lesson was.
3. Educational apps and games primarily serve to diversify classes, providing students with an active form of expression, and teaching them teamwork and competition. This is a creative way to review or learn material, as it's not passive learning from a textbook but rather an opportunity for each participant to engage.
4. Smartphones are used by students not only during classes, but also outside of them for communication purposes and can be used to create attractive tasks assigned by the teacher, e.g. students making a video on a given topic as homework, thanks to which students stimulate creativity and the possibility of learning the material in a variety of ways.
5. Electronic journals facilitate efficient communication between parents and teachers, allowing teachers to issue interactive reports. Thanks to the electronic journal, parents receive essential information about their child, including attendance and grades, while teachers receive information about lesson topics, goals, descriptive grades, and student information.
6. E-learning platforms provide learning opportunities during distance learning and allow users to return to saved materials. They are used to share and display content to other participants.

What drives people to see great opportunities in the use of digital technologies in education?

Digital technologies were introduced into schools based on the belief that they improve the quality of teaching and adapt it to the realities of the 21st century. Digital technologies are intended to prepare students for life in the information society and the future labor market. Furthermore, the European Union promotes the development of digital competences as the foundation of modern education (c.f. Tarkowski, Majdecka, Penza-Gabler, Sienkiewicz, Stunża, 2018).

The greatest opportunities for the use of digital technologies include:

– individualization of teaching, i.e. with the help of educational platforms and applications it is possible to adjust the pace and form of learning to the needs and abilities of the student, which contributes to equal opportunities (c.f. Kinal, 2015);

– greater student engagement, as the introduction of new technologies increases the attractiveness of lessons. By using multimedia or educational games, we can maintain student attention longer and more easily, which supports the memorization process (c.f. Hojnacki, 2011);

– support for teachers and administration, i.e., digital technologies used by teachers include electronic journals that enable online communication, streamline school operations, and monitor student progress. These also include websites that facilitate preparation for specific classes, such as Testporal, Quizizz, WorldWall, Crazy Numbers, and many others (c.f. Musiał, 2018);

– development of key competences of the future, the task of digital technologies is to develop creativity, critical thinking, communication and cooperation – all these skills are crucial in the dynamic world of work (c.f. Konieczyńska, 2024);

– teaching-learning efficiency (project work) – students can collaborate online, not only with their classmates but also with people from other countries, which allows for the exchange of experiences between children;

– exercises using websites – thanks to the use of an algorithm, the child immediately receives the correct answer after solving the task, which facilitates faster correction of errors;

– adapting the teaching process to the needs of students, individualization of teaching – students can learn at their own pace;

– motivate learning using fun elements by introducing competition in ad hoc electronic games, e.g. Kahoot;

– quick and unlimited access to information and teaching content.

What are the most frequently identified threats to the use of digital technologies in education?

The most common threats include those resulting from excessive transfer of a child's/student's activity to the digital (virtual) world:

– inhibition of child development: children may have delayed speech development, poor vocabulary, emotional problems or social inhibitions – difficulties in establishing contacts with peers and adults;

– decreased concentration – children's attention span is short, at the age of 5 to 7, it can be a maximum of 30 minutes. This time is shortened, which means that their performance in any given activity will be lower;

– addiction to screens, phones and games – colorful pictures, flashing lights, interesting formulas make children easily addicted;

– the health impact of excessive blue light on eyesight is damaging. Children slouch when sitting at a computer or phone, which worsens their posture. Frequent sitting, on the other hand, leads to less exercise and, consequently, weight gain and other musculoskeletal problems.

– overstimulation of children – in today's world, we are surrounded by a multitude of stimuli, from music in stores, pop-up and interactive advertisements, to movies and online games. This leads to overstimulation not only of children but also of society as a whole. We lose the ability to regulate excess stimuli in the body, which has disastrous consequences for the nervous system;

– inhibition of creativity – ready-made answers, quick solutions at your fingertips inhibit children's creativity, they lack childlike curiosity;

– using unverified knowledge: no verification of information generated by ChatGPT, no verification of any sources of information (not everything on the Wikipedia page is true, after all, it is written by random people).

– pressure to constantly monitor the child's progress, including grade checks: electronic journals, grade notifications, and absence notifications. Children feel pressured, afraid of getting a lower grade or missing school.

– cyberbullying – students are unaware of the negative consequences of their inappropriate online activities. Cyberbullying primarily affects children's mental health, which can even lead to depression. Learning appropriate, balanced, and safe internet use is crucial to avoid tragic consequences. As teachers, we must quickly respond to any signs of cyberbullying, educating our students accordingly.

Educational strategy using modern digital technologies

Current educational strategies should incorporate modern technologies, which in today's world are essential for holistic planning of learning, enabling students to improve and develop fundamental areas: cognitive, social, emotional, and motor/physical. This is achieved through meticulously planned activities by the teacher and the student's step-by-step execution of each task.

In the context of digital technologies, educational strategies implement modern forms through applications, interactive learning platforms, computer games, or a set of electronic toys that intuitively guide students through successive levels of difficulty, providing motivation and satisfaction. These intrusive activities

provide teachers with transparent feedback and the ability to adjust the task's difficulty to suit the student's individual potential. This educational format is also a great way to foster group integration and foster healthy competition. Kits, programs, and even coding blocks (e.g., coding mats, Beebots, Scratch, Lego) are an example of how we can comprehensively create a comprehensive learning environment, making learning enjoyable and fostering children's natural motivation. A seamless blend of learning and play is particularly important: logical and critical thinking, creativity, and effective problem-solving.

A digital educational strategy also offers numerous opportunities to support children with special educational needs, increasing their sense of support, understanding, and empowerment, and creating an environment that fosters comprehensive development. The teacher becomes a guide and facilitator for the student, while technology, used responsibly and effectively, becomes not only a mass conveyor of information and a form of entertainment, but also a model, full of inspiration and potential, in the ever-evolving learning process.

Own research methodology

Looking at this topic through the eyes of students and future teachers, we wonder whether our eagerness to embrace technological advancements might lead us into deeper problems that will have irreversible consequences for us in the future. Reflecting on our memories, childhoods, the methods used in school, and our student experience, we can confidently say that despite the lack of significant use of technology in our teaching, learning was more effective in terms of social interaction, the adoption of values, and the acquisition of skills and knowledge.

Looking at children in school today, we can see dramatic differences in both their growth and functioning. This is due to the rapidly evolving opportunities available. However, we recognize that problems are emerging that were unacceptable in our time. We search for the trigger, the source of it all, and we return to the pandemic era, when technology determined our future. Back then, there was no other option, and when we saw how it “made” our lives easier, we went further, perhaps a step too far. We are currently at a point where we wonder whether this represents an opportunity for us or a threat to the new generation.

For the purposes of this research, a diagnostic survey was used, with a questionnaire designed primarily for students of preschool and early childhood education preparing to work with children in preschool and early childhood education. The survey, developed on the Forms platform, consisted of two sets of questions. The first set focused on the opportunities for using digital technologies and contained six categorized questions and one open-ended question. The second set focused on the threats arising from the use of digital technologies and contained 11 categorized questions and one open-ended question.

Research results

The pilot study was conducted among 41 students from several fields of study, from whom 30 students of pedagogy were selected for analysis. This was an online survey using open-ended questions, allowing for free, extended responses from a purposively selected group of respondents. Of the 30 students, 29/30 were women, and 1/30 were men. Of the 30 students surveyed, their fields were: first-year PPiW (University of Rzeszów) – 6 students; second-year PPiW (University of Rzeszów) – 18 students; third-year PPiW (University of Rzeszów) – 1 student; fourth-year PPiW (University of Rzeszów) – 3 students; and second-year special education – 2 students.

The first series of questions addressed to respondents concerned educational opportunities resulting from the use of digital technologies.

To question (5) about the attractiveness of learning, 18 characteristic responses from respondents were selected (original spelling): classes are more interesting, new technologies = fun, games, new solutions, motivation, variety, speed, unconventional methods, dynamics, diverse forms, personalization, individualized learning, learning = fun, experiments, visualizations, children's engagement, stimulating curiosity, and the attractiveness of digital content (not just e-textbooks). It can be concluded that digital technologies increase the attractiveness of learning through their engaging format. New methods are becoming an excellent factor in encouraging children to learn. They stimulate curiosity, diversify activities, and allow children to associate learning with fun.

Question (6) about learning effectiveness yielded 17 characteristic responses from respondents: faster memorization and easier memorization thanks to visualization, adapting the difficulty level to students' abilities, eagerness to learn, combining pleasure and usefulness, individualized pace of work, immediate response/result, multi-sensory knowledge acquisition, better understanding of the topic, attractiveness of knowledge, monitoring of student progress, educational programs, combining theory with practice, using diverse materials, longer retention of knowledge, optimizing time and efficiency of content delivery. Teaching effectiveness is enhanced by the use of digital technologies, which facilitate memorization and understanding of the topic. They allow for quick verification of knowledge and presentation in an accessible, engaging format.

When asked (7) about adapting the teaching process to students' needs, respondents selected 9 characteristic responses, stating that: this helps adjust the difficulty of tasks to the students' level; weaker children are more likely to learn thanks to an attractive format; it supports students with various learning difficulties (e.g., through the use of a speech synthesizer); algorithms are used for this purpose, allowing us to utilize various forms of work; thanks to the possibility of repeated, independent repetition of material, knowledge retention is increased; interactive forms of learning foster the development of independent thinking and

problem-solving skills; individualization encompasses not only the pace but also the level of tasks; the effectiveness of digital education depends on the quality and design of the programs used – they must be tailored to the child's needs and abilities. Digital technologies enable learning to be tailored to the needs and abilities of students. By using appropriate algorithms, we have a way to match tasks to the child's level of knowledge – without boredom or excessive demands. They can also help students with various disabilities access knowledge.

To question (8) about learning motivation, 6characteristic responses were selected: children associate these activities positively with the use of computers, films, and projectors. This is learning through play, which is extremely attractive to children and therefore motivating. Children are more likely to use these tools thanks to the use of interactive tasks, platforms, badges, rankings, and the ability to compare their results with others or simply with statistics. Children associate digital technologies with everyday activities. The speed of results and the ability to immediately correct errors encourage children to complete tasks. Competitions and awards provide external motivation for children. The mere use of modern technologies creates this effect of novelty and curiosity. The use of digital technologies in the form of games, activities, films, and competitions motivates children to continue learning. Thanks to instant answers and corrected errors, children see their mistakes and how they can improve, which encourages them to use such solutions.

In response to question (9) about quick and unlimited access to information, respondents gave the following 5 typical answers: *the use of digital technologies makes it easy to search for information, which is perfect for students to immediately satisfy their curiosity about a given topic; creating a virtual database with students and placing relevant materials there can not only further speed up the data search process, but also provide access to verified knowledge; thanks to such easy access, children quickly learn to verify data and learn critical thinking through independent data search, the knowledge stored in a phone allows children to develop their own interests at any time and place, it also helps in shaping information literacy.* The presence of digital technologies in schools makes it easier for children to access information, which is easily and quickly available. They allow children's curiosity to be satisfied in all aspects. It is important to remember to advise children to check the sources and origin of information so that they can avoid misinformation.

In response to the question (10) about the electronic journal, respondents selected 5 characteristic responses, stating that: *Using digital technologies in the context of an electronic journal allows for tracking a child's progress at any time. We have an easy and fast flow of information and an excellent way to communicate with our students' parents. It is accessible at all times, which is extremely practical for parents working in demanding professions. It is a way to monitor*

a child's behavior, grades. The electronic journal provides access to the schedule, ensuring that information reaches parents and is not forgotten by the children. An electronic journal is a fantastic convenience, allowing for a quick flow of information and easy contact between teachers and parents. However, it should be used with caution to avoid creating a tense atmosphere or exerting excessive control over the child and their grades. After all, it's not the grades that matter most, but the child.

To the question (11) about "Other educational opportunities", 4 characteristic answers were selected, in which the respondents wrote that (): *digital technologies influence the way of teaching, access to knowledge and interaction between students and teachers, it is a great way to adapt materials to the individual needs of children, which consequently leads to increased learning efficiency, it develops children's digital competences that are necessary in the future.*

A summary of the educational opportunities created by digital technologies

As we have seen, digital technologies in schools aid in learning and assessing children's work and knowledge. They can be an excellent means of communication between teachers and parents. They serve as an ideal way to enrich classes, supporting individuality, the pace of work, and students' interests. Their engaging format encourages and motivates students to learn, think creatively, solve problems, and explore various educational methods that deepen and consolidate knowledge. However, it is important to remember to use them wisely, so that modern technologies become a unique opportunity to stimulate the skills necessary in today's world.

The second series of questions addressed to respondents concerned educational threats resulting from the use of digital technologies

The first question in this series (12) concerned students' developmental delays. 14 characteristic responses were selected, in which respondents indicated: *inhibited socialization skills, lack of need for personal development, lack of desire to seek knowledge because it is readily available, inhibited motor development, lack of independence, lack of emotional development, lack of conversation, lack of critical thinking, lack of contact with peers, concentration problems, lack of fine motor skills, speech disorders, lack of manipulative experience and contact with nature as important factors in child development. The dependence of negative effects on the scale and manner of technology use is not about the mere presence, but rather about overuse or inappropriate implementation.* Overuse of digital technologies can lead to significant learning difficulties and a lack of socialization in young people. They may experience a wide variety of problems that may be impossible to completely remedy.

The next question (13) concerned students decline in concentration. 6 characteristic responses were selected, in which respondents wrote: *difficulty focusing*

attention for extended periods, overstimulation of students, accustomed to short forms of learning resulting in an inability to focus for extended periods, and a decline in the ability to process and remember information in-depth (referring to the quality, not just the length of attention span). Difficulty persevering with task-based work and adapting to traditional forms of education (not just focusing but also maintaining cognitive effort). The teacher's important role in maintaining concentration using digital media can be both helpful and disruptive, depending on how it is used. Too much digital technology can lead to a decline in concentration, causing children to lose the ability to maintain attention for longer periods. Students lose motivation to pursue long-term goals and are unable to concentrate on them, let alone achieve them with any effort.

The next question (14) concerned addiction to the Internet, computers, etc., 10 characteristic answers were selected, in which the respondents wrote as follows: *Too frequent use of computer equipment with Internet access can lead to a stage in which a child will not want to spend time in any other way than on the Internet, overusing this form of spending time can lead to addictions and limiting interests, treating a phone or tablet as a break from time spent with a child, lack of control over time spent online can be disastrous, children lose the ability to self-regulate, creativity, the desire for spontaneous play and curiosity are limited, sleep problems and other health problems appear, this can also lead to neglect of home and school duties, children lose socialization skills*. Addiction to a computer/Internet, etc. can lead to the loss of socialization skills in children, they lose the desire to spend time and play with peers. Children lose the desire for spontaneous play and childlike curiosity about the world, they turn into clicking robots.

The next question (15) concerned addiction to immediate rewards (attractive, endless links). 5characteristic responses were selected, with respondents stating the following: *children become accustomed to rewards; in every situation, they crave more and more. Children are reluctant to engage in sustained effort, preferring everything quickly and easily. Students no longer do anything they want or for the satisfaction of it, but because they will get something in return. Without rewards, there is no work. Children are lost in the real world, and the lack of immediate rewards and additional stimuli leads to boredom and frustration. They become accustomed to rewards and crave more and more.* The problem of immediate rewards is very significant; children do anything to get what they want, and they lack the drive to develop or acquire new skills. The lack of gratification can lead to frustration and aggression, making it difficult to communicate with such a child.

In question (16) about the impact on health, respondents wrote: *overuse of digital technologies can lead to deterioration of vision and hearing, and can also lead to obesity due to lack or limited exercise, prolonged sitting in front of a screen can lead to vision, spine, and sleep problems. It can also cause poor*

posture. Headaches can occur due to excessive screen use. It also negatively impacts the development of the musculoskeletal system. It also impacts mental health through limited peer contact. As can be seen, this has a huge impact on children's health, ranging from vision impairments to poor posture, sleep problems, and mental health issues.

The next question (17) concerned irreversible changes in brain function. 6 characteristic responses were selected, in which the respondents responded as follows: *overuse of digital technologies causes a regression in speech development; children increasingly experience problems with attention, emotions, and concentration; damage to the nervous system, attention problems, and cognitive development disorders also occur; children may have damage to the parts of the brain responsible for controlling emotions, self-control, and impulsivity; the ability to think deeply and remember is weakened.* Overuse of digital technologies can lead to significant problems with the centers of emotional control and concentration. This can also lead to damage to the nervous system, which is currently irreversible and harmful to our society.

The next question (18) concerned student overstimulation. Respondents provided 5 characteristic responses: *constant access to multiple stimuli (sound, image, movement, etc.) can overload children's nervous systems and lead to mental fatigue. Excessive stimuli hinder deeper information processing and limit the ability to focus on a task for extended periods. This can lead to stress and anxiety – children cannot process so many stimuli simultaneously, they may become tired and drowsy. After prolonged exposure to digital stimuli, they may have trouble calming down, and they may experience problems with emotion regulation.* Overstimulation affects not only children but also adults. In our opinion, it is a plague of today's civilization, taking a heavy toll. This leads to mental fatigue, a decrease in concentration, and problems with emotion regulation.

Question (19) about inhibiting creativity. Respondents in 6 selected characteristic answers wrote: *By using ready-made content, children stop being creative, they don't feel like doing anything, because why bother? It's already online, students don't want to break the mold, by using technology excessively, there is a lack of space for free play and creative thinking, the use of technology limits independent experimentation; there is a decline in interest in traditional forms of learning and play, in addition, too much control by teachers and parents can make children reluctant to seek new, their own solutions.* In today's world, children's creativity is at a very low level, ready-made templates and online solutions inhibit and limit children's natural creativity. We need to focus even more on developing it so that our offspring's passion is not just scrolling on their phones, but simply something more.

The next question (20) concerned the use of unverified knowledge. The study participants, in their 5 selected characteristic responses, wrote: *children believe*

that everything on the internet is true, they do not check sources, they approach information found online uncritically, there is a risk of perpetuating false or harmful beliefs, children do not have the ability to obtain information reliably. It is worth checking the sources of our information, thus avoiding disinformation and perpetuating false beliefs. This is very important in shaping children's views, we must be vigilant and teach them to verify the knowledge they find online.

When asked about cyberbullying (21), the interviewers selected 6 characteristic responses, stating: *It appears when parental control fades, it manifests as hate speech, it can be caused by aggression in games, later online aggression can spill over into real life, it can lead to harassment, stress, depression, and exclusion from children's communities, children can be both victims and perpetrators of cyberbullying.* Cyberbullying is a plague on our civilization, hate speech, harassment, and aggression all have a huge impact on children's behavior and well-being. We may not even realize the damage this can cause to the younger generation.

To question (22) concerning the pressure to monitor students, the respondents in the selected 8 characteristic answers answered as follows: *children learn only for good grades, not for the knowledge itself, students feel controlled at every step, children's well-being decreases, children associate their value with school grades, they feel that they are not allowed to make mistakes, children feel that the result is more important than the learning process itself or the child's involvement in it, children lose their natural motivation to learn, fear of assessment and comparison with other students appears.* Too much pressure to monitor children's learning results can be detrimental. Students feel trapped, comparison with others and identification with a specific grade is problematic, because children no longer learn for knowledge, but only for a specific grade, and this is out of fear.

Question (23) about other negative aspects of using digital media in the selected 4 characteristic answers, respondents wrote as follows: *children do not feel the need to spend time with peers, they deceive their parents that they are doing homework while in fact they are playing and watching, social isolation occurs, difficulties in relationships with other people.*

A summary of the educational threats posed by digital technologies

According to respondents, digital media in schools pose numerous risks, ranging from developmental delays and addictions to serious mental and physical health damage and dependence. Social relationships at such a young age are particularly important for the proper socialization process. Digital technologies do not enable the full development of basic social functions, such as empathy and cooperation. Using only remote learning methods limits direct contact with teachers, making it more difficult to obtain reliable feedback from students to fully tailor individual learning content.

Conclusion

Our topic aims to demonstrate the conscious use of modern technologies in schools. Based on the opinions of our students, we can conclude that technologies can significantly support and increase the effectiveness of education for the younger generation, who are growing up in a modern environment that offers many opportunities to support and even replace our own activities. Innovative activities in schools provide an opportunity to wisely utilize and support education on many levels, to diversify classes, which leads to increased student engagement in tasks beyond the traditional format and beyond the school walls in an engaging way. However, over-reliance on the entire upbringing and education process leads to a simplification of teaching and can lead to the omission of significant aspects of learning, socialization, and the use of pedagogical methods. Digital opportunities should be adapted to demonstrate students' creative approaches to course topics without replacing fundamental factors such as reasoning and reflection. Providing ready-made materials will significantly impact the future functioning of units. It is crucial to engage students in generating their own ideas and creative activities without searching for ready-made content, so that future generations can act based on their own assumptions, while being safely inspired, and so that they are not passive recipients of all media content. Conscious and careful consideration of this topic is key to the proper functioning of all units in the educational process.

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Possibilities of Applying FreeCAD in Teaching the Technology Subject

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Abstract

The use of CAD systems is currently one of the common educational problems. Their use in the field of technical education can now be considered non-compliant, especially at higher secondary education at vocational technical schools and universities. Their application is also important in primary school and it is necessary to distinguish the difficulty and availability of the program for the school. The FreeCAD is also available for a complex CAD system usable for the needs of technology teachers at lower secondary education. This paper deals with the possibilities of its use in the creation of working ideas.

Keywords: FreeCAD, technical drawing, 3D modelling, sheet metal, technical education

Introduction. CAD systems in the technical education

Teaching of technical subjects is an important pillar of the development of expertise and practical skills in areas such as engineering, architecture, electrical engineering, design and production. This kind of education combines theoretical knowledge with practical applications aimed at solving design, production and technological and procedural problems. The basis is systematic education leading to technical capabilities from the level of primary education, through lower secondary education, higher secondary education at vocational technical schools to university education at universities.

In recent decades, this process has undergone a fundamental transformation thanks to digitization and the wide use of computer tools, where CAD (Computer

Aided Design) also plays a key role (Kučerka, 2025). These systems allow the creation of 2D technical drawings and 3D models that define the exact dimensions and shape of the proposed products and are essential for modern project activity. CAD systems provide a practical tool for students that supports the development of spatial imagination, accuracy and ability to create complex products of products (Damaren et al., 2025). In addition to the design, they allow simulation, analysis and integration with production systems, including CNC and 3D technologies, providing students with a comprehensive view of the entire production process from design to implementation.

