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All learning paths lead to knowledge

This special issue is published under the patronage of Roman Hrmo and Lucia Kristofiakova. Its goal is an exchange of relevant trends, research results and hands-on experience within engineering pedagogy.

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Engineering Pedagogy

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Editorial

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This special issue of R&E-SOURCE, entitled "All Learning Paths Lead to Knowledge", has been prepared under the editorial guidance of Roman Hrmo and Lucia Krištofiaková, both affiliated with DTI University. The aim of this issue is to present and disseminate current trends, research findings, and practical perspectives in engineering pedagogy, thereby contributing to the ongoing development of educational theory and practice in technical disciplines. To effectively fulfil their professional roles, encompassing teaching, training, and the comprehensive development of learners, educators must possess a solid command of their subject matter, appropriate pedagogical preparation, and a broad base of general knowledge. In this context, the Internationale Gesellschaft für Ingenieurpädagogik (International Society for Engineering Education – IGIP) plays an important role in advancing and institutionalising engineering pedagogy. IGIP was founded in 1972 at the University of Klagenfurt by Professor Adolf Melezinek. The establishment of engineering pedagogy as a distinct academic discipline represented a significant milestone, as it introduced the first systematic scientific integration of engineering sciences and pedagogical theory. Already in the 1970s, questions related to European integration in education and the development of standardised profiles for educators were recognised as key priorities in teaching, training, and learning. Engineering pedagogy has since developed into an interdisciplinary scientific field, combining insights from pedagogy, psychology, and the technical sciences to improve the effectiveness and quality of education in technical domains. The central focus of engineering pedagogy is the body of knowledge required to prepare educators responsible for teaching future engineers in technical disciplines. In this regard, IGIP actively supports scientific research and coordinates and promotes international cooperation and initiatives in engineering education. The contributions included in this special issue address a broad range of topics related to contemporary challenges and developments in engineering and technical education. These include teacher education, engineering education, emerging trends in subject didactics, accreditation processes, curriculum development, quality assurance in education, technical teacher training, key competencies, the integration of social sciences into engineering education, information and communication technologies in education, talent development, lifelong learning, as well as problem situations and challenges in educational practice.

The editors would like to express their sincere appreciation to Mgr. Andrea Fedorová for the careful language proofreading of this special issue.

Roman Hrmo and Lucia Krištofiaková

R&E SOURCE

Vol. 13 (2026), Special Issue 1: Engineering Pedagogy
All learning paths lead to knowledge

Digitalisation and AI Tools in the Hands of Teachers

Challenges and opportunities for 21st Century Education

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Abstract

Digitalisation has become an important and increasingly indispensable component of education worldwide, including Slovakia. The labour market is undergoing transformations in this domain as well, creating conditions for the future workforce to engage with digital technologies and artificial intelligence tools. Its significance has been reflected not only in one aspect of the implementation of the new curriculum but also in the need to provide teacher education in this field. For example, positions such as School Digital Coordinators and Regional Teacher Support Centres have been established, with a thematic focus on digitalisation. Numerous other educational institutions and universities have also initiated various training programmes in this area, further demonstrating the significance of integrating innovations and digitalisation into schools. The aim of this paper is to present primary school teachers' perspectives on the use of digital technologies and artificial intelligence in education, to assess the extent of their utilisation, and highlight their importance in 21st-century education.

Keywords: Digital Technologies, Artificial Intelligence, Digitalisation

1 Digital World

The digital economy represents a concept that emphasises the penetration of information and communication technologies into production sectors and subsequently into the entire society, thus forming a digital society. The implementation of digitalisation in the economic sphere aims to strengthen the competitiveness of the economy, both at the micro level, i.e., the competitiveness of individual companies that introduce digital elements, and at the macro

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level, i.e., national or international competitiveness. Achieving comprehensive digitalisation of the economy will not be sufficient with only local initiatives of individual entrepreneurs; it will be necessary to coordinate and support this process at the national level (Veber et al., 2018, p. 13).

Governments of developed countries realise that digitalisation is a key phenomenon of the present and one of the fastest-growing segments of the economy. Although we are probably only at the beginning of the digitalisation era, it is clear that leaving this segment solely to market forces is not sufficient. A certain degree of intervention by state authorities is not only useful but also necessary, especially in the following areas:

- Cybersecurity and data protection, especially personal data,
- Facilitation of digital interactions, interoperability, and data portability (communication protocols),
- Integration of digitalisation into public administration (e-government),
- Adjustments to the legal framework (regulations and deregulations) resulting from digitalisation (including the shared economy, etc.),
- Changes in the content of education in the school system and in informal education (requalification, lifelong learning),
- Public support for projects focused on the digital economy and support for research (Veber et al., 2018, p. 22).

Digitalisation will likely significantly affect the labour market. Employment, its growth, and changes in its structure have always been influenced by the needs of employers, the development of the economic cycle, and various structural changes within the economy and individual sectors. In addition to these key factors, there are many others that affect the unemployment rate, such as demographic development, migration for work abroad, the level of the education and requalification system, and the generosity of the social network (Veber et al., 2018, p. 82).

Shapiro (2019, p. 15) in the publication titled New Childhood, translated in 2020, describes views on digitalisation from various perspectives. He states that among the many concerns of parents, teachers, and educators are worries that digital games damage eyesight, harm the brain, cause obesity, depression, and more. He also mentions many questions focused, for example, on whether the speed and ease of communication prevent children from being good conversational partners, or whether the development of critical thinking is hindered by simple and always available interactive stimulation, and others. The author's simple answer is – no.

1.2 Digital School

Despite the increasing and more effective use of information and communication technologies (ICT) by teachers, a significant proportion of educators still lack the necessary skills and confidence to integrate these tools into their teaching. Many of them gradually feel the need to develop their competencies in this area. Those who want to move from simple texts and presentations to various interactive tools also show interest in education (Bobot et al., 2012, p. 4).

The authors further state that: 'Information technologies are constantly evolving. They are a common means of communication for students, as well as a tool for processing information. They are becoming established in families and public life. It is up to the teachers how effectively they can use this advantage' (Bobot et al., 2012, p. 23).

According to Burgerová (2003, p. 12), it should not be forgotten that education is the beginning of all transformations. One of the tasks of the school is to ensure access to information technologies and their use for all students. This includes professional training, acquiring general competencies in the field of information technologies, and improving communication skills, thus preparing the upcoming generation for ongoing changes. Ignoring global trends in education would further deepen the existing differences between countries. Information and communication technologies create an environment that simplifies various activities and transactions.

The state educational programme defines the general objectives of schools and the key competencies necessary for the balanced development of students' personalities. This matter is addressed by numerous prominent institutions, such as OECD, UNESCO, ISTE, ATC21, Partnership for 21st Century Skills, and others (e.g., UNESCO, 2011 or Binkley, 2010). These institutions often come up with their own views and classifications. For example, according to ISTE (International Society for Technology in Education, 2007), the following competencies are important for effective learning and a productive life of young people in a digital society:

1. Creativity and innovation: creating original works, expressing and testing hypotheses, for example, using models and simulations.
2. Communication and collaboration: the ability to work in teams, develop intercultural understanding, and present information in various ways according to the audience.
3. Research and information fluency: planning research, searching, organizing, and evaluating various sources and processing them for research purposes.
4. Critical thinking, problem-solving, and decision-making: responsibly identifying problems and questions related to task-solving, collecting necessary data, making qualified and ethical decisions, and analysing them.
5. Digital citizenship and lifelong learning commitment: a positive attitude towards technology in collaboration, creation, and learning, safe, legal, and ethical use of information and technologies, and personal responsibility for one's own learning.
6. Effective use of technology (Kalaš et al., 2013, p. 103).

1.2 Quality and Education

The only way to maintain the competitiveness of states in the current world and thus ensure the prosperity of citizens is through innovation and quality. The condition for ensuring permanent innovations of higher quality services and products is quality education (Turek, 2015, p. 46). Most experts, including politicians, sociologists, economists, and other science experts, agree that the future of humanity and the nations of all states depend on the quality of education, which also applies to the teaching process (Turek, 2015, p. 47).

The current trend in education is mobile learning, which uses mobile devices to carry out various interesting and interactive learning activities in different environments, such as nature, museums, or trips. This approach focuses on integrating modern technologies, which are close and attractive to young people, into the educational process. The informatization of education includes the incorporation of digital technologies into the educational process of children, pupils, and students, thus supporting their comprehensive development in all developmental areas. This process contributes to the development of skills needed for the 21st century and to achieving various educational goals (Kalaš et al., 2013, p. 29).

In connection with the development of computer networks, especially the internet and mobile technologies, one of the basic advantages is unlimited access to information, knowledge, or education. Studying and learning using online technologies is possible anywhere and anytime. This is related to the possibility of individualization and flexibility, as well as many other advantages for the student (Zounek et al., 2021, p. 236).

2 Education in the 21st Century

In connection with the ever-increasing need for knowledge in working with digital technologies and the influence of artificial intelligence, it can be said that these aspects need to be considered in the education of pupils and students. Many of them are already using or beginning to use and explore these digital tools.

This trend will become increasingly prominent, and the skills associated with their use will be required from future graduates in the labour market, for which they need to be prepared. This task also falls on the 'shoulders' of schools and teachers. Many schools today already have school digital coordinators, whose tasks include ensuring the flow of innovations related to digitalisation into the schools, as well as educating the teaching and professional staff in this area. However, a challenge may be the willingness to accept the importance of digital tools and artificial intelligence tools in education, as it often raises various questions about their appropriateness, caused by the abundance of information sources, diversity of views, and different generations looking at them. Just as there is a diversity of opinions, there is also a variation in the level of equipment in schools or the skills of teachers.

The aim of our research is therefore to present the views of schoolteachers on digital tools and artificial intelligence tools in the educational process of schools in the Nitra region and to indicate the extent of their knowledge, which is also reflected in their use in schools.

2.1 Research Objective and Methods Used

The main objective of the research was to determine the experiences of teaching and professional staff in schools related to the use of artificial intelligence tools in practice. A secondary objective was to ascertain their views on the opportunities that artificial intelligence tools bring to their practice, as well as to identify any concerns they have regarding their use in education. The research sample consisted of 106 participants from ten schools in the Nitra region of Slovakia.

Research methods used:

- Analysis and synthesis,
- Questionnaire method,
- Mathematical-statistical method,
- Deduction.

2.2 Research Questions and Hypotheses

Key Question:

- What are the experiences and opinions of teaching and professional staff in schools regarding the use of artificial intelligence tools in practice, and what opportunities and concerns do they identify?

Research Questions:

- What experiences do the research participants have with using digital tools and artificial intelligence tools in practice?
- What opportunities do artificial intelligence tools bring to teaching practice according to their opinions?
- What is the level of interest among research participants in using artificial intelligence tools?
- What concerns do the research participants have regarding the use of artificial intelligence tools in education?

Research Hypotheses:

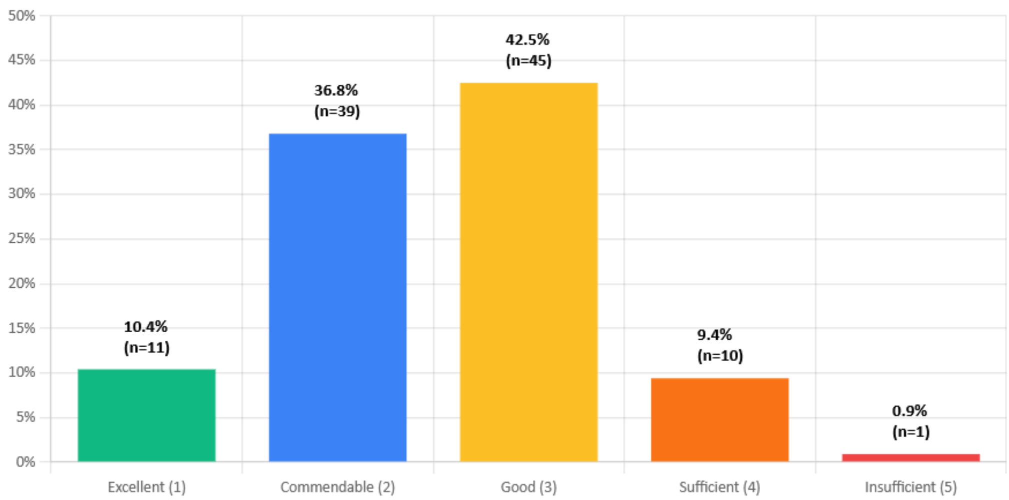
- H1: More than half (50%) of the research participants have experience using artificial intelligence tools.
- H2: The most of research participants can envision using digital tools and artificial intelligence in their work.
- H3: The greatest interest among research participants is associated with the use of artificial intelligence tools.
- H4: Less than half (50%) of the research participants have a negative opinion on the use of artificial intelligence tools.

Assumptions:

- We assume that at least 50% of the participants already have some experience with using artificial intelligence tools.
- We assume that the majority of research participants will perceive the opportunities brought by artificial intelligence tools positively for their practice.
- We assume that the greatest interest among research participants will be associated with the use of artificial intelligence tools.
- We assume that less than 50% of the research participants will have a negative opinion on the use of artificial intelligence tools.

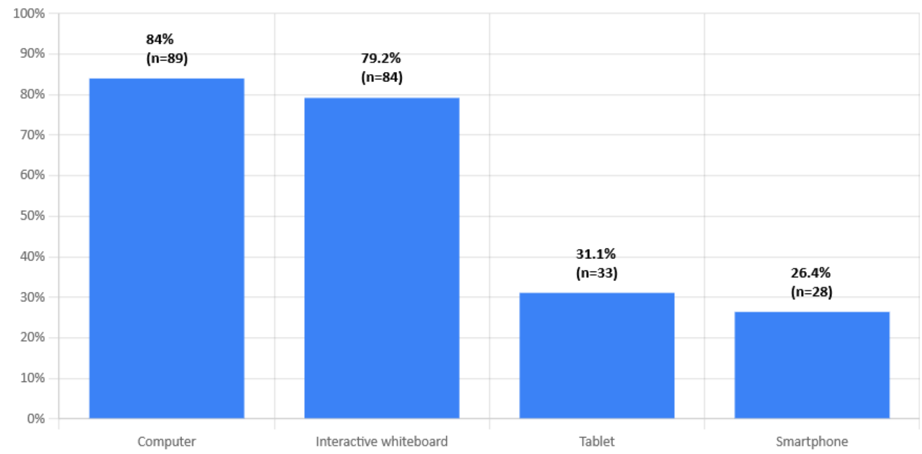
3 Research Results

The first item of the online questionnaire aimed to determine the participants' level of skills in using digital technologies, where 42.5% of participants rated their skills at level three (good). The second largest group is 36.8% of participants who rated themselves with a grade of two (commendable). Almost the same number of participants rated themselves with a grade of excellent – 10.4% of participants, and a grade of four – sufficient, 9.4% of participants. Only one participant, i.e., 0.9%, rated themselves with a grade of five (insufficient).



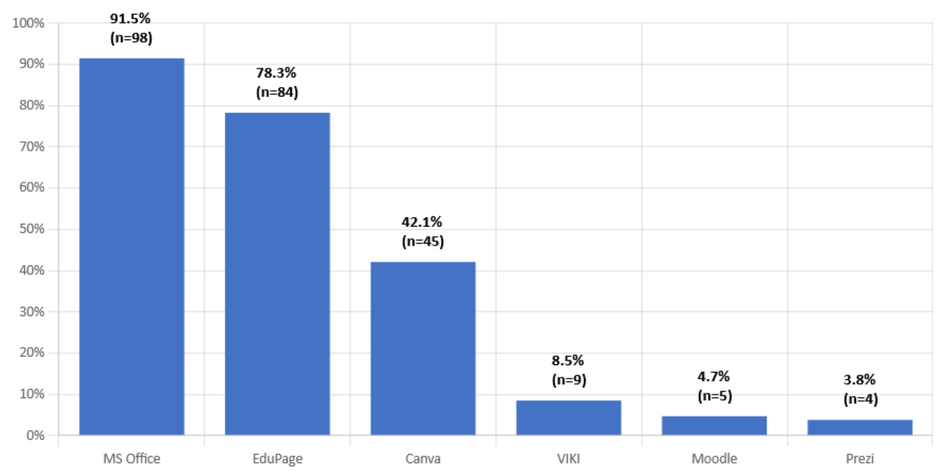
Graph 1: How do you rate your level of skills in using digital technologies?

The aim of the following questionnaire item was to find out which digital devices participants commonly use in teaching. The two most used digital devices identified by the research participants were computers (84%) and interactive whiteboards (79.2%). Tablets were identified by 33 participants, representing 31.1% of participants. Smartphones were the fourth digital device, identified by 26.4% of participants. Projectors, visualisers, interactive floors, and Lego robots each appeared once (0.9%) among the responses.



Graph 2: How do you rate your level of skills in using digital technologies?

For lesson preparation, participants most frequently use MS Office (PowerPoint, Word, Excel), with 97 responses, representing 91.5%. EduPage is used by 78.3% of the research participants, and the third most used platform is Canva (42.1%) and the information and educational platform VIKI, used by 8.5% of participants. Moodle is used by 4.7% of participants, and Prezi by 3.8%. Each of the following was mentioned once (0.9%): Wordwall, Mentimeter, Padlet, Learningapps, Zborovňa, Kahoot, YouTube, ChatGPT, websites, and the response 'I do not use any.' From these responses, it can be inferred that the most of participants use common tools and school applications. Less known and used are platforms and applications that are not commonly used or required in school practice.

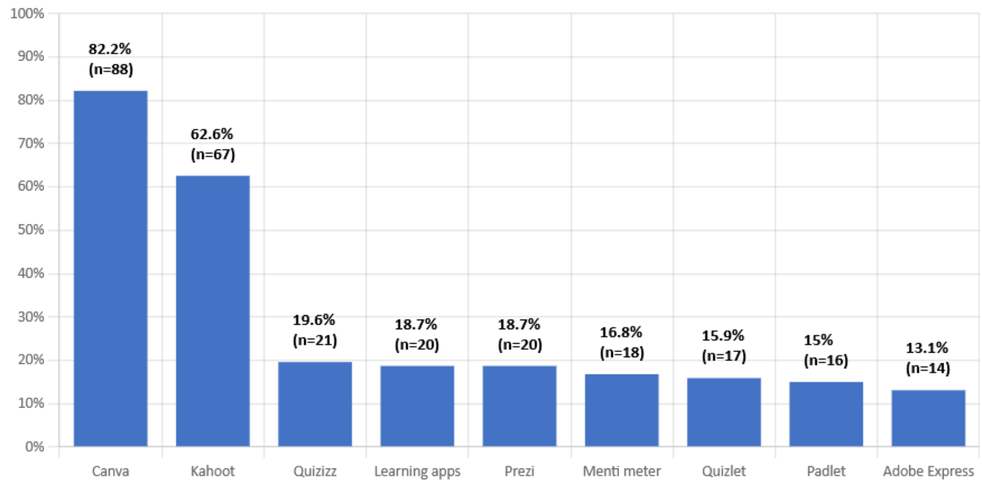


Graph 3: What digital applications or programmes do you use for lesson preparation?

The fourth item of the online questionnaire concerned whether participants were familiar with any of the listed digital tools. The most of research participants responded that they knew Canva (82.2%) and Kahoot for creating quizzes, with 67 participants, representing 62.6%. Twenty-one participants – 19.6% of responses – knew the Quizizz (now Wayground) platform. Similarly, 18.7% of participants identified the Learningapps platform and the Prezi programme. Mentimeter was known by 16.8% of participants.

A tool similar to Kahoot and Quizizz is Quizlet, known by 15.9% of participants. Padlet was known by 15% of participants and Adobe Express apps by 13.1%. Among the less known tools is the Actionbound platform, known by 2.8% of participants, and tools for creating simple websites for students. The most well-known of these is the Blogger application, known by four (3.7%) participants of the research sample, followed by G sites at 1.9% and Studenthosting at 0.9%.

The platform for creating animated videos, Videoscribe, was known by 6.5% of participants. Tools that were not identified include Plickers, Drilleo, Miro, and Figma, which are mainly used for assessment and collaboration.

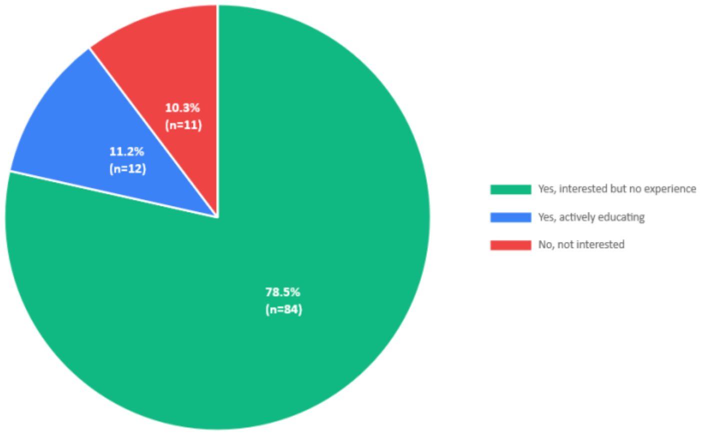


Graph 4: Are you familiar with any of the listed digital tools?