The use of the CAD system has become the subject of research of several scientific publications, focusing on the possibilities and effectiveness of its application in teaching. The implementation of research in CAD teaching has shown the possibility of improving the student experience of learning and increasing the academic level. CAD courses taught in coordination with other subjects allow students to develop complex competences related to technical drawing and graphic communication (Redon Santafé, Piquer Vicent, Haba Guerra, García-Domínguez, 2016). Research in the field of CAD/CAE systems for the creation of e-learning courses of technical objects at universities points to the potential of these technologies to modernize the educational process and improve the interactivity of teaching (Kozlov, Harlashkin, 2018).

According to Park, Han, and Lim (2025) The use of CAD technologies in teaching technical subjects significantly contributes to the development of key skills for the 21st century, such as critical thinking, collaboration and computing thinking, which is the basis for success in integrated STEM education. One of the key questions in CAD education is the choice between specialized academic software and commercial solutions. Research points to the need to consider specific needs of the educational process in choosing the right tools (Rubio, 2014).

The use of CAD systems requires some degree of management of work with the program (Koziar, Hubal, Burchak, Botviniev, Saveliev, 2025) and knowledge from other disciplines such as mathematics, technical drawing or design. Their use in lower secondary education in the form of pupils' education has not been the subject of research so far. In our paper, we will focus on the analysis and exploring of one of the freely available Open Source CAD software FreeCAD in terms of preparation for the lesson and the creation of working ideas for the subject of technology at lower secondary education, based on the curriculum of this subject.

The subject matter of the study. FreeCAD software

FreeCAD is freely available open-source CAD software for 3D modelling, designed especially for engineering and technical drawing. Unlike many commercial programs, such as Solidworks or Autodesk Inventor, FreeCAD is

completely free and can be used without any license fees in education. Its main advantage is that it is modular and customizable, which means that it can be extended with new functions using different desks (workbenches).

Working in FreeCAD is based on parameter modelling. This means that every object that is created retains its history and can be changed at any time its parameters.

The user interface is divided into several main parts:

1) Workbar panel: It is located up and is used to switch between different modules (workbenches). Each workbench is specialized in a type of work, such as 2D sketches, 3D modelling, or technical documentation.

2) The model of the model: on the left side there is a tree structure that shows all the objects you created (parts, operations, sketches). Clicking on individual items you can return to and edit them.

3) Working window: The central part is used to visualize the 3D model.

4) Task and features panels: On the right side, panels are displayed to modify the properties of selected objects and to control various operations.

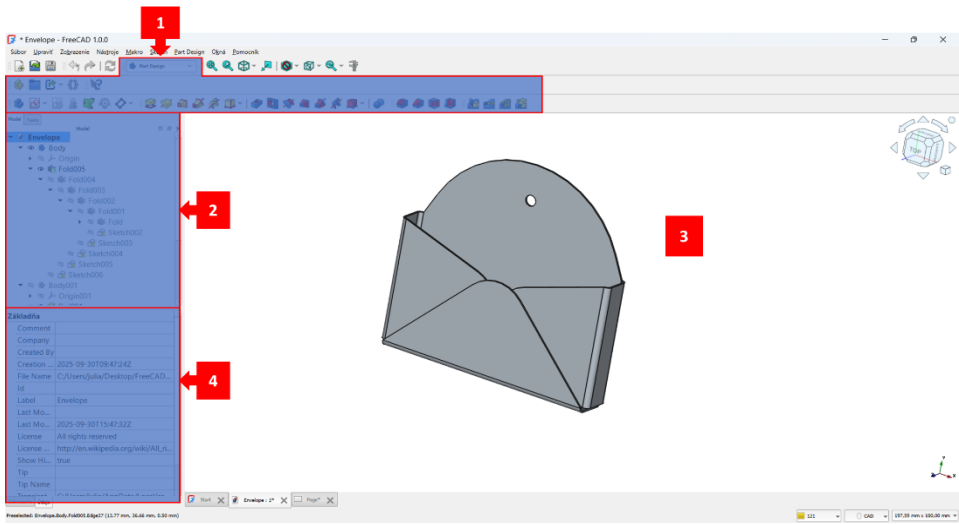

Figure 1. FreeCAD user interface

Research methodologies and tools

The research methodology consists of three main phases:

1. Phase 1 The study of the documentation is focused on official documentation from the FreeCAD in the form of tutorials in order to understand theoretical foundations and functions of the desk.

2. Phase 2. The object is a metal bent envelope and its developed shape of the clip, designed to store paper links. Workbench tools are tested for sketching,

modelling, sheet metal formation and drawings. The output is a file with a working theme model in FreeCAD. The implementation of this section is in 3 steps:

- Step 1: Creation of 2D sketches in Sketcher module and their transformation into 3D models using Part Design.
- Step 2: Design and modelling of plate components in Sheet Metal module.
- Step 3: Creating a technical drawing in the TechDraw module.

3. Phase 3.: Analysis and evaluation to critically evaluate FreeCAD based on the practical experience of the experimental phase. Partial appreciation of modules: Sketcher, Part Design, Sheet Metal, TechDraw.

Development (analysis of research results)

The FreeCAD is a comprehensive CAD System for creating models, assemblies, drawings, specific technical parts such as thin sheets, but also various analyses or programs for CNC or 3D printing. It contains a wide range of modules in a program called workbenches or workbenches. The basic working environment can be considered relatively intuitively responded to by traditional user interfaces that the user can be accustomed to from other regular user programs. Selected workbenches are pre -installed within the basic installation. The user can make other workbenches in the Addon Manager in the offer, to which there is a relatively good description for what they are for. For our needs, it was necessary to finish the workbench Sheetmetal, which was not part of the basic installation. Before working with individual workbenches and the environment, it is necessary to make the input user settings in the Tools menu to adjust the user preferences.

Creation of 2D sketches in Sketcher module and their transformation into 3D model using Part Design: Workbench Sketcher work environment can be considered intuitive, consisting of the necessary tools of elements (point, line, arc, circle …). An important role is played in the creation of sketches, a group of tools by which the user can define all the necessary bonds of the elements (horizontal/vertical binding, parallelism, equality …) and dimensional links (dimensions) that determine the size or location of the individual elements. From the point of view of tool work efficiency as a disadvantage, the unconventional character of the tool, such as the line and the grouping of dimensional bonds into the drop-down menu, can be considered as a disadvantage. If the shape and all the necessary dimensional and positional bonds are comprehensively defined, the sketch will change the colour, and the sketcher can be stacked by the Close command in the TASK panel that the user returns to the part of the Part Design. In this workbench, the user chooses several 3D volume sketches. This volume part can be manipulated in space by sliding, zoom or rotation. Or choose an area in which a new sketch can be created and gradually model more complex shapes by adding or removing volume based on a sketch, or various shape elements such as collision, rounding, normalized hole or thread.

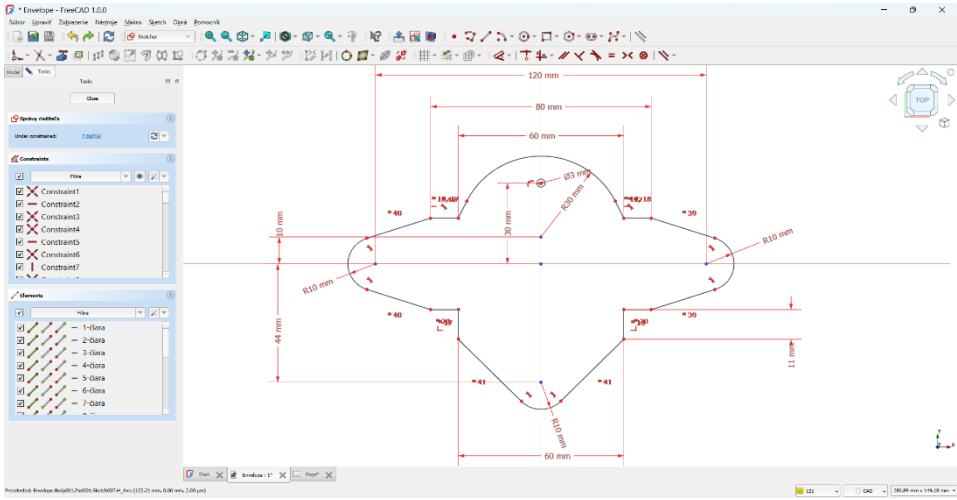

Figure 2. Sketcher – 2D sketch creating

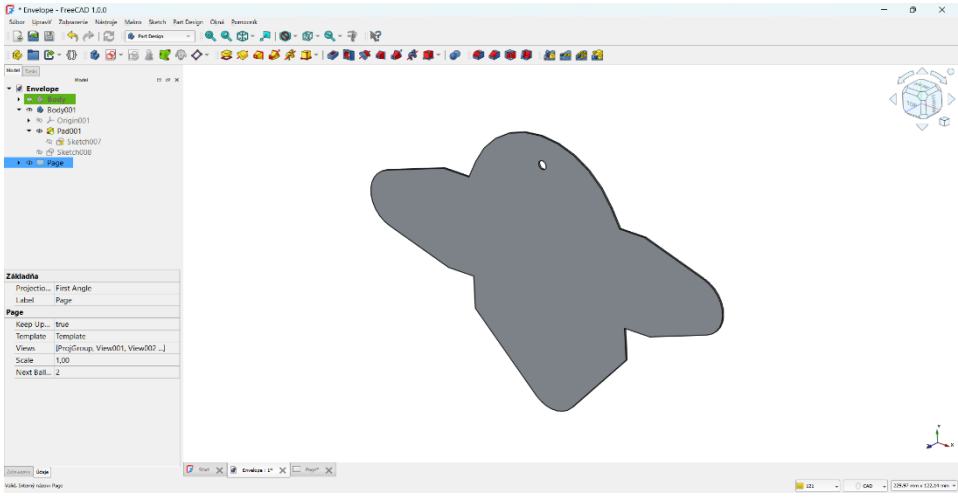

Figure 3. Part Design – 3D body creating

The design and modelling of plate components in the Sheet Metal module: The creation of a bent model from the developed shape cannot be considered in principle. For individual bends, we defined a line on the surface of the inner bend, which corresponds to the bending line and gradually bent the flat shape into the desired shape using the Fold and Wall tool. The disadvantage can be considered that workbench does not have the same Sketcher tool as the line causing repeating steps and switching between Part Design and Sheetmetal tools.

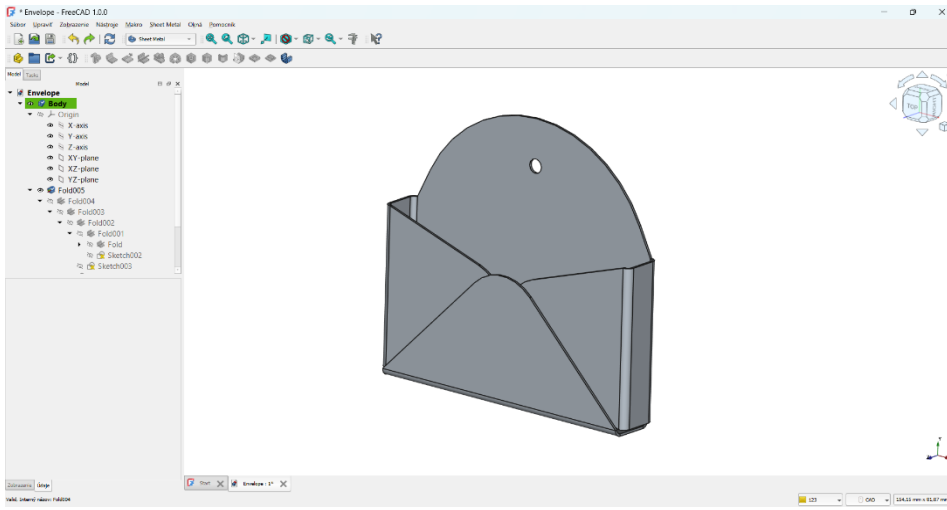

Figure 4. SheetMetal – metal bending

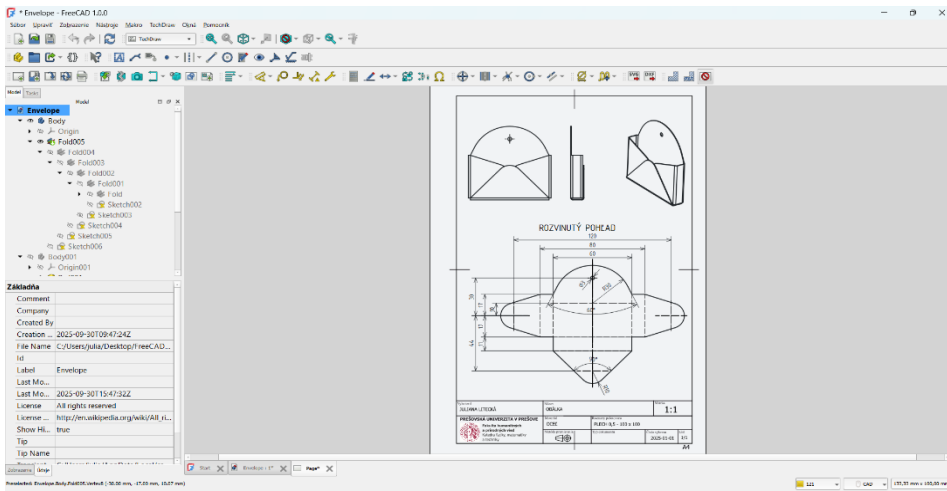

Figure 5. TechDraw – technical dawing

Creating a technical drawing in the TechDraw Module: Module Tech-Draw provides a wide range of tools and options for creating drawings, including the necessary views, dimensional dimensions and drawing elements (axes, centres of circles and arches, notes, link lines or special symbols). For this module, it is necessary to make a relatively wide range of settings before starting, so that the view corresponds to the appropriate technical standard determining the criteria for drawing drawings. Here we have to say that the possibilities are not sufficient and

not intuitive for the user. An important role in the creation of drawings is the template of the modified drawing format according to the user's needs or the institution. Templates can be created through the Inkscape vector program and uploaded to the appropriate folder with predefined templates of drawing formats according to multiple standards. Adding views and their settings is all the necessary options for basic display in the first or third quadrant. There is no possibility to choose a colourful variety or look with invisible edges in the settings window. There is also no possibility to not display lines from rounded edges. When combining the views of several bodies as in this case, the developed shape and bent shape, it is necessary to create two separate files and merge these into one, so that the views can be added gradually. All kinds of necessary code can be added to the menu, it is easy to align them. We consider it insufficient, however, but tools for the creation of technical elements such as symmetry axis, centres of circles and arches, legacy lines. These elements cannot be mass edited in bulk, the thickness and type of line does not answer the requirements of the line type even after the initial settings. There is no possibility of free drawing and editing of lines, such as bending lines. We had to project these after drawing in the sketchbook in a developed view. Overall, this workbench would require a more detailed overwork aimed at automating tools in accordance with the requirements of technical standards.

Conclusions

We consider the CAD System FreeCAD to be a very suitable tool for designing working ideas and creating technical documentation. For developers behind the main, we recommend that you remove key shortcomings in tools and options for settings of individual workbench. For the motivation of teachers to use this program, we recommend training in the form of video tutorials or workshops focused on the FREECAD tools and possibilities.

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Performance Evaluation of Selected Containerization Methods in Web Services Applications

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Abstract

This paper evaluates the performance of selected containerization methods. As part of the research, infrastructure was created using Google Cloud public cloud, and then load tests were conducted for each containerization method using Apache JMeter. The study has shown that choosing the right containerization method depends on the service to be implemented. It was demonstrated that the highest performance was achieved by combining Podman with Docker. An example implementation and performance of Kubernetes technology, together with Docker and autoscaling using Google Cloud, was demonstrated. The project demonstrates high educational value by combining theory with practice through cloud-based infrastructure testing using Google Cloud and Apache JMeter. It helps learners understand container behavior under load, resource usage, and orchestration techniques. Additionally, the study emphasizes critical decision-making in selecting appropriate technologies based on specific service requirements. It serves as a practical teaching tool for IT and computer science education, offering insights into real-world DevOps workflows, scalability strategies, and performance optimization.

Keywords: Kubernetes, Docker, Podman, Google Cloud, Apache JMeter

Introduction

Nowadays, web services play a key role in the operation and dynamic growth of many organizations, from small start-ups to multinational corporations. With each passing day, the role of IT infrastructure continues to grow in ensuring the scalability, reliability, and performance of the services in question. Before the advent of containerization, virtualization dominated the market as the main technology enabling efficient management of IT resources. Virtualization allowed the creation of multiple virtual machines (VMs) on a single physical server, which significantly

increased the efficiency of using available resources. Each VM ran in an isolated environment, which provided security and the ability to run different operating systems on the same hardware. This technology revolutionized the way companies managed their data centers, enabling server consolidation, reducing operating costs, and increasing flexibility in IT infrastructure management.

This work has significant educational value as it introduces students and professionals to the practical application of containerization technologies in modern IT infrastructures. By comparing Docker, Podman, LXC, and Kata Containers through real-world performance testing in a cloud-based environment, the project provides a hands-on framework for understanding key concepts such as resource allocation, container orchestration, and load balancing. The detailed deployment process using Google Cloud, the use of Apache JMeter for testing, and the comparative analysis of metrics allow learners to gain insights into how different container engines behave under various workloads. This experiential learning approach deepens theoretical understanding and equips learners with essential skills needed in cloud computing, DevOps, and systems engineering.

From a didactic perspective, the study also highlights critical thinking in selecting the right technology for a given use case, emphasizing that there is no one-size-fits-all solution in containerization. The evaluation encourages learners to assess trade-offs between performance, security, scalability, and usability. Furthermore, the integration of tools like Kubernetes and CI/CD pipelines introduces students to industry-standard practices, helping bridge the gap between academic knowledge and real-world implementation. As a teaching aid, the project can be used in advanced IT and computer science courses to demonstrate infrastructure planning, container deployment strategies, and performance benchmarking in a controlled, replicable environment.

Containerization

However, over time, containerization has started to gain popularity, offering even greater efficiency and flexibility. Containerization has made it possible to isolate applications so that only the elements necessary for a service to function properly are stored in containers. What is more, if you send a person from your team a ready-made container image, for example, one is 100 percent sure that the person will have an identical environment once it is up and running, which makes teamwork much easier. Containerization, due to its lightness, reliability, simplicity, and speed, quickly found a huge number of followers and instantly conquered the market. Hosting one's applications on servers or virtual machines was quickly replaced by containerization, which now dominates the production environments of most companies, combined with tools for orchestrating them, such as Kubernetes or Docker Swarm (Fava et al., 2024).

Containerization offers lower resource consumption, faster application start-up, and better scalability compared to traditional virtual machines, making it the

preferred solution in modern IT infrastructures. Virtualization has been central to the development of IT, enabling efficient management of resources through virtual machines. However, containerization has introduced a breakthrough, offering application isolation, lightness, reliability, and speed. With tools such as Kubernetes, containerization has replaced traditional servers and virtual machines, providing better scalability and performance in modern IT infrastructures.

Virtualization involves creating a virtual computer environment that is opposite to the physical environment. This allows organizations to divide the resources of a host machine into several different, separate, completely virtual, isolated machines. These machines can interact independently and embed different operating systems and applications. Type one virtualization, also known as bare metal virtualization, involves the installation of virtualization software directly on a physical server that acts as a virtualization host. No or minimal host operating system is required, and the virtualization layer runs directly on the hardware. Type two virtualization, also known as hosted virtualization, involves installing virtualization software on an existing operating system (host) that is already running on a physical server. The virtualization software runs as an application on this operating system (Zordevic, Timcenko, Lazic, Davidovic, 2022). Examples of such solutions are VMware Workstation (for Windows and Linux), Oracle VirtualBox, and Parallels Desktop (for macOS) (https://azure.microsoft.com/pl-pl/resources/cloud--computing-dictionary/what-is-virtualization; https://kubernetes.io/blog/2020/12/08/kubernetes-1-20-release-announcement/).

Containerization is a technology that has conquered the IT market in a very short time. A container is a defined environment that contains everything needed to run an application, including code, execution environment, libraries, tools, and system configuration, which ultimately results in the lightness and speed of running such a container. Containers are isolated from each other and from the host on which they are run, which allows the application to run consistently and independently of the surrounding environment, however, if necessary, it is also possible to create a special network, which is created inside the host machine and in which it is possible to create individual working environments and ensure communication between individual units. Another very important aspect is that containerization enables developers and system administrators to easily deploy, run, and manage applications in different environments, which contributes to faster software delivery, improved infrastructure performance and flexibility, and increased application security. Containerization also enables easier deployment of microservices-based architectures and the use of continuous integration and delivery (CI/CD) techniques (Fava et al., 2024; Zeng, Wang, Deng, Zhan, 2017; https://cloud.google.com/logging/docs/agent/ops-agent).

There are several different container engines in the IT market, each with its own unique features and advantages. Until recently, the dominant position was

held by Docker Runtime, which was widely popular among organizations. However, in recent years, Kubernetes, as one of the leading container management platforms, has expressed a preference for containerd as the standard runtime for containers. While this announcement has not made containerd the only choice, it has certainly increased its popularity in the Kubernetes ecosystem. In addition to Docker Runtime and containerd, there are other container engines on the market, such as Podman, CRI-O, Linux Containers (LXC), and Kata Containers. Each of these engines has its place and use, depending on the users' needs and preferences. It is also worth noting that Docker currently uses containerd as its default runtime for containers.

Docker was initially a private project, continuously developed by a company located in South Africa, specifically by Solomon Hykes and Sebastien Pahl. The first Docker container was launched in 2011 before being released to the public in 2013. Since Docker was made public, it has become increasingly popular. It is an open platform for creating, delivering, and running applications. With this containerization technology, one can isolate applications from the infrastructure so that we can quickly deliver new versions of a given software. Docker uses a client--server architecture, which means that the Docker client communicates directly with the Docker daemon, which takes care of building, running, and distributing containers. The client and daemon can run on a single system, or it is possible to connect the Docker client to a remote daemon. The Docker client and daemon communicate using the REST API, UNIX sockets or the web interface. Another Docker client is Docker Compose, which directly enables working with applications that include multiple containers (Fava et al., 2024; Zeng et al., 2017; https://www.docker.com/resources/what-container/; https://www.geeksforgeeks.org/architecture-of-docker/).

Podman, unlike other containerization methods, does not have daemons, i.e. it does not require any continuously running processes in the background to manage the container. Instead, it uses system calls, which are made directly via the command line. With this rather non-standard solution, containers are run in the context of the current user, which is beneficial for security and isolation. It was created to facilitate the entire process of running, sharing, and deploying applications through containers and OCI (Open Container Initiative) container images. It relies on an OCI-compliant container execution environment to connect to the operating system and create running containers. It provides both a CLI command line and applications along with a graphical user interface (Similar to Docker Desktop). A very important point is that containers in a sub-master can be created and run by both an administrator and a normal user (in Docker, by default, Docker commands can be executed either from root or by assigning a user to a Docker group) (Zordevic et al., 2022).

Its history is closely linked to the evolution of container technologies and the need for more secure and flexible container management tools. It all started with

the development of Docker, which was introduced in 2013 and quickly revolutionized the way applications are created, deployed, and managed through containerization. Docker became the standard for container management, but it ran with a central daemon (dockerd), which raised some issues around security, stability, and permissions management. As production environments and the open-source community began to recognize these limitations, there was a need for a tool that could manage containers without a central daemon, offering greater security and flexibility. Red Hat, a company actively developing open-source technologies, took on this task. Thus was born the Podman project, which was created as part of a larger ecosystem of tools called libpod for managing containers without a central daemon. The first versions of Kata Containers Kata Containers is a container technology that combines the features of virtual machines and containers, providing isolation and security at the virtual machine level while retaining the lightness and flexibility of containers. It uses hypervisor-level virtualization to run each container in an isolated, dedicated virtual machine. Creating such dedicated container spaces provides a much higher level of security and isolation from the rest of the system. It is Open Container Initiative (OCI) compliant, which enables integration with other existing tools such as Kubernetes, for example. It runs on both Linux and Windows-based applications as well as various cloud environments (Poojara et al., 2018; Gamess, Parajuli, 2024).

Kata Containers is a solution that is ideal for deployments requiring a high level of security and isolation. Kata containers consist of several components that, working together, ensure that containers run securely inside nested VMs. The first component is the agent, which runs exactly inside the VM and is responsible for communicating with the container running in that VM. It is also responsible for container management, process start-up, network, and file system management. The second component is the Runtime. Runtime manages the lifecycle of containers running in the VM. There is integration with popular container orchestrators such as Docker Swarm and Kubernetes. The third component is the Hypervisor, which provides the virtualization layer on which lightweight VMs are run. Another is Shim, which acts as an intermediary between the runtime and the agent in the VM. It is responsible for passing signals and data between the processes running on the host machine and the agent in the VM. The last component is the Proxy. It can be used to manage communication between multiple containers running in a single VM (Gamess, Parajuli, 2024; Randazzo, ITinnirello, 2019; https://katacontainers.io/docs/; https://github.com/ kata-containers/kata-containers/blob/main/docs/Limitations.md).

LXC (Linux Containers) is a tool for creating and managing containers on Linux systems that offers lightness and isolation similar to virtual machines but with less resource overhead. Containers in LXC, thanks to the use of namespaces and cgroups, are fully isolated from each other and the host system, ensuring secure and stable operation. The namespaces mechanism isolates processes,

networks, the file system, and other resources, while cgroups control the consumption of resources such as CPU, memory, and I/O. This allows users to run multiple containers on a single host while retaining full control over the allocated resources. LXC is often used as a core technology in cloud and virtualization environments, enabling organizations to manage computing resources flexibly and efficiently. Through its architecture, LXC enables developers, administrators, and organizations to run applications in isolated containers, helping to increase the security and efficiency of software deployments (Poojara et al., 2018; https://kubernetes.io/pl/docs/concepts/overview/; https://kubernetes.io/docs/concepts/architecture/).

Docker Swarm was originally introduced by Docker, Inc. in response to the need to manage and orchestrate Docker containers in production environments. The first versions were developed as part of the Docker Engine project, allowing users to run and manage applications in containers on multiple nodes. As the Docker ecosystem evolved, Docker Swarm became more popular, offering a tool to scale and manage applications in an automated and efficient manner. Since Docker Engine 1.12, Swarm Mode has been integrated directly into Docker Engine, simplifying the process of running and managing Swarm clusters. Docker Swarm is popular among organizations that use Docker containers to deploy their applications in cloud and on-premises environments. With its ease of use, integration with Docker tools, and ability to scalability, Docker Swarm remains an essential tool in the container ecosystem, although competition in the container orchestration market has increased in recent years, with Kubernetes becoming the dominant platform in the field (https://azure.microsoft.com/pl-pl/resources/cloud-computing-dictionary/what-is-virtualization; https://www.docker.com/ resources/what-container/; https://kubernetes.io/pl/docs/concepts/overview/).

Kubernetes is a flexible open-source platform that enables control and management of applications and services running in containers. It allows configuration and automation of tasks in a declarative manner. Kubernetes is constantly evolving, offering a wide range of services, support, and tools. It was patented, developed, and made public by Google in 2014. Kubernetes supports application scaling, failure handling, and various deployment strategies. For example, with Kubernetes, it is easy to manage the roll-out of new software versions according to canary deployments, rolling updates, or blue/green deployments. With the creation of a cluster using the public cloud, one can very quickly create a workload ready for traffic from all over the world. Kubernetes is currently the most widely used tool for creating such environments and has a very good reputation. Kubernetes is a complex platform consisting of many components that help orchestrate containers and allow flexible container management, i.e., for example, maintaining a specific number of pods, or scaling them horizontally and vertically (https://kubernetes.io/pl/docs/concepts/overview/; https://kubernetes.io/docs/ concepts/architecture/).

Development of a test environment for examining individual containerization methods

In order to deploy the application, the Google Cloud public cloud was used, more specifically, the Compute Engine service. For this purpose, a Virtual Private Cloud was created, i.e., a network in the space of a given project in the cloud, and at the network level, a firewall was configured to allow the HTTP requests necessary to test the performance of the application, which will be generated using Apache JMeter. To carry out a meaningful experiment for the project, virtual machines with identical configurations (4 vCPUs and 16 GB of RAM) were created, and a WordPress deployment with a MySQL database was carried out on them on the various containerization methods. Each test using different containerization methods will use the same infrastructure shown in Figure 1. Only the containerization engine will be changed, i.e., Docker, Podman, LXC, and Kata Containers, respectively, for each test.

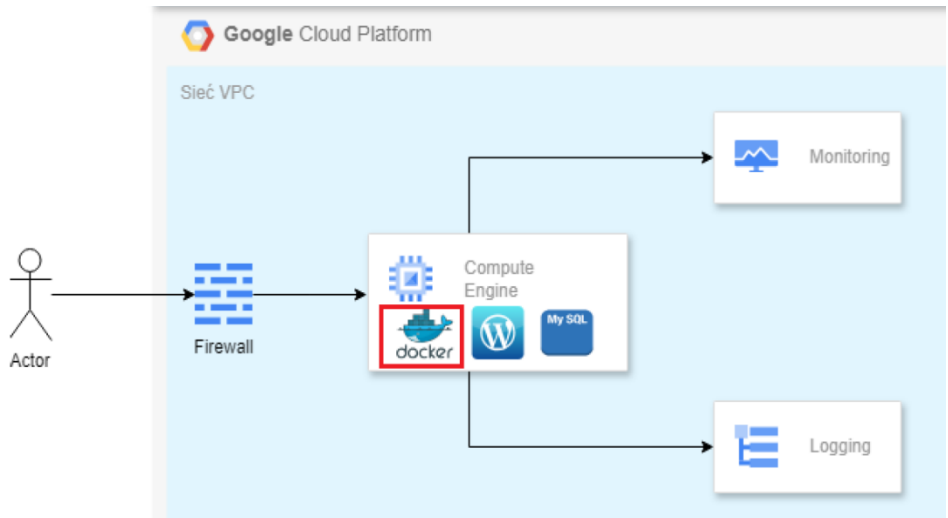

Figure 1. Implementation diagram of the test infrastructure

The Compute Engine service's built-in monitoring was used to verify the behavior of a given containerization method at times of increased traffic. To access more advanced metrics, an agent (Ops Agent) was additionally installed on the VM, which was responsible for collecting and sending metrics to Google Cloud. Google Cloud provides very good monitoring. In real-time, it shows a number of graphs responsible for the individual resources of individual virtual machines, such as, for example, CPU utilization level, RAM utilization, disk metrics, or network utilization metrics. Some examples of [%] metrics for Docker are shown in Figure 2 and Figure 3.

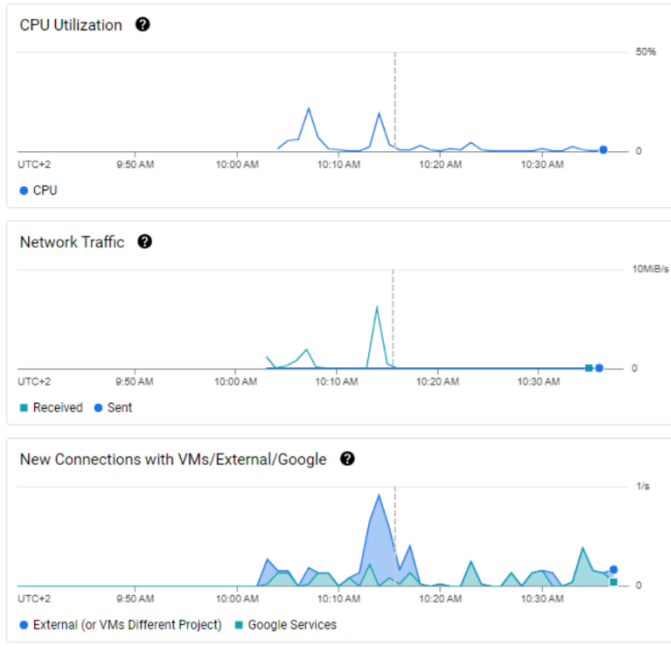

Figure 2. CPU utilization [%] and network traffic metrics for Docker

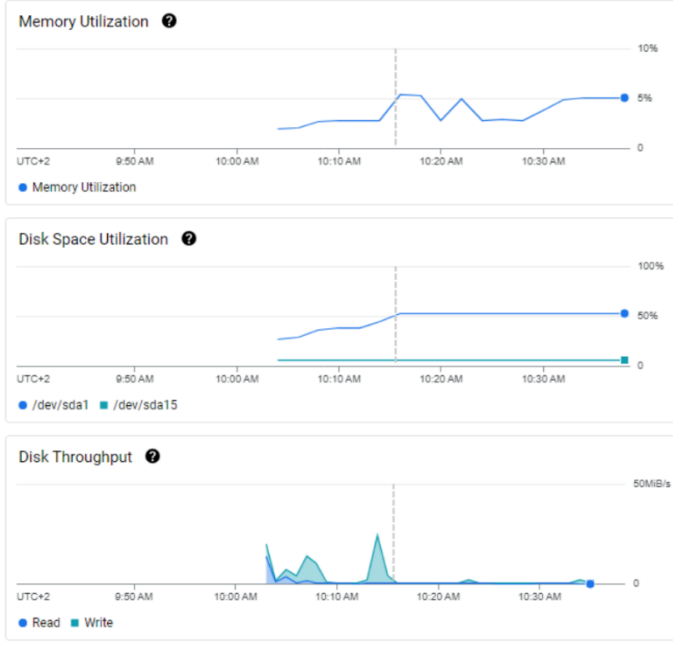

Figure 3. Memory and disk space utilization [%], disk throughput metrics for Docker

Comparative analysis of selected containerization methods

Load tests were carried out to evaluate the methods described. A machine with a 4vCPU and 16 GB RAM configuration was chosen. Any 'larger' machine would have coped better with the traffic simulated in this project, but the configuration most commonly used in real-world conditions was chosen. The simulations started by assuming extremely low parameters. A duration of one second and a traffic volume of 1,000 requests for 10 repetitions is unrealistic for infrastructures that base their production environment on single VMs in such a configuration, and CPU consumption values can reach almost 100%. In tests, the duration increases. The test results for each containerisation type in turn are summarised in Table 1–4. The results can be used as a reference for further simulations.

Table 1. Docker performance results

Number of requests	Test duration [s]	CPU usage [%]	Memory usage [%]
100 x 5	1	14.01	6.20
100 x 10	1	28.01	6.63
1000 x 5	1	63.14	9.58
1000 x 10	1	93.62	10.17
1000 x 10	5	95.29	11.27
1000 x 15	5	99.62	13.11

Table 2. Kata Containers performance results

Number of requests	Test duration [s]	CPU usage [%]	Memory usage [%]
100 x 5	1	21.52	23.12
100 x 10	1	25.62	25.62
1000 x 5	1	87.32	31.25
1000 x 10	1	98.14	30.52
1000 x 10	5	99.48	32.96
1000 x 15	5	99.99	34.67

Table 3. Podman performance results

Number of requests	Test duration [s]	CPU usage [%]	Memory usage [%]
100 x 5	1	12.05	3.95
100 x 10	1	27.95	4.07
1000 x 5	1	61.57	6.23
1000 x 10	1	91.61	7.38
1000 x 10	5	97.46	9.18
1000 x 15	5	99.38	11.59

Table 4. LXC performance results

Number of requests	Test duration [s]	CPU usage [%]	Memory usage [%]
100 x 5	1	3.74	15
100 x 10	1	4.59	15.23
1000 x 5	1	78.77	20.2
1000 x 10	1	99.27	22.43
1000 x 10	5	99.99	26.49
1000 x 15	5	99.99	30.21

In the containerization methods used, significant differences can be seen between both container start-up and stopping speeds, server resource consumption, and container security. Comparative results for performance tests of CPU consumption and RAM consumption are shown in Figure 4 and Figure 5.

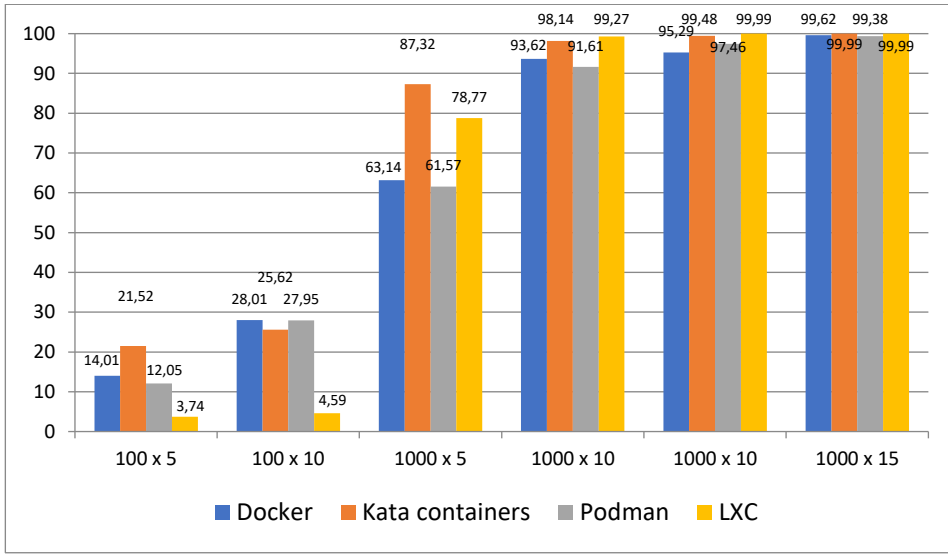

Figure 4. Performance test results for CPU consumption [%]

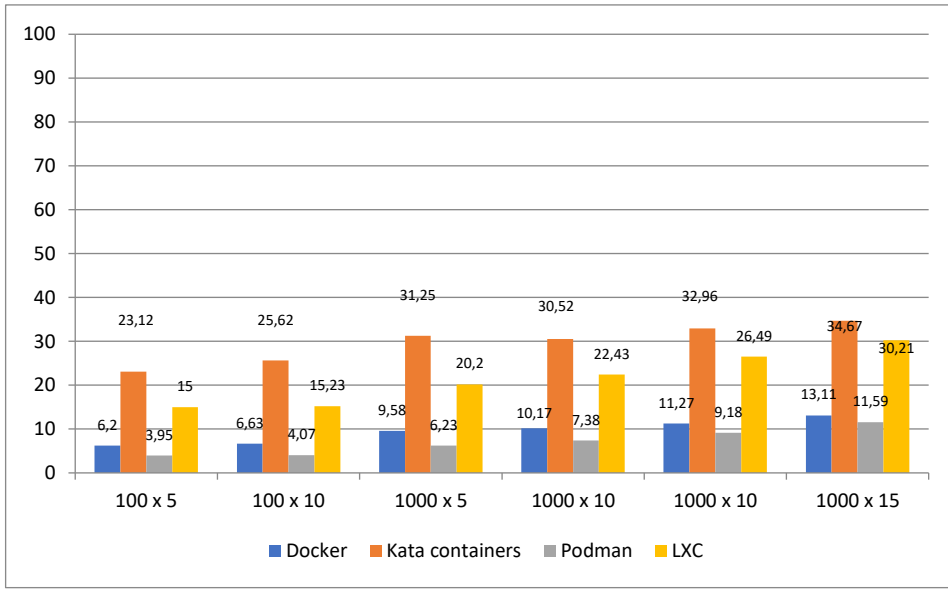

Figure 5. Performance test results for RAM consumption [%]

Analysis of the performance tests showed that the containerization method that used the fewest resources to handle the given amount of server load was Podman, followed by Docker, LXC, and Kata. When it comes to the speed of starting and stopping containers, Docker comes first, followed by Podman, LXC, and Kata. It is worth noting that Kata used by far the most resources of the host machine and, with the increasing number of containers, could, despite its highest level of security, prove to be a poor solution when it comes to, for example, hosting a web service. LXC has a very high RAM load, but with fewer requests per publicized service, it was by far the best performer in terms of CPU usage. With more requests, the CPU usage increased significantly, which may mean that LXC is not as well-optimized for high traffic (like Docker or Podman). It may find use, for example, in internal organizational services. The big disadvantage of LXC is that it is not possible to use ready-made images from the public Docker Hub repository. When creating a service using LXC, you have to base it on a Linux operating system image and prepare the entire configuration yourself inside an empty container. LXC is also the least user-friendly for new and novice users due to its complex networking solution; the user themselves has to ensure that the service is properly publicized through appropriate forwarding rules, whereas with other containerization methods, the whole thing is done automatically. Both Docker and Podman, on the other hand, are well suited for the deployment of publicized services, due to their fast creation and setup times for new containers. They are suitable for horizontal scaling and vertical scaling and are great at preparing an organization's infrastructure for sudden increases in traffic and server load. For this reason, they are probably the most commonly used containerization method, together with Kubernetes, for the deployment of services that are prepared for global, regional, or general public traffic.

Both Docker and Podman have several integrated tools that can greatly facilitate the work of all users using these containerization methods. Performance tests aside, it should also be noted that they performed best with incoming traffic. The key point, however, is that despite their long list of advantages, both of these containerization methods are nowhere near Kata Containers in terms of security. All of these containerization methods have their advantages as well as their disadvantages, and their implementation in an actual project should be determined by the respective requirements for the service to be implemented.

Conclusion

The research presented here has shown that choosing the right containerization method depends on the service to be implemented. All the methods described have both advantages and disadvantages. If you want to deploy a public service that is prepared for heavy traffic, then Docker or Podman would be the best choice. However, focusing on providing a high level of security at the expense of

performance and overall resource consumption, Kata Containers is the best solution. For internal organizational services based on the Linux operating system, LXC containers are worth considering.

All of these methods work very well, sticking to their priorities. However, it is worth emphasizing that all containerization methods by themselves may not be sufficient for all organizations. If a company starts to grow dynamically and would like to exploit the full potential of containers and prepare its infrastructure for a potentially sudden large surge in service load, it would need to focus its attention on a container orchestrator. Containers combined with Kubernetes (or Docker Swarm) and the public cloud can significantly improve the performance of any infrastructure, both in terms of security, performance, and overall cost per infrastructure, while providing dynamic vertical scaling of servers (Worker Nodes) and application instances (Pods). Introducing such a concept will allow a given infrastructure to be prepared for massive traffic (even global) while maintaining a very good level of service availability and reliability, and customer satisfaction.

The tests carried out allow recommendations to be made for the use of the methods described. The Docker and Podman platforms are worth using for web applications, containers containing applications, and all dependencies that can be easily deployed through the CI/CD process. They can work well for creating isolated test environments.

LXC is the ideal choice when the user needs to create a fully isolated operating system and HPC (High-Performance Computing) environment. For high--performance computing, LXC can provide low virtualization overhead, which is crucial in HPC.

Kata Containers will find its use in the deployment of sensitive applications by creating containers in virtual machines (nested virtualization). It provides great security, so it can find its use in applications where isolation and security are the highest priority.

The conducted research provides a valuable educational foundation for students and professionals aiming to deepen their understanding of containerization technologies. By working with real-world tools such as Docker, Podman, LXC, and Kata Containers in a cloud-based testing environment, learners gain practical experience in deploying, configuring, and benchmarking web services. The use of Apache JMeter for load testing and the analysis of system metrics through Google Cloud monitoring equips participants with essential skills in performance evaluation, infrastructure planning, and decision-making in IT systems. This hands-on approach encourages active learning and bridges the gap between theoretical knowledge and professional practice.

From a didactic perspective, the project fosters critical thinking and problem--solving by presenting real implementation scenarios with measurable outcomes. It highlights the importance of selecting the right containerization method based

on specific service requirements such as performance, scalability, or security. Furthermore, it introduces learners to modern DevOps practices, CI/CD pipelines, and container orchestration tools like Kubernetes, which are essential in today's IT landscape. As such, this work can be effectively integrated into university courses, workshops, or training programs focused on cloud computing, system administration, and application deployment strategies.

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General Computing Using CUDA Technology on NVIDIA GPU

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Abstract

The article presents a detailed analysis of the computing capabilities of the GPU (Graphics Processing Unit) using NVIDIA Compute Unified Device Architecture (NVIDIA CUDA) compared to traditional sequential computing methods. For this purpose, an application implementing the Gaussian blur algorithm was developed. Then, an implementation of the problem was created in the form of a program. The next step presented the methodology of conducting a study comparing the efficiency of solving the problem with several test configurations. Then, research was carried out during which the data obtained in the form of program implementation times were collected. This paper aims to evaluate the computational capabilities of the GPU using NVIDIA CUDA compared to traditional sequential computing methods. The comparison was made through a developed application that implements the Gaussian fuzzy algorithm. The article can serve as a valuable educational resource for teaching parallel programming and algorithm optimization using GPU and CUDA technologies. The conducted analysis also provides a strong example of an educational project that combines algorithm theory with practical application in the context of improving computational performance.

Keywords: CUDA, NVIDIA, GPU, Technology, Gaussian Blur, Parallel Compute

Introduction

Central Processing Units (CPUs) are the foundation of computers designed for general computing tasks, having a broad instruction set. This allows CPUs to handle a wide variety of computing tasks. Early CPUs had only one core responsible for executing arithmetic instructions (Kirk, Hwu 2009). A single-core processor can perform calculations sequentially, meaning that each instruction must

be executed in turn. The core cannot move on to execute the next instruction before the current instruction has finished. Despite the fact that they are less advanced than modern multi-core counterparts, single-core processors are still effective at efficiently managing lightweight, unparalleled tasks (Andersch et al, 2002; Bakyo, 2003). Among other things, they offer a simpler memory hierarchy, which makes their design cost lower compared to multicore processors. Furthermore, software designed specifically for single-threaded environments typically shows higher performance on single-threaded applications due to limited context switching and minimal interference from other competing processes.