In the next questionnaire item, our goal was to determine the participants' interest in advanced technologies such as artificial intelligence, data analysis, or machine learning.

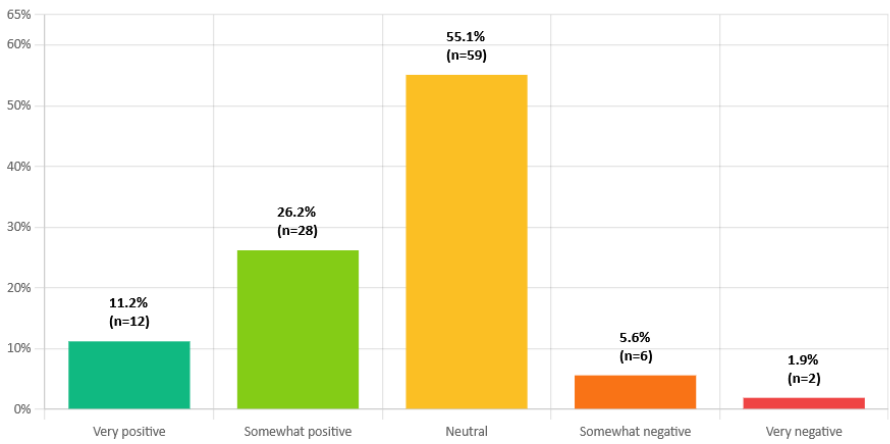
The most responses were recorded at the level of 'yes, I am interested, but I have no experience yet,' which was indicated by 78.5% of participants, representing 84 out of the total number of participants. Twelve participants, i.e., 11.2%, are actively educating themselves. However, 10.3% of participants are not interested.

Based on these results, it can be seen that the majority of teaching and professional staff in schools show interest in this area but do not yet have any experience.



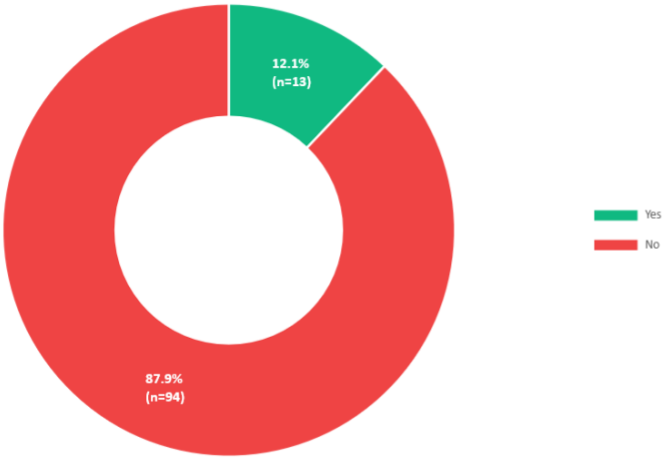
Graph 5: Are you interested in advanced technologies such as artificial intelligence, machine learning, or data analysis?

The aim of the next item in the online questionnaire was to determine opinions on the use of artificial intelligence tools in education. We consider this finding to be a significant source of information to motivate future use of artificial intelligence tools. The largest portion of research participants - 55.1% have a neutral opinion on the use of artificial intelligence tools in education. A somewhat positive opinion is held by 26.2% of participants. Twelve participants, or 11.2%, expressed a very positive opinion. A somewhat negative opinion is held by 5.6% of participants, and 1.9% have a very negative opinion. We consider these to be positive results, indicating that most participants are open to using artificial intelligence tools in education.



Graph 6: What is your current opinion on the use of artificial intelligence tools in education?

The seventh item we examined aimed to determine whether the research participants already have any experience using artificial intelligence tools in the educational process. To this question, 94 participants, or 87.9%, responded that they do not. Only 12.1% of them already have experience using these tools. This result may be caused by various aspects but suggests the need for educating the research participants in working with these tools so that they can use digital tools and artificial intelligence tools in their practice and have sufficient knowledge about these tools, which are currently becoming known to young people and thus also to school students. This result is also related to the participants' responses and the results shown in graphic representation no. 5, where the majority of participants expressed that they have no experience in this area.



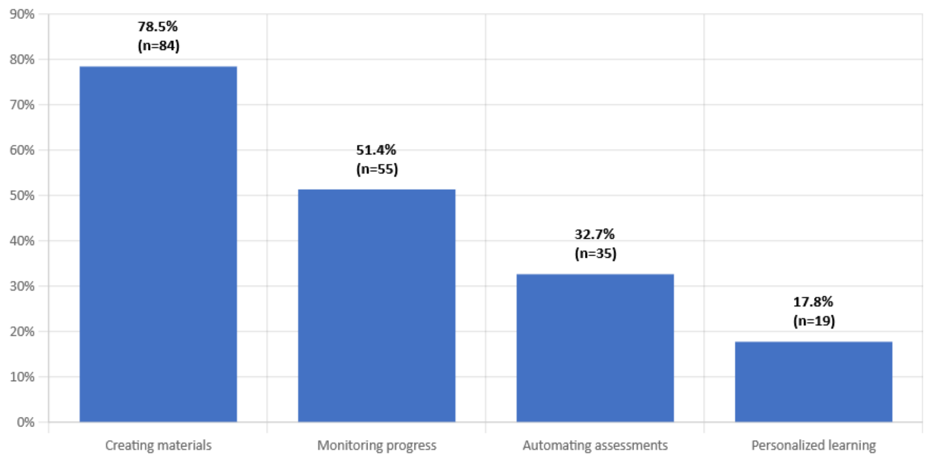
Graph 7: Do you have experience using artificial intelligence tools in education?

In an open-ended questionnaire item, we investigated which specific artificial intelligence tools participants use. Seven participants mentioned ChatGPT. The online graphic design tool Canva was mentioned three times. The following tools were each mentioned once: Padlet, D-ID, Copilot, Wocabee, and Google applications.

The aim of gathering additional data was to understand how participants think artificial intelligence could improve the teaching process or support them in their work. Participants had the option to select multiple possibilities where they believe artificial intelligence could be helpful. Creating teaching materials was selected by 78.5% of participants. The second most common response was monitoring student progress using artificial intelligence tools, mentioned by 51.4% of participants.

32.7% of participants believe that artificial intelligence could help with automating assessments, and 17.8% see the improvement of the teaching process in the possibility of personalized learning. One participant, representing 0.9%, mentioned using AI as a source of inspiration for teaching and other activities and facilitating lesson preparation. Another 0.9% of participants indicated that they do not know or see any way AI could help.

These results indicate that research participants perceive the potential for improving activities through the use of artificial intelligence tools in their practice.

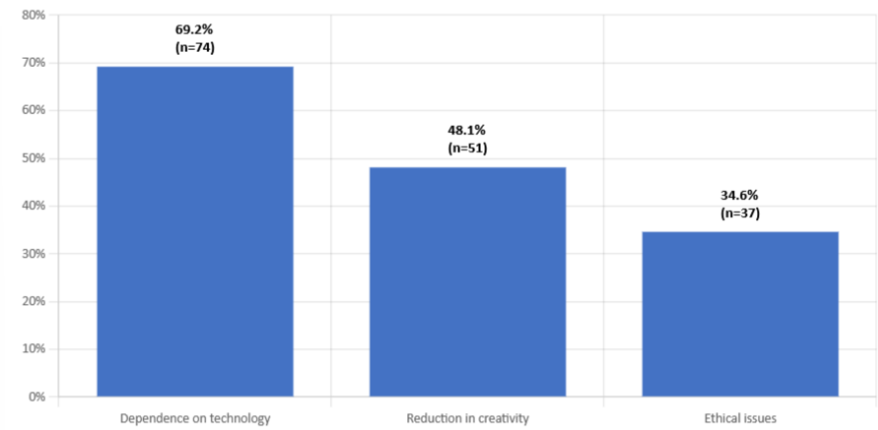


Graph 8: How do you think artificial intelligence could improve the teaching process or support you in your work?

What challenges or risks associated with the use of artificial intelligence tools in education do research participants see? Most participants consider the risk of students becoming dependent on technology, which was indicated by 69.2% of participants. A reduction in the creative elements of teaching is seen as a risk by 48.1% of them. Ethical issues were marked by 34.6% of responses.

One percent of participants see the following challenges and risks: students will only play and experiment through trial and error, excessive reliance on the accuracy of results achieved using AI, loss of attention when using AI, critical approach to the results offered by AI, misuse and completion of assignments by artificial intelligence.

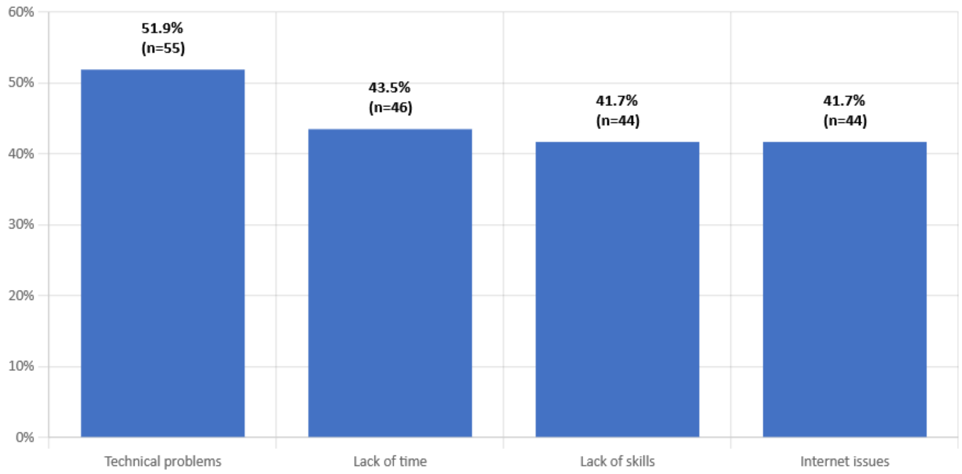
Awareness of the challenges and risks associated with the use of artificial intelligence in education is important for the proper handling of AI tools and preventing negative phenomena associated with it.



Graph 9: Do you see any challenges or risks associated with the use of artificial intelligence in education?

In the following item of the questionnaire, we asked our research participants about the challenges or problems they most frequently face when using digital technologies in teaching. More than half (51.9%) reported technical problems with devices. The second most common issue, according to 43.5% of participants, is the lack of time to prepare materials. An equal number, i.e., 41.7% of participants, expressed challenges or problems related to a lack of technical skills and internet connectivity.

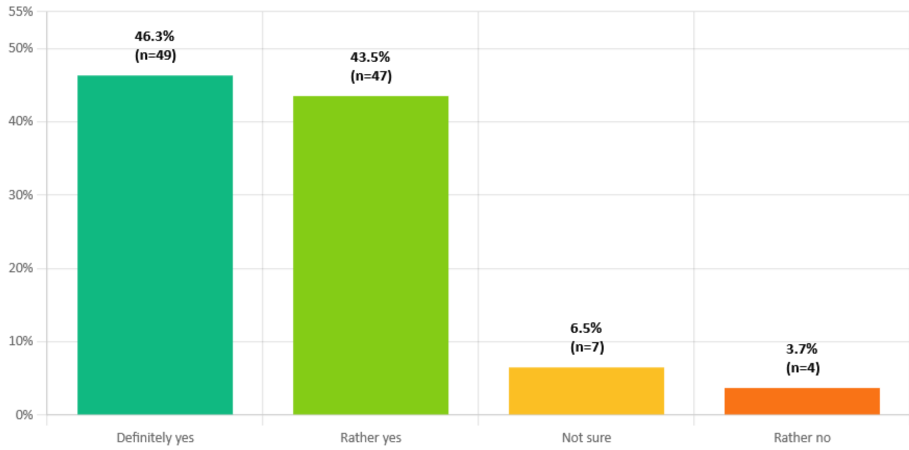
The participants' responses reflect the situation in schools, where technical equipment often does not meet today's needs and these devices do not provide sufficient reliability in their use.



Graph 10: What challenges or problems do you most frequently face when using digital technologies in teaching?

One of the most significant findings is whether the research participants would like or can imagine using digital tools and artificial intelligence tools in their work. A very positive finding is that the largest portion of participants can imagine their use and would definitely like to use them, which is as high as 46.3%. Another positive result is the second most frequent answer – rather yes, which was indicated by 47 participants, representing 43.5% of responses.

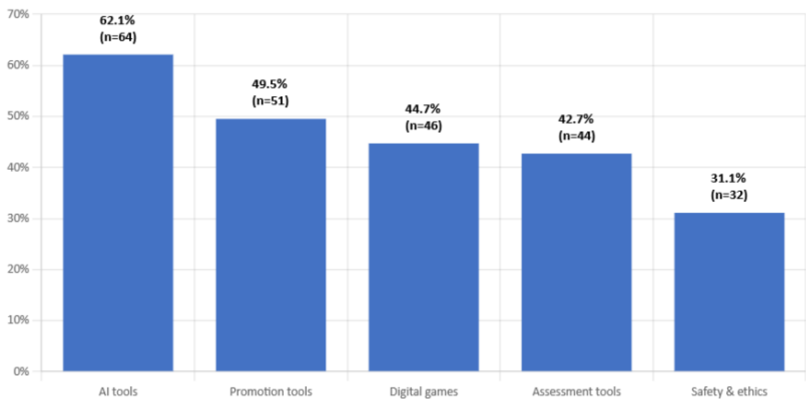
6.5% of them are still unsure, and 3.7% of participants marked rather no. We did not record any responses in the definitely not option, which also contributes to the positive outcome of our findings.



Graph 11: Would you like to use, or can you imagine using digital tools and artificial intelligence tools in your work?

In the last item of the questionnaire, we tried to find out from the participants which area they would like to better understand or learn to use if they want to use these tools. Participants had the option to select multiple choices. Artificial intelligence tools, including tools for generating images, design, presentations, text content, and conversations, tools for lesson planning, creating educational materials and worksheets, creating musical content, or improving a foreign language, were the most frequently selected response by the research participants, at 62.1%. Tools for promotion and presentation and creating simple websites, such as Canva, Prezi, Adobe Express applications, Webnode, and similar, were selected 51 times, which is 49.5%. Tools for creating simple digital games in education received 44.7% of the selections.

Digital tools for assessment, feedback, and creating quizzes were marked by 42.7% of respondents. In the area of safety and ethical behavior in the online space, 31.1% of participants expressed an interest in gaining knowledge and skills.



Graph 12: If yes, which area of digital tools or artificial intelligence tools would you like to better understand or learn to use?

4 Discussion and Conclusion

Based on the research conducted, it is possible to confirm three out of the four hypotheses we formulated, along with their associated assumptions. A pleasing finding for us is that 78.5% of the research participants are interested in advanced technologies such as data analysis, artificial intelligence, or machine learning, despite having no prior experience with them. We consider it positive that only 7.5% of the research participants have a view on the use of artificial intelligence tools that is worse than neutral. The first hypothesis was rejected because more than 50% of participants, specifically 87.9%, have no experience with using artificial intelligence tools. Among the opportunities that artificial intelligence presents for their work, participants most frequently perceive the possibility of easing their work in creating teaching materials or tracking student progress.

A good result is that only 0.9% of participants do not see any opportunities for simplifying work with artificial intelligence tools. The biggest concern among the research participants is the dependence on technology, which is a natural concern associated with the use of digital technologies by children and young people. The second hypothesis, which was confirmed based on the research results, is that the majority of research participants, specifically 89.8%, can imagine or would like to use digital tools and artificial intelligence tools in their work. This result indicates that the research participants recognize the importance and impact of technology on life today. Hypothesis No. 3: the greatest interest among research participants is associated with the use of artificial intelligence tools, can be confirmed. Among the offered areas of digital tools, participants most frequently indicated their interest in mastering and using artificial intelligence tools.

Digital technologies have become a part of people's lives. Therefore, it is necessary to discuss their impact and the opportunities they offer not only for a person's professional life but also for education. For schools to offer quality education, it is necessary to reflect on this area, which is increasingly coming to the forefront and is currently a highly discussed topic. Although artificial intelligence is not a new concept, its tools have recently become widely available to ordinary users, and this trend will continue. We believe that intensive education of schoolteachers and professional staff is very necessary for their proper use and implementation into the teaching process.

We concur with the authors’ collective that digital literacy is, and will continue to be, an essential skill, forming part of the qualifications required for individuals seeking to succeed in the labour market and related domains. Therefore, in school education, even at the elementary level, subjects focused on mastering and using digital technologies will be essential. At the same time, a reasonable proportion of traditional teaching without digital tools should be maintained, and sufficient instruction should be provided to ensure mastery of the fundamental knowledge required for the standard operation and use of digital technologies (Veber et al., 2018, p. 97).

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Level of Creativity of Students in Study and Vocational Programmes at a Secondary School

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Abstract

This study addresses the level of creativity among students in secondary vocational education and training programmes. The topic remains highly relevant and is increasingly being incorporated into the educational process by teachers. The research focuses on students' creativity across various fields within these programmes, analysing differences and patterns in their creative abilities. Overall, the study examines the issue of creativity in adolescents within the context of vocational education.

Keywords: Verbal Creativity Study, Figurative Creativity, Study Program, Vocational Programme

1 Introduction

1.1 Research Topic

An effective teacher seeks strategies to facilitate students' long-term and efficient retention of knowledge. Accordingly, a variety of methods are employed to support the learning of subject matter. Teaching methods constitute a crucial component of the educational process, as they enable the effective transmission of relevant content to students. In the contemporary educational context, it is necessary to employ not only traditional methods, such as lectures and explanations, but also non-traditional approaches that encourage independent learning and problem-solving. These methods additionally foster the development of logical, analytical, and creative thinking skills. Zelina (1996) cites one of the foremost experts in the

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field of creativity, E. P. Torrance, who asserts that the development of students' creativity depends fundamentally on the presence of creative teachers.

This results from the conditions of the educational process and it is desirable to focus, concentrate attention on the development of the creative personality not only of the learner (educator), but to the same extent also of the teacher (educator), because progress in the education and training of students depends to a large extent and essentially, primarily, on the teacher's approach to teaching. At secondary vocational schools, students' education is primarily based on vocational subjects. This study examines the level of creativity among students in secondary vocational education and training programmes. The topic remains highly relevant and is increasingly being incorporated into the teaching process by educators. The research focuses on students' creativity across various fields within these programmes, comparing different areas of study. Overall, the study analyses the issue of creativity in adolescents within the context of vocational education. It focuses on comparing the achieved results of creativity in terms of variables, namely independent variables such as gender and the type of school the students attend. The dependent variables are creativity and its components – fluency, flexibility, originality and elaboration. This research can help to create a picture of the creativity of students in secondary vocational schools and compare the results.

1.2 Research Objectives

The main objective of the research is to determine whether there are differences in verbal and figurative creativity among secondary vocational school students in terms of major. The second objective is to determine whether there are differences between students in terms of gender.

1.3 Hypotheses

H1: We assume that there are statistically significant differences in verbal creativity among secondary vocational school students in terms of major.

H2: We assume that there are statistically significant differences in figurative creativity among secondary vocational school students in terms of major.

H3: We assume that there are statistically significant differences in verbal creativity among secondary vocational school students in terms of gender.

H4: We assume that there are statistically significant differences in figurative creativity among secondary vocational school students in terms of gender.

1.4 Method

To determine the level of figurative creativity of secondary vocational school students with the subsequent possibility of adequate interpretation of the obtained data, the standardised Torrance Figural Test of Creative Thinking – Circles (Jurčová, 1984) was used in the research.

The analytical intelligence test – the Sentence subtest was used to determine the level of verbal creativity (Svoboda, 1999). The test was accompanied by a questionnaire in which students were to fill in their gender, age and field of study.

1.5 Description of the Research Sample

The research is conceptualised as quantitative. It is carried out on a sample of 271 students of the study and vocational programmes attending the Secondary Vocational School of Business and Services in Nové Mesto nad Váhom. Study programme with a study duration of 4 and 5 years, hotel school – in this field, it is also possible to study in the dual education system. Study programmes with a study duration of 4 years – tourism services, business school, and salesperson. Vocational programmes with a study duration of 3 years, cook, hairdresser, joiner, car repairman – mechanic, car repairman – electrician. Postgraduate study with a study duration of 2 years – entrepreneurship in crafts and services. The research sample consisted of a total of 271 students in the study and vocational programmes. In the study programme, there were 47 men and 133 women (17.34% men and 49.08% women), and in the vocational programme, there were 59 men and 32 women (21.77 men and 11.81 women).
The average age of students in both fields was 17.4 years, of which 17.5 years for students of the study programme and 17 years for students of the vocational programme. The overall distribution of scores is in Table 2.