As technology has advanced, processor manufacturers have begun to add multiple cores to a single processor, giving rise to multi-core processors. Modern consumer desktops typically feature quad-core or six-core configurations, while high-end servers and HPC platforms have dozens of cores per socket. Multi-core processors allow multiple threads to run simultaneously, leading to increased performance for parallel workloads (Polsson, 2012).

The advent of multi-core processors has brought more opportunities to improve system-level performance with parallel processing techniques such as symmetric multi-core processing (SMP), asymmetric multi-core processing (AMP), and NUMA architectures. SMP involves evenly distributing computational tasks between identical cores that have equal access rights to memory and I/O resources. AMP, on the other hand, assigns unique functions to individual cores, creating dedicated channels for specific activities (e.g., video encoding and decoding, network traffic management). NUMA architectures involve grouping cores around localised memory banks, minimising latency associated with memory requests (Gwizdała, 2016; Intel's First Microprocessor).

Optimising multi-core processor computing requires consideration of key elements such as cache hierarchy and shared resource allocation strategy. Ensuring that tasks are appropriately allocated between available cores ensures optimal resource utilisation and alleviates potential bottlenecks resulting from insufficient memory or I/O device bandwidth. GPUs were originally designed to process images and video on screens, but were not as efficient as CPUs in terms of processing power. Nevertheless, they were more efficient at certain tasks due to their parallel processing architecture, which allowed multiple allocated tasks to be processed simultaneously. This parallel processing capability of GPUs was used by developers to increase the performance of an entire computer or server. GPUs began to be used for more general computing tasks, which is now commonly referred to as GPU computing (Choquette, Lee, Krashinsky, Balan, Khailany, 2021).

The article can serve as a valuable educational resource for teaching key concepts in computer science, particularly within courses focused on computer architecture, operating systems, and parallel programming. It offers a clear introduction to the evolution of CPUs from single-core to multi-core processors, helping

students understand the motivations and benefits of parallel processing. Concepts such as SMP, AMP, and NUMA architectures can enrich discussions on system--level optimization and task scheduling. The comparison between CPU and GPU architectures provides a foundation for exploring the differences between sequential and parallel computing, while the transition of GPUs into general-purpose computing devices introduces students to modern hardware acceleration. Especially noteworthy is the innovative perspective on GPU computing, with a focus on how NVIDIA's parallel architecture has revolutionized data processing beyond traditional graphics tasks. By highlighting the repurposing of GPUs for general-purpose computation (GPGPU), the text demonstrates the originality of leveraging massively parallel architectures to achieve performance gains across various computing domains. The discussion on memory hierarchy and resource allocation strategies supports practical lessons in software engineering and system design. This material can be effectively used for both theoretical understanding and practical lab exercises, such as benchmarking different hardware configurations. It encourages critical thinking about how technological advances influence software development and system performance. By presenting these topics coherently and innovatively, the text supports the development of a well-rounded understanding of modern computing systems, which is essential for future IT professionals.

Building a sample CUDA program

The CUDA example application presented shows an implementation of a simple program whose task is to perform the sum of two input matrices, A and B of size N x N, and write the result to matrix C. The primary function responsible for performing this operation is VecAdd, which is executed on the GPU as a kernel using CUDA (Ghorpade, Parande, Kulkarni, Bawaskar; Dehal, Munjal, Ansari, Kushwaha, 2018).

Initially, memory allocation is done on both the host and the CUDA device to store the input matrices A and B, along with the resultant matrix C. Dynamic allocation was invoked via malloc on the host side to reserve space for each matrix. Once memory is allocated, the input arrays are initialised on the host before being copied to device memory using cudaMalloc to allocate memory on the CUDA device and cudaMemcpy to transfer data between host and device memory.

The main piece of code resides within the VecAdd kernel, prefixed with _global_, where each thread computes one element from the final matrix C by adding the corresponding elements of matrices A and B. Each thread is identified to compute a specific subset of indexes through the following expression, which defines the variable i:

```
i = blockDim.x * blockIdx.x + threadIdx.x
```

Where blockDim.x indicates the number of threads per block, while blockIdx.x represents the index of the current block in execution relative to all running blocks. Finally, ThreadIdx.x indicates the position of a thread inside its corresponding block. The mapping presented here helps to distribute work evenly across multiple threads, ensuring efficient use of the computational resources available on the GPU. Before performing the operation, we check that the index i does not exceed the size of the matrices being computed. If everything is correct, the kernel continues. At the very end, after executing the GPU kernel with VecAdd<<blocksPerGrid, threadsPerBlock>>, the results stored in the C array must be moved back to the system RAM so that they become available to the CPU again. The cuda-Memcpy command is executed, where the data is now moved from the CUDA device to the host. Once completed, the allocated device memory is freed by calling cudaFree for all GPU-side variables. We also free the memory on the host using the built-in free() function, after which the application is terminated (Fatica, 2008; Tullsen, Eggers, Levy, 1995).

Gaussian blur

The Gaussian function, also known as the Gaussian curve or bell curve, was developed by German mathematician Carl Friedrich Gauss in the early 19th century. Gauss introduced the concept of a normal distribution, which is a continuous probability distribution characterised by a symmetrical bell-shaped graph. This distribution is often used to model real-world phenomena in which there is a tendency towards a central value, with decreasing probability of extreme deviations from this value (Ibrahim, ElFarag,Kadry, 2021).

The Gaussian blurring technique involves calculating a weighted average of the pixel intensities around each target pixel in the input image. These weights are determined according to their position along the Gaussian curve, meaning that more weight is given to pixels closer to the centre than those at the edges. As a result, the output image appears softer and less noisy compared to the input, making Gaussian blur a popular choice for postprocessing tasks such as noise reduction, edge smoothing, and antialiasing. The formula for the two-dimensional Gaussian blur function has the following form:

$$G(x,y) = \frac{1}{2\pi\sigma^2}\, e^{-\frac{x^2+y^2}{2\sigma^2}}$$

Gaussian blurring is a widely used technique in various fields due to its effectiveness in reducing high-frequency noise. Thus, the algorithm reduces the noise output, which is the reason for its variety of applications. One of these is data animation, where Gaussian blurring gets rid of elements that can be subjected to an identification process. For example, a blurred face, together with other covered data on an ID card, will make it significantly more difficult to trace a person.

Another application is the simulation of motion blur. Animations created with computer programmes require the closest possible reproduction of reality in order to accurately reproduce the situations occurring in it. Gaussian blur allows the simulation of motion blur, so that animators are able to convincingly reflect the movement of an object over time.

Performance testing of sequential and parallel processing

The performance test to be carried out was the application of a Gaussian blur to images. The Gaussian blur will be applied through an application that can run in CPU calculation mode and using CUDA technology. The application also measures the time during which the calculations will be performed. It allows a time comparison to be made between the two calculation methods.

Measurements were made on a dataset of selected images with different resolutions. These files have the following resolutions: 512 x 512, 1280 x 720, 1920 x 1080, 2560 x 1440, 3840 x 2160, and 7680 x 4320, respectively (Figure 1). Several images with different dimensions were selected to see if there was an effect on the execution time of the programme from the number of pixels processed. For each case, the test was performed 10 times, with their output value being their average. The data was automatically collected by an automation script, which at the end of the run saves the results in CSV format for analysis.

The Gaussian blur overlay programme was run in a minimum system load situation to allow it to use as many system resources as possible to ensure consistent and maximum performance.

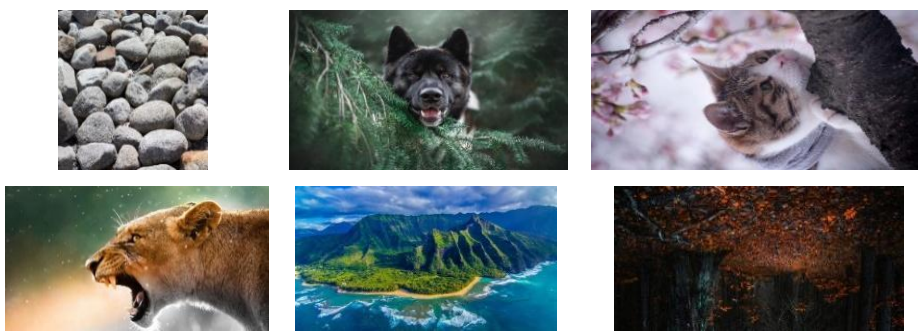

Figure 1. Images on which tests were conducted

Implementation of the Gaussian blur algorithm

The entire programme fits into approximately 420 lines of code, written in C++, specifically in the C++17 standard (https://gcc.gnu.org/onlinedocs/gcc/Optimize-Options.html; https://en.cppreference.com/w/cpp/thread/thread; https://en.cppreference.com/w/cpp/chrono). The programme is divided into an

initialisation part, a computation part, and a finalisation part (Figure 2). It implements the Gaussian fuzzy algorithm in two ways: sequential computation and parallel computation. The supported image format is PNG only.

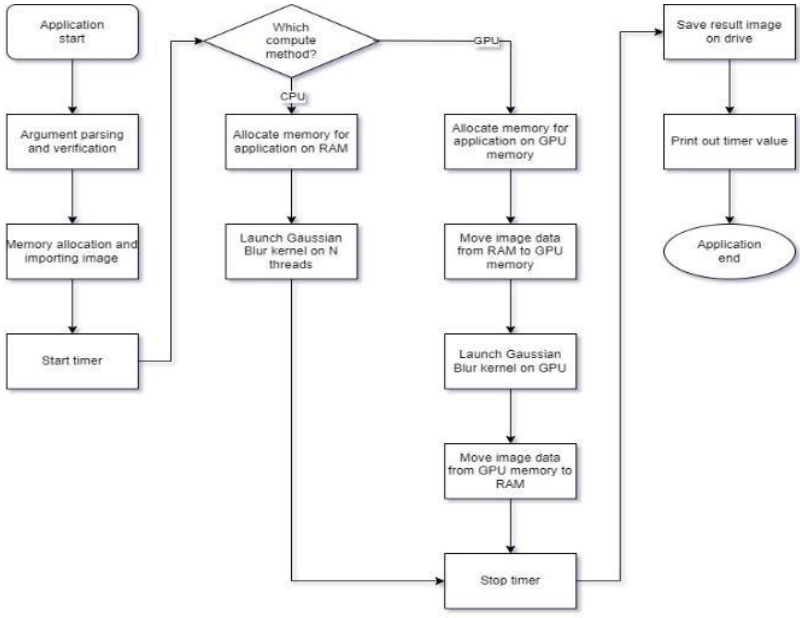

Figure 2. Block diagram of the designed Gaussian blur application

The first task of the program after it has started (the initialisation part) is to parse the arguments that determine its operation. The path to the input image is then checked for correctness. Once the programme has started, a timer is started to measure the length of the segment. The application allocates the appropriate amount of memory for storing the image data to RAM or in the memory of the graphics card, depending on the device performing the calculation. The next step is to allocate sub-tasks to the number of threads specified in the arguments to the program, and to call the function that will start the calculation. A subtask is a fragment of the whole task – applying a Gaussian blur. When the calculation is complete, we copy the results to the output variable and stop the timer. We then save the processed image with the superimposed Gaussian blur in the specified path, after which we write out the status of the timer, which will show us how long it took to complete the task. Finally, we release the reserved memory to avoid situations where the memory would not release automatically. At this point, the programme is terminated (https://docs.nvidia.com/cuda/cuda-c-programming-guide/index.html; https://docs.nvidia.com/cuda/cuda-runtime-api/index.html).

Analysis of measurement results

The first test carried out was to check the effect of the Gaussian blur radius on execution time. The comparison was done on a "Leaves" image with a resolution of 7680 x 4320 with different numbers of allocated CPU threads, and blur radii with the following values: r = 2, r = 4, r = 6, r = 8, and r = 10. The figure shows six distinctive trends, each allocated to one of the test cases. The X-axis shows the number of threads allocated to the task, from 1 thread to the maximum number of threads available on the processor – 12, while the Y-axis shows the Gaussian blur processing time in milliseconds.

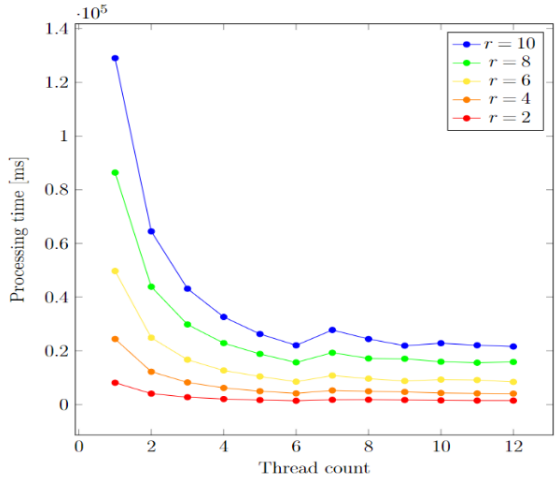

Figure 3. Gaussian blur processing time based on tested blur radius for a 7680 x 4320 image using 12 CPU threads

With a larger value of the Gaussian blur radius, the processing time of the programme increases. The reason for this phenomenon is the increase in the number of pixels required to determine the blur factor for a single point in a given region, which translates into a greater number of operations needed to be performed. The second highlighted element is the correlation of processing time to the number of threads dedicated to the task. As the number of threads increases, the computation time decreases. The rationale for this relationship is the process of allocating subtasks to the processor. The programme allocates an equal number of pixels to be processed for each thread, so that the computational performance will increase with the number of allocated threads. Upon closer observation, it can be seen that there is an anomaly. When a computation is allocated to several threads greater than the number of physical CPU cores, the task execution time does not decrease. When a task is allocated to 7 threads, the process takes noticeably longer to execute than with 6 threads (Figure 3).

Another element investigated was the effect of the number of threads allocated to apply Gaussian blur and image resolution, i.e., the number of pixels computed, on processing time.

Figure 4 shows six distinctive trends, analogous to the previous graph, each assigned to one of the test images. The X-axis shows the number of threads allocated to the task, from 1 thread to 12, while the Y-axis represents the Gaussian blur processing time in milliseconds. Analysing the graph, we can see a relationship. The resolution of the image has a proportional effect on the processing time of the Gaussian blur algorithm. The trend for the 'Leaves' image significantly diverges from the rest, where, for it, the time spent on calculation was 15.8 seconds at best. This is due to the fact that as the pixels required for processing increase, we will see the running time of the algorithm increase.

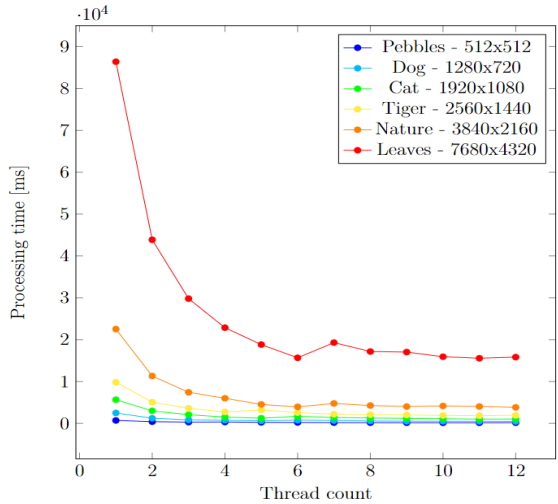

Figure 4. Gaussian blur processing time based on image resolution and allocated thread count

Figure 5 shows six different cases of CPU thread configuration and one GPU (CUDA) configuration, where each case has a trend. The X-axis represents the number of pixels of the processed image on a logarithmic scale, and the Y-axis represents the time taken by the programme to complete the task, also placed on a logarithmic scale. The logarithmic scale has been used for data clarity. CPU trends are tested in 1, 2, 4, 6, 8, and 12 thread situations, where CUDA was allocated the maximum number of cores available – 4864. After examining the graph shown, it becomes clear that there is a direct proportional relationship between the number of pixels computed and processing time in each configuration tested. This relationship is somewhat less pronounced in the case of CUDA.

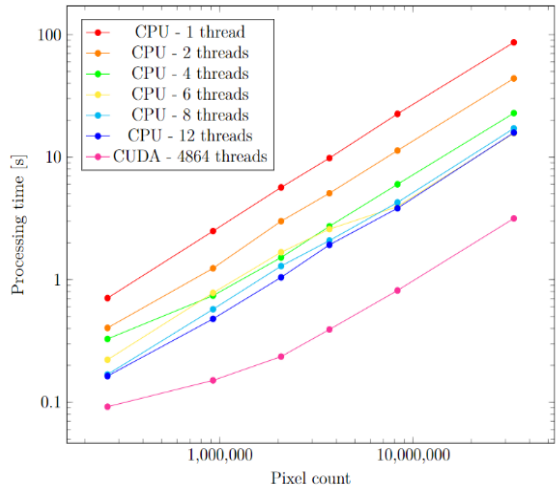

Figure 5. Gaussian blur processing time based on image resolution and allocated thread count on different devices

Table 1. Collection of results from Gaussian blur application on CPU and CUDA device

Pixel count	Processing time for 12 CPU threads [ms]	Processing time for 4864 CUDA threads [ms]	% Difference
262 144	163.46	91.88	77.91
921 600	478.80	150.71	217.70
2 073 600	1044.23	235.68	343.07
3 686 400	1923.91	392.26	390.47
8 294 400	3827.68	816.49	368.80
33 177 600	15830.40	3161.32	400.75

Optimization

Optimisation methods were used in the development and compilation of the application. As a result, the programme is able to perform the task faster while maintaining the structure of the algorithm. Two methods were used that allowed a significant reduction in the execution time of the calculations. The first optimization method used is the so-called loop boring. This involves replicating the contents of the for loop to create N copies together with the original, thus reducing the number of iterations needed. The second optimization method used lies in the NVCC compiler (NVIDIA CUDA Compiler, NVCC). The compiler has a number of flags that optimise the programme at the compilation stage. One of these is the -O3 flag, which imposes more than 80 different optimisation methods. With this flag, the compiler improves the performance of the application at the expense of compile time and debuggability. However, this method has one disadvantage: The functioning of the application may be subtly altered. Taking this into account, the hashes of the resulting images were checked in both situations. It turned out that the hashes are identical, which means that the resulting images are identical.

The consistency of the programme's performance is maintained, which means that this optimisation method can be applied to the rest of the tests performed.

The test was performed with different numbers of allocated CPU threads on the 'Leaves' image, assuming a Gaussian blur radius of r = 8. The highest resolution image was chosen to make the possible discrepancy as large as possible.

Table 2. Collection of results from Gaussian blur application on CPU with and without applying optimizations during compilation

Pixel count	Processing time without optimizations [ms]	Processing time with optimizations [ms]	% Difference
262 144	917.75	163.46	461.45
921 600	2897.84	478.80	505.22
2 073 600	6663.05	1044.23	538.08
3 686 400	10368.00	1923.91	438.90
8 294 400	23891.70	3827.68	524.18
33 177 600	97657.00	15830.40	516.89

Figure 6 shows two situations: a program compiled with optimisations and without optimisations. By analysing the graph, we are able to conclude that the execution time of the program compiled with optimisations is significantly less than without optimisations, regardless of the number of pixels. The difference in performance is clear and significant. The processing time of the programme compiled with the aforementioned optimisations is faster by an average of 497%, and by 538% in the best case. The optimisations applied had a very positive effect on the execution speed.

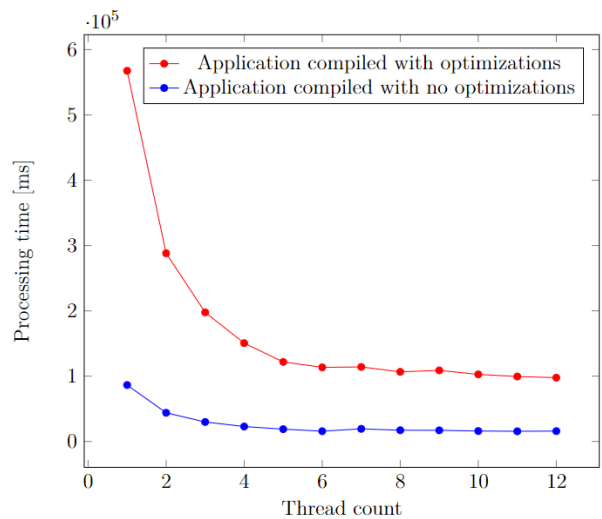

Figure 6. Performance comparison on the CPU without optimizations and with optimizations on an image with a resolution of 7680 x 4320 and a Gaussian blur radius of r = 8

Conclusion

This paper analyses and compares the computational performance between central processing units (CPUs) and graphics processing units (GPUs) using NVIDIA Compute Unified Device Architecture (CUDA) technology. In this case, a Gaussian blur overlay operation was applied to the images. A wide range of resolutions, up to 8K (7680x4320), were used for the test to highlight the impact of task size on execution time. Optimisation strategies such as loop boring and the use of built-in optimisation methods in the NVCC compiler were applied.

Analysis of the resulting data shows a significant speed-up in the execution of Gaussian fuzzing operations on the GPU compared to the CPU. Specifically, the performance difference ranged from 77% up to 400% advantage for the GPU, depending on the resolution of the image under test. The conclusions obtained from the practical part of the work indicate the performance potential of the GPU to accelerate complex tasks typically performed on traditional CPUs.

Studies have confirmed the performance advantage of GPUs using CUDA technology over conventional CPU-based computing. More precisely, this advantage exists for several problems, such as the manipulation of large arrays and intensive numerical calculations. Further developments in the field of algorithms will make it possible to use them on the GPU, allowing an increase in computing power for more problems.

The article serves as a highly effective educational resource for teaching modern computing concepts, particularly in the fields of parallel programming, high-performance computing, and system optimization. By comparing CPU and GPU performance through a practical implementation of the Gaussian blur algorithm using NVIDIA CUDA technology, students gain hands-on experience in understanding the impact of data size, task distribution, and hardware architecture on computational efficiency. The use of high-resolution image processing, up to 8K, allows learners to grasp scalability challenges and appreciate the performance potential of GPUs. Innovative techniques such as loop unrolling and NVCC compiler optimizations demonstrate real-world strategies for improving code execution, fostering critical skills in performance tuning. The originality of applying traditional algorithms to cutting-edge GPU architectures highlights how established methods can evolve through hardware advancements. This educational approach not only deepens students' understanding of architecture-level differences but also equips them with key competencies in parallel and heterogeneous programming–skills that are increasingly essential in AI, data science, and modern software engineering. Moreover, analyzing real performance data enhances students' analytical thinking and problem-solving abilities, while exposing them to the innovations of GPU computing and the transformative role of NVIDIA technologies in accelerating complex computations.

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PART THREE

SELECTED ISSUES IN TEACHER EDUCATION

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"Multitasking" and Its Impact on Students from Teachers' Perspective

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Abstract

The demanding pace of modern society pushes us to multitask in order to achieve maximum efficiency and effectiveness. A key open question is whether multitasking is effective? Numerous studies have demonstrated the effects of "multitasking" on a psychological, cognitive and socio-emotional level. The results showed that students who engage in multitasking more often while completing their schoolwork tend to have lower academic performance. In addition, it was shown that multitasking is positively correlated with increased procrastination.

Keywords: multitasking, media multitasking, procrastination, school performance

Introduction

Several studies have showcased the impact of multitasking in the cognitive functions of the brain, with memory and attention being prominent. Therefore, attempting to perform two or more tasks simultaneously contributes to repeated switching between tasks, as well as to an increase in unfinished tasks (Gazzaley, Rosen, 2016; Cheever, Peviani, Rosen, 2018; Madore, Wagner, 2019).

However, despite the effects, teenagers, given their familiarity with technology, tend to adopt multitasking in their daily lives, even claiming that it contributes to concentration (Butler, Weywadt, 2013; Kaiser Family Foundation, 2010). Despite the prevailing perception of adolescents, several studies have highlighted the negative consequences of multitasking. More specifically, multitasking and media multitasking has been directly correlated with an increase in pre-existing levels of anxiety in adolescents, as a compensatory factor for the avoidance of

stressful situations, procrastination and reduced school performance (Carvalho, Hopko, 2011; Reinecke, Hofmann, 2016; Kokoc, 2021).

Taking the above into consideration, this study investigated adolescents' familiarity and opinions about multitasking, the association of multitasking with school anxiety, procrastination, and decreased school performance. The research questions that are asked are the following:

1. How is multitasking related to the academic performance of adolescent students?

2. How is multitasking linked to procrastination as a means of avoiding stressful situations?

Literature Review

The term "multitasking" comes from the world of computers and describes the ability of an operating system to perform multiple tasks simultaneously. However, the human brain does not work in the same way as an operating system. Despite the widespread use of the term in the literature, it is not always encountered with the same terminology. Sometimes it can be referred to as the simultaneous execution of two tasks and sometimes as the coordination of different life roles. As mentioned above, multitasking refers to the execution of multiple simultaneous tasks, either physical or mental, at the same time (Kramer, Schmidt, 2021). Attempting to perform two or more tasks simultaneously results in repeated switching between tasks, contributing to an increase in incomplete tasks. Attempts to perform tasks simultaneously cause interference between networks, contributing to slower information processing and errors (Madore, Wagner, 2019).

Media multitasking has been directly associated with the emergence of psychopathology in adolescents. More specifically, it is linked with increased levels of sensation seeking (Sanbonmatsu, Strayer, Medeiros-Ward, Watson, 2013), social anxiety, depression, and neuroticism (Becker, Alzahabi, Hopwood, 2013). For adolescents experiencing stress and anxiety, media addiction in the hope of reducing distress may be maladaptive because, despite the immediate relief it provides, it may prevent them from learning adaptive coping strategies that help solve problems (Carvalho, Hopko, 2011; Cheever, Peviani, Rosen, 2018). Moreover, the singularities that are observed in adolescent brain development, make them particularly vulnerable to the dangers of media multitasking and may lead to deficits in social interaction (Cheever et al., 2018). At the same time, media use and multitasking during face-to-face communication constitutes a new communication "norm" (Xu, Wang, David, 2016). Adolescents' high engagement in media multitasking contributes to disengagement from important social functions (Wallis, 2010; Armakolas, Lora, Waligóra, 2024). Adolescents who multitasked in the media faced greater difficulties in focusing attention in their daily lives (Baumgartner, van der Schuur, Lemmens, te Poel, 2018).

Reinecke, van der Schuur, Lemmens, and te Poel's (2018) study of a sample of German adolescents suggested that although internet multitasking is directly related to procrastination, it is not directly related to reduced psychological functioning, suggesting that not all forms of internet use associated with procrastination are necessarily harmful.

Admittedly, multitasking, especially with Social Networking Media (SNM), while learning, studying, and completing schoolwork is rapidly increasing among adolescents in the digital age and is directly related to decreased school performance (Demirbilek, Talan, 2018; Lau, 2017). Furthermore, it has been correlated with problems with attentional distraction and difficulties with self-regulation of students (May, Elder, 2018; Wu, 2017; Papanikou, Armakolas, Panagiotakopoulos, Dritsas, 2023). Additionally, it was found that adolescents who multiprocessed in NCDs to an excessive extent exhibited lower attentional control and reduced school performance (Kokoc, 2021; Armakolas et al., 2025).

Research Methodology

To support the results of this study, qualitative research was chosen. During the initial stage of the research design, the researchers selected weighted scales that answered the research questions, after adjusting the scales. Regarding the interviews, a total of six secondary school teachers participated, all six of whom were women. The interviews were conducted in person during the month of April 2024. During the interviewees' passage through the space, the researcher referred extensively to the purpose of the research, the maintenance of confidentiality, as well as the participants' right to interrupt or withdraw from the interview at any time. In addition, the interviewees were informed about the recording and transcription of the interviews. The first questions that were posed concerned demographic data. The above techniques aimed at creating a climate of intimacy and trust between the interviewer and the interviewee, before proceeding with the main part of the questions (Bell, Waters, 2018). The duration of the interviews ranged from 30 to 40 minutes.

As far as the quantitive study is concerned, to enhance the validity and reliability of the questionnaire, a pilot application was implemented before its final form. The axes that emerged from the interviews were the following: A) Multitasking and adolescence, B) Procrastination and adolescence, C) School performance and adolescence. The first axis concerned the effectiveness of multitasking and the questions arose from the work of David, Kim, Brickman, Ran, and Curtis (2015) and Junco and Cotten (2012). The second axis concerned the measurement of procrastination. and was developed according to the research of Hasanagic, (2019). The third axis was based on the research of Birchmeier, Grattan, Hornbacher, and McGregory (2015).

Analysis – Results

Thematic Axis 1: Multitasking and Adolescence

In terms of this axis, we wanted to explore the views of educators on whether multitasking is a characteristic of adolescents and we focused primarily on media multitasking. Secondly, we examined (depending on the answer given to the initial question) the possible causes of multitasking. In addition, we attempted to investigate the frequency of multitasking as well as the tasks that adolescents choose to perform simultaneously during their studies at home, focusing mainly on distraction due to mobile phones or computers.

More specifically, regarding the first research question on whether they consider that "multitasking" is a characteristic of adolescents, and specifically media multitasking, all teachers responded positively. “For the most part, yes, I believe so.” (P.3). “Of course, I consider it a characteristic of adolescents.” (P.4). However, one participant, despite giving a positive response, emphasized that each student is an individual case, stating: *“I believe so, although of course each student’s case is different”* (P.5). With regard to the reasons behind the emergence and adoption of multitasking among adolescents, all teachers pointed to the use of technological devices such as mobile phones and computers. One teacher characteristically remarked: *“Most children are quite absorbed by electronic means of engagement (primarily mobile phones)… they show difficulty concentrating on a single activity, because their mind is often ‘stuck’ on the message they are waiting for, or on the reactions they ‘expect’ to receive from a post…”* (P.3). Similarly, other teachers highlighted the pervasive role of technology in students’ lives, noting: *“Mobile phones have now become an extension of their hand”* (P.6), and *“The mobile phone and the computer do not allow them to focus entirely on the task they have undertaken. They function as a constant distraction…”* (P.4).

In addition, four teachers mentioned the hectic and demanding pace of everyday life as a possible reason for the emergence of multitasking among adolescents, noting that it contributes to the lack of time needed for concentration and the completion of a single task. As they characteristically stated: *“…the modern pace of our society somehow forces us all to be potential ‘multitaskers’*.” (P.2); and *“A possible cause could be the generally faster pace of daily life, in which both their parents and most members of society are also engaged.”* (P.3). Finally, one participant identified the lack of personal interests on the part of adolescents as another potential reason for the appearance of multitasking.

In the next question, the participants were asked whether they believe that during study time at home adolescents fully concentrate on their work or if their attention is likely distracted by the mobile phone or the computer, all teachers responded affirmatively, stating that adolescents’ attention is indeed diverted. Regarding the tasks they perform simultaneously, they mentioned the following: sending messages, watching videos, sharing and commenting on photos and

videos, listening to music, playing electronic games, following news feeds, and checking reactions to posts they have uploaded. Characteristic statements include the following: *"They listen to music, communicate with their classmates, play games."* (P.1); *"...they chat or comment on messages and photographic material. They may, of course, also just browse through the news feed or watch videos of humorous interest."* (P.3); and *"...as well as check the reactions to a post they have uploaded."* (P.6).

Furthermore, three of the teachers attributed the teenagers' distraction during the study to having social media accounts and the fear of missing out on important information. An indicative statement is the following: *"...has profiles on various Social Media and they believe that they must be active constantly, lest they miss some important news, information and find themselves outside the company and developments.*" (P.2).

In conclusion, regarding the first thematic axis, all teachers stated that multi-tasking is a characteristic feature of adolescents and attributed its adoption both to the use of technological devices (mobile phone, computer) and to the demanding pace of everyday life. Furthermore, all teachers agreed that adolescents' attention is distracted during study time at home and reported that they simultaneously engage in the following activities: sending messages, watching videos, sharing and commenting on photos and videos, listening to music, playing electronic games, browsing news feeds, and checking reactions to posts they have uploaded. Finally, three of the participants highlighted the significant role played by social media.

Thematic Axis 2: Procrastination and Adolescence

In the present section, we attempted to examine the possible procrastination that adolescents display regarding their school duties and obligations, based on the responses we received from the teachers, as well as the reasons they usually give for requesting an extension to complete a school assignment or to change the agreed date of a test.

More specifically, in the first question posed which refers to when students submit the homework assignments given to them, the majority of teachers reported that students hand in their work even after the submission deadline, while some do not submit it at all. Characteristic statements include the following: 'Many will hand in an assignment much later, after repeated pleas, or not at all.' (P.4). 'Possibly even after the submission deadline.' (P.6). Only one teacher mentioned that students usually submit their work by the actual deadline."

In terms of the second research question which investigates if students wish to request an extension for completing a school assignment or a change in the date of a pre-arranged test, all teachers responded positively. The most common reason put forward was the students' overloaded daily schedule due to extracurricular activities and the study required for other subjects. 'Often the reasons are that they

will not have enough time because of their private tutoring lessons, or because they have to study for another test…' (P.3). '…they tell me that they have many extracurricular activities and other subjects to study, and because of this, their time is overburdened.' (P.5)."

To conclude, regarding the second thematic axis, it was observed that students generally show a pronounced procrastination about their schoolwork and obligations. The most common reason for wanting to extend either a school assignment or an exam was the students' busy daily schedule.

Thematic Axis 3: School performance and adolescence

In the present axis we studied adolescents' school performance based on their active participation in class during the lesson. We also investigated their school performance based on their actual school performance during the previous four months, evaluated by teachers as poor, average, excellent.

Specifically, when asked if most students actively participate in class, four out of six teachers reported that the number of students who actively participate has decreased dramatically. "No, many of my students do not actively participate in class. "*With difficulty I manage to get a small percentage to participate and not always the same*." (P.4). "*Unfortunately, not, and certainly not to the same degree*." (P.3). At the same time, one participant stated that they usually participate actively, while a teacher stated that it depends on the lesson and the stimuli they receive from the teacher.

Regarding the question whether they believe that students intend to check their cell phones during class, and for this reason, they are probably not participating, three of the teachers answered positively. Specifically, they stated: "*The mobile phone is an important tool for communicating continuously and during the lesson. They do not participate and are often distracted by the mobile phone, either openly or secretly*." (P.4). "*Their mobile phone is an extension of their hand*." (P.6). At the same time, two of the participants noted that mobile phone is not the main reason for non-participation. "*Surely all students would like to be able to check their mobile phone, but it is not a main reason for non-participation, in my opinion*." (P.3).

Finally, a teacher stated that the cell phone is not a reason for not participating in class because its use is prohibited during class time.

In the last question regarding student performance during the previous four months, most of the teachers reported that many students have average to poor performance, with few student exceptions. *The answer was indicative: "Average (for most students), bad for a fairly respectable percentage (25-30%), excellent for a few children (usually 2–3 per class of 16–18 children)* (P.3).

Possible reasons for students' mediocre performance are the lack of motivation and stimulation on the part of students, learning gaps, and the students' overloaded

daily schedule. "*In my school due to lack of stimulation*." (P.2). "*They have many gaps in their knowledge, have many extracurricular activities, and do not know how to study*." (P.5). Worth mentioning is the statement of an educator who attributed the lack of motivation on the part of students to the general disorientation of modern society. *"...in an era of easy enrichment through hyper-self-promotion (thanks also to social media), children are impressed and want to imitate a 'skill' that does not require the cultivation of any other skill..."* (P.3).

To conclude, a significant number of students don't actively participate mainly due to their low academic level, lack of interest, and the teaching approach, while the use of mobile phones does not constitute a primary reason for non--participation. Finally, regarding students' performance, it was described as average, with only a few exceptions, and attributed to the lack of motivation and stimulation on the part of the students, to learning gaps, and to their overloaded daily schedule.

Discussion

The research findings align partially with prior studies, confirming that multitasking, particularly with media, is a prominent trait among adolescents. This finding supports the conclusions of researchers like Baumgartner et al. (2018) and Foehr (2006), who noted that media multitasking has become a lifestyle for teenagers. Furthermore, the study revealed that most adolescents don't find it difficult to perform multiple tasks at once, a result consistent with the research conducted by Butler and Weywadt (2013) and Carrier, Cheever, Rosen, Benitez, and Chang (2009).

Regarding procrastination, we concluded that it is evident in the adolescent population based on the study's findings. According to educators, students often submit their assignments after the deadline and frequently ask for extensions to complete a school project or to change the date of a pre-arranged test. This finding is consistent with the research of Beutel et al. (2016), which examined the increase of procrastination in the youth population, as well as with the research of Özer, Demir, and Ferrari (2009).

As far as procrastination is concerned, it became clear that the more students engage in multitasking, the higher their levels of procrastination. Multitasking has been directly associated with procrastination in previous research as well. Specifically, the use of the Internet is considered a potential alternative multitasking activity for procrastinating individuals for the following reasons: thanks to mobile Internet connections and smartphones, media content and communication are almost ubiquitous and permanently available with virtually no cost or effort (Klimmt et al., 2018). Furthermore, several online activities (e.g., social media use, gaming, and watching videos) promise instant gratification and pleasant experiences and can therefore be particularly attractive to those who postpone

tasks when faced with an aversive or difficult assignment (Sirois, Pychyl, 2013; Ettinger, Cohen 2020).

Adolescents' perception of their proficiency in multitasking may not reflect reality due to developmental differences related to brain function (Carrier, Cheever, Rosen, Benitez, Chang, 2009; Carrier, Rosen, Cheever, Lim, 2015). Finally, it was found that students who are more frequently involved in multitasking while completing their schoolwork tend to have lower self-reported academic performance, as well as lower actual academic performance. This finding is supported by a multitude of studies (Junco, Cotten, 2012; Demirbilek, Talan, 2018; Rosen et al., 2013; Lee, Lin, Robertson, 2012; Kokoc, 2021).

Conclusion

Regarding the first research question, a clear distinction emerges. While students who perceive multitasking as effective in completing their school obligations demonstrate high levels of both self-reported and actual academic performance, this positive association is contradicted by their actual behavior. Specifically, the data show that the more frequently students engage in multitasking, the lower their performance tends to be, indicating a significant gap between perception and reality Furthermore, with regard to the tasks they perform most extensively while studying at home, the findings of the qualitative study revealed the following: sending messages, watching videos, simultaneous engagement with social media, sharing and commenting on photos and videos, listening to music, playing electronic games, browsing news feeds, and checking reactions to posts they have uploaded.

Regarding the second research question, we conclude that the more students engage in multitasking, the higher levels of procrastination they exhibit. Additionally, the findings showed that procrastination is evident in the adolescent population regarding their school duties and obligations. From this finding, we conclude that the fast pace of daily life pushes adolescents to adopt multitasking as a way of life, which contributes to the increase of procrastination.

Future research could focus on the development of reliable and valid scales for measuring multitasking during adolescence. Finally, it is considered appropriate to examine the variations in multitasking across the different stages of adolescence and levels of schooling.

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Comparison of Subjects and Methods of Assessing Knowledge at Universities in Poland and Italy Based on the Preschool and Early School Education Program at the University of Rzeszów and the Suor Orsola Benincasa University in Naples

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Abstract

This article compares early childhood education teacher training systems in Poland and Italy, based on the University of Rzeszów and Suor Orsola Benincasa University in Naples. The aim is to examine whether specific solutions used at the Italian university could be introduced into the Polish programme and among Polish students. The research addressed students' opinions on mandatory and optional courses and preferred methods of knowledge assessment. The study employed a diagnostic survey method using an interview questionnaire. The results of the survey show students' preference for facultative subjects over mandatory subjects, and projects and multimedia presentations as favoured types of knowledge assessment. The findings indicate a need for improvement and further reflection on the preschool and primary education study programme.

Keywords: early education students, curriculum, comparison, Poland, Italy

Introduction

Within the framework of the Bologna Process, the European Union has achieved significant milestones in its efforts to harmonize higher education systems across member states. One of the key instruments of this unification is the European Credit Transfer and Accumulation System (ECTS), which facilitates the transfer of academic credits and enables the comparison of students' acquired knowledge and skills across different institutions and countries.

The studies of preschool and early school education share a common structure at both universities, more specifically a five-year duration and the division of courses into lectures, laboratory classes, and workshops. Additionally, in both

programmes, students are required to complete a total of 600 hours of mandatory school practice. Lastly, many courses appear in both the Polish and Italian curricula, reflecting shared educational foundations despite contextual differences.

Table 1. Representative examples of courses taught during a five-year degree program in preschool and primary school education in Poland and Italy

Examples of courses included in both Polish and Italian curricula:	General Pedagogy, General Psychology, Methodology of Scientific Research, Didactics, Sociology, History of Pedagogy, Methodology of Physical Education, Technology in Schools, Mathematics, Art Education, Music Education, Environmental Studies, English Language, Polish/Italian Language (mother tongue)
Examples of courses specific to the Polish curriculum	Philosophy, Cross-Cultural Studies, Anthropology, Interpersonal Communication, Physical Education, Self-Image Formation, Developmental Psychology, Clinical Psychology, Social Psychology, Educational Psychology
Examples of courses specific to the Italian curriculum	Children's Literature, Geography, Elements of Chemistry and Physics, Child Neuropsychiatry

Table 2. Comparison of study schedules at the University of Rzeszów and Suor Orsola Benincasa University in Naples. Preschool and primary school education[a]

	University of Rzeszów	University Suor Orsola Benincasa
Entrance exam	**No**	**Yes**[b]
Number of subjects to complete PL – *separately counted lectures and workshops / discussion groups / seminars* IT – *separately counted lectures and laboratories / workshops*	**117**	**53–54**[c]
Number of subjects in the form of lectures or lectures with discussion elements	**53**[d]	**30–31**
Number of subjects in the form of workshops / discussion groups / seminars / laboratories	**64**[e]	**22–23**
Maximum number of ECTS/CEF credits for the course	**26**[f]	**12**[g]
Minimum number of ECTS/CEF credits for the course	**1**[h]	**1**[i]
Facultative subjects	**No**	**Yes**[j]
Duration of lectures and workshops/discussion groups/seminars/laboratories	**1,5–2,3h**	**2–3h**[k]

[a] Source: created by the author based on the study schedule for the preschool and primary school education program published on the University of Rzeszów website and the study schedule for the primary education program (*Scienze della formazione primaria*) on the UNISOB website.

[b] Entrance exam consists of: linguistic and logical comprehension, literature, history, geography and math.

[c] Depending on the number of facultative subjects passed.

[d] 15h x 46, 30h x 7.

[e] 15h x 26, 30h x 26, 45h x 8, 60h x 2, 120h x 1, 180h x 1.

[f] English language – 6 semesters.

[g] Italian language and grammar – 2 semesters; Italian literature – 2 semesters; Elements of natural sciences – 2 semesters).

[h] Cultural Anthropology – 1 semester, workshop; Intercultural Education – 1 semester, lecture; Preschool and Early School Education System – 1 semester, lecture.

[i] 12 subjects – laboratories and workshops with corresponding lectures.

[j] The requirement to earn 8 ECTS credits from elective courses in the third year.

[k] Classes usually last 2 hours with a break in the middle. However, some subjects (especially laboratories) last 3 hours but end after about 5 weeks. After that, during the semester, students have time to work on projects and can consult any questions (online or in person) with the lecturer.

The overview of subjects taught in both programs and displayed in Table 1 shows that the Polish curriculum includes a much broader specification of psychology-related courses, which are not present in the Italian programme. For instance, following the introductory course in General Psychology, Polish students attend separate courses in Developmental, Clinical, Social, and Educational Psychology. These distinctions reflect the greater diversification of subject areas in Poland. Other major differences between the Polish and Italian study programmes are summarised in Table 2.

As can be found in Table 2, Polish students complete nearly twice as many courses as their Italian counterparts. Consequently, the average number of ECTS credits per course is lower in Poland. One argument in favour of the Polish system is that a considerable proportion of courses are conducted in the form of workshops, seminars, and discussion groups, which place greater emphasis on students' active participation in the learning process.

Methodology

According to Jerzy Apanowicz, research may focus on socio-economic, educational, cultural, and other activities. That includes entities (individuals), objects, phenomena, and processes that shape the organizations, structures, motivations, personalities, knowledge, attitudes, and experiences of particular individuals and social groups (Apanowicz, 2005, p. 72). Another definition indicates that the term "subject of research" refers not only to objects and material entities in the literal sense but also to phenomena and events that these entities experience or influence. Such research subjects may include, for example, employees, medical professionals, primary and secondary school teachers, institutional staff, the phenomenon of unemployment, the process of education with its conditions and outcomes, as well as students' interests, aspirations, social attitudes, work methods, and social conflicts (Maszke, 2008, p. 91).

In the research presented in this article, the subject has been defined as: the professional preparation of preschool and early childhood education teachers in Poland and Italy.

In order to pursue this research, it was also necessary to determine its purpose. According to Maszke (2008, p. 28), the aim of scientific inquiry is to provide verifiable knowledge that enables the description, understanding, and explanation of phenomena and processes relevant to the researcher, as well as the prediction of their consequences.