Complete/incomplete secondary school studies	Study programme		Vocational programme		Together
Gender	Men	Women	Men	Women	
Absolute abundance	47	133	59	32	271
Relative abundance	17,34	49,08	21,77	11,81	100

Table 1: Frequency distribution of the sample by field.

Age	15-16	17	18	19	20 and more	Together
Absolute number	76	67	62	47	19	271
Relative number	28,04	24,72	22,87	17,34	7,01	100

Table 2: Distribution of students by age category.

1.6 Instrument Used

To measure figurative creativity, the Torrance Figural Test of Creative Thinking (T-59) was used, which was standardised for our conditions by Marta Jurčová in 1984. In this test, a test with circles was used, where the test subjects had to draw 36 circles in any way so that they could create pictures. They could draw into the circles, between them, connect them, etc. Originality, fluency and flexibility of answers are assessed. Jurčová (1984) allows for the evaluation of elaboration in this task, but in this case, standard norms were followed, and this component of creativity was not assessed.
To measure verbal creativity, an analytical intelligence test was used, the sentence subtest, where the author is R. Meili. The test was developed in 1928 for the purposes of school and career counselling. The task of the respondents in the sentence subtest will be to create as many meaningful sentences as possible within a time limit of two minutes, with each sentence containing all the words selected for them. The words entered can be inflected and used in the plural and must be used as nouns. They cannot be used as verbs or adjectives. The sentences must be meaningful and express an idea.

1.7 Data Analysis

Data Collection
The research is conducted during the 2024/2025 school year at the Secondary Vocational School of Business and Services in Nové Mesto nad Váhom, during the classroom teaching. Respondents are informed in advance about the anonymity of the testing, and its content is explained to them. Examples are given to them so that the testing has the highest possible validity.

Data processing
Both creativity tests are evaluated according to the manuals. The Excel programme with the real-statistics statistical add-on is used for statistical data processing. We work with data such as the field of study, gender, level of verbal creativity and level of figurative creativity as variables. As part of the descriptive analysis of the research sample, we use descriptive statistics (absolute and relative frequency, standard deviation, arithmetic means, medians). We carry out verification of quantitative hypotheses.

2 Results – Statistical Evaluation of Verbal Creativity Results

We are interested in whether there would be significant differences between students of the vocational programmes and the study programmes in verbal creativity, where we use the

Sentence subtest. Representation of the frequency of individual respondents is divided into levels (below average, average and above average creativity).
H1: We assume that there are statistically significant differences in the mean value of verbal creativity between students at secondary vocational schools in terms of study field.

Verbal creativity	Below-average level of creativity	Average level of creativity	Above-average level of creativity	Together
Study programme	50	34	7	91
Vocational programme	37	104	39	180
TOTAL %	32.1%	50.9%	17.0%	100%

Table 3: Distribution of students according to their level of verbal creativity in terms of subject.

Representation of the frequency of individual students according to the level (below average, average, above average creativity) of verbal creativity, which is formed by the vocational and study programmes. We see that in both groups of students; it falls into the average range of verbal creativity (50.9%).

α=0.05	Average	Median	Modus	Standard deviation	Dispersion	D'Agostino-Pearson	F-test	T-test
Verbal creativity of study programmes	12.511	12	12	4.803	23.0669	0.1057	0.6581	0.0000
Verbal creativity of vocational programmes	8.286	8	4	4.603	21.1841	0.0731		

Table 4: Statistical differences in verbal creativity by field of study

The values of descriptive statistics are in the table – mean, median, mode, standard deviation and variance. We decided to use the d'Agostino-Pearson test to verify normality in the comparison. We could also use the Shapiro-Wilkow test, which, however, is extremely sensitive to even small deviations from normality in larger samples over 50, which can lead to rejection of the hypothesis of a normal distribution. d'Agostino–Pearson is more robust in larger samples because it combines tests for skewness and kurtosis. Since the value of the d'Agostino-Pearson test of normality is greater than the chosen significance level α=0.05 in both samples, the distribution can be considered normal. The course can be seen in the rank-sum graphs.

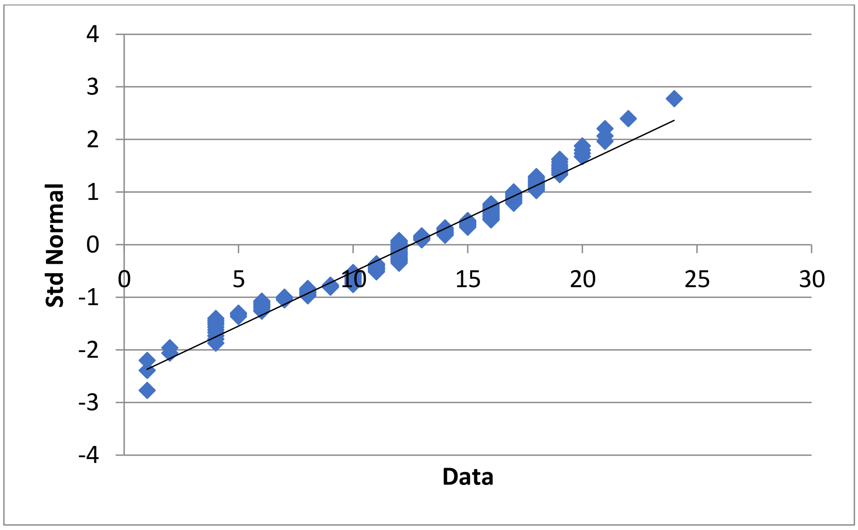


Chart 1: Rankite chart verbal creativity of study programmes.

The core of the data is fairly normal. The lower tail on the left contains values that are below the line, meaning more extremely low values. The upper tail on the right contains values that are above the line, but less significantly than the lower tail.

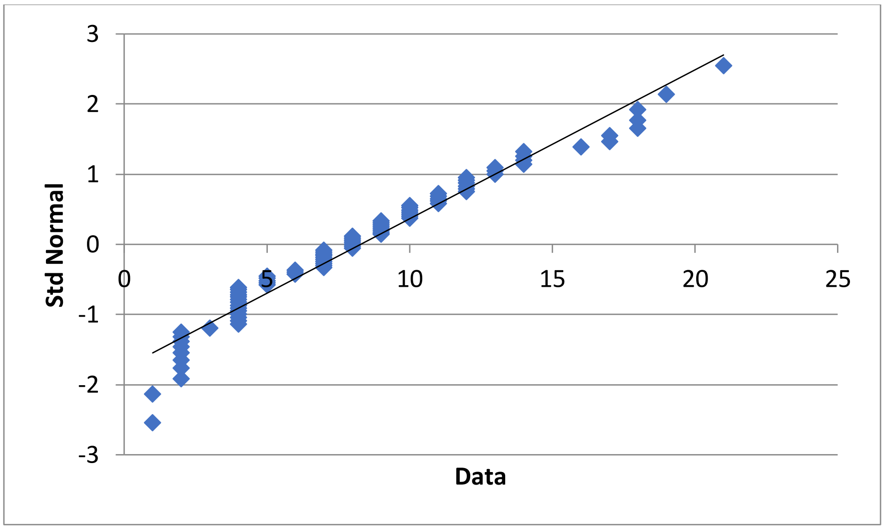


Chart 2: Rankite chart verbal creativity of vocational programmes.

The data deviate more from normality, especially in the lower tail, which can also be seen in the smaller p-value of the d'Agostino-Pearson test. However, this is not a problem because the t-test is very robust to possible deviations from normality, especially if the variance ratio is less than 2. In our case, it is only 1.08, which can be calculated from the variance values given in the table.
Since the t-test for independent samples has two alternatives, with equality or inequality of variances, we also tested the difference in variances. Since the p-value of the F-test is greater than the selected significance level α=0.05, we consider the variances to be equal.

Since the probability value of the t-test is less than the significance level p (0.0000) < α (0.05), we conclude that there is a statistically significant difference in average verbal creativity between the study and vocational programmes. The study programmes achieved a significantly higher average score.

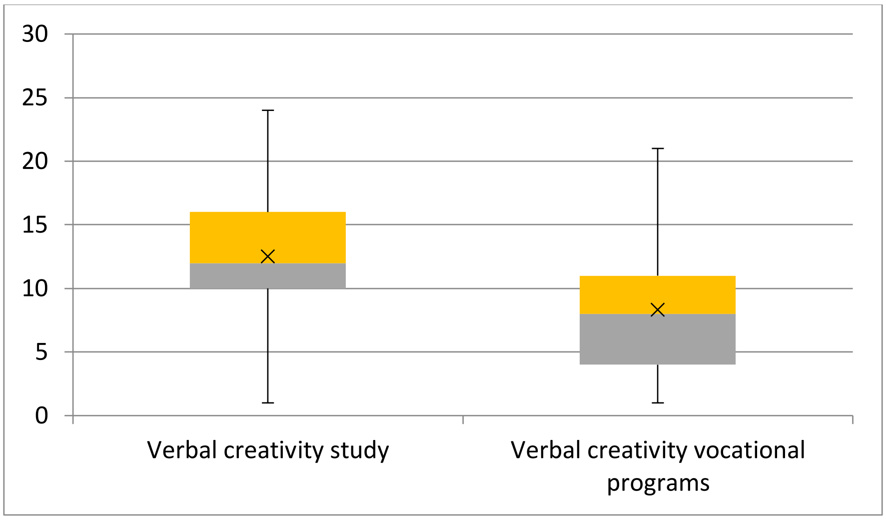


Chart 3 Box plot verbal creativity study and vocational programmes

The lines represent the minimum and maximum values. The crosses represent the averages. The coloured boundaries of the boxes represent the medians. The bottoms of the boxes are the lower quartiles, and the tops of the boxes are the upper quartiles. It can be seen that the study programmes achieved higher scores and the result is statistically significant. Hypothesis *H1 was confirmed.*

H2: We assume that there are statistically significant differences in the mean value of figurative creativity among secondary vocational school students in terms of field.

α=0.05	Average	Bedian	Modus	Standard deviation	Dispersion	D'Agostino-Pearson	F-test	T-test
Figural creativity of study programmes	31.28	31	30	13.524	182.892	0.7975	0.0080	0.0003
Figural creativity of vocational programmes	25.879	25	24	10.506	110.374	0.2774		

Table 5: Statistical differences in figurative creativity in terms of field.

Normality is in order because the p-values of the d'Agostino-Pearson test are greater than the significance level α=0.05. Evidence is also seen in the rank-sum plots, where the points almost perfectly follow the line of the standardised normal distribution.

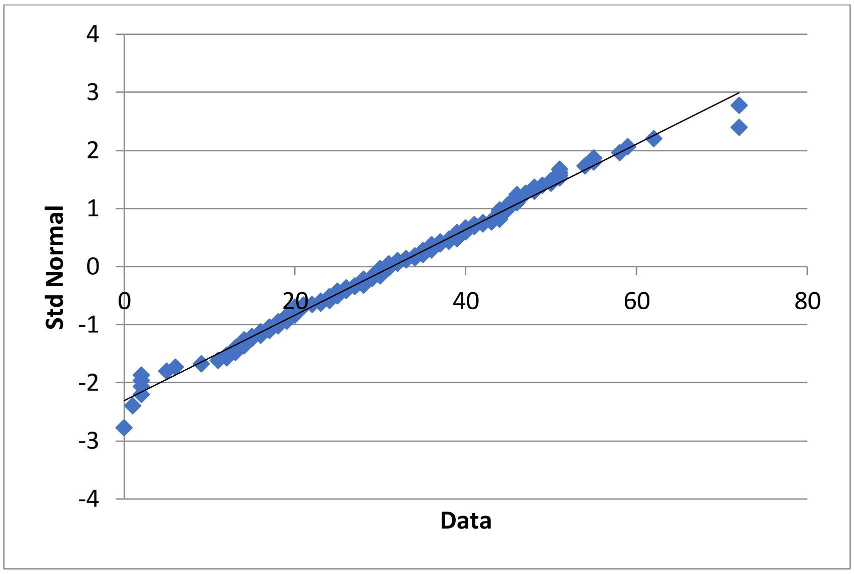
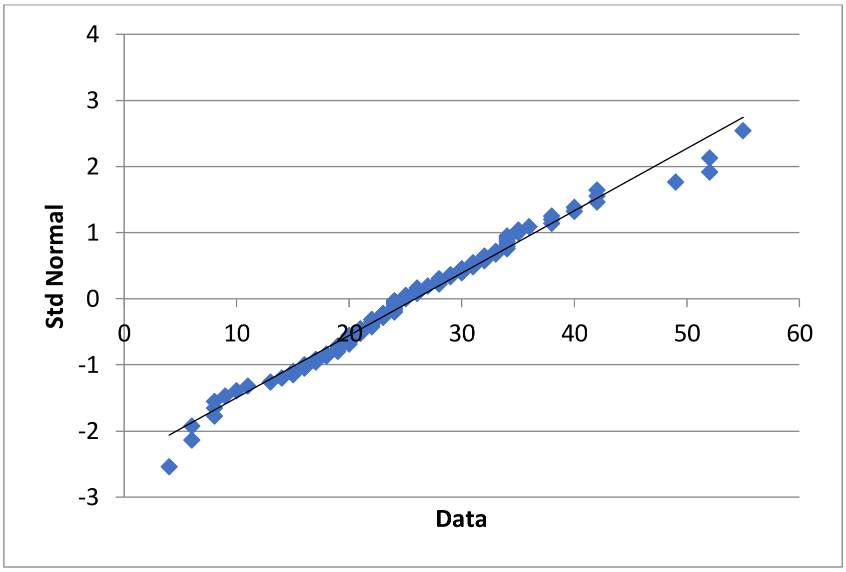
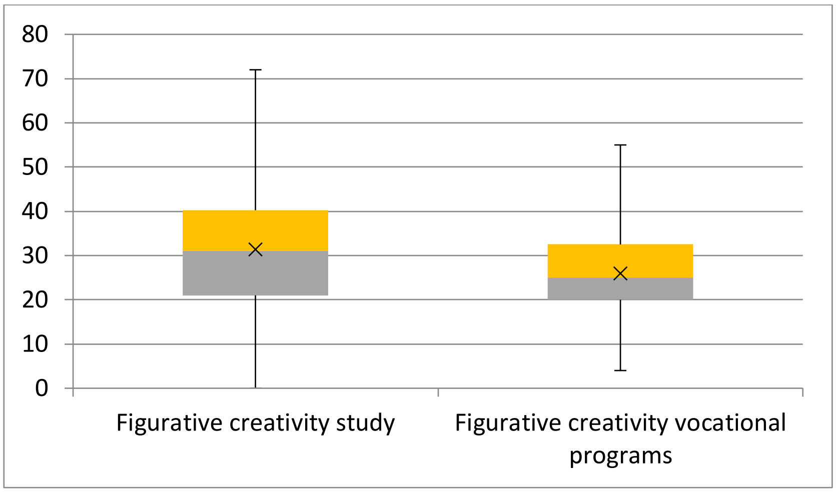


Chart :4 Rankite chart figurative creativity of study programmes.



Graph 5: Rankite graph figurative creativity of vocational programmes.

Since the F-test value for the variance is less than the significance level α=0.05, the variances are statistically significantly different. Therefore, we used a t-test with inequality of variances for verification. Since the probability value of the t-test for the two-sided alternative hypothesis is less than the significance level p (0.0003) < α (0.05), we conclude that there is a statistically significant difference between the selections of study and vocational programmes. Study programmes achieved, on average, a statistically significantly higher average figurative creativity.



Graph 6: Box plot figurative creativity study and vocational programmes.

The lines represent minimum and maximum values. The crosses represent averages. The coloured boundaries of the boxes represent medians. The bottoms of the boxes are the lower quartiles, and the tops of the boxes are the upper quartiles. It can be seen that the study programmes achieved higher scores and the result is statistically significant. *Hypothesis H2 was confirmed.*

H3: We assume that there are statistically significant differences in verbal creativity between secondary vocational school students in terms of gender.

Verbal creativity	Below-average level of creativity	Average level of creativity	Above-average level of creativity	Together
Women	18.2%	60.0%	21.8%	100%
Men	53.7%	36.8%	9.5%	100%

Table 6: Frequency distribution of students according to their level of verbal creativity in terms of gender.

Representation of the frequency of individual students according to the level (below average, average, above average creativity) of verbal creativity, which is formed by men and women. We can see that women have a significantly higher average level of verbal creativity (60%), compared to men, who had an average level of verbal creativity of 36.8%. The table shows that up to 53.3% of men had a below-average level of creativity, while for women it was only 18.2%.

α=0.05	Average	Median	Modus	Standard deviation	Dispersion	D'Agostino-Pearson	Mann-Whitney Test
Verbal creativity in men	8.566	8	4	5.118	26.1908	0.0166	0.0000
Verbal creativity in women	12.715	12	12	4.454	19.8391	0.4929	

Table 7: Statistical differences in verbal creativity by gender.

This d'Agostino-Pearson test indicates a violation of normality in men; we used the nonparametric Mann-Whitney test for two independent samples for comparison.

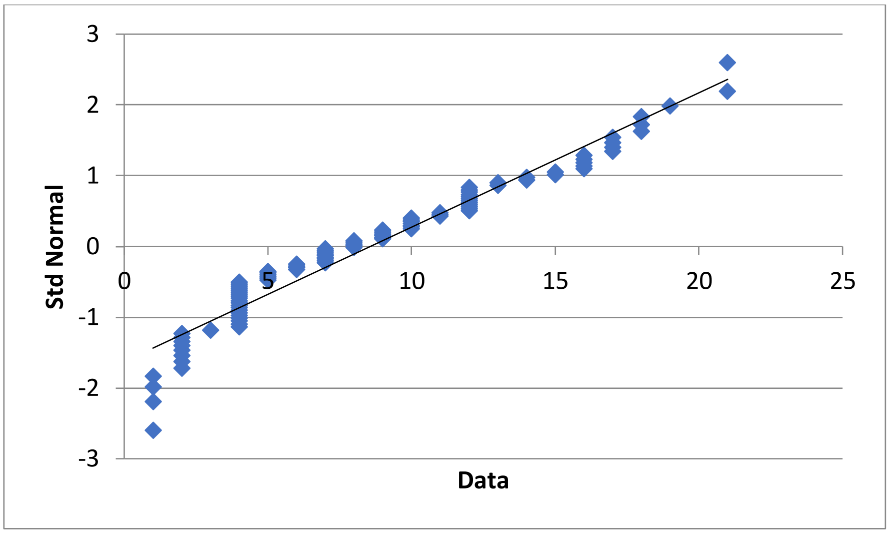
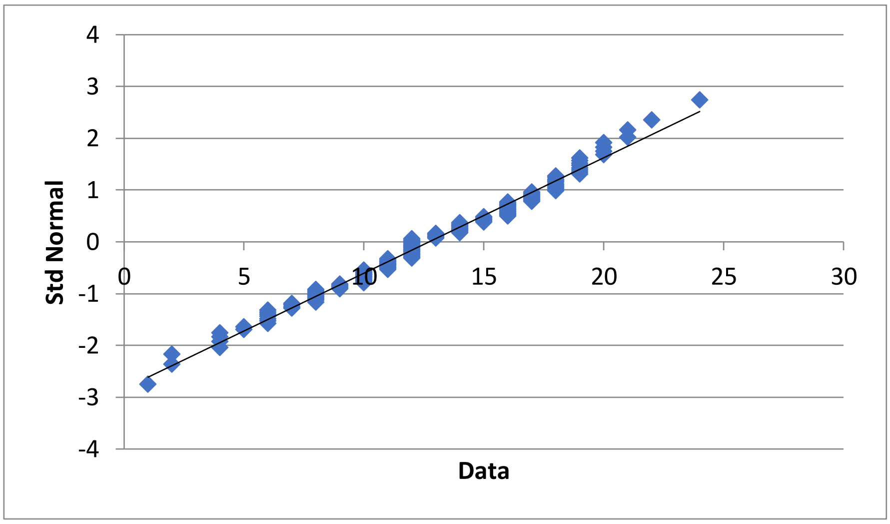


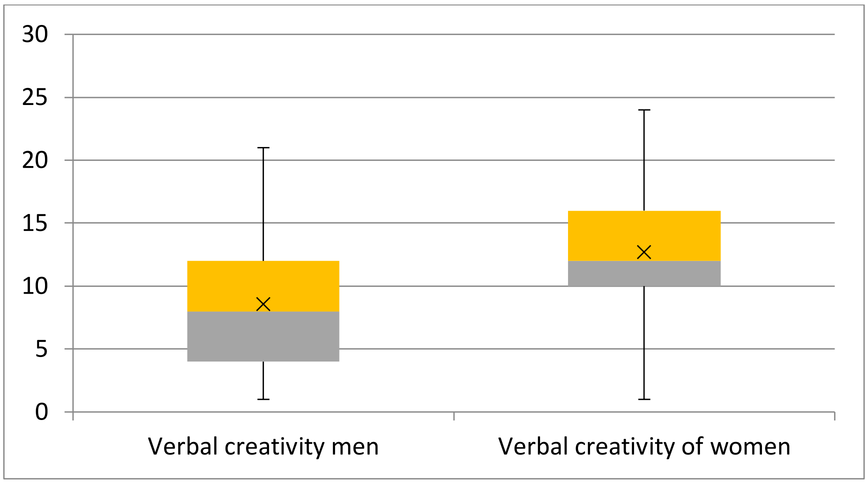
Chart 7: Rankite chart of male verbal creativity.

In the rank-sum graph for men, significant deviations can be seen, especially in the lower tail, and an s-shaped data curve, which indicates deviations from normality. Whereas women are normally distributed, and the values almost ideally follow the straight line of the standardised normal distribution.



Graph 8 Rankite graph of female verbal creativity

Since the probability value for the two-sided alternative hypothesis is less than the significance level p (0.0000) < α (0.05), we conclude that there is a statistically significant difference in medians between the selections.



Graph 9: Box plot of verbal creativity in men and women.

The box plot shows that verbal creativity in women is statistically significantly higher. Hypothesis *H3 was confirmed.*

H4: We assume that there are statistically significant differences in figurative creativity between secondary vocational school students in terms of gender.

α=0.05	Average	Median	Modus	Standard deviation	Dispersion	D'Agostino-Pearson	F-test	t-test
Figural creativity in men	24.509	24	30	12.730	162.043	0.2079	0.5130	0.0000
Figural creativity in women	32.849	32	44	12.023	144.559	0.1159		

Table 8: Statistical differences in figurative creativity by gender.

This d'Agostino-Pearson test indicates that normality is in order.

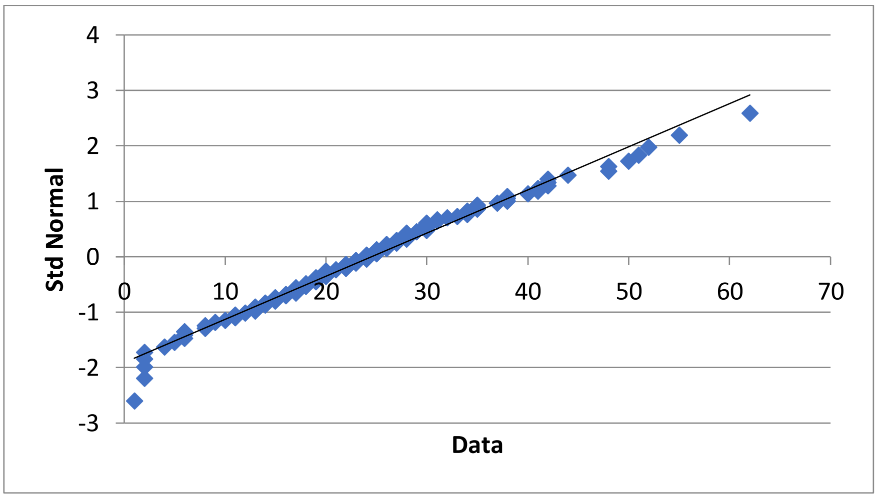


Chart 10: Rankite chart of male figurative creativity.

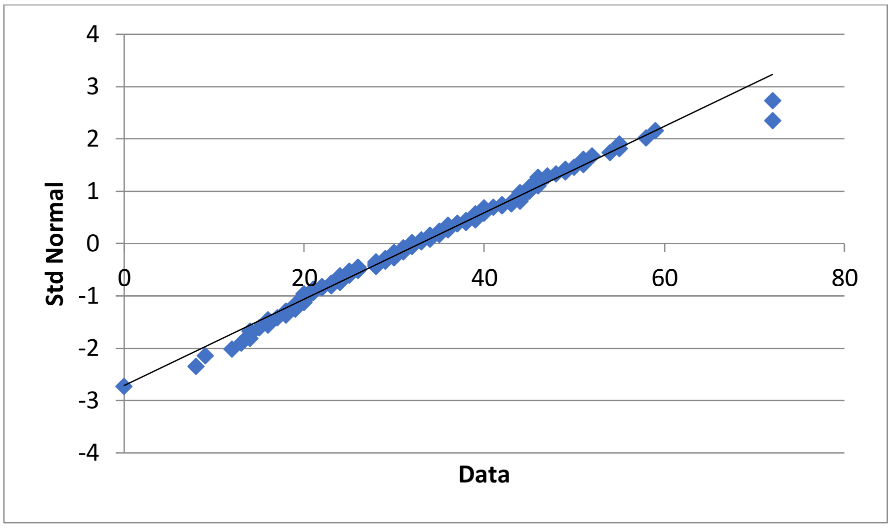


Chart 11: Rankite chart of female figurative creativity.

According to the F-test, we see that the variances are not statistically significantly different. Therefore, we used a t-test with equal variances for comparison. Since the probability value of the t-test for the two-sided alternative hypothesis is less than the significance level p (0.0000) <α (0.05), we conclude that there is a statistically significant difference between the selections. Women achieved a statistically significantly higher average figurative creativity on average.

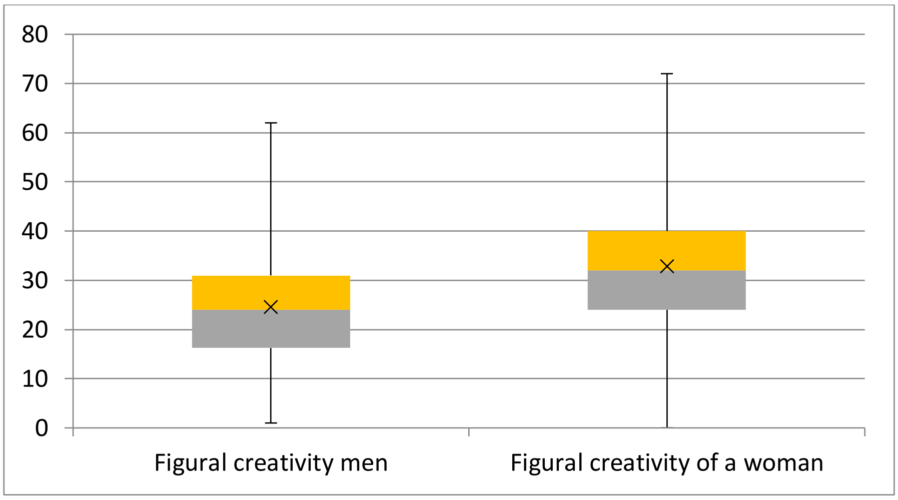


Chart 12: Box plot of figurative creativity in men and women.

From the box plot, we can see that there are significant gender differences in figurative creativity, where women achieved higher figurative creativity. *Hypothesis H4 was confirmed.*

3 Conclusion

The research results indicated that students enrolled in the study programme demonstrated a higher level of verbal creativity than those in the vocational programme. This difference may be attributed to the greater complexity of the curriculum, higher demands on abstract thinking, and more frequent opportunities for developing language and communication skills within study programmes. These findings suggest that the type of educational field can exert a significant influence on the development of creative thinking, particularly in the domain of verbal expression. The findings also emphasise the need to support creativity in vocational programmes – for example, by introducing activities oriented towards the development of language competencies, working with text and creative problem solving.

The development of creativity should be part of all educational fields, as it represents an important competence for the professional and personal growth of students. In verbal creativity, women achieved a higher level compared to men. This difference was particularly evident in the areas of originality, fluency, and flexibility of word associations. The findings suggest that women may be more effective in using language skills in verbal creative tasks, which may be related to a combination of biological, social, and cultural factors. Although gender differences are not absolute and there is considerable individual variability, the results support the need for further research into how different factors influence creative processes. In conclusion, understanding these differences can inform the design of educational and development programmes that better align with individual strengths and promote the cultivation of creativity across the student population.

Our research confirmed that students in study programmes demonstrated a higher level of figurative creativity compared with those in vocational programmes. This difference may be attributed to greater demands on abstract thinking, more complex curricular content, and the more frequent application of creative processes within study programmes. The findings indicate that the type of educational field can significantly influence the development of students' creative abilities.

The research also underlines the need for systematic support for creativity in vocational programmes, especially through activating methods, project-based teaching and opportunities for practical creative activity. Strengthening these elements could contribute to balancing the differences between individual types of fields and to the overall development of students' creative potential. In the area of figurative creativity, it turned out that women achieved higher scores than men. This difference suggests that women may exhibit greater flexibility, originality, or attention to detail when solving visual-creative tasks.

Although these findings are specific to the research sample, they highlight the need for further investigation into gender differences in creativity, particularly with regard to social, cultural, and educational factors that may influence such differences. The results also underscore the importance of fostering the development of creative abilities in both sexes, considering their unique characteristics and individual needs.

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All learning paths lead to knowledge

Identifying Critical and Underdeveloped Digital Competence Areas Among Pre-Service Teachers Using the DigCompEdu Framework

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Abstract

This study presents preliminary findings from a pilot research project investigating the digital competencies of pre-service teachers. Grounded in the DigCompEdu framework, the research identifies areas where teacher trainees exhibit the highest and lowest self-efficacy, alongside those they perceive as most critical for their professional careers. Fifty-eight first-year trainees completed a self-assessment based on the framework. Results indicate that participants rated themselves highest in Area 2: Digital Resources (33.03%) and Area 1: Professional Engagement (30.36%), while reporting lower proficiency in Area 5: Empowering Learners (22.41%) and Area 6: Facilitating Learners' Digital Competence (23.16%). Frequency analysis revealed that participants prioritised Area 3: Teaching and Learning (27.6%) and Area 6 (22.4%), signalling a discrepancy between current perceived competence and professional priorities. Overall proficiency was situated at level A2 on the DigCompEdu scale, reflecting a foundational level of digital tool integration. These findings suggest that while trainees recognise skill gaps in vital areas, there is an urgent need for targeted training in learner-centred digital pedagogy. This research underscores the necessity of employing established frameworks in early teacher education to foster balanced development across all competence domains.

Keywords: Digital Competence, Digital Pedagogy, Self-Assessment

Introduction

In a contemporary landscape defined by rapid transformation, initial teacher education faces a significant challenge in preparing the next generation of educators for increasingly

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multifaceted professional demands. Furthermore, pre-service teachers must cultivate a robust sense of vocation, ensuring the long-term sustainability and reinforcement of their professional interest and motivation. However, this requires considerable effort on the part of teacher training institutions, as the educational environment and system in which graduates will have to work is not only complex but also constantly changing.

The rapid integration of digital technologies into educational paradigms necessitates a comprehensive understanding of pre-service teachers' digital readiness (Wallace et al., 2022). This readiness is crucial for equipping future educators with the competencies required to navigate and leverage digital tools effectively in diverse learning environments, particularly as they will be teaching digitally native students (Kivunja, 2013). Despite the imperative for digital proficiency, many educators, including pre-service teachers, express dissatisfaction with their digital knowledge and skills, often limiting their integration of technology to basic, demonstrative applications (Pongsakdi et al., 2021). This highlights a significant gap between the theoretical understanding of digital education and its practical implementation, underscoring the need for more targeted and effective training initiatives (Reisoğlu & Çebi, 2020). Consequently, various frameworks have emerged to delineate the characteristics and assess the development of teachers' digital competence, serving as essential guides for both current and future educators (Ma & Ismail, 2025; Rakisheva & Witt, 2022).

One such prominent framework, DigCompEdu, provides a robust model for evaluating and developing the digital competencies of educators across various dimensions (Santo et al., 2022). This framework not only outlines essential digital skills but also emphasises the pedagogical application of technology, moving beyond mere technical proficiency to encompass effective integration into teaching and learning processes (Alarcón et al., 2020). This study will therefore utilise the DigCompEdu framework to analyse the digital readiness of pre-service teachers, focusing on their self-assessed capabilities and the implications for their professional development within the evolving educational landscape (Tsankov & Damyanov, 2019) (Akbar & Biyanto, 2022). This analysis will further identify specific areas where pre-service teachers may require additional support and training, thereby contributing to the refinement of teacher education programmes to better prepare them for the demands of contemporary digital pedagogy (Çebi & Reisoğlu, 2019).

Such an examination is vital for understanding the current educational baggage that pre-service teachers possess upon enrolment, enabling institutions to effectively redesign teaching and learning processes (Niţă & Guţu, 2023). Moreover, it is imperative for pre-service training programmes to cultivate not only technical skills but also a deeper understanding of how digital technologies can transform pedagogical approaches, ensuring that future teachers are well-equipped to guide students through a digitally driven educational journey (Reisoğlu & Çebi, 2020).

Drawing upon the aforementioned context, this study aims to synthesise and analyse the findings of a pilot investigation into the digital competencies of pre-service teachers. To this end, two research questions were formulated:

1. In which DigCompEdu competence areas do pre-service teachers report the highest and lowest scores?
2. Which digital competence areas do pre-service teachers perceive as most significant for their professional preparation?

Addressing these questions will facilitate the identification of less-developed digital competencies and establish which domains pre-service teachers prioritise within their pedagogical practice.

1 Literature Review

The emphasis on digital competence among pre-service teachers is currently a critical determinant in ensuring the effective integration of digital technologies within educational settings. The modernisation of education should be spearheaded by practitioners who possess a comprehensive understanding of the complexities inherent in utilising Information and Communication Technology (ICT) for both pedagogical delivery and broader educational purposes. The challenge of equipping pedagogical graduates with the set of knowledge and skills proposed by experts should be taken up by all universities that consider themselves modern, focused on high efficiency, and with an eye on preparing teaching staff with high innovation potential (Tomczyk, 2024). The integration of digital competences in educational practices appears to be challenging and ineffective in many educational institutions, thus highlighting the necessity for ongoing research regarding the incorporation of digital skills in teacher education (Dolezal et al., 2025).

Many teacher education programmes, for instance, have yet to fully incorporate robust training modules that address the multifaceted nature of digital competence, focusing instead on narrow technical proficiencies rather than broader pedagogical applications (Falloon, 2020; Instefjord & Munthe, 2015).

As Spiteri and Rundgren (2018) demonstrate in their review of 27 articles, it is essential to emphasise the importance of teachers' professional development in utilising digital technology for educational purposes, with a particular focus on its sustainable integration within their pedagogical practices. Educators must possess not only the capacity to utilise digital technology, but also the appropriate attitudes and the understanding necessary for the practical application of these skills.

According to the review of Tiwari & Magre (2025), the major global trends in teacher training programmes include: a) Increasing integration of digital skills; b) Focus on digital content creation; c) Attention to communication and collaboration. Despite these positive trends, the review identifies several significant shortcomings: a) Short practical implementation; b) Limited digital security awareness; c) Insufficient focus on problem-solving applications; d) Need for more empirical evaluation. In the context of Strydom's (2021) study, it is imperative to evaluate the efficacy of digital literacy short courses critically. The study emphasises the necessity to adopt a framework that fosters a robust theoretical foundation, acknowledges individual differences, and demonstrates sensitivity towards psycho-sociocultural factors associated with technology adoption and utilisation. This approach, as outlined by Strydom, is proposed as a means to enhance the effectiveness of educational programmes, particularly in the context of 'standardised courses'. As Kaminskienė et al. (2022) assert, a significant challenge in the realm of teacher education is creating opportunities for students to engage in deliberate practice, thereby cultivating the skills essential for effective classroom teaching. Simultaneously, these initiatives should foster a more nuanced theoretical grasp of teaching and learning among pre-service educators. Rakisheva and Witt (2023) emphasise that ensuring the quality training of future teachers requires a clear action plan, including benchmarks, metrics, and indicators of progress for the use of technology in education. Her review of existing ICT competence frameworks highlights their potential to guide initial teacher education by outlining expected digital skill sets and supporting the integration of technology into pedagogy. However, she also identifies a significant gap: most frameworks were not initially designed for pre-service teachers, and many lack empirical validation or the ability to adapt to different educational contexts.

In-service and pre-service teacher development programmes often aim to improve not only technical skills but also attitudes and beliefs about the value of digital tools in teaching and learning. Although Pongsakdi et al. (2021) focus on in-service teachers, their findings are highly relevant for pre-service teacher education. If attitudes can be positively shaped through well-designed training, then early exposure during pre-service education could play a vital role in developing long-term digital readiness. The study conducted by Tondeur et al. (2021) provides clear evidence that the attitudes of preservice teachers are likely to play a significant role in the development of 19 digital competencies. Specifically, preservice teachers who held more positive attitudes towards digital technology demonstrated a pronounced focus on collaboration. In contrast, those with less positive attitudes experienced a more complex engagement with the six strategies and placed greater emphasis on feedback. This aligns with Tiwari and Magre's (2025) call for teacher education curricula to include not only skill development but also reflection and modelling to support attitude change.

The study of Maderick et al. (2016) demonstrated that pre-service teachers often overestimate their digital readiness, particularly in pedagogical and evaluative applications of technology. This discrepancy is especially relevant here, as several participants in our study rated themselves highly in general digital literacy but scored noticeably lower in domains requiring pedagogical integration or critical use of technology.

1.1 The system of Teacher Education in Hungary

In Hungary, initial teacher education has been situated within the higher education sector since 1958. From 1974, training was delivered at the college level as a three-year programme, which was subsequently extended to four years in 1994. The Hungarian model follows [3] a concurrent structure, wherein theoretical instruction and practical school-based experience are undertaken simultaneously. The following conclusions can be drawn regarding the relationship between the teacher training system and public education (Barabási, 2022):

- Teacher training takes place in a separate network of institutions.
- Graduates can teach in the lower grades of primary school (grades 1-4).
- They can teach subjects corresponding to their field of expertise in grades 5 and 6 of primary school.
- There is an overlap between graduates of teacher training colleges who can teach in grades 5-8 and those who can teach in schools.

In addition to objective competencies, perceived self-efficacy performs a critical function, even if self-reported data do not necessarily offer an accurate representation of an individual's actual proficiency. However, the primary objective of assessing perceived competence is not to yield an objective measurement of skill, but rather to foster pedagogical self-reflection.

2 Research Material and Method

During the 2024/2025 academic year, a pilot study was undertaken to assess the digital competencies of students enrolled in primary teacher education programmes. Using the DigCompEdu self-assessment tool, the research sought to evaluate participants' digital proficiency across several dimensions. This overarching aim was subdivided into two specific objectives: first, to identify the least developed areas of students' digital competence; and second, to determine which areas students prioritised for further professional development. The survey was administered anonymously via an online platform at Apor Vilmos Catholic College, a higher education institution in Hungary. This pilot forms part of a more extensive longitudinal research project. While the current phase focused on first-year distance learning students, subsequent stages of the study intend to gather comparative data from both senior year groups and full-time students.

2.1 Participants

The research was conducted with first-year students enrolled on the Primary School Teaching programme. From a total number of 70 distance learning students, 58 participated in the survey, yielding a response rate of 82.85%. The sample comprised 91% female and 9% male participants. It should be noted that the current study is limited in scope, as it is based solely on the preliminary findings of this pilot phase, which focused exclusively on distance learning students. Within the first semester of the curriculum, students are required to complete 10 hours of practical training in Information Technology (IT), with a further 10 hours of practical application scheduled for the second semester.

2.2 Instruments

The self-assessment of digital competencies is pivotal for educators within the contemporary digital landscape. Such reflective practice establishes favourable conditions for the effective integration of digital technologies in pedagogy, while simultaneously facilitating continuous professional development and long-term career growth. Studies (Moreira et al., 2023; Nguyen & Habók, 2023) have shown that teachers' self-assessment of their digital skills is a decisive factor in determining the successful implementation of digital technologies in the classroom. However, it must also be noted that although the development of digital competences as part of teacher training is essential, it is not sufficient in the long term; therefore, it is necessary to strengthen teachers' individual motivation and inspiration for regular and continuous self-development.

Consequently, as Dias-Trindade et al. (2021) assert, educators can comprehend the integration of technology into their pedagogical practice, the requisite training to enhance their competencies in underperforming domains, and the progression to digital proficiency. It is imperative to acknowledge that educators' knowledge is perpetually evolving, thus underscoring the necessity for ongoing learning and self-development. Furthermore, in view of the rapid evolution of this type of knowledge, proficient users recognise that they are not yet fully prepared and that there is always a need to develop their knowledge.

The present study investigates the digital competences of pre-service teachers by utilising the Teachers (DigcompEdu) Framework as a foundational conceptual framework. In addition to the six areas of competence in teachers' professional activities (1. Professional Engagement, 2. Digital Resources, 3. Teaching and Learning, 4. Assessment, 5. Empowering Learners, 6. Facilitating Learners´ Digital Competence), the DigCompEdu Framework also sets out six progressive levels of proficiency (Table 1). Based on the points achieved, respondents can be assigned to the appropriate group, as shown in the following table (Table 1).

Digital Competence Level	Score
A1 – Newcomer	less than 19 points
A2 – Explorer	between 19 and 32 points
B1 – Integrator	between 33 and 47 points
B2 – Expert	between 48 and 62 points
C1 – Leader	between 63 and 77 points
C2 – Pioneer	more than 77 points

Table 1: Digital competence levels of the DigCompEdu CheckIn Questionnaire.