The primary objective of the presented study was to collect information on and identify potentially beneficial changes in the process of preparing teachers in Poland resulting from the comparison with the Italian system.

This in turn leads to the practical objective of the study, which was to formulate a proposal for modifications to the curriculum of preschool and early childhood education.

According to Łobocki (2009, p. 107), research problems are questions to which we seek answers through scientific research. The author also emphasises what does not constitute a research problem. It is not every question posed by a person, nor a question to which an obvious or direct answer is expected (Łobocki, 2009, p. 107). Another definition highlights that research problems should be important from the point of view of theory development and/or relevant to practice. Furthermore, they must be correctly formulated, realistic, and, in most empirical sciences, verifiable (Klepacki, 2009, p. 41).

The main (general) research problem was formulated as follows: What components (elements) of teacher education in Italy have the potential to improve the quality of teacher preparation in preschool and early childhood education in Poland?

Based on the general research problem, specific research questions were identified:

1. What are students' opinions about the groups (modules) of core and optional subjects?
2. What are the preferred methods of course completion among students of preschool and early childhood education?

The research method applied to this study was a diagnostic survey. A. Maszke (2008, p. 172) states that it is a way of gathering knowledge about phenomena, events, or processes occurring in the social environment that are of interest to the researcher, based on surveying the opinions and views of people selected through specific criteria.

The technique being used in this research was the interview. Janusz Sztumski defines it as a guided conversation involving at least two individuals: the interviewer and the respondent. However, it is not a casual conversation, but such a conversation through which the researcher wants to obtain from the respondent the data specified by the research objective (Sztumski, 2010, p. 176).

Based on the degree of standardisation, the interview can be classified as either standardised or non-standardised (Maszke, 2008, p. 222). In this study, the first type, also called a questionnaire-based interview, was employed. This type is characterised by the interviewer adhering to a predetermined list of questions that are identical for all respondents and predominantly closed-ended.

To conduct the research, it was necessary to design an appropriate research instrument. An electronic interview questionnaire was developed using the Google Forms platform. The full title of the tool was *Interview Questionnaire for Polish Students of Preschool and Early School Education Concerning the Introduction of Solutions Adapted from the Italian Education System in Master's Degree Studies in Primary Education*. The questionnaire was distributed electronically to students in October 2024.

A total of 55 participants (53 women and 2 men) studying preschool and early school education at the University of Rzeszów responded anonymously to the questions. The students represented the following years of study:

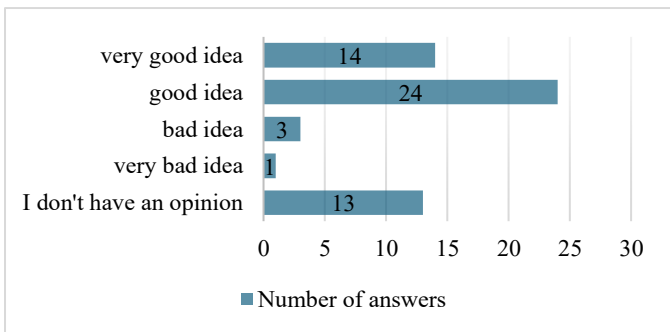
a) second – 7 respondents;
b) third – 10 respondents;
c) fourth – 13 respondents;
d) fifth – 25 respondents.

Analysis of the results

As mentioned in the previous section, two specific questions were formulated for this study: what are students' opinions about the groups (modules) of core and optional subjects, and what are the preferred methods of course completion among students of preschool and primary school education. The questionnaire items were designed to address these research questions and to provide data that would enable their detailed analysis.

1. What are students' opinions about the groups (modules) of core and optional subjects?

Polish students of preschool and primary school education, as future teachers, are required to acquire a broad range of knowledge and skills before beginning professional work with children. The idea of dividing courses into core and facultative subjects occasionally appears in academic conversations among students, often in response to the extensive and sometimes overwhelming number of courses included in the study programme. However, contrary to Italian universities, this system has not yet been implemented as a standard practice in Poland, where the curriculum remains fully predefined and mandatory.

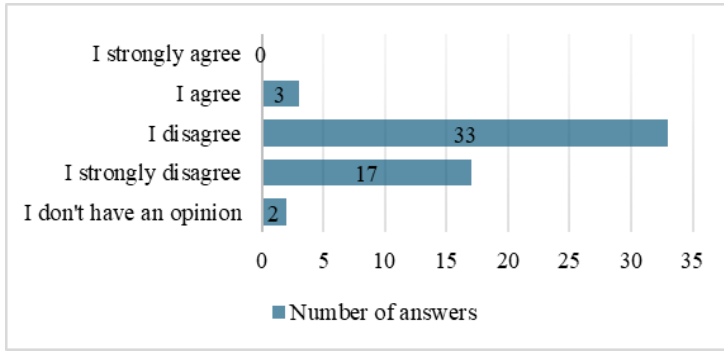


Graph 1. Response to the statement: The introduction of core and facultative subjects is...

An analysis of the responses presented in Graph 1 reveals a high level of consensus among students (38 out of 55) regarding their positive attitude towards a division into core and facultative subjects.

The subjects identified by students as the most essential included Fundamentals of Psychology for Teachers, Fundamentals of Preschool and Early School Pedagogy, courses on Supporting the Development of Children in Preschool and Early School Age, and Methodology of Various Types of Education.

Conversely, among the subjects considered less essential – and therefore more suitable as optional – respondents most frequently indicated: Theoretical Foundations of Pedagogical Activities, Culture of Language, Organisation of Preschool and School Work, and Psychological and Pedagogical Foundations of Foreign Language Teaching.



Graph 2. Response to statement: I consider all subjects taught in the preschool and primary school education program to be useful in the perspective of my future career

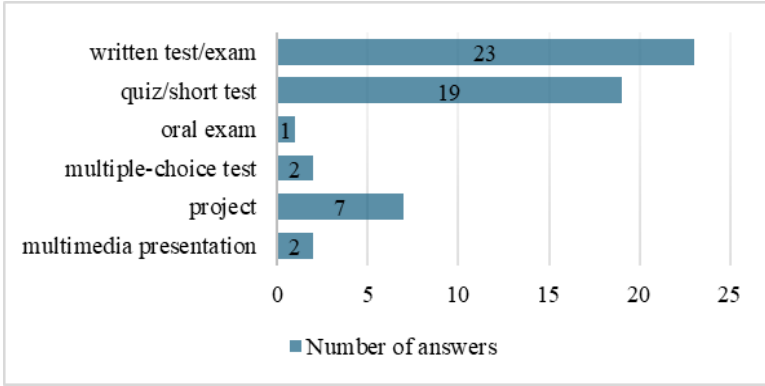
The perceived need for such a division of subjects may stem from the students' belief that the study programme is excessively extensive and demanding. Moreover, respondents indicated the presence of courses they considered of limited relevance to their future professional careers (see Graph 2).

2. What are the preferred methods of course completion among students of preschool and early childhood education?

Written examinations and short tests constitute one of the most common forms of knowledge assessment in Poland, beginning as early as the first stages of education. Oral examinations, by contrast, are considerably less frequent. Consequently, Polish students usually tend to feel more comfortable with written rather than oral forms of evaluation throughout the entirety of their educational path.

The situation appears to be quite the opposite among Italian students. From primary school onwards, they are encouraged to engage actively in classroom discussions and oral presentations. As a result, many Italian students report feeling more confident during oral examinations at university, while expressing greater anxiety about written assessments[l].

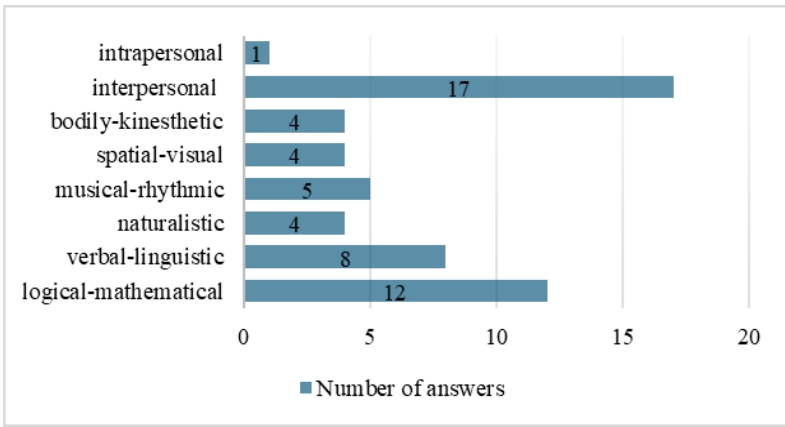
[l] Based on informal conversations with Italian students in Naples and an interview with an early education student at Suor Orsola Benincasa University.



Graph 3. Answer to the question: Which method of assessing the knowledge acquired during classes has been used the most during your studies so far?

As shown in Graph 3, the most common forms of assessment used in university lectures-written examinations/tests and quizzes/short tests – largely correspond to the assessment methods that students encountered during earlier stages of their education. Therefore, by the time they begin their university studies, students can be expected to be well accustomed to written examinations and short test. However, the preferences and self-reported abilities declared by the respondents suggest a more complex situation.

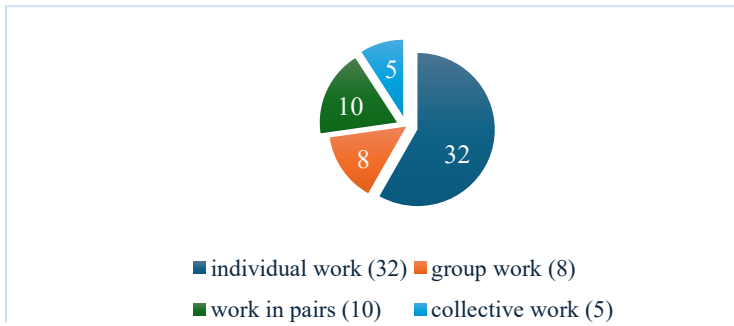
As shown in Graph 4, when asked about their dominant types of intelligence (according to Gardner, 2009), many preschool and early childhood education students identified strong behavioural and interpersonal communication skills. Additionally, their responses indicated predispositions and talents related to logical--mathematical and linguistic intelligence.



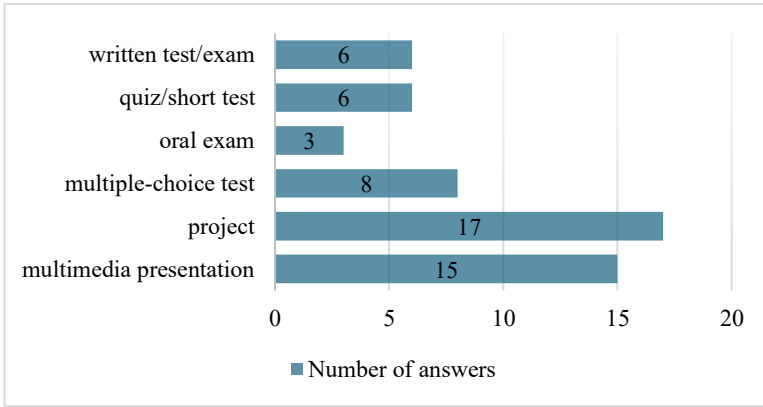
Graph 4. Answer to the question: Based on your own knowledge and experience, what is your dominant type of intelligence (according to Gardner's theory of Multiple Intelligences)?

However, these predispositions and the students' preferred ways of testing knowledge do not align with the current structure of their university studies. Students who display a preference for working with others and a learning-by-doing approach should not be assessed solely on the basis of theoretical knowledge they have memorised. Instead, they should be given opportunities to demonstrate their abilities through more interactive and collaborative forms of assessment, such as group projects.

In contrast, the responses to the question concerning students' usual mode of work show that individual and independent tasks remain the most common form of learning. As illustrated in Graph 5, there is a clear dominance of individual work which corresponds with the prevalence of written test and quizzes – tools designed to evaluate individual achievement. Nevertheless, the modern labour market increasingly values soft skills such as problem solving, teamwork, empathy, and communication – competences that are difficult to develop in isolation.



Graph 5. Answer to the question: What is the most popular form of testing acquired knowledge during your studies?



Graph 6. Answer to the question: Which method of testing knowledge is the easiest for you – which one do you feel most confident about?

The research indicates that students with diverse dominant intelligences feel most confident when assessed through multimedia presentations, project work, and, to a lesser extent, multiple-choice tests (see Graph 6). However, these forms of verifying knowledge did not rank highly among the methods of verifying knowledge used currently at university. The discrepancy suggests a misalignment between students' strengths and the actual assessment practices applied in their programmes.

Conclusion

This study has identified several areas in the training of future teachers that could benefit from improvement. The survey results revealed that students generally prefer having facultative courses rather than a fully mandatory curriculum. Furthermore, project-based assessment and multimedia presentations emerged as the most favoured forms of knowledge evaluation. Within the context of current preschool and primary school education programmes at Polish universities, these findings suggest that there remains considerable potential for enhancing flexibility and innovation in the Polish higher education system.

Taking into account the cultural and systemic differences between the two countries, the study concludes that certain elements of the Italian model of teacher education could be reasonably adapted and implemented in Polish preschool and primary school studies to improve the overall quality and relevance of teacher preparation.

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Scientific

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Motivation and Preferences of Primary School Teachers in the Field of Continuing Education

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Abstract

The article focuses on the opinions of primary school teachers teaching the subject of Practical Education: on the offer, motivation, and preferences in the field of further education. The main objective was to find out in which topics and forms teachers would need to innovate their knowledge. The data were obtained using an electronic questionnaire, which was sent to 1,186 primary schools and completed by 196 teachers from all over Slovakia. The results showed that while teachers perceive the courses offered by state institutions as partially sufficient, they consider the courses offered by other educational institutions to be more attractive and suitable. Their main motivation for education is an internal need and desire for self-development, followed by the possibility of salary advancement. Teachers prefer innovative and refresher training, which is delivered remotely using online workshops. Conversely, they are least interested in traditional lectures and conferences. In terms of content, they are most interested in acquiring new knowledge, innovative methods, and practical skills.

Keywords: primary school teachers, preferences, continuing education, questionnaire

Introduction

Teacher professional development is a complex process that helps teachers to continuously improve. Its main goal is to deepen their knowledge and skills, acquire new qualifications, and develop their abilities so that they can teach more effectively or hold higher positions, such as in school management.

This process involves various types of education, such as:

1. Acquiring new qualifications for higher career levels.
2. Verifying teachers' existing skills so that they can advance to a higher level in their careers.
3. Study and training necessary to meet the qualification requirements for other roles.

It is important that teachers actually use and evaluate the skills they have acquired in practice. This process is regulated in Slovakia by Act No. 138/2019 Z. z. However, professional development is not just about formal education. It also includes professional practice and creative activity of the teacher, scientific and research work and publishing activity, and, of course, self-education and the routine performance of work activities, which also contribute to the continuous development of the teacher's expertise.

Several experts have addressed the topic of professional development for teachers and agree that it is a key tool for improving the quality of education. Pivovarčiová (2021) emphasizes that professional development should be a systematic process in which teachers set their own goals and create plans with the support of the school. Managers should provide them with individual attention and support.

Osvaldová and Vrabcová (2021) add that lifelong learning for teachers is not just about offering courses, but about a comprehensive system linked to career growth. Although the concept of a "learning organization" is ideal, schools often fail to implement it due to bureaucracy, lack of teamwork, and poor teacher participation in decision-making. A high-quality and diverse range of courses is essential for teacher development.

Research by authors such as Stronge and Hindman (2003) confirms that effective teachers acquire these skills and qualifications before entering the profession. However, the findings of Gul, Kanwal, and Khan (2020) and Bawaneh and Ali Khaled (2020) are mixed, as they did not find a strong correlation between qualifications and teaching approaches. Nevertheless, Darling-Hammond et al. (2001) and Wayne and Young (2003) found a strong relationship between teacher certification and student achievement, particularly in subjects such as Mathematics and reading.

Many teachers participate in continuing education, but their motivation may not always be professional development. Some do so only because it is a mandatory requirement of their employer. A study conducted by Sadeghi and Richards (2021) in Iran examined what professional development activities English teachers engage in and what motivates them to do so. They surveyed 24 teachers from public schools and private language institutes and came to the following conclusions:

1. Teachers from public schools were almost never involved in further education.

2. Teachers from private institutes were much more active. Their activities included consultations, online courses, watching educational videos, and studying English as a second language textbooks.

Teachers' motivations varied, ranging from no motivation at all to specific goals such as improving their own English or obtaining qualifications to teach at university. Ideally, of course, teachers would engage in continuing education primarily to improve their teaching skills.

Aim and methodology of the research

At the first level of primary schools, the educational area of Man and the World of Work is currently represented by the subject Practical Education, which is included in the curriculum for the third and fourth grades of primary school. The subject is usually taught by primary school teachers. The aim of the research was to find out the opinions of primary school teachers on their motivation and preferences in the area of further education, in which topics they would need to innovate their knowledge and in what form. We chose a questionnaire of our own design as the research tool. The questionnaire contained demographic data: region, age, qualifications for teaching subjects, and the following items:

1. How do you rate the educational offerings of state institutions?
2. How do you rate the educational offerings of other educational institutions on the market that offer education in the field of education?
3. What motivates you to pursue further education?
4. Select the type of education that would suit you best
5. What is your preferred form of continuing education?
6. How would you like to be educated?
7. How would you not like to be educated?
8. What would you like to learn during continuing education?

The questionnaire was electronic and sent by email to all primary schools (1,186 schools) (Statistical Yearbook, 2023). The questionnaire was to be completed by primary school teachers. We received 196 fully completed questionnaires.

Research results

The questionnaire was completed by respondents from all regions. The Prešov region had the highest representation, while respondents from the Bratislava region had the lowest representation (Table 1). We often encounter a similar distribution of respondents in educational research.

Table 1. Distribution of respondents by region

Region	%
Banská Bystrica region	11
Bratislava region	4
Košice region	16
Nitra region	18
Prešov region	21
Trenčín region	6
Trnava region	8
Žilina region	16

The Bratislava region is usually the least represented in research samples. This is probably because teachers there are inundated with various questionnaires from other universities, of which there are many in the Bratislava region.

The age structure of respondents consisted of 11% of teachers under 30, 19% of teachers aged 31 to 40, 34% aged 41 to 50, 33% aged 51 to 60, and 3% of respondents aged 60. Of the 196 respondents, 61% were qualified to teach primary education. The remaining 39% of respondents reported teaching qualifications for other subjects (most commonly biology, chemistry, technology), special education qualifications, or educator qualifications.

The first piece of information we wanted to find out from the respondents was their experience with continuing education courses organized by state institutions, (Figure 1).

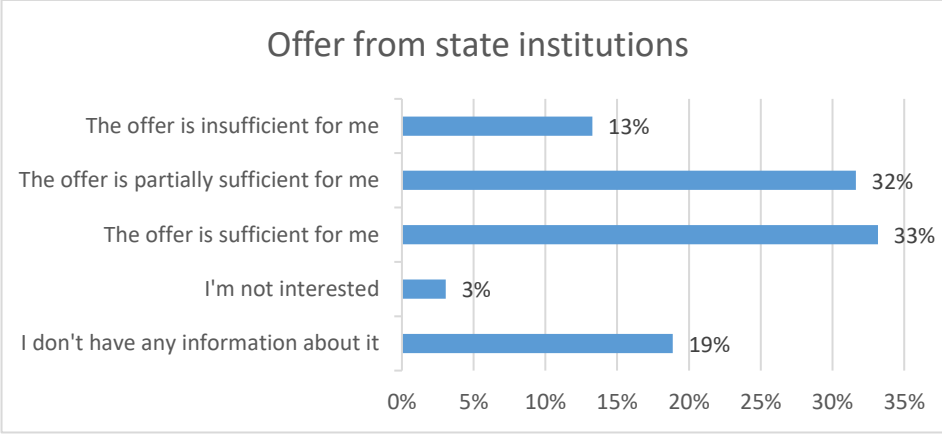

Figure 1. Evaluation of courses offered by state institutions

We found that primary school teachers consider the range of continuing education courses organized by the state to be sufficient (33%) or partially sufficient

(32%). For 13% of respondents, the offer is insufficient, and as many as 19% of respondents have no information about these offers. 3% of respondents are not interested in the training offer – these are teachers approaching retirement who are no longer interested in further training.

This number is repeated in the next item, which asked whether the range of continuing education courses for teachers offered by other educational institutions is sufficient (Figure 2).

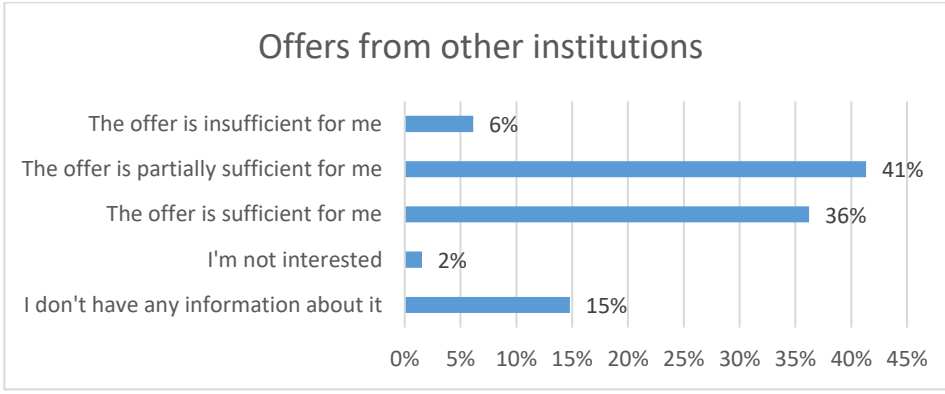

Figure 2. Evaluation of courses offered by other institutions

The range of courses offered by external institutions is sufficient for 36% of respondents and partially sufficient for 41% (Figure 2). Of course, primary school teachers must have professional competencies in all educational areas, they make up a large part of the teaching community, and therefore the range of courses on offer should be commensurate with this. Comparing the respondents' answers to this and the previous item, we can conclude that respondents consider the courses offered by other educational institutions (other than state institutions) to be more suitable and attractive for their further education.

The next item in the questionnaire examined the motivation of primary school teachers to pursue further education, (Figure 3).

Most respondents cited their own inner conviction and the need to learn as their motivation (65%). Another large group were those respondents who were motivated to pursue further education by the prospect of advancing to a different career level and thus a higher salary (45%). The needs of the school are taken into account by 38% of respondents when planning their further education, and 11% of respondents expect to be placed in a different career position after completing their education (Figure 3).

We also surveyed respondents about their preferred type of education, (Figure 4). They could choose from the following options: specialization, pre-certification, innovation, refresher, and other, where they could add their own choice.

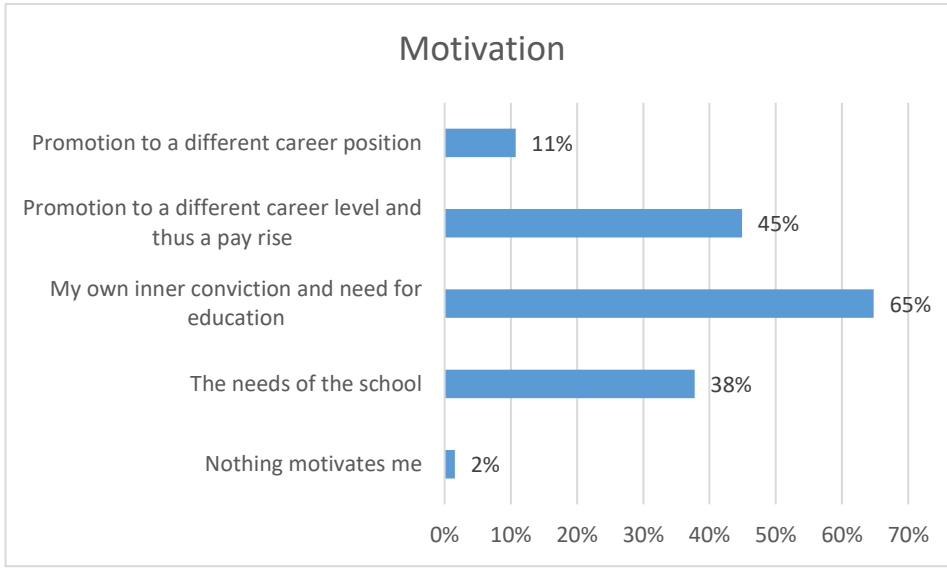

Figure 3. Respondents' motivation for further education

Most respondents prefer innovative (61%) and refresher training (27%). Other types of training were represented significantly less, with specialised training at 4% and pre-certification training at 7%.

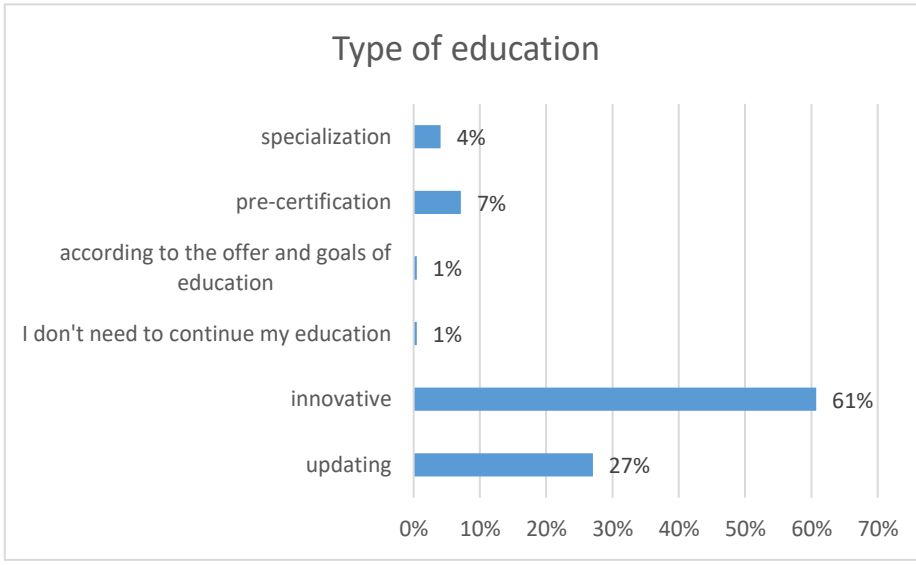

Figure 4. Preference for type of training

In the "other" option, respondents indicated "depending on the offer of objectives and training" or expressed the opinion that they were not interested in further training (Figure 4).

Another item in the questionnaire focused on the form of training that would suit respondents, (Figure 5).

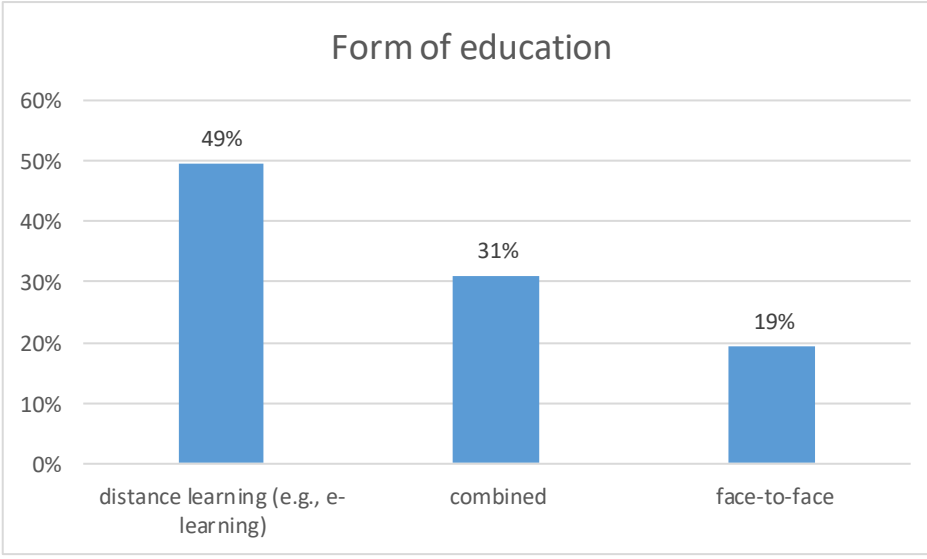

Figure 5. Preferences for the form of education

Almost half of the respondents prefer distance learning, e.g., in the form of e-learning. 31% prefer a combined form of education, and only 19% of respondents favored face-to-face education (Figure 5).

When specifying the form of education, respondents could choose from the following options: conference, online workshop, lecture, workshop, and they could enter their own option in the "other" option, (Figure 6).

The preferred training methods are workshops (34%) and online workshops (40%). 20% of respondents would choose lectures for training and 5% would choose conferences. The "other" option reflected a lack of interest in training as well as the possibility of alternating training methods (Figure 6). Another item verified the respondents' answers by asking about training methods that did not suit them. Respondents identified conferences (43%) and lectures (28%) as the least suitable methods of education. The previous answers were thus fully confirmed.

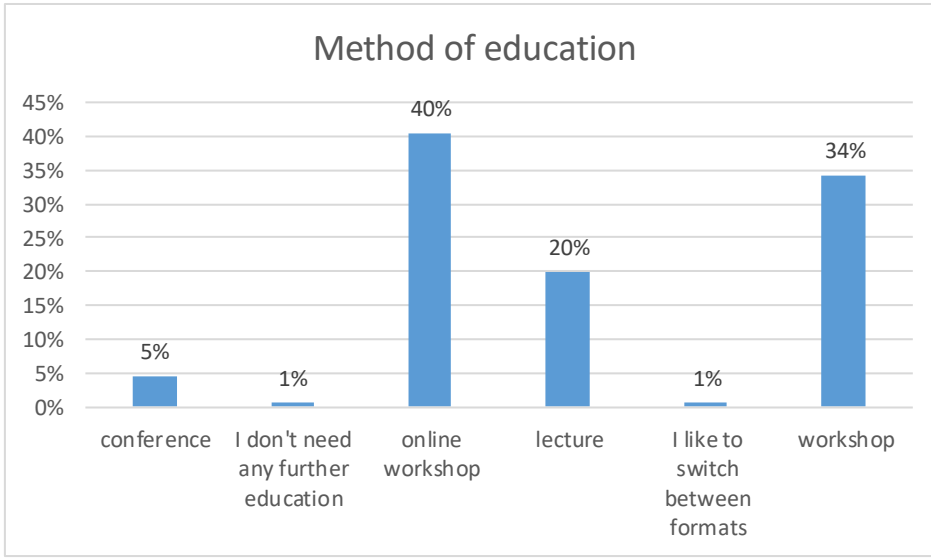

Figure 6. Preferences for training methods

We gave respondents the opportunity to write in an open-ended question what they would like to learn in further education, (Figure 7).

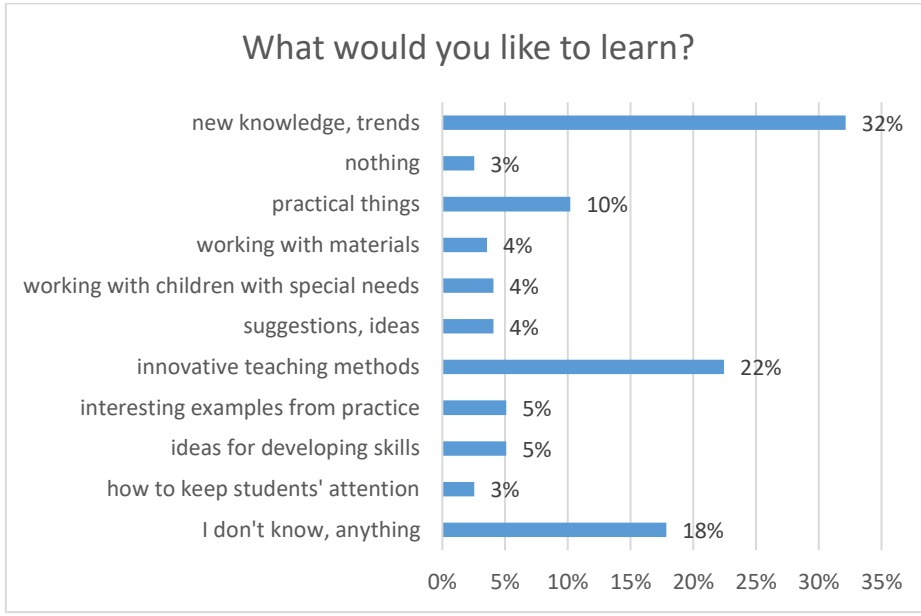

Figure 7. Topics of interest in continuing education courses

The majority of respondents chose the answer "new knowledge, trends" (32%), innovative teaching methods (22%) and practical matters (10%). Eighteen percent of respondents did not indicate any preferences in the area of continuing education, and 3% are not even interested in continuing education (Figure 7).

The results show that teachers rate the continuing education offered by state institutions as sufficient (33%) or partially sufficient (32%). An even larger proportion of respondents (36% and 41%) consider the offer from other educational institutions to be sufficient or partially sufficient, which indicates that they consider this offer to be more attractive.

The main motivation for further education for most teachers is their inner conviction and need to learn (65%), with the possibility of salary progression also playing an important role (45%).

In terms of training preferences, teachers most prefer:

- type of training: innovative (61%) and refresher (27%),
- form of training: distance learning (almost 50%) and combined learning (31%),
- method of training: online workshops (40%) and workshops (34%).

Conversely, respondents indicated that conferences (43%) and lectures (28%) were the least suitable methods. In an open question about training topics, respondents most often mentioned an interest in new knowledge and trends (32%), innovative teaching methods (22%), and practical skills (10%).

Conclusion

The research showed that primary school teachers have strong intrinsic motivation for further education, especially when it is linked to innovation and the acquisition of practical skills. Their preferences lean towards modern and flexible forms, such as distance and combined learning courses with an emphasis on interactive online and traditional workshops. Conversely, traditional forms of education, such as lectures and conferences, are the least attractive to them.

The results show that although there are training opportunities offered by both state and non-state institutions, primary school teachers consider the opportunities offered by non-state institutions to be more suitable and attractive. There is a clear need for training programs to be more tailored to the specific needs of teachers, with an emphasis on the practical applicability of new knowledge and methods. Understanding these preferences and needs is key to developing relevant and effective continuing education programs that will be attractive to teachers and at the same time help them improve the quality of the teaching process.

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Modern Requirements for the Training of Scientific Personnel in Environmental Specialties Within the National Academy of Agrarian Sciences of Ukraine

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Abstract

The article presents an analysis of the current state of training scientific and academic staff by Ukrainian higher education institutions and research establishments during the special period of Ukraine's gaining independence, in particular at the Institute of Agroecology and Environmental Management of NAAS.

It is emphasized that as early as 1999 the Cabinet of Ministers of Ukraine approved the Regulation on the training of academic and scientific staff, and starting from 2016 the training of academic and scientific personnel in Ukraine has been reformed in accordance with the requirements of the Bologna Agreement.

The authors emphasize that ensuring a healthy lifestyle and quality education is one of the key goals of the UN Sustainable Development Summit and requires an integrated approach and the provision of quality education that will foster the development of life competencies, strengthen health, and improve the quality of life of all members of society.

The functions of quality assurance in education are performed by the National Agency for Higher Education Quality Assurance, which has gone through its own path of formation and reform and has incorporated in its activities the best practices of Western agencies, including lessons learned from correcting previous mistakes.

Keywords: European integration of Ukraine in the field of education, by joining the Bologna Process, practices for improving the system of training academic and teaching staff, modernization of the conditions for the development of science in Ukraine

Introduction

An important prerequisite for the development of science is the improvement of the system for training scientific and academic staff. In Ukraine, a system for training such personnel has been created and is functioning successfully. This work is carried out by academies, higher education institutions, research institutes, and in industry (Kyslyi, 2009).

On 1 March 1999, the Cabinet of Ministers of Ukraine, by Resolution No. 309, approved the Regulation on the training of academic and scientific staff, which regulates activities in the field of training academic and scientific personnel and is mandatory for all higher education institutions and research establishments of Ukraine, regardless of their subordination and form of ownership (Regulation, 1999).

The training of scientific and academic staff is the process of obtaining a higher scientific qualification (scientific degree) and developing skills for conducting scientific, scientific-technical, teaching, and organizational activities, which usually takes place in postgraduate and doctoral studies. It involves educating individuals who already have higher education to carry out independent scientific research and to teach in higher education institutions (Tonkha, Mehbaliyeva, Nagorniuk, 2019). The main aspects of the training of scientific and academic staff include professional training, teaching activities, scientific activities, and the system of attestation of academic personnel.

Table 1. Main aspects of the training of scientific and academic staff

Professional training	It is the process of developing in an individual the knowledge, skills, abilities, and qualities necessary for successful work in a chosen profession. For scientific and academic staff, this means deep mastery of knowledge in a specific field, the methodology of scientific research, and pedagogical excellence.
Scientific activity	It includes the ability to conduct research, write scientific papers, publish them, participate in conferences to present and validate obtained scientific results, and defend a dissertation.
Teaching activity	This is teaching in higher education institutions, which includes instructional, methodological, and organizational work with students.
Attestation system	After completing the training and successfully defending the dissertation, the applicant is awarded a scientific degree (for example, Candidate or Doctor of Sciences) and conferred an academic title (for example, Associate Professor or Professor).

Since the beginning of Ukraine's independence, the authorities of our state have consistently declared their intention to introduce European principles in all spheres of public life. An important component of Ukraine's European integration aspirations is integration and deepening cooperation with European countries, especially in the field of higher education and scientific activity.

In 2005, Ukraine signed the Bologna Declaration, thereby officially joining the Bologna Process and undertaking the commitment to introduce European educational standards into the higher education system in the course of reforming the national educational system. For many years, our country has been moving along the path of change, reform, and transformation, striving to join the European educational area (Khan, 2017).

The main final document of the 2015 World Summit on Sustainable Development (the UN Sustainable Development Summit) is **"Transforming our world: the 2030 Agenda for Sustainable Development".**

Ensuring a healthy lifestyle and quality education is one of the key goals of the Summit and requires an integrated approach that includes developing in children and adults the skills of a healthy way of life, rational nutrition, physical activity, adherence to hygiene and daily routines, and, to provide this knowledge and these skills, the provision of quality education that will promote the development of life competencies and the strengthening of health.

In Ukraine, the functions of quality assurance in education are performed by the National Agency for Higher Education Quality Assurance, which has incorporated in its activities the best practices of Western agencies, including lessons learned from mistakes.

The National Agency for Higher Education Quality Assurance is an important stage in the reform of Ukrainian higher education. However, it is obvious that it is impossible to achieve qualitative changes solely through properly formulated requirements for educational activities, and also without adequate funding, which is linked to the capabilities of the national economy and the expectations of society. Nevertheless, clearly defined tasks and the rhetoric itself create a framework for an adequate understanding of the situation and movement in the right direction (New Accreditation System, 2020).

In the context of the increasing globalization of higher education, cross-border quality assurance plays a key role in strengthening international cooperation, raising academic standards, and ensuring the mutual recognition of qualifications (Stukalo, Kovalska, 2025).

Subject of the research

The subject of the research is the training of scientific personnel in environmental protection specialties, which includes obtaining higher education in environmental, economic, agronomic, geographical, and other related specialties and fields of knowledge, as well as conducting scientific research. It encompasses various levels (from bachelor's to postgraduate studies) and is aimed at forming specialists who can assess, monitor, and solve problems related to environmental pollution, the rational use of natural resources, and the preservation of biodiversity.

Methodology and subject of the research

The methodology of training scientific personnel is a theory of cognition that encompasses the principles, forms, and methods of scientific inquiry within the educational process. The subject of the research includes the study of the process of training specialists, their scientific activity, scientific knowledge, as well as the formation of their competencies and professionalism.

The methodology of training scientific and academic staff includes:

a) Theoretical research methods: analysis, synthesis, abstraction, generalization, induction, deduction, classification, etc.;

b) Empirical research methods: experiment, observation, description, methods of data collection and processing;

c) System research methods: systemic, functional, and concrete-sociological approaches.

d) The subject of scientific research includes:

e) Training process – the study of the stages of scientific activity and the formation of skills and knowledge of postgraduate students;

f) Scientific knowledge – the study of cognitive processes taking place in science;

g) Competence formation – the development of professional, analytical, creative, and communication skills in future researchers;

h) Professional development – the study of ways to obtain scientific degrees and academic titles.

Development (analysis of research results)

Ensuring the quality of higher education is a process that consists of **internal** (the quality assurance system within the educational institution) and **external** (state regulation, standardization, accreditation, licensing) mechanisms. It involves the evaluation and improvement of educational and managerial processes, resources, as well as the alignment of learning outcomes with the requirements of students and society (Bekh, Malinovskyi, Andrushchenko, 2004; Babyn, 2011).

The internal quality assurance system includes:

1. Quality of personnel.
2. Educational, methodological and didactic support of educational programs.
3. Information and library resources.
4. Satisfaction of students and employees with social conditions.
5. Material and technical support.

The components that should ensure the effectiveness of external quality assessment processes and the independence of relevant institutions include:

1. Standardization.
2. Licensing of educational activities.
3. Accreditation of educational programs and institutional accreditation.
4. External independent assessment of learning outcomes.

5. Institutional audit.
6. Monitoring of educational quality.
7. Public accreditation of educational institutions.

In addition, ensuring the quality of education means the development of life and communication competencies, as well as the formation of health-preserving competence among teachers themselves, the intellectual and moral development of those who teach, and the ability to acquire and use modern scientific knowledge, etc. (Environmental Education, 2013).

International cooperation between European quality assurance agencies is constantly expanding and improving. It includes such forms of collaboration as: involving foreign specialists in specific disciplines in the evaluation process and including them in accreditation commissions; including foreign colleagues or experts in the governing body or steering committee of an agency in another country; using existing international standards and criteria in evaluation and accreditation; and applying internationally developed indicators (descriptors) of learning outcomes for bachelor's and master's degrees (Babyn, 2011).

Gradually, national qualification criteria are being integrated into a single framework of qualification requirements within the European Higher Education Area, which is formed on the basis of a common understanding of learning outcomes and competencies acquired by graduates of higher education institutions and research establishments (Finikova, Sharova, 2014).

At the Institute of Agroecology and Environmental Management of NAAS, the training of highly qualified scientific personnel is carried out through postgraduate studies, which were established in 1994, and doctoral studies, which have been operating since 1995, in the following specialties::

a) 03.00.16 – ecology (biological and agricultural sciences);

b) 08.00.06 – economics of environmental management and environmental protection (economic sciences).

Figure 1. Department of Scientific Personnel Training and Methodological-Information Support of the Institute of Agroecology and Environmental Management of NAAS

In 2016, in order to carry out educational activities at the third (educational and scientific) level of higher education, an appropriate license was obtained, granting the right to train Doctors of Philosophy and Doctors of Sciences in the following specialties:

a) 051 – Economics (05 Social and Behavioral Sciences);
b) 101 – Ecology (10 Natural Sciences);
c) 201 – Agronomy (20 Agricultural Sciences and Food).

In 2020, the Department of Scientific Personnel Training and Methodological--Information Support of the Institute of Agroecology and Environmental Management of NAAS successfully passed the attestation procedure and received the relevant certificates valid until 01.07.2026.

Figure 2. Accreditation certificates of educational and scientific programs of the third educational and scientific level at the Institute of Agroecology and Environmental Management of NAAS

In 2025, the specialty codes were changed in accordance with the new classification system, which replaces the old numerical codes with alphanumeric ones to make the classification more convenient and concise. This change reflects the update approved by the Ministry of Education and Science of Ukraine.

According to the updated codes, the Institute provides training of specialists in the following specialties and fields of knowledge:

C1 – Economics (C – Social Sciences, Journalism and Information);

E2 – Ecology (E – Natural Sciences, Mathematics and Statistics);

H1 – Agronomy (H – Agriculture, Forestry, Fisheries and Veterinary Medicine).

Currently, the Institute of Agroecology and Environmental Management of NAAS has 2 doctoral candidates and 34 postgraduate students (including 11 in full-time (day) study; 22 in full-time (evening) study; and 1 in part-time study). Scientific supervision of postgraduate and doctoral students is carried out by 3 Candidates of Sciences and 23 Doctors of Sciences, among whom are: 3 Academicians, 2 Corresponding Members, and 14 Professors.

Regulatory and legal support, material and technical resources, and educational and scientific activities are presented on the Institute's website, which is again preparing to undergo re-attestation, taking into account all previous shortcomings and comments (Institute, website).

These include:

1. Development of the technical assignment to define the goals, objectives, and object of the research.
2. Selection of the research direction in order to learn how to define topics and substantiate the relevance of the research.
3. Theoretical and experimental studies, which involve the collection of scientific data, their analysis, processing, and interpretation.
4. Generalization and evaluation of the results: formulation of conclusions and assessment of their significance.
5. Organizational aspects: drawing up a research plan and distributing roles if it is a team project (Nagorniuk, Ridei, Sobchyk, 2017).

However, it is not only formal aspects that require improvement of the system for training scientific and academic staff.

To improve the system of professional development for academic staff based on modern educational technologies, it is necessary to maintain key factors for the successful defense of dissertation research, individualization of study programs, and flexible forms of learning (Walat, Kuzin, 2020; Mudrak, Sobchyk, Nahorniuk, Yashnik, Tarasenko, 2019; Zabelin, Kubitskyi, 2024).