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3 Results

The proficiency level in digital competencies is measured on a scale that varies according to the specific area or domain and the number of competencies included within it. The mean average of the total results is 27.293, with a standard deviation of 8.997. Consequently, the level of teachers' proficiency can be classified as 'Explorer – A2', as illustrated in Table 1. When analysed in a stratified manner, the findings reveal that the majority of respondents (60%) were located at the proficiency level 'A2–Explorer', 26% were at level 'B1–Integrator', and 12% demonstrated a proficiency level 'A1–Newcomer', as illustrated in Figure 1. However, none of the respondents are at levels 'C1-Leader' and 'C2-Pioneer'.

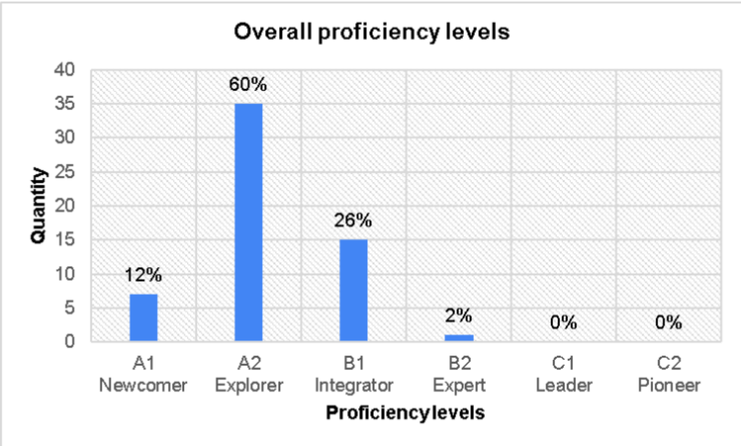

Figure 1: Overall proficiency levels.

The results for individual areas are displayed in the table below (Table 2). The results indicate that AREA 5 – Empowering Learners (22.414) can be identified as the weakest area, while AREA 2 – Digital Resources (33.034) is the strongest area. The analysis of the results indicates that the strongest area (AREA 2) is currently classified as level B1, but this classification is based exclusively on a value of 1.034. In addition, it can be posited that, except for AREA 1 – Professional Engagement and AREA 2, all other areas are situated closer to the lower level (A1) than the higher level (B1) based on their values. This distribution of data indicates that the values are minimal, and the respondents' digital competence is inadequate.

	AREA 1	AREA 2	AREA 3	AREA 4	AREA 5	AREA 6
Mean	30.362	33.034	24.983	25.000	22.414	23.155
Standard Error	1.367	1.490	1.450	1.591	1.329	1.572
Median	30	33	23	22	21	19
Mode	26	33	17	22	17	17
Standard Deviation	10.410	11.351	11.046	12.115	10.122	11.973
Coefficient of Variation	0.343	0.344	0.442	0.485	0.452	0.517
Proficiency Level	A2	B1	A2	A2	A2	A2

Table 2: Descriptive statistics of digital competence areas.

To identify which digital competence areas were perceived as most important for future teaching practice, participants were asked to select the single area they considered most essential. The frequency analysis demonstrated (Figure 2) that Area 3 was selected most frequently (16 selections, 27.6%), followed by Area 6 (13, 22.4%) and Area 2 (11, 19.0%). In contrast, areas 5, 1, and 4 were selected with comparatively lower frequency, with 8 (13.8%), 5 (8.6%), and 5 (8.6%) selections, respectively. This finding suggests a tendency among participants to assign greater importance to specific areas, particularly Areas 3 and 6, relative to other areas.

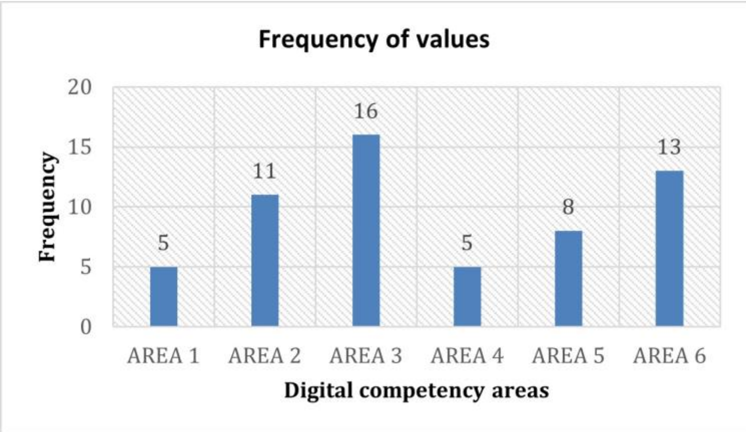

Figure 2: Frequency analysis.

Figure 3 compares the relative mean digital competence scores and the proportion of participants selecting each area as the "most important" competence. The mean competence scores, which had been normalised to the highest-scoring area (Area 2, 100%), ranged from 67.9% (Area 5) to 100% (Area 2). In contrast, the perceived importance percentages, based on participant selections, ranged from 8.6% (Areas 1 and 4) to 27.6% (Area 3). Areas 3 and 6 have been assigned significantly higher importance ratings than expected, given their actual levels of competence. Conversely, Areas 1 and 4 have been allocated lower importance ratings, despite displaying comparatively higher competence scores.

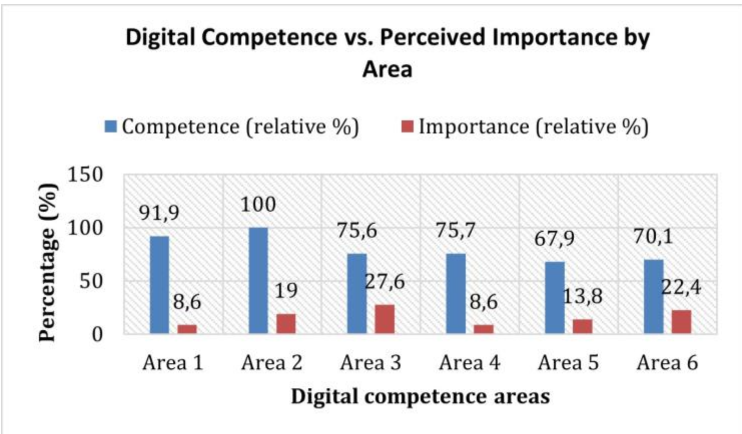

Figure 2: Percentage of digital competence and perceived importance.

4 Discussion

Using the DigCompEdu framework, this study investigated the digital competencies of pre-service educators—a subject of significant contemporary debate within the field. It addressed two primary objectives: 1) in which competence areas do trainees exhibit the highest and lowest levels of proficiency? 2) which digital domains do they perceive as most critical for their professional development?

Question 1 revealed that pre-service teachers were most skilled in Area 2: Digital Resources, with an average score of 33.03. They also did well in Area 1: Professional Engagement (30.36). On the other hand, participants scored lowest in Area 5 (22.41) and Area 6 (23.16), which involve using technology to help learners and assess their digital skills.

This suggests that although future teachers feel confident in finding and creating digital materials or sharing them online, they lack experience in using these tools in ways that adapt to different learner needs or explicitly build students' digital skills.

These findings align closely with those reported by Howard et al. (2021), who argue that initial teacher education should include more training on using technology in a learner-centred manner.

Regarding RQ1, pre-service educators rated themselves highest in Area 2: Digital Resources, as indicated by their mean scores (33.03), with Area 1: Professional Engagement close behind (30.36). The lowest ratings came from Area 5: Empowering Learners (22.41) and Area 6: Facilitating Learners' Digital Competence (23.16).

Looking at RQ2, frequency analysis showed participants most often prioritised Area 3: Teaching and Learning (27.6%). This was followed by Area 6 (22.4%) and then Area 2 (19%). Curiously, areas with the highest self-ratings for competence, namely Areas 1 & 2, did not appear as top priorities.

Rather than this, future educators focused on segments such as Area Three and Six, where their survey results indicated a weaker performance overall compared to other areas profiled by the DigCompEdu framework's six aspects. Such disparities between actual skills and perceived importance suggest that pre-service teachers know exactly where they need improvement ('skill gaps'), and value enhancing those critical yet underdeveloped competencies.

Maderick et al. (2016), referencing similar findings regarding self-assessed digital competence, also document this phenomenon. The considerable difference between seen-importance rankings and expected ones based on competence scores further bolsters our thoughts; perceived importance relies heavily on perceived professional demands rather than current skill levels.

This aligns with Pongsakdi et al. (2021), who found that digital pedagogy training can shift teachers’ attitudes toward technology use, especially in areas they initially viewed as challenging.

The findings suggest that the design of initial teacher education programmes may require re-evaluation. At present, such programmes primarily focus on addressing identified skill deficits; however, they could also be realigned to incorporate the competencies that pre-service teachers themselves identify as essential for their future professional roles. By using a well-structured digital competence framework (Rakisheva, 2023), training can encompass both areas currently deemed crucial and those where skills are generally weaker. This could lead to a more even level of digital readiness among those who have recently qualified as teachers.

5 Conclusion and Limitations

The study sought to identify the most and least developed competence domains within the DigCompEdu framework among pre-service teachers, while also determining which areas were perceived as most critical for their future professional practice. Regarding reported proficiency, the results indicated that Area 1 (Professional Engagement) and Area 2 (Digital Resources) were rated most highly. Conversely, Area 5 (Empowering Learners) and Area 6 (Facilitating Learners' Digital Competence) received the lowest mean scores, suggesting specific deficits in learner-centred digital application.

Regarding perceived importance, participants primarily prioritised Area 3 (Teaching and Learning) and Area 6 (Facilitating Learners' Digital Competence). This is a notable finding, as these domains were among the lowest-rated competencies in terms of self-efficacy. This suggests that respondents value professional growth in areas where they currently perceive their proficiency to be limited.

The overall digital competence of the respondents was situated at level A2 on the DigCompEdu proficiency scale, reflecting a foundational level of digital tool integration within pedagogical practices.

The findings highlight a significant developmental gap: the necessity of addressing those competencies that are currently underdeveloped yet perceived as vital by the majority of pre-service teachers. These predominantly revolve around learner-centred digital pedagogy – i.e., how best to use technology in teaching young people so that it meets their needs or interests – as well as fostering students' abilities with digital tools (see also Smith & Doe, 2020).

Embedding proven frameworks into early teacher training can help ensure all competence areas are developed more evenly. Nonetheless, we must consider certain limitations when interpreting these results. All participants were first-year pre-service teachers, many of whom had limited experience with classroom instruction or using digital tools in education. Their competence ratings and opinions reflect a beginner's view of the profession rather than fully formed ideas about teaching priorities. Furthermore, this group might not represent pre-service teachers at other stages of training. Findings may differ for later cohorts, who have more classroom experience; indeed, researchers elsewhere have noted similar trends (e.g., Johnson et al., 2019).

It would be valuable if future research could compare these aspects —digital skills and perceived priorities —across different years of teacher education to see how trainees' views evolve.

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Readiness of State-, Private- and Church-Run Kindergartens to Use STEM Education

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Abstract

Between 2022 and 2023, the authors conducted a nationwide survey of kindergarten teachers across all regions of Slovakia to analyse their readiness to implement STEM education into early childhood activities. The representative sample of randomly selected respondents included an appropriate distribution of state, private, and church-run kindergartens. This article presents key findings from a comparative analysis of teacher readiness across these different school types. Specifically, the findings relate to three survey items: the lack of information regarding STEM as a possible barrier to implementation; teachers' responses to the statement: "I find it difficult to explain why and how STEM experiments work"; and the self-assessed adequacy of their knowledge within individual STEM areas.

Keywords: STEM Education, Pre-Primary Education in Kindergarten, Comparative Study

1 Introduction

International research into the application of STEM education within pedagogical practice confirms the diverse benefits of this concept; furthermore, it highlights the necessity of implementing this approach across all educational tiers, beginning with preschool and primary education (Larkin, & Lowrie, 2023; Penprase, 2020; Donmez, 2020; Akcay, 2018; DeJarnette, 2018; Kelley, & Knowles, 2016; Zollman, 2012). Regarding the requirement to introduce STEM

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education as early as preschool education (MacDonald, et al. 2020; Cunningham et al., 2018; DeJarnette, 2018; Tippett & Milford, 2017; Cluver et al., 2013), we conducted research focused on assessing the professional readiness of the pre-primary education environment in Slovakia for the application of integrated STEM education strategies (Brečka et al., 2025). The partial tasks of the research were:

- identify the level of teachers' familiarity with the concept of STEM education,
- identify which factors act as obstacles to the implementation of STEM education in kindergartens,
- identify which factors act as motivators for the implementation of STEM education in kindergartens,
- identify what specific teaching methods (organizational forms, teaching aids, and procedures) teachers use in this (as well as traditional) education,
- identify the level of teachers' competence in relation to selected activities necessary for effective STEM education.

A key factor in selecting a research sample representative of the population of kindergarten teachers in Slovakia was:

- ensuring an objective assessment of the researched phenomena about which respondents were consulted.

  This objectivity is significantly influenced by the professional experience teachers acquire throughout their careers. Consequently, when selecting a representative sample of questionnaire respondents while maintaining a predominantly random selection process, it was essential to ensure the inclusion of experienced teachers with a sufficient length of service.

Further factors included:

- ensuring the representation of all regions within Slovakia;
- ensuring an adequate proportion of state, private, and church-run kindergartens.

Ultimately, the representative survey sample comprised 372 respondents. At the initial stage, the research data were evaluated for the entire sample without distinguishing between different groups. Subsequently, results were compared across individual subgroups, which were categorised according to segmentation factors: length of teaching experience, highest level of professional education, the region in which this education was acquired, and the type of school (state, private, or church-run). Finally, the results recorded within these categories were compared, and the statistical significance of any identified differences was tested.
The type of kindergarten in which respondents were employed emerged as a highly significant segmentation factor; specifically, significant differences were identified when comparing the responses of teachers from state, private, and church-run kindergartens (StK, PrK, and ChK).
To illustrate the most notable findings, a comparison of the results across these three categories is presented below for three specific survey items:

- Item 1 focused on assessing the lack of information regarding STEM as a potential barrier to implementing STEM education in kindergartens;
- Item 2 examined teachers' responses to the statement: 'I find it difficult to explain why and how STEM experiments work';
- Item 3 focused on the perceived adequacy of their knowledge within individual STEM areas.

2 Perception of the Lack of Information about STEM as a Potential Barrier to its Broader Implementation

Figure 1 illustrates the assessment of a lack of information regarding STEM as a potential barrier to the implementation of the STEM concept in kindergartens. The results are presented for three distinct categories: teachers from state kindergartens (StK), private kindergartens (PrK), and church-run kindergartens (ChK).

Teachers evaluated the lack of information as a potential obstacle to the broader integration of STEM within the kindergarten environment using a five-point scale:

1 - I completely disagree,
2 - I rather disagree,
3 - I don't know,
4 - I rather agree,
5 - I completely agree.

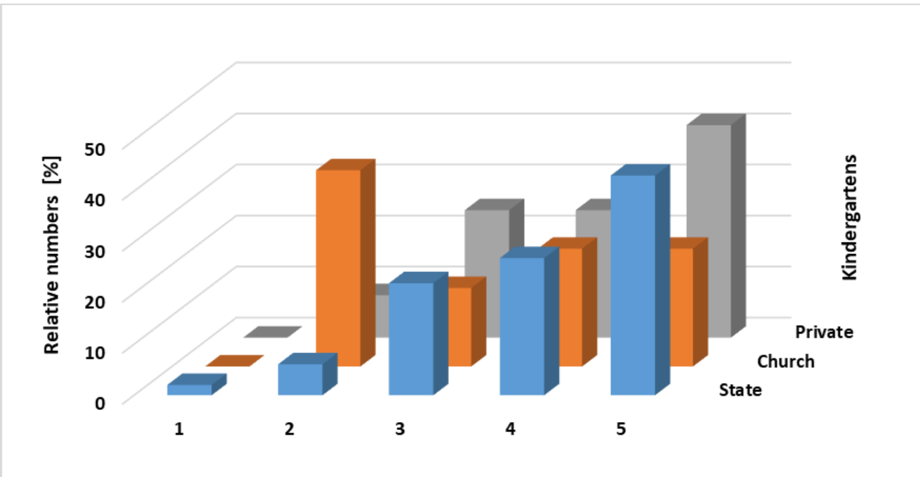

Figure 1: Perception of the lack of information about STEM education as a barrier to its implementation in practice. (Own research).

As the figure 1 shows, the highest number of respondents with insufficient information are in state and private kindergartens (StK - 43%; PrK – 42%). Teachers (respondents) from church-run kindergartens fare better – only 23% of teachers feel they lack information, while as many as 38% disagree that they have little information. There are several reasons why kindergarten teachers may lack information about STEM, including the availability of educational programs, school curricula, technological equipment, and support from school management. One of the significant reasons is the limited range of educational programs available to teachers, especially in state and private kindergartens.

If schools do not organise systematic training courses and seminars focused on STEM education, teachers lack sufficient opportunities to acquire the necessary knowledge and skills. In state schools, this issue may be exacerbated by a lack of financial resources and administrative obstacles related to participation in educational activities. Although private schools can organise tailor-made training, the emphasis is not always on STEM, as these institutions may prioritise alternative educational approaches. Another significant factor is the variation in school curricula and educational philosophy across different types of kindergarten. Church-run kindergartens often have fewer staff and can provide a more individualised approach to education, which is also reflected in better teacher awareness. In state schools, there is greater pressure to adhere to centrally set curricula; this may leave less room for new educational approaches and innovations such as STEM.

Although private kindergartens have more freedom to create their own curricula, without clear guidance and support, teachers may feel uncertain about how to effectively implement STEM in pre-school education. Another significant factor is the availability of technological equipment and its practical application. If teachers lack access to modern technologies, digital tools, and methodologies suitable for STEM education, both their awareness and their willingness to incorporate technology into teaching decline. State kindergartens often face limited budgets for technological innovation, which can prevent teachers from developing their digital skills. In contrast, private kindergartens may have better financial resources to purchase technology; however, if methodological support is lacking, the mere availability of equipment is insufficient to improve the relevant knowledge and skills of the teaching staff.

The final key aspect is the support provided by school management and educational institutions. If leadership does not place sufficient emphasis on STEM education or offer teachers opportunities for professional development, awareness levels remain low. In church-run schools, management may be more actively involved in supporting staff; this may explain the lower level of perceived lack of awareness compared to the state and private kindergartens.

3 Teachers' Self-Reflections on Their Ability to Explain Why and How STEM Experiments Work

Figure 2 presents the responses of individual categories of teachers (differentiated according to the segmentation factor of kindergarten type) to the statement "I find it difficult to explain why and how STEM experiments work." Teachers were asked to assess their potential problems with performing this professional activity using the same 5-point scale as was given at the previous item.

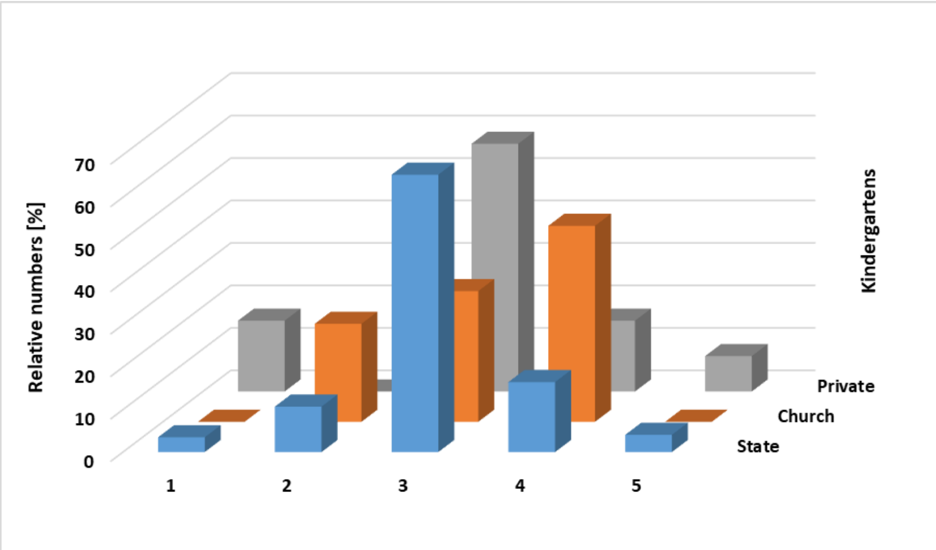

Figure 2: Self-assessment of teachers' professional readiness to explain why and how experiments work. (Own research)

As the figure 2 shows, the greatest uncertainty while assessing the severity of problems they have in explaining how STEM experiments work was reported by respondents working in state and private kindergartens (value 3 “I don't know” of the used scale: StK – 65% of the respondents, PrK – 58% of the respondents). This essentially indicates a general lack of preparation among teachers for STEM teaching.