The individualization of study programs is a key element of the professional development system for academic staff. The need for this approach lies in the fact that each lecturer has their own unique needs, interests, and professional motivations, which should be taken into account to ensure the maximum effectiveness of the educational process.

Digital learning management technologies make it possible to use such tools as electronic portfolios and analytical platforms, which enable more effective tracking of professional development. It is also important to introduce online courses and webinars for convenient and flexible learning (Zabelin, Kubitskyi, 2024).

The introduction of hybrid learning makes it possible to combine distance and in-person formats, creating conditions for flexibility and accessibility of education both for academic staff and for learners, taking into account different learning styles and working conditions, as well as saving time and resources (Zabelin, Kubitskyi, 2024).

Conclusions

Thus, modern requirements for the training of scientific personnel include in-depth knowledge in the specialty, critical thinking skills, the ability to conduct research, analyze and present results, as well as adherence to academic integrity and the formal requirements for scientific works. It is important to ensure the high quality of scientific output, in particular articles, which must be logically structured and comply with established standards.

These requirements for knowledge and skills imply deep and rigorous expertise of the candidate (specialist) in their field, enabling them to engage in scientific activity professionally. A researcher's skills require the ability to formulate the aim and objectives of the study, develop a methodology, carry out theoretical and empirical research, and analyze the results obtained. Analytical and critical thinking provide the capacity to critically evaluate existing knowledge and formulate one's own scientific conclusions. At the same time, academic integrity is the fundamental basis of a scientist's moral profile, requiring compliance with ethical standards and including the avoidance of plagiarism and other forms of academic misconduct.

In terms of requirements for scientific works, the logical and clear structure is assessed, including an introduction, the main body (divided into sections and subsections), conclusions, and a list of references. It is important to be able to substantiate the relevance of the topic, clearly formulate the aim and objectives, and define the object and subject of the research. High-quality content is determined by the scientific novelty of the work, which should contain new knowledge and results that have theoretical or practical value.

Equally important is the ability to comply with the technical requirements for formatting texts, such as layout, margins, indents, font size, and spacing, which may differ depending on the publication.

Other important aspects of effective training of scientific and academic staff include lifelong learning, continuous professional development, and deepening of knowledge in one's own and related fields, as well as practical training. The system of professional development should be oriented toward international standards, introduce modern approaches to teaching and management in the educational sphere, which will contribute to the globalization of the educational process and increase the competitiveness of academic staff. Such approaches would not only enhance the level of professional training, but also help create conditions for the individual development of personnel.

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Utilization of Statistical Methods in Educational Research

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Abstract

Statistical methods play a key role in educational research. This paper focuses on the significance and application of statistical methods in educational research, demonstrating how these methods can be used to examine the effectiveness of different teaching methods, evaluate educational interventions, and identify factors influencing learning. Basic statistical procedures, such as statistics, correlations, regression analyses, t-tests, and statistical hypotheses are discussed. The paper also highlights common errors in the use of statistical methods and stresses the importance of carefully selecting appropriate statistical tools. The aim is to provide educators and researchers with a practical overview.

Keywords: statistical method, educational research, regression, hypothesis, result

Introduction

Statistical methods play a crucial role in educational research because they allow for the objective analysis and interpretation of data gathered from studying educational processes, interventions, and outcomes. They enable researchers to test hypotheses, compare groups, identify relationships between variables, and uncover factors influencing education. Methods such as t-tests, correlation analyses, regression analyses, and ANOVA are commonly used to evaluate the effectiveness of teaching methods, improve educational programs, and support decision-making in education.

ANOVA (Analysis of Variance)

ANOVA is a statistical method used to test differences between three or more groups. Its main goal is to determine if there are significant differences between the means of these groups. ANOVA compares variability between groups with variability within groups to decide whether the observed differences are not just due to chance. This method is commonly used in experimental research, such as in education, psychology, or when testing the effectiveness of various treatment methods (Heiman, 2006).

Use of T-test in Educational Research

A T-test is a statistical tool used in educational research to compare the means of two groups to determine if there is a statistically significant difference between them. This method is frequently applied to evaluate the effectiveness of teaching methods, programs, or interventions in education. For example, a T-test can compare students' test results who participated in different instructional activities to determine if one method yields better outcomes than the other. It helps educators and researchers verify if the observed differences are not merely by chance (Chraska, 2016).

Use of Regression and Correlation Analysis in Educational Research

Regression and correlation analysis are statistical methods used in educational research to explore relationships between variables. Correlation analysis measures the strength and direction of the relationship between two variables, such as the relationship between study time and academic performance. It helps to identify associations but does not establish causality. Regression analysis takes this further by examining how one or more independent variables affect a dependent variable, allowing for predictions, such as how different teaching methods impact student success. Both methods are commonly employed to identify key factors influencing education and to better understand the effectiveness of teaching approaches.

Use of PAST Software in Educational Research

The PAST (PAleontological STatistics) software is a free statistical tool that is also used in educational research for data analysis. It offers a wide range of statistical methods, including basic descriptive statistics, correlation and regression analysis, ANOVA, t-tests, cluster analysis, and more as can be seen in (Krpec, 2013). Thanks to its user-friendly platform, it is ideal for researchers, educators, and students who need to quickly and efficiently analyze data. It aids in assessing the effectiveness of teaching methods, studying the influence of various factors on learning, and other educational research activities (Fraenkel, 1993).

Practical examples of calculations in statistical research

Practical examples of calculations in statistical research often involve data analysis using various statistical methods. Here are three examples:

T-test: Used to compare the means of two groups. For example, in research on the effectiveness of two teaching methods, it tests if the differences in student outcomes are statistically significant.

ANOVA (Analysis of Variance): Used to compare more than two groups, such as examining the average test scores of students from different schools.

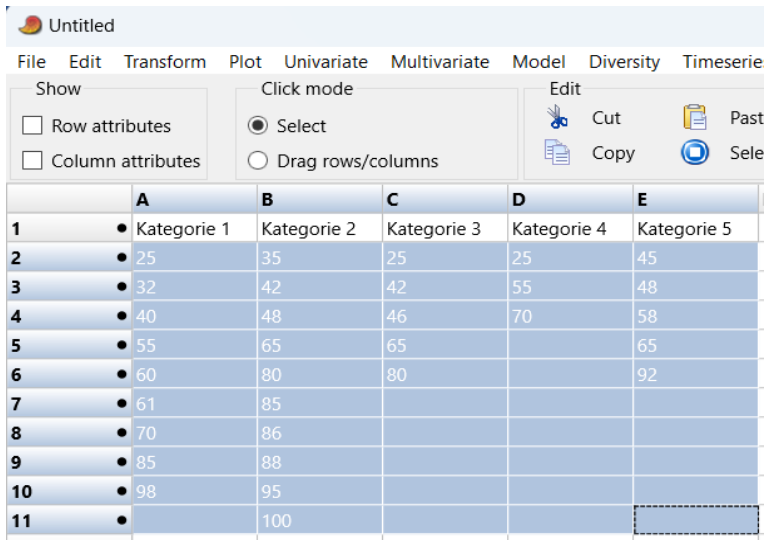
Regression and Correlation Analysis: Evaluates the relationship between a dependent and independent variable, like the impact of study hours on grades. Each method has unique uses and interpretations, allowing for a detailed understanding of data patterns in pedagogical research.

Using the ANOVA method in a pedagogical example

32 master's students in the Teaching of Vocational Subjects program took a test scored from 0 to 100 points. The test focused on concepts related to social sciences. The students were divided into five categories:

1. Category: Primary School Teachers.
2. Category: Secondary School Teachers.
3. Category: Government Employees.
4. Category: Private Sector Employees.
5. Category: Security Forces and Emergency Services Employees.

Points in the first category: 25, 32, 40, 55, 60, 61, 70, 85, 98 (9 students), Points in the second category: 35, 42, 48, 65, 80, 85, 86, 88, 95, 100 (10 students), Points in the third category: 25, 42, 46, 65, 80 (5 students), Points in the fourth category: 25, 55, 70 (3 students), Points in the fifth category: 45, 48, 58, 65, 92 (5 students).



	A	B	C	D	E
1	Kategorie 1	Kategorie 2	Kategorie 3	Kategorie 4	Kategorie 5
2	25	35	25	25	45
3	32	42	42	55	48
4	40	48	46	70	58
5	55	65	65		65
6	60	80	80		92
7	61	85			
8	70	86			
9	85	88			
10	98	95			
11		100			

Figure 1. Inputting data into the PAST program

Determine if there is a significant relationship between the test scores and the employment category of the students.

To solve this task, use the ANOVA (Analysis of Variance) statistical method.

Verifying pedagogical data for normality using the PAST program as can be seen in Figure 1:

1. Testing data for normality, α = 0.05, "p" calculated value.
2. Normality condition of the data: p > α.

Shapiro-Wilk W, see Figure 2: 0.8962 > 0.05, 0.1827 > 0.05,

0.9101 > 0.05, 0.6369 > 0.05, 0.3389 > 0.05, normality is fulfilled for all data categories.

Anderson-Darling A, see Figure 2: 0.9026 > 0.05, 0.1591 > 0.05, 0.8102 > 0.05, 0.4867 > 0.05, 0.3203 > 0.05 – normality is fulfilled for all data categories.

Tests for normal distribution

	A	B	C	D	E
N	9	10	5	3	5
Shapiro-Wilk W	0,9702	0,8929	0,9757	0,9643	0,8863
p(normal)	0,8962	0,1827	0,9101	0,6369	0,3389
Anderson-Darling A	0,1692	0,4988	0,1846	0,2296	0,341
p(normal)	0,9026	0,1591	0,8102	0,4867	0,3203
p(Monte Carlo)	0,939	0,1622	0,9003	0,6278	0,363
Lilliefors L	0,1241	0,2278	0,2036	0,253	0,2281
p(normal)	1,179	0,1451	0,7117	0,652	0,5361
p(Monte Carlo)	0,9554	0,1568	0,7468	0,6337	0,5418
Jarque-Bera JB	0,3832	1,091	0,3174	0,3541	0,7245
p(normal)	0,8256	0,5796	0,8533	0,8377	0,6961
p(Monte Carlo)	0,7752	0,2135	0,829	0,6244	0,2104

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Close Help Recompute

Figure 2. The calculated significance level "p" values for normality

Results of the ANOVA testing method:

Using the PAST program, the selected ANOVA method applies the following conditions:

1. If p > α, the alternative hypothesis H1 is rejected.
2. If p < α, the null hypothesis H0 is rejected.

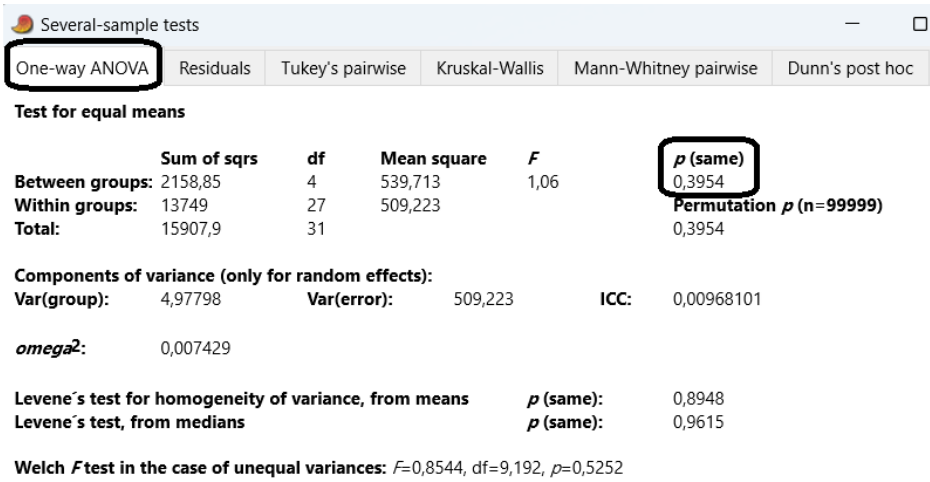


Figure 3. Calculated "p" value for ANOVA

Formulation of hypotheses:

Hypothesis H_1: $p < \alpha$, There is a statistically significant relationship between the test score results and the employee categories at the significance level $\alpha = 0.05$.

Hypothesis H_0: $p > \alpha$, There is no statistically significant relationship between the test score results and the employee categories at the significance level $\alpha = 0.05$.

Conclusion of ANOVA testing: $\alpha = 0.05$, $p = 0{,}3954$, see Figure 3. Since $p > \alpha$, we accept hypothesis H_0. Based on the ANOVA results, we reject the alternative hypothesis H_1 in favor of the null hypothesis H_0. This suggests there is no significant relationship between the test scores and the employee categories.

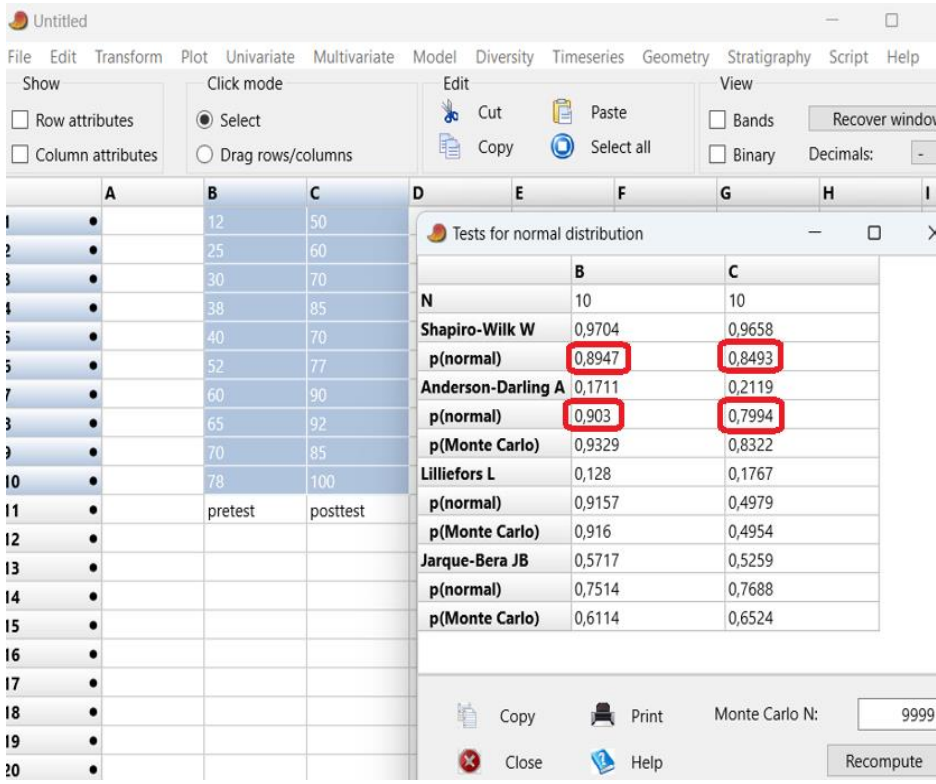
Use of the T-test in Educational Research

We can best illustrate the use of the T-test with an example. Ten students wrote a pretest on statistical concepts at the beginning of the semester with scores of 12, 25, 30, 38, 40, 52, 60, 65, 70, and 78 (maximum 100 points). After completing the semester, the same group wrote a post-test with scores of 50, 60, 70, 85, 70, 77, 90, 92, 85, and 100.

Evaluate the knowledge improvement after the semester using a T-test and the PAST statistical program.

Results of the T-test:

1. Testing data for normality, $\alpha = 0{,}05$, "p" – calculated value.
2. Normality condition of the data: $p > \alpha$ (Rudolf, 2021).



	A	B	C
1		12	50
2		25	60
3		30	70
4		38	85
5		40	70
6		52	77
7		60	90
8		65	92
9		70	85
10		78	100
11		pretest	posttest
12			
13			
14			
15			
16			
17			
18			
19			
20			

	B	C
N	10	10
Shapiro-Wilk W	0,9704	0,9658
p(normal)	0,8947	0,8493
Anderson-Darling A	0,1711	0,2119
p(normal)	0,903	0,7994
p(Monte Carlo)	0,9329	0,8322
Lilliefors L	0,128	0,1767
p(normal)	0,9157	0,4979
p(Monte Carlo)	0,916	0,4954
Jarque-Bera JB	0,5717	0,5259
p(normal)	0,7514	0,7688
p(Monte Carlo)	0,6114	0,6524

Figure 4. Pretest and Posttest Score Input and Normality Results

Verification of educational data for normality in PAST software:

1. Normality testing, $\alpha = 0.05$, "p" – calculated value.
2. Normality condition: $p > \alpha$.

Shapiro Wilk W, see Figure 4:

$0.8947 > 0.05$, $0.8493 > 0.05$ normality is satisfied for both data categories.

Anderson Darling A, see Figure 4:

$0.903 > 0.05$, $0.7994 > 0.05$ normality is satisfied for both categories.

PAST program using the T-test method:

1. If $p > \alpha$, the alternative hypothesis H1 is rejected.
2. If $p < \alpha$, the null hypothesis H0 is rejected.

Hypotheses as can be seen in Figure 5:

1. H1: $p < \alpha$, statistically significant paired differences exist between pretest and posttest scores.
2. H0: $p > \alpha$ No statistically significant paired differences exist between pretest and posttest scores at $\alpha = 0.05$.

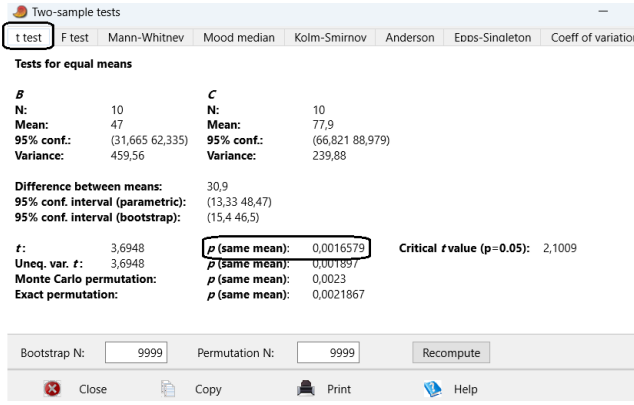


Figure 5. Calculated "p" value for the T-test

Conclusion of the T-test:

$\alpha = 0.05$, $p = 0.0016579$, Since $p < \alpha$, we reject the null hypothesis H_0. Based on the results of the T-test, we can confirm that there are significant paired differences, indicating an improvement in students' knowledge. For example, this could be related to the introduction of new teaching methods.

Use of Regression and Correlation Analysis in Pedagogical Research with the Support of the PAST Statistical

We will use the same example from the previous chapter and apply regression and correlation analysis with the support of the PAST software as can be seen in Fig. 6. Ten students took a pretest at the beginning of the semester on statistical terms, scoring 12, 25, 30, 38, 40, 52, 60, 65, 70, and 78 (with a maximum score of 100). After completing the semester, the same group took a posttest with scores of 50, 60, 70, 85, 70, 77, 90, 92, 85, and 100. Evaluate the effectiveness of their knowledge after the semester (Rudolf, 2021).

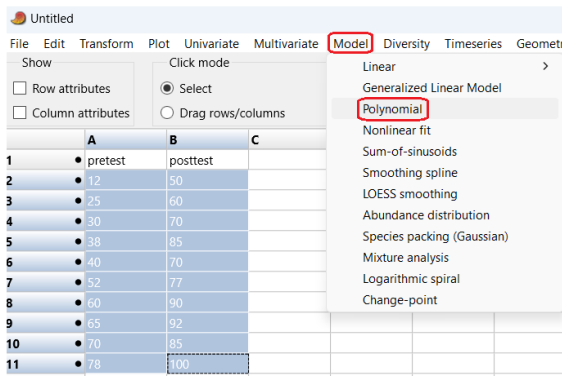


Figure 6. Loading pretest and posttest scores and selecting the function

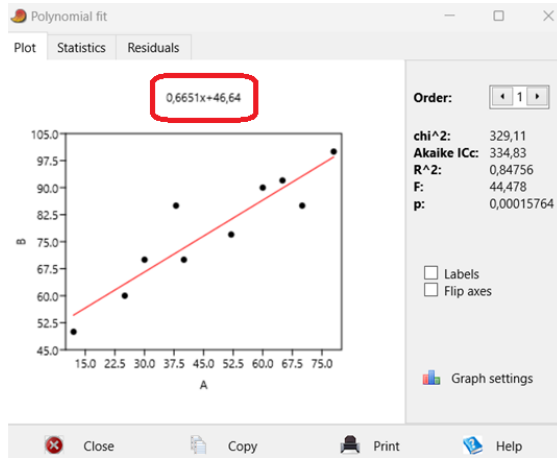


Figure 7. The displayed linear function of the regression analysis

Based on the representation of the linear regression function in the form of a first-degree polynomial, it can be observed that the points are distanced from the line (see Figure 7). This indicates an increase in students' knowledge and scores in the post-test compared to the pre-test. If the points were on the line, knowledge would remain unchanged, and the relationship would follow the function of the line not passing through the origin ($y = 0.6651x + 46.64$). However, the correlation coefficient result shows a high dependency between pre-test and post-test scores (see Figure 8), reflecting changes before and after the event (Andel, 2019).

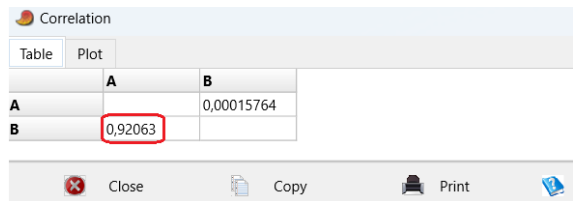


Figure 8. The correlation coefficient of the dependence between pretest and posttest scores

Analysis of results

The analysis of results using selected statistical methods such as ANOVA, t-test, and regression and correlation analysis in educational research provides key conclusions about the relationships between variables and the effectiveness of teaching methods. ANOVA is used to compare the means of multiple groups to determine if statistically significant differences exist. T-tests examine the differences between two groups, often applied in evaluating intervention programs. Regression and correlation analyses reveal relationships between independent and

dependent variables, offering valuable insights for educational decision-making. The findings underscore the importance of using statistical methods for drawing informed conclusions.

Conclusion

Statistical methods such as ANOVA, T-tests, regression, and correlation analysis play a critical role in educational research for analyzing and interpreting data within educational environments. ANOVA compares multiple groups, while the T-test focuses on differences between two groups. Regression and correlation analysis provide insight into relationships between variables. These methods are explained with examples from educational practice. Selected methods ensure objective and scientifically supported results, which can lead to improvements in educational strategies and interventions within pedagogical research.

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