The highest level of agreement with the statement that they have problems while explaining how STEM experiments work on the used scale (4 - "I rather agree, i. e. I think that I find it difficult to explain why and how STEM experiments work") was recorded in case of the respondents from church-run and private kindergartens (ChK – 46%; PrK – 17%). Conversely, the highest number of teachers who have no problem explaining STEM experiments was in case of the respondents from church kindergartens (23% of them rather disagree that they would find it difficult to explain why and how STEM experiments work). As already mentioned, these results may be related to insufficient teacher training or limited material and technical equipment - if schools do not have enough tools for experimentation, teachers may have problems with practical demonstrations. Low confidence in their own abilities may also play a role here, as STEM is not traditionally a dominant area in pre-primary education, and teachers may be concerned about their explaining phenomena correctly. Teachers working at church-run kindergartens feel more confident than the others, what may be related to better methodological support or a different approach to education.

4 Teachers’ Self-Reflection on Their Knowledge in Individual STEM Areas

Figure 3 presents an overview of the responses of individual categories of teachers (differentiated according to the segmentation factor of kindergarten type) to the statement "I have sufficient knowledge of individual STEM areas" using the same scale of 1 – 5.

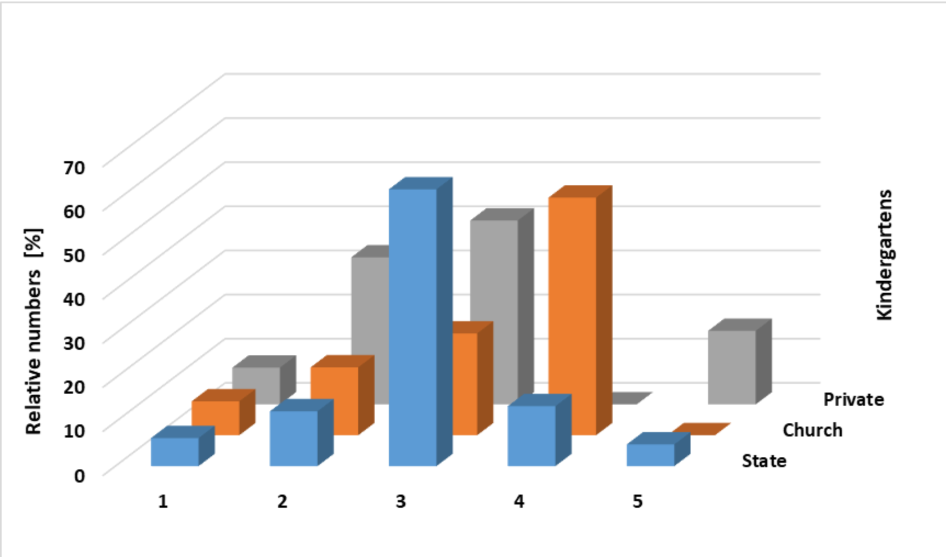

Figure 3: Self-assessment of teachers' sufficient knowledge in individual STEM areas. (Own research)

As the figure 3 shows, the vast majority of respondents working in state kindergartens expressed uncertainty about the level of their STEM knowledge. This uncertainty may be related either to a genuine lack of education in individual areas or to insufficient practice in the STEM implementation. Overall, as many as 63% of the respondents cannot assess if their knowledge in individual STEM areas is or is not sufficient (rating 3 on the scale - „I don't know whether I have or have not sufficient knowledge in individual STEM areas“), which ultimately means that most kindergarten teachers (regardless of the type of the kindergarten at which they work) are unsure of their STEM knowledge or of sufficiency of their STEM knowledge.

Teachers working in church kindergartens manifested the highest level of teacher selfconfidence in STEM knowledge, which may be due to their better professional training, but in our opinion, it is more likely a result of the greater emphasis placed in these kindergartens on innovative teacher training (whether in the form of self-education or further formal education). It is precisely the group of respondents working in church-run kindergartens that, unlike the groups of respondents working in either state or private kindergartens, consider their knowledge in STEM areas to be sufficient (up to 54% of teachers working in church -run kindergartens rated themselves on a scale value of 4 – „I rather agree, i. e. I think I have sufficient knowledge of individual STEM areas”). The greatest variability in responses was recorded in case of the teachers working in private kindergartens.

It is interesting to compare results recorded in case of the subgroups of respondents working in church-run and private kindergartens. In both subgroups, a relatively high percentage of respondents were unable to assess the adequacy of their knowledge in individual STEM areas. However, a significantly higher percentage of such respondents (almost twice as many) was found in the subgroup of respondents working in private kindergartens. In both subgroups, a relatively large number of respondents (especially compared to the subgroup of respondents working in state kindergartens) declared that they probably or definitely have this knowledge (stating the scale value of 4 – „I rather have, i. e. I think I have sufficient knowledge “, and 5 – „I completely agree, i. e. I definitely have sufficient knowledge”). However, while a relatively high number of respondents from church-run kindergartens are unable to assess their knowledge (31%), several times higher relative number of respondents from church-run kindergartens "modestly" state that they think they have sufficient knowledge (scale value 4 – „I rather agree, i. e. I think I have sufficient knowledge, 46% of the respondents), the situation is the opposite within the subgroup of teachers working in private kindergartens. In addition to a significantly higher relative number of respondents who are unable to assess their knowledge (58%), there is a significant, but not very large, group of respondents who "confidently" assess themselves as definitely having the necessary knowledge (rating 5 of the scale – „I completely agree, i. e. I definitely have sufficient knowledge, 8% of the respondents). Potential differences between various types of kindergartens may be attributed, for example, to the more rigid and less flexible systems within state kindergartens; this can inhibit innovation, including within STEM education. Conversely, church-run kindergartens often benefit from greater methodological support and smaller class sizes, allowing for better individualisation of learning. Private schools exhibit greater variability in teacher quality; while some educators are highly prepared, others may possess minimal STEM-specific training. This analysis indicates that STEM education in kindergartens has room for further improvement, particularly regarding teacher training. Church-run kindergartens demonstrate the highest levels of teacher confidence in STEM knowledge, whereas state and private kindergartens exhibit greater uncertainty and lower levels of confidence in this area.

5 Conclusion

The results presented, which compare three selected aspects of the readiness of teachers in state, private, and church-run kindergartens to implement the STEM concept within the pre-primary education environment, represent only a small portion of the research undertaken (Brečka et al., 2025). The overall research results confirm that while the implementation of STEM education in Slovak kindergartens possesses significant potential, it simultaneously faces several challenges. Kindergarten teachers demonstrate an interest in developing their STEM competences; however, they frequently encounter a lack of information, an absence of continuing professional development, and limited material or technical resources. These findings highlight the need for systematic support for teachers, addressing not only their professional and technical skills but also the development of their pedagogical competences and their ability to apply innovative teaching methods. Consequently, a key factor for the successful implementation of STEM is the availability of high-quality methodological support and educational materials.

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Intercultural Communication and Competence in the Process of Internationalisation of Higher Education Institutions

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Abstract

The internationalisation of higher education institutions is traditionally evaluated using quantitative indicators such as student mobility and international partnerships. However, its qualitative dimension—particularly everyday intercultural communication and academic inclusion—remains underexplored. This paper examines intercultural communication as a key determinant of the quality of internationalisation at the University of Žilina (UNIZA). The aim of the study was to identify perceptual differences between university teachers and international students regarding intercultural preparedness, language clarity, participation, and adaptation to the academic environment. A quantitative questionnaire survey conducted among staff members and international students was analysed using descriptive and comparative methods. The findings indicate that an inclusive academic environment does not emerge automatically from diversity itself but requires the systematic development of intercultural competence among university staff and students. Based on the identified needs, a set of developmental activities was implemented, including the creation of a document entitled *Ten Principles of Intercultural Communication*, the development of a methodological guide, and the organisation of intercultural workshops. The paper highlights the necessity of the systematic development of intercultural competence as an integral component of strategic internationalisation. By linking empirical analysis with institutional interventions implemented within the project, it contributes to the discussion on the qualitative dimension of internationalisation and offers in higher education.

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Keywords: Intercultural Communication, University Environment, Internationalisation of Higher Education, Intercultural Competence

1 Introduction

The internationalisation of higher education institutions is currently one of the key strategic priorities of the European Higher Education Area. It is most frequently assessed using quantitative indicators such as the number of international students, Erasmus+ mobility programmes, and international partnerships. However, this approach primarily reflects the structural dimension of internationalisation. Considerably less attention is paid to the quality of everyday academic interaction, which ultimately determines whether internationalisation is genuinely inclusive and effective.

The presence of international students fundamentally reshapes the communicative dynamics of the university environment. Classrooms become spaces where varying language levels, educational backgrounds, and differing understandings of authority, participation, and assessment intersect. If these differences are not acknowledged and addressed, they may lead to misunderstandings, passivity, frustration, and, in extreme cases, academic underperformance. Internationalisation should therefore not be understood merely as an administrative process but as a process of intercultural transformation. It requires the systematic development of intercultural competences among university staff and the creation of an environment that respects linguistic, cultural, and social diversity.

The key question thus becomes: To what extent is the university environment prepared to work with cultural plurality not only at the level of strategic documents but also in everyday teaching practice?

2 Intercultural Competence in Higher Education

Intercultural competence refers to the ability to communicate effectively and appropriately in situations of cultural diversity. According to Byram's model (1997), it encompasses knowledge, attitudes, interpretative skills, and the capacity for critical cultural reflection.

In higher education, this competence requires a particularly strong reflexive dimension — the ability to recognise one's own cultural assumptions, academic norms, and implicit expectations that may not be self-evident to international students. In this context, intercultural competence is not merely a general communication skill but a professional competence that directly influences teaching quality, student participation, and the academic climate.

2.1 Intercultural Competence as Part of the Professional Profile of University Teachers

In higher education, intercultural competence can be analysed through three interconnected components. The cognitive dimension involves an understanding of cultural differences, linguistic specifics, and academic conventions across contexts. The affective dimension includes openness, empathy, and tolerance of ambiguity arising in intercultural encounters. The behavioural dimension refers to the ability to adapt communication styles, clarify expectations explicitly, and respond sensitively to diverse behavioural patterns (Deardorff, 2006).

For university teachers, intercultural competence entails more than communication in a foreign language. It involves creating a safe learning environment in which students feel comfortable asking questions, participating in discussions, and presenting their views without fear of ridicule. It also requires interpreting student behaviour not through stereotypes but as potentially culturally conditioned norms.

University teachers act as carriers of academic culture. Through their communication style, task formulation, and assessment practices, they implicitly convey norms that may not be transparent to international students. Intercultural competence therefore includes the ability to reflect on one's own cultural assumptions, formulate academic expectations explicitly, and adapt communication strategies to student diversity. Clear guidelines, transparency of assessment criteria, and explicit task requirements form the foundation of an inclusive academic environment.

Contemporary intercultural approaches increasingly move beyond national categorizations towards intersubjective and situational perspectives. The focus shifts from "where students come from" to "how we function together in specific academic situations". Cultures are no longer treated as fixed group categories, but as dynamic communicative processes shared within particular educational contexts.

2.2 Language Clarity and Academic Literacy

Meeting formal language requirements does not necessarily guarantee full comprehension of academic discourse. Technical terminology, idiomatic expressions, and implicit assessment criteria may represent significant barriers even for students with adequate language proficiency.

Language anxiety (*Foreign Language Anxiety – FLA*) can further reduce students' willingness to participate in discussions. Silence may therefore reflect a fear of failure rather than a lack of interest. Language anxiety creates psychological barriers that affect memory processes, reduce self-confidence, and generate tension and apprehension (Horwitz, 1986).

Teachers play a key role in mitigating these barriers. Contemporary pedagogical approaches consider learning styles (visual, auditory, kinaesthetic), students' cultural backgrounds, and emotional states. The use of supportive strategies — such as breathing techniques, visualisation, and positive feedback — may reduce stress and enhance engagement (Kissová et al., 2024).

An interculturally competent teacher formulates instructions clearly and in a structured manner, supports explanations visually, summarises key points, and distinguishes between content quality and linguistic form. Particular attention should be given to explaining concepts such as 'critical analysis', 'independent work', or 'plagiarism', which may not carry universal meanings across cultural contexts.

2.3 Intercultural Environment and Student Adaptation

Adaptation to a new academic environment is often accompanied by uncertainty and culture shock. Teachers' communication styles significantly influence the extent of this uncertainty. Consistent assessment practices, clearly defined rules, and respectful feedback reduce stress and help prevent misunderstandings.

Intercultural competence thus also manifests in the ability to create a supportive academic climate that enables active participation without fear of misunderstanding or embarrassment. When students feel safe, engaged, understood, and successful, their resilience and motivation increase, thereby enhancing their willingness to communicate even in a second language. Seligman (2018) refers to this optimal state of psychological well-being as *flourishing* (PERMA).

Component	**Description**	**Implications for Intercultural Education**
Positive Emotions	Cultivating positive emotional states that support well-being.	Foster an inclusive climate through supportive feedback and respect for diversity.
Engagement	Active and focused involvement in learning.	Use student-centred, culturally responsive teaching strategies.
Relationships	Building trust-based interpersonal connections.	Promote dialogue, collaboration, and social integration.
Meaning	Understanding learning as purposeful and goal-oriented.	Connect study content with professional and societal relevance.
Accomplishment	Achieving goals and developing competence.	Encourage gradual progress and provide formative feedback.

Table 1: Key Domains of the PERMA Model and Recommendations for Teachers.

3 Methodology

3.1 Research Design

The research was conducted at the University of Žilina (UNIZA) as part of a project focused on developing intercultural communication and supporting an inclusive academic environment. The primary objective was to empirically examine how university teachers and international students perceive the quality of intercultural communication, language clarity, inclusiveness, and available support mechanisms. The study assumed that staff members' self-perception of intercultural preparedness may differ from the lived experiences of international students. Accordingly, the following research questions were formulated:

RQ1: How do university teachers and staff evaluate their preparedness for intercultural communication?

RQ2: How do international students perceive language clarity, inclusiveness, and academic support?

RQ3: Are there significant perceptual differences between staff and students in the examined areas?

The study employed a quantitative design with a comparative analytical approach.

3.2 Research Sample and Data Collection

The research sample consisted of two groups: 56 teachers and administrative staff members at UNIZA, and international students enrolled in Slovak-language study programmes (n = 56). Participation was voluntary and anonymous. Data were collected through an online questionnaire distributed across several faculties of the university.

The questionnaire was constructed on the basis of theoretical models of intercultural competence and practical challenges identified in the university environment. It included closed-ended items measured on a five-point Likert scale, as well as several open-ended questions allowing respondents to elaborate on their experiences.

The questionnaire examined the following areas:

- clarity and comprehensibility of communication
- transparency of assessment criteria
- support for classroom participation
- perception of cultural diversity
- availability of support during adaptation difficulties.

Parallel thematic items were included for both groups to enable comparative analysis. The collected data were processed using descriptive statistical methods. For closed-ended items, response frequencies, mean values, and measures of dispersion were analysed. Comparative analysis focused on identifying differences between the group of university staff and the group of international students across the examined areas. Open-ended responses were analysed using thematic analysis, with attention to recurring patterns of experiences and perceived challenges.

The research did not constitute an isolated activity but served as an analytical basis for subsequent project interventions aimed at the development of intercultural competence among university staff. The identified problematic areas provided a foundation for the design of development measures and educational activities implemented in the following phase of the project.

4 Results

4.1 Teachers' Perspective

A total of 56 university teachers and staff members at UNIZA participated in the questionnaire survey. The aim was to examine how they perceive the university's intercultural climate, their preparedness for communication with international students, and which situations they consider problematic.

The responses indicated that the majority of participants evaluate their communication with international students as appropriate and professional. Teachers reported efforts to formulate assignments clearly, maintain openness to questions, and adjust the pace of instruction to students' language abilities. The intercultural environment was frequently described as enriching and motivating.

At the same time, respondents identified several challenges, including language barriers and students' communication insecurity, passivity in discussions, differing expectations regarding teacher authority, and variations in the understanding of academic rules (e.g., independence in work, citation practices).

Teachers particularly highlighted situations in which students did not understand an assignment but did not ask for clarification. Limited initiative among some students in discussions or teamwork was also perceived as problematic. Some respondents reflected on the need for more systematic support and methodological guidance in addressing intercultural classroom situations.

The findings suggest that although teachers perceive their approach as inclusive, they are also aware of the limits of their preparedness and the need for further development of their intercultural competence.

4.2 International Students' Perspective

The questionnaire survey conducted among international students focused on their experiences with communication, their sense of belonging, and adaptation to the academic environment at UNIZA.

The responses (n = 56) indicate that students generally appreciate the openness and support provided by the university. They positively evaluated teachers' attitudes, the availability of consultations, and efforts to clarify technical terminology.

At the same time, students identified several areas of difficulty, including the ambiguity of certain assignments and assessment criteria, a fear of making linguistic errors during oral presentations, uncertainty when participating in classroom discussions, and challenges in navigating the academic system and its regulations.

Students also pointed out that in some cases they do not feel sufficiently confident to ask questions or openly express misunderstanding. Language insecurity and cultural differences in perceptions of authority may lead to passivity, which may subsequently be misinterpreted as a lack of interest. A significant factor that emerged was the need for clearly formulated rules, transparent assessment practices, and structured support during adaptation to the new academic context.

These findings further highlight the importance of adequate language proficiency in accordance with the Common European Framework of Reference for Languages (CEFR), not only for the successful completion of academic studies but also for effective participation in academic communication. Insufficient language confidence may increase levels of language anxiety, which can negatively affect students' active engagement and overall well-being within the academic environment.

4.3 Comparative Analysis

The comparison of responses provided by UNIZA teachers and staff and international students indicates a certain perceptual difference. Responses were measured on a five-point Likert scale (1 = strongly disagree, 5 = strongly agree), where M represents the mean value and Δ denotes the difference between the groups.

Area of Evaluation	**Staff (M)**	**Students (M)**	**Difference (Δ)**
Clarity of instructions and assignments	4.2	3.5	0.7
Transparency of assessment	4.0	3.4	0.6
Support for classroom discussion	4.3	3.2	1.1
Sense of safety when expressing opinions	4.1	3.3	0.8
Respect for cultural diversity	4.4	3.8	0.6
Availability of consultations	4.5	4.0	0.5

Table 2: Comparison of Intercultural Communication Evaluation.

While teachers generally evaluate intercultural communication positively and express openness towards diversity, international students more frequently report insecurity in participation, concerns about making language errors, and a need for more explicit clarification of academic expectations.

Staff Perspective	**Student Perspective**	**Common Denominator**
Passivity in discussions	Language insecurity	Limited participation
Lack of initiative	Fear of negative evaluation	Low self-confidence
Unclear responses to assignments	Unclear expectations	Need for explicitness
Different understandings of authority	Reserved attitude toward the teacher	Cultural norms of participation
Differences in academic habits	Difficulty navigating the system	Adaptation to the academic environment

Table 3: Thematic Comparison of Identified Problem Areas.

The thematic analysis indicates that teachers and students identify similar situations but interpret them differently. While teachers refer to student passivity, students point to language insecurity and concerns about evaluation. The findings suggest that internationalisation requires not only goodwill and openness but also systematic methodological guidance and institutional support for intercultural reflection at the institutional level.

4.4 Implications of the Findings

The identified differences between staff self-evaluation and students' experiences highlight the need to:

- communicate academic expectations more explicitly,
- reduce language anxiety through the creation of a safe discussion climate,
- support diverse forms of student participation,
- systematically develop teachers' intercultural competence.

These findings served as the basis for the design of intervention activities implemented within the project framework, including workshops, case studies, role-playing activities, and methodological support.

To strengthen the intercultural approach at UNIZA, a formally adopted document entitled *Ten Principles of Intercultural Communication* was developed. This document comprises ten supportive strategies and recommendations derived from practical experience in subject-specific teaching and intercultural communication within the academic environment.

Another key outcome was the development of a methodological guide entitled *Intercultural Communication in the University Environment*, aimed at supporting teachers and university staff in building intercultural competences and contributing to the creation of an inclusive, open, and safe academic environment for all students.

5 Discussion

The findings confirm that internationalisation in higher education represents a complex process whose quality depends on everyday interaction between teachers and international students. Empirical evidence from UNIZA indicates the existence of a moderate perceptual difference between university teachers and international students, particularly in the areas of language clarity, participation, and the explicitness of academic expectations.

These findings emphasise the need for the systematic development of intercultural competence as an integral component of the professional profile of university teachers. An inclusive academic environment requires a reflective approach to pedagogical practices, differentiated forms of participation, and the conscious creation of psychologically safe discussion spaces.

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The results may also be interpreted through theoretical models of intercultural competence, which highlight the importance of the reflexive dimension. According to Byram's concept (1997), intercultural competence does not merely involve a positive attitude towards diversity but also the ability to engage in critical cultural self-reflection and adapt behaviour to specific communicative contexts. This reflexive component appears to be particularly crucial in intercultural teaching environments.

Students' passivity in classroom discussions may further be explained through cultural dimensions of authority and participation. In contexts characterised by higher power distance, challenging a teacher is less common, which may lead to the misinterpretation of silence as disengagement. The findings therefore support the need for differentiated forms of student engagement and the creation of space for diverse communicative styles.

Language insecurity emerged as another significant factor. Even with formally sufficient language proficiency, fear of negative evaluation may reduce students' willingness to participate actively. These findings correspond with research on language anxiety, which highlights its impact on participation and academic performance. Intercultural competence therefore also entails sensitivity to linguistic limitations and the ability to distinguish between content quality and the formal linguistic accuracy of student contributions.

The empirical data further suggest that inclusive environments do not emerge automatically from the mere presence of diversity but require deliberate pedagogical strategies and systematic institutional support. A key practical implication is the need to connect individual teacher reflection with structured institutional measures. The development of intercultural competence should not be left to personal experience alone but should form part of continuous professional development.

A limitation of the study lies in its implementation at a single institution and in the use of self-report instruments based on respondents' subjective perceptions. Future research could involve a broader sample, longitudinal monitoring of changes in the intercultural climate, and analysis of the relationship between perceptual data and students' academic achievement.

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All learning paths lead to knowledge

Microcontrollers as a Tool for an Interdisciplinary Approach in Education

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Abstract

Interdisciplinary education is an approach that integrates knowledge from various scientific fields into a unified and practically applicable framework. Currently, this concept is primarily realised through the STEM (Science, Technology, Engineering, and Mathematics) framework. STEM emphasises the integration of the natural sciences, engineering, technology, and mathematics, thereby creating the necessary conditions for developing critical thinking, problem-solving, and creativity. Unlike traditional curricular approaches, STEM does not present disciplines in isolation but strives for a synergistic connection between them. This creates a system that is more accessible to students and more closely aligned with real-world scenarios. Interdisciplinary education significantly contributes to the development of those 21st-century competences essential for the modern era. These include the ability to utilise modern technologies, apply theoretical knowledge in practice, and flexibly synthesise information from disparate areas. As an educational tool, microcontrollers represent a technological platform that supports the implementation of this interdisciplinary approach; they are utilised in projects that combine elements of computer science, physics, mathematics, and technology. This article examines their integration into teaching and the potential for connecting theory with practice through experimental and experiential learning.

Keywords: STEM Education, Microcontrollers, Interdisciplinary Learning

1 Introduction

The integration of microcontrollers into the educational process represents a contemporary approach to teaching technical and scientific subjects, with a particular emphasis on creativity,

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experimentation, and interdisciplinary learning. Traditional educational systems frequently compartmentalise disciplines such as physics, computer science, and technology; this tends to limit pupils' ability to synthesise theoretical knowledge with practical experience. The inclusion of microcontrollers, such as Arduino or the BBC micro:bit, into the curriculum addresses this challenge by facilitating experiential learning. This approach encourages pupils to develop independent thinking, enhances their problem-solving skills, and enables the application of knowledge within real-world situations.

2 Interdisciplinarity

Interdisciplinary thinking is the ability to integrate the knowledge and ways of thinking of two or more disciplines in order to achieve cognitive progress in ways that would be impossible or unlikely using only a single disciplinary approach (Mansilla, 2005, pp. 14–21; Mansilla & Duraising, 2007, pp. 215–237; Spelt et al., 2009, pp. 365–378). Thinking from the perspective of different disciplines helps to understand everyday experiences, such as sustainability issues (Bestelmeyer et al., 2015, pp. 37–43).

Interdisciplinary thinking leads to more complex, sophisticated, and advanced understanding. To facilitate the development of interdisciplinary thinking, interdisciplinary learning opportunities are needed. Students need support in synthesising two or more disciplines (Glancy & Moore, 2013, pp. 2–10; Spelt et al., 2009, pp. 365–378).

Looking for connections, identifying common features, and evaluating different methods, assumptions, and values from each discipline builds interdisciplinary thinking (Hursh et al., 1983, pp. 42–59).

Spelt et al. (2009, pp. 365–378) identified six conditions of the learning process that enable interdisciplinary thinking. The first four conditions are gradual progress, linearity, interactivity, and milestones with questions that support the development of interdisciplinary thinking. The remaining conditions focus on achieving interdisciplinarity and reflection. STEM education (science, technology, engineering, and mathematics) is a well-known example of interdisciplinary education that removes barriers between disciplines (Sahin, 2015, pp. 3–14; Vasquez et al., 2013, pp. 3–8).

By integrating disciplines, STEM education provides opportunities to learn and solve relevant real-world problems (Bybee, 2013, pp. 1–12; English, 2016, pp. 1–8). STEM education thus facilitates the building of interdisciplinary thinking. In the last two decades, STEM education has attracted the attention of many education systems. However, due to the rapid spread and growth of STEM education, its definition has changed over time. STEM education is not a clearly defined field, unlike scientific disciplines such as physics, biology, chemistry, mathematics, and computer science (Li et al., 2019, pp. 1–13).

Hasanah describes four definitions of STEM: as a discipline, as teaching, as a field, and as a career (Hasanah, 2020, pp. 2–10). The acronym STEM is used as a label for any event, programme, or activity that involves one or a combination of the four STEM disciplines, which leads to ambiguity and a lack of substantive meaning (Bybee, 2013, pp. 1–12; Vasquez et al., 2013, pp. 3–8). The acronym STEM has been expanded to include other disciplines and emphases, such as STEAM ("A" for arts) and STREAM ("R" for reading and writing) (Tan & Kidman, 2021, pp. 24–52). There are different interpretations of the integration of STEM disciplines, with many advocating disciplinary integrations to equip students with the skills needed to solve multidisciplinary problems. Others express scepticism due to insufficient content coverage and limited conceptual development (English et al., 2016, pp. 1–8). In recent years, a new term, STEAM, has been introduced, which includes the arts in these areas (Cook, 2016, pp. 11–12; Land, 2013, pp. 547–552).

Many ways of achieving this have been proposed (Henriksen, 2014, pp. 1–5), for example, using artistic design in project-based learning scenarios (Connor et al., 2015, pp. 37–47). Studies show that the use of artistic elements in the teaching of STEM disciplines can lead to increased student creativity (Marmon, 2019, pp. 3–10; Zhbanova, 2019, pp. 2–12), although it is unclear to what extent this is due to the arts and to what extent to the multidisciplinary nature of STEM disciplines in general, as shown by Aguilera and Ortiz-Revilla (2021).

Assessment practices therefore play a key role in STEM education reform. However, when implementing STEM education to support innovation and improve teaching methods, certain challenges may arise. These challenges stem mainly from teachers' personal characteristics and experiences, which may affect their openness to new teaching methods (Al Salami et al., 2017, pp. 63–88; Lin et al., 2022, pp. 24–52).

For example, male teachers may be more inclined to adopt STEM pedagogical methods, while female teachers may be more inclined to adhere to traditional teaching approaches (Hernández & Muñoz, 2020, pp. 369–386).

This may be due to the influence of gender on teachers' beliefs and attitudes toward teaching, or it may be related to sociocultural factors. In addition, the subject that teachers teach may affect their openness to new teaching techniques. For example, science and technical subject teachers may more easily understand and accept the concepts and methods of STEM education, while humanities teachers may perceive them as unfamiliar or confusing (Smith et al., 2015, pp. 182–201).

Some related studies have found that STEM education may not have a significant impact on innovation and the improvement of teachers' pedagogical methods. For instance, even though teachers completed training in STEM education, no significant changes or improvements were observed in their subsequent teaching practices. These findings suggest that in the process of implementing STEM education to promote innovation and improve teaching approaches, we must fully take these factors into account and seek appropriate strategies to overcome the related challenges (Brown et al., 2019, pp. 1–12).

2.1 Virtual laboratories

The efficacy of virtual laboratories within STEM education has been validated by numerous scientific studies. For instance, Lynch and Ghergulescu observed that such environments provide pupils with valuable opportunities to conduct experiments at their own pace within a controlled setting, while simultaneously addressing resource limitations, safety concerns, and geographical constraints. These authors identified several key benefits, including the provision of immediate feedback for pupils, opportunities for inquiry-based learning, and the elimination of hazards inherent in physical laboratories. Furthermore, the effectiveness of these simulations in supporting pupils' learning is well-documented; their research particularly highlights the pedagogical value of virtual laboratories when they are integrated into a broader educational framework that aligns virtual experiences with specific learning objectives and assessment strategies.

2.2 Online platforms for education

Similarly, platforms such as Tinkercad, Arduino, and the BBC micro:bit emerge as effective and accessible tools within STEM education. Tinkercad has proven particularly valuable for teaching electronics and circuit design. In a comparative study of interfaces for learning circuitry and coding with Arduino, Tselegkaridis, Sapounidis, and Papakostas observed that pupils utilising a graphical user interface (GUI), such as Tinkercad, reported a more profound understanding of how components within microcontroller circuits are interconnected. The intuitive, visual nature of the Tinkercad environment appears to foster a conceptual understanding of complex electronic systems.

The Arduino platform is becoming increasingly common in STEM education as an accessible and versatile tool for teaching electronics, programming and design principles. Compared to alternatives, the Arduino platform offers excellent technical capabilities; initially, fewer educational resources were available, but this gap has increasingly been addressed in recent years. Several studies have examined the specific educational benefits of Arduino-based learning. Chaudry used Arduino Uno microcontrollers as an extra-credit activity in undergraduate physics courses and recorded increased student interest in physics and a better understanding of fundamental physics concepts (Marzoli et al., 2021, pp. 364–378).

The BBC micro:bit platform is particularly well-suited for beginners, owing to its inherent simplicity and ease of use. This underscores the necessity of selecting appropriate technologies based on pupils' level of experience and specific educational requirements. Furthermore, the financial cost of procuring laboratory kits equipped with microcontrollers remains a significant barrier to the adoption of these teaching resources. This fundamental issue, as reported by Hsiung et al. (2010), prompted the development of a cost-effective microcontroller trainer that pupils can retain, thereby enhancing their learning experience. This strategy successfully addressed challenges within microcontroller-related courses delivered via both distance education and campus-based formats by bypassing typical institutional budget constraints. Ultimately, the use of such training kits is indispensable for the study of microcontroller systems and embedded-systems technology.

Theoretical knowledge alone is insufficient to consolidate concepts within electronics and embedded systems education. Simulation kits offer a cost-effective solution for enhancing educational outcomes. It is essential that pupils are able to translate classroom theory into tangible applications through the development of physical devices. The factors outlined in the introduction of this paper informed the focus of our research, which analyses findings related to the integration of microcontrollers into teaching. The research problem was specifically defined to be addressed through an analysis of the responses to the following research questions:

Research questions (RQ)
RQ1: Does the use of microcontrollers affect students' achievement?
RQ2: Does working with microcontrollers support understanding of interdisciplinary relationships?
RQ3: Does students' attitude toward STEM subjects change after activities involving microcontrollers?
RQ4: Do students perceive working with microcontrollers as more engaging than traditional teaching?
RQ5: Do the results differ between groups of students with different forms of instruction?
RQ6: Does the integration of microcontrollers influence students' problem-solving skills?
RQ7: What is the impact on students' motivation to continue in STEM fields?
RQ8: Does teamwork improve when working with microcontrollers?

Hypotheses (H)
H1: The intervention will improve the understanding of interdisciplinary relationships.
H2: Students in the experimental group will perceive the instruction more positively.
H3: The results of the groups will differ statistically significantly.
H4: Microcontrollers will support the development of problem-solving skills.
H5: After the activity, interest in further study in the STEM field will increase.
H6: Microcontrollers will improve students' collaboration in a team.

Based on the research results of other authors, we created an initial database of information necessary for carrying out research focused on examining the integration of microcontrollers as a tool for an interdisciplinary approach in education.

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Authors who have addressed this issue:

- Šebo, M., et al. (2023): *Microcontrollers in interdisciplinary education*. KEGA project no. 019UKF-4/2023.
- Krajinčák, E. (2021): *Technical education at secondary schools in an online environment*.
- Krajinčák, E. (2022): *Distance education in the training of technical subject teachers at primary and secondary schools with a specific focus on electrical engineering*.
- Bellová, R. (2021): *An interdisciplinary approach to science education in the context of Slovak schools*.
- Akis, A. P., et al. (2024): *Using Arduino in Science, Technology, Engineering, and Mathematics (STEM) Education: Bibliometric Analysis*.
- Sulimro, F. L., et al. (2023): *Arduino Microcontroller Boards in Digital Learning for Science and STEM Education*.
- Guarda, G. F. (2023): *A systematic review of the use of BBC Micro:bit in K-12 education*.
- Filipe, J., et al. (2024): *Integrated STEAM education for student creativity: iSTEAM educational sequence*.
- Kefalis, C., et al. (2025): *Hands-on STEM learning experiences using digital fabrication technologies*.

We provide more detailed information from selected published studies by these authors, which we compared in terms of their aim, methodology, research sample, and the contribution of the implemented experiments.

A. P. Akis, et al. (2024)

Aim: To examine *Using Arduino in Science, Technology, Engineering, and Mathematics (STEM) Education: Bibliometric Analysis.* **Methodology:** Bibliometric analysis. **Sample/scope:** Analysis of publications over a defined period (hosted in databases such as Scopus/Web of Science). **Key findings:** Arduino has strong potential in STEM activities; limited international cooperation; increasing number of publications. **Strengths:** Relevance for school practice, open access (where available), clear recommendations for implementation. **Weaknesses:** Sometimes limited sample sizes, short-term measurements, few longitudinal studies.

F. L. Sulimro et al. (2023)

Aim: To examine *Arduino Microcontroller Boards in Digital Learning for Science and STEM Education: A Bibliometric Analysis (2012–2022)*. **Methodology:** Bibliometric analysis. **Sample/scope:** Analysis of publications over a defined period (hosted in databases such as Scopus/Web of Science). **Key findings:** Mapped trends and hot topics; growing use of digital learning; significant role of Arduino in maker education. **Strengths:** Relevance for school practice, open access (where available), clear recommendations for implementation.

Weaknesses: Sometimes limited sample sizes, short-term measurements, few longitudinal studies.

G. F. Guarda (2023)
Aim: To examine a systematic review of the use of BBC Micro:bit in K–12 education. **Methodology:** Systematic review. **Sample/scope:** Systematic review of selected studies with a synthesis of findings and gaps. **Key findings:** Micro:bit is used in science and computing; affordable and easy to use; gaps in longitudinal impact studies. **Strengths:** Relevance for school practice, open access (where available), clear recommendations for implementation. **Weaknesses:** Sometimes limited sample sizes, short-term measurements, few longitudinal studies.

J. Filipe, et al. (2024)
Aim: To examine integrated STEAM education for student creativity: the iSTEAM educational sequence. **Methodology:** Empirical study (intervention) (see source). **Sample/scope:** Intervention or case study with specific classes/tasks (see original article for methodological details). **Key findings:** iSTEAM sequences improved creativity and engagement of 9th- and 10th-grade students; practical design-focused tasks are effective. **Strengths:** Relevance for school practice, open access (where available), clear recommendations for implementation. **Weaknesses:** Sometimes limited sample sizes, short-term measurements, few longitudinal studies.

C. Kefalis et al. (2025)
Aim: To examine hands-on STEM learning experiences using digital fabrication technologies. **Methodology:** Empirical/case study. **Sample/scope:** Intervention or case study with specific classes/tasks. **Key findings:** Digital fabrication (FabLab) with microcontrollers supports situated STEM learning and skills development. **Strengths:** Relevance for school practice, open access (where available), clear recommendations for implementation. **Weaknesses:** Sometimes limited sample sizes, short-term measurements, few longitudinal studies.

E. Krajinčák (2024)
Aim: To examine the effectiveness and possibilities of technical education at secondary schools in an online environment. **Methodology:** Research based on questionnaires, analysis of distance-learning activities, and observation. **Sample/scope:** Students and teachers of technical subjects at selected secondary schools during the period of online teaching (2021–2023). **Key findings:** Online technical education is feasible with the use of digital tools and virtual laboratories; the greatest benefit is found in blended (hybrid) forms of instruction. **Strengths:** Current research clearly focused on practice; identifies real problems faced by teachers; empirical data from Slovak schools. **Weaknesses:** Limited sample size and duration of the experiment; results are not directly comparable with foreign meta-analyses.

E. Krajinčák (2022)
Aim: To examine the possibilities of distance education in the training of technical subject teachers with a focus on electrical engineering. **Methodology:** Qualitative analysis and model design of a distance-teaching system with testing of selected modules in practice. **Sample/scope:** Students of teacher-education programmes with a technical focus at the Faculty of Education, UKF; pilot verification within specialised subjects. **Key findings:** Distance education is effective when the content structure is clear and technical tools are available; it supports the development of digital literacy in future teachers. **Strengths:** Relevant topic; methodological support for the education of technical subject teachers; practical applicability for teaching practice. **Weaknesses:** Smaller sample of respondents; absence of quantitative measurements of skills effectiveness.

R. Bellová (2021)
Aim: To examine the level of interdisciplinarity in science education in the context of Slovak schools. **Methodology:** Empirical study based on a questionnaire survey of primary and secondary school teachers. **Sample/scope:** Teachers of science subjects (physics, biology, chemistry) at primary and secondary schools; approximately 200 respondents. **Key findings:** Teachers support an interdisciplinary approach but face a lack of methodological materials and time demands in teaching. **Strengths:** Real data from the Slovak context; clear identification of teachers' needs and barriers to interdisciplinarity. **Weaknesses:** Questionnaire survey without verification in practice; no experimental verification of effects.

M. Šebo et al. (2023) – KEGA project no. 019UKF-4/2023
Aim: To implement microcontrollers into teaching at primary and secondary schools in order to support interdisciplinary learning. **Methodology:** Applied research project; development of teaching aids, methodological materials and e-learning, verification in schools. **Sample/scope:** Primary and secondary schools involved in the project; teachers of technical and science subjects. **Key findings:** The use of microcontrollers increases students' motivation and enables the integration of physics, informatics, and technology; confirms the effectiveness of project-based learning. **Strengths:** Direct practical impact, up-to-date topic, interdisciplinary integration; creation of methodological outputs for practice. **Weaknesses:** Results are still interim; no published large-scale analysis of effectiveness yet.

3 Analysis and Interpretation of Results

Through the rigorous processing, examination, and analysis of the results, several graphical representations were developed; these allow the findings from the cited literature to be interpreted in the context of integrating microcontrollers into education. The presented graphs facilitate a comparison between groups of pupils, an assessment of the time demands associated with specific tasks, and an evaluation of pupils' knowledge levels and attitudes towards working with microcontrollers. These data provide a concise synthesis of the findings, derived directly from the values illustrated in the referenced figures.

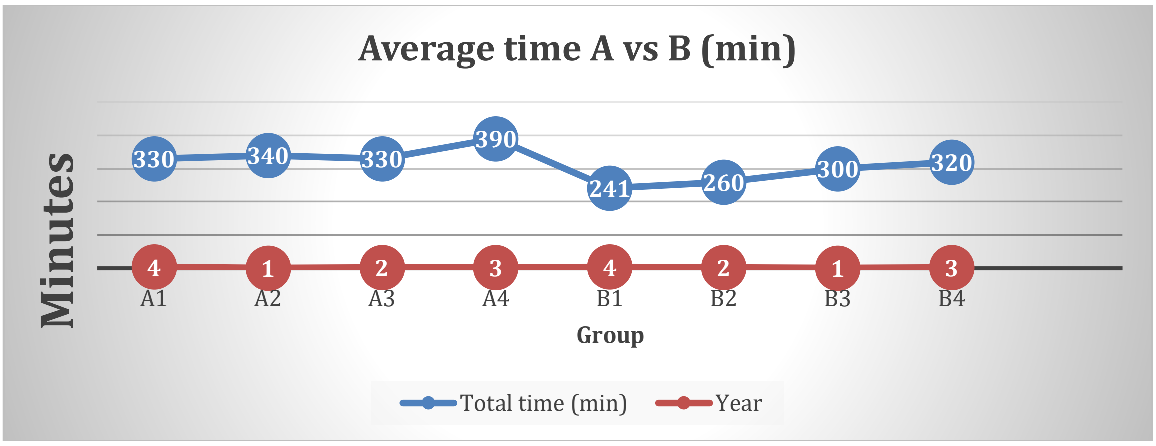

Figure 1: Average time A vs B. Source: Krajinčák E 2024.

The graph illustrates the duration of task completion across the individual groups. From the values presented, it is evident that Group A completed the experiments in an average of 347 minutes, whereas Group B achieved a lower average of 280 minutes. This 67-minute disparity suggests higher efficiency within Group B, which operated under a different instructional framework. The range of values within Group A (330–390 min) indicates greater variability in the working pace; conversely, Group B demonstrated more consistent performance (241–320 min). These data confirm that the organisation of teaching and the methodology of task implementation significantly influence the time demands of the experiments.

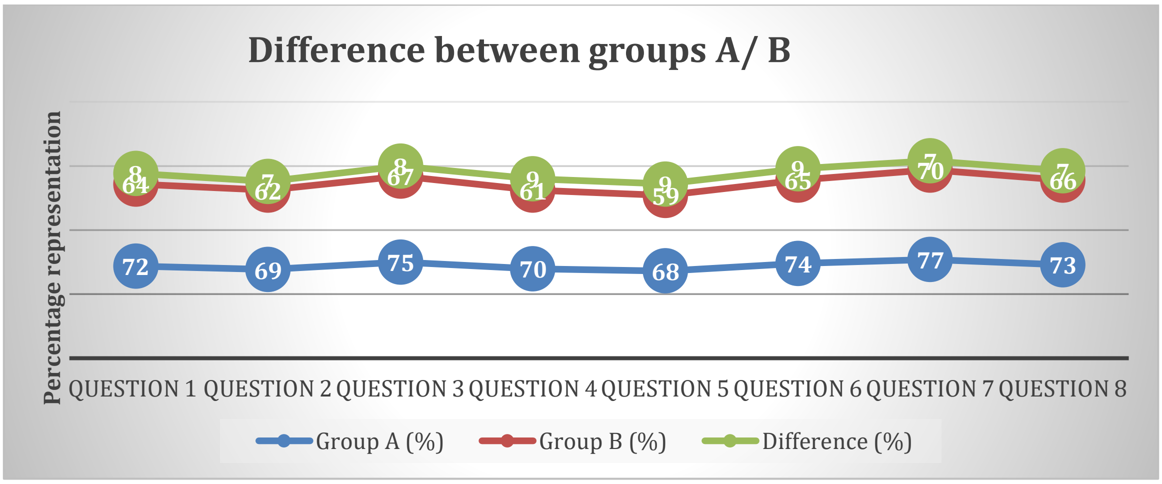

Figure 2: Difference between groups A/B. Source: Krajinčák E 2024.

The graph illustrates the percentage differences between Group A and Group B for the individual questionnaire items. In all eight questions, Group A achieved higher values of correct or agreeing answers, with differences ranging from 7 to 9%. The most pronounced difference was recorded for questions 4, 5, and 6, where Group A achieved a success rate higher by 9%. These results suggest that pupils in Group A had a better understanding of, or a more positive attitude towards, the monitored areas after completing instruction with microcontrollers. Overall, the graph confirms that the experimental group achieved consistently better results across all questionnaire items.

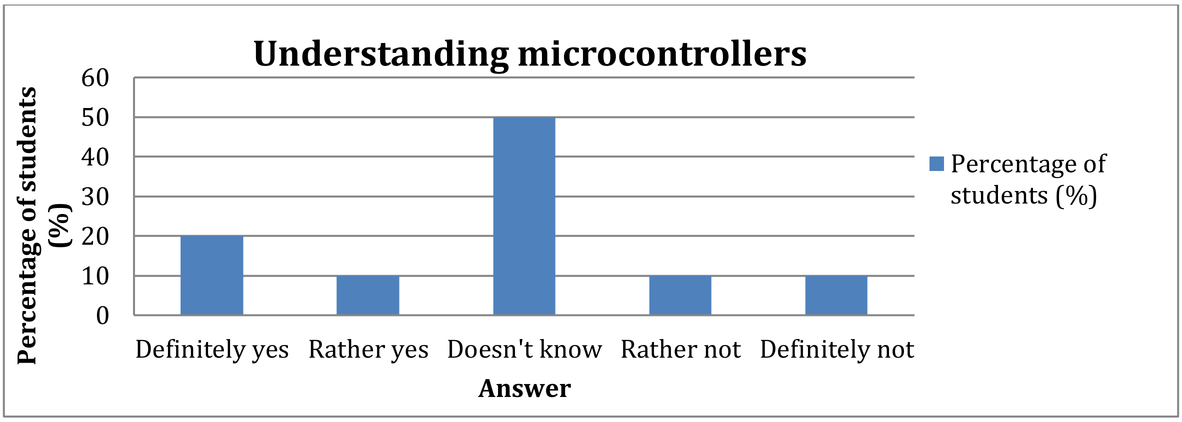

Figure 3: Understanding microcontrollers. Source: Kovács B 2024.

The graph illustrates the level of pupils' knowledge about microcontrollers before the practical activities were carried out. The results indicate that as many as 50% of pupils chose the answer "Don't know", which suggests that the term microcontroller was unfamiliar to them prior to instruction. Only 20% of pupils answered, "Definitely yes" and 10% "Rather yes", which together represents 30% of pupils with at least partial knowledge in this area. A further 20% of pupils ("Rather no" and "Definitely no") confirmed that they had not encountered microcontrollers before. The results point to a low initial level of knowledge of the issue, which underlines the need to incorporate microcontrollers into technology and informatics teaching already in earlier grades.

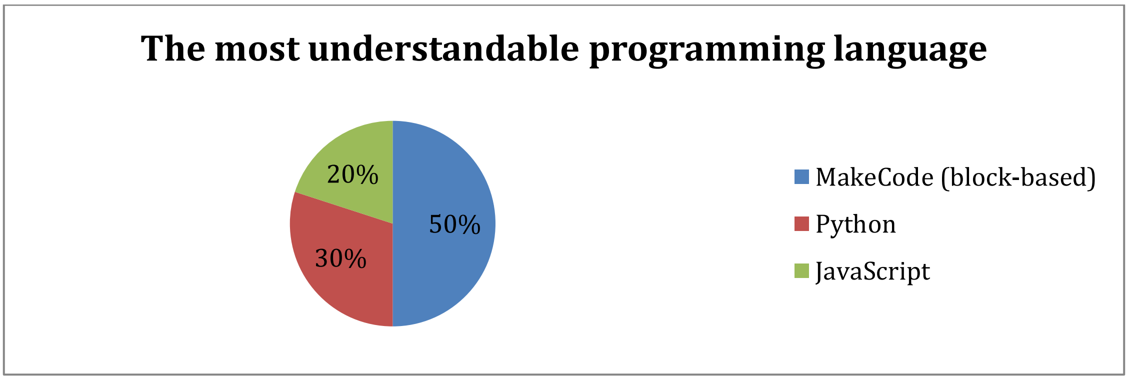

Figure 4: The most understandable programming language. Source: Kovács B 2024.

The graph illustrates which programming language pupils considered the most understandable when working with microcontrollers. Most pupils (50%) indicated block-based programming in the Make Code environment as the clearest and easiest to understand, as it is visual and intuitive. 30% of pupils preferred Python, which points to growing familiarity with text-based programming. The remaining 20% chose JavaScript, which is less frequently used in the educational environment of primary and secondary schools. The results confirm that block-based environments such as Make Code are the most suitable pathway for beginners to understand the basics of programming microcontrollers.

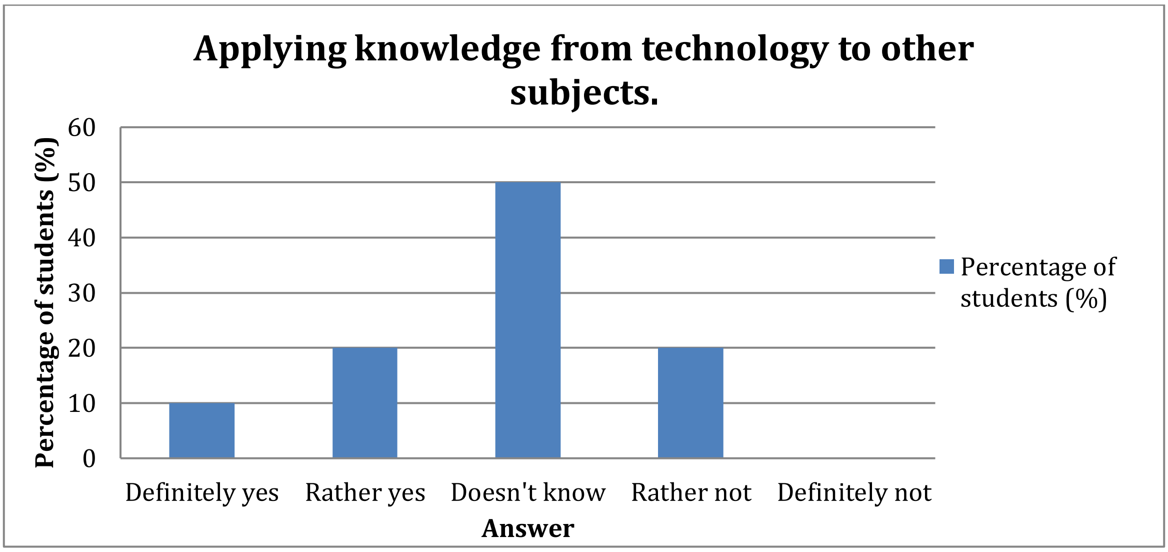

Figure 5: Applying knowledge from technology to other subjects. Source: Kovács B 2024.

The graph illustrates the extent to which pupils perceive the possibility of using knowledge from the subject Technology in other areas of instruction. The largest proportion of pupils (50%) answered “Don’t know”, which indicates uncertainty when it comes to linking content from Technology with other subjects. A further 20% of pupils chose “Rather yes”, while the same proportion (20%) answered “Rather no”. Only 10% of pupils are convinced that they can actively apply what they learn in Technology in other subjects. The results point to the need for stronger cross-curricular integration and systematic support for teachers in designing interdisciplinary tasks that enable pupils to practically apply technical knowledge also in science and informatics subjects.

4 Conclusion

Microcontrollers have become an integral part of modern life, embedded within almost every electronic device encountered daily. Despite their ubiquity in items ranging from mobile telecommunications hardware to household appliances, their presence often remains unnoticed by the end-user. Today, it is rare to find a functional electronic device that does not rely on a microcontroller for its operation. Our investigation into the integration of microcontrollers within the educational process was prompted by several factors. Principal among these is their compact dimensions and low power consumption, which render them ideal for portable or energy-constrained applications. From an economic perspective, a significant advantage lies in their ability to integrate input/output functions and memory onto a single board; this results in greater efficiency and cost-effectiveness compared to alternative microprocessor systems.

Drawing upon the analysis and implementation of educational activities using microcontrollers in educational practice, we identified several key advantages and potential areas for improvement. It is important to continue developing and innovating in the field of technical education to effectively prepare future generations for the challenges of the digital world.

The results of the analysis, interpreted through the presented figures, offer an overview of the outcomes achieved during the investigation. The displayed data show the basic differences between the groups, the time required to complete the activities, and pupils' responses to individual questions. The results serve primarily as illustrative support for the presented data and help to complement the overall picture of the implemented activities. On this basis, it is possible to create a general comparison of the monitored variables, while a more detailed evaluation would require further research and more extensive processing.

The research findings can serve as a valuable source of information and inspiration for teachers interested in integrating technologies into the educational process and supporting interdisciplinary relationships. Future studies could broaden understanding and inform the design of optimal ways of using microcontrollers in various educational contexts, thereby contributing to further development in this area. Developments in the field of microcontrollers are advancing rapidly, both in terms of hardware and software.

For this reason, microcontrollers are increasingly being integrated into the educational process already at primary schools, especially at the lower secondary level. Pupils often do not perceive microcontrollers merely as educational tools, but rather as devices capable of enhancing their daily lives. Research has demonstrated that the integration of microcontrollers into the curriculum significantly bolsters pupils' motivation. Furthermore, these tools can be effectively utilised to facilitate cross-curricular links, serving as a practical medium for implementing interdisciplinary education.

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Experiences and Preferences: Face-to-Face and Distance Chemistry Education

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Abstract

The content, quality, and efficiency of education affect not only the level of scientific and technical knowledge and the development of production technologies but, above all, the demands of social and production practice. Understandably, new requirements for content and educational forms are also being developed in this changing environment. Chemistry is one of the disciplines that provides education in the fields of science and technology. The prerequisite and factor for the sustainable development of education at present is undoubtedly the development of innovative teaching methods and approaches, accompanied by professional qualifications in chemistry. In this paper, we address the issue of comparing in-person and distance learning in chemistry. The survey aimed to find out how primary and secondary school teachers perceive face-to-face and distance education in the science discipline. We focused on their experiences, opinions, advantages, disadvantages, and classroom problems encountered in both forms of education.

Keywords: Education, Chemistry, Pre-Service Teacher, Digital Competence, Teaching Form

1 Introduction

The contemporary educational environment is undergoing dynamic changes driven by technological progress, societal demands, and growing practical needs for the quality of vocational and professional education (OECD, 2020; Stebila et al., 2023; Žáčok et al., 2023). The content, quality, and effectiveness of education influence not only the level of scientific

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and technical knowledge but also the overall development of production technologies and the competencies required in modern society (Yemini et al., 2025).

Chemistry, as a natural science discipline, plays a significant role in shaping scientific thinking and developing practical skills; therefore, it is essential to address the effectiveness of different forms of chemistry instruction (Hofstein & Lunetta, 2004; Hofstein & Kind, 2012; Bretz, 2019). Its importance as a core natural science subject also underpins other technical disciplines. Chemistry provides students with fundamental scientific reasoning, an understanding of natural processes, and practical skills applicable across many different science subjects.

During 2019 and the subsequent years, a substantial shift in instructional formats occurred. The predominantly face-to-face forms of education used until then were significantly altered. The pandemic period accelerated the transition to distance (online) education. It raised new questions regarding the suitability and comparison of distance and face-to-face learning, as well as their limitations and potential, particularly in experiment-based subjects (Hofstein & Lunetta, 2004; Means et al., 2010; Seery, 2015; Bretz, 2019; Hodges et al., 2020).

Education during the pandemic, and especially in the post-pandemic period, has brought forward unresolved questions concerning the effectiveness of different instructional formats, differences in teachers' perceptions, and the lack of empirical studies specifically focused on chemistry education (Tsaparlis & Sevian, 2013; Taber, 2014; Seery, 2015; König et al., 2020; Trust & Whalen, 2020). Concerning the interconnection and sustainability of education, issues related to the effectiveness of individual instructional forms, teachers' perceptions, and the scarcity of chemistry-specific empirical research have become increasingly prominent. In a changing educational environment, it is understandable that requirements for instructional content and teaching methods are evolving as well. From the perspective of sustainability and practical relevance, chemistry education should support the development of competencies applicable in real-world contexts, including environmental awareness, responsible use of materials, and the application of chemical knowledge in everyday and professional practice.

This study aims to analyse how primary and secondary school teachers perceive face-to-face and distance instruction in chemistry and to identify the advantages, disadvantages, and challenges associated with both methods. Furthermore, the study seeks to assess which instructional formats and methods teachers consider more effective and under which conditions.

2 Material and Methods

This study focused on teachers' perceptions of hybrid (face-to-face and asynchronous online) instruction in chemistry at primary and secondary schools. The aim was to identify how this combined approach can enhance the advantages of both instructional modalities. Particular attention was paid to selected chemistry topics, as chemistry education includes laboratory activities that require experimental work and the development of practical skills, not only in handling chemical substances but also in using laboratory equipment.

Data were collected through a questionnaire survey designed to capture teachers' subjective experiences and evaluations of different instructional approaches. The questionnaire consisted of 15 closed-ended and 3 open-ended questions (18 items in total). The survey was conducted between 2022 and 2024 among chemistry teachers at primary and secondary schools. Participation was voluntary, and the sample was intended to represent a wide range of teaching experience. The questionnaire covered demographic information (teaching experience, type of school, subjects taught), experience with face-to-face and distance teaching, perceived effectiveness of different instructional forms, identified problems and barriers, and teachers' views on sustainability and innovation in chemistry education.

The research sample included 50 teachers, of whom 30 taught chemistry (28 women and 2 men). Most respondents were from primary schools; among grammar school teachers, 4 women and 2 men participated. All participants had at least 5 years of teaching experience and had been teaching since at least 2019.

The collected data were processed using descriptive statistical methods. Responses to closed-ended questions were analysed quantitatively using frequencies and percentage distributions to summarise teachers' experiences and evaluations of different forms of instruction. Selected items were compared according to school type and length of teaching experience. Responses to open-ended questions were analysed qualitatively using thematic analysis. Participants' statements were coded and grouped into main thematic categories reflecting the benefits, limitations, and barriers of hybrid instruction in chemistry education. All data were processed anonymously.

3 Results and Discussion

Among the advantages of online and face-to-face instruction were flexibility (online) and practical learning and peer interaction (face-to-face). As reported by Carter et al. (2025), self-discipline and pacing pose key challenges in online education, whereas those associated with face-to-face instruction were minimal.

About the forms of instruction and the items included in the questionnaire, the study focused on the following areas:

- identifying teachers' experiences with both forms of education,
- identifying the advantages and disadvantages of both forms of education from teachers' perspectives,
- comparing the effectiveness of individual forms of education in terms of achieving educational objectives,
- examining the problems encountered in chemistry teaching in both forms of education,

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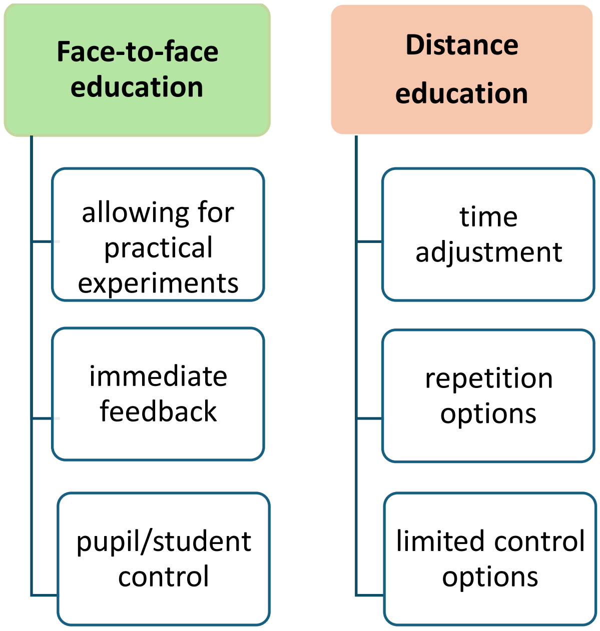
- proposing recommendations for practice and for the further development of innovative teaching methods, including identifying which form of instruction is perceived as more effective for different types of learning content.

3.1 Teachers' Experiences with both Forms of Education

In the introductory section of the questionnaire, teachers' experiences with face-to-face and distance education were compared. When the questionnaire items were grouped according to perceptions of face-to-face education in comparison with online education, teachers evaluated the forms of education as follows (Scheme 1):



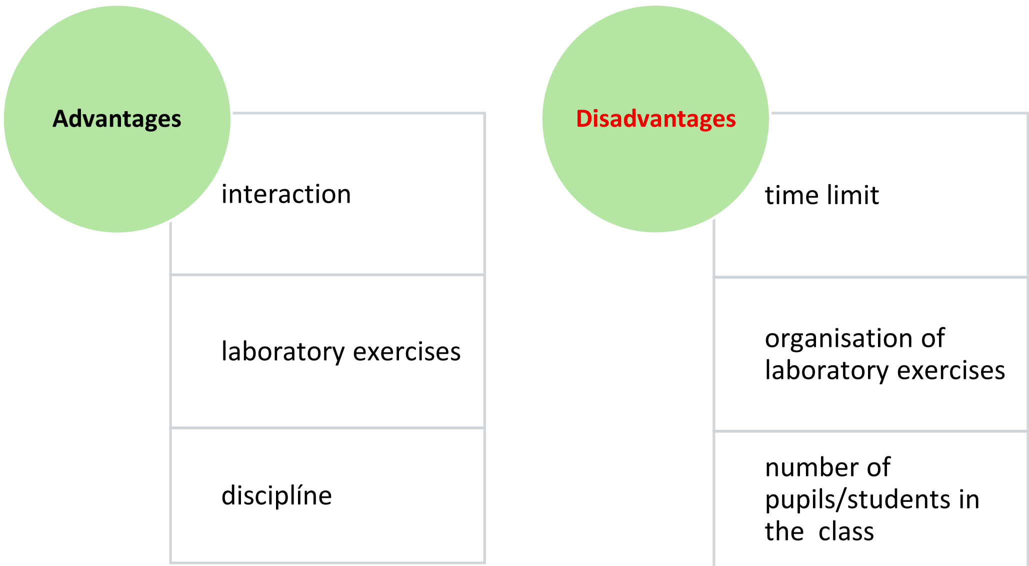
Scheme 1: Comparison of Face-to-Face and Distance Education in Chemistry at Primary and Secondary Schools.

When comparing the results, the majority of respondents reported that face-to-face education feels more natural and also allows them to verify knowledge through practical experiments. As noted by Velempini and Maruatona (2025), for full self-realisation, individuals need to acquire basic knowledge, skills, and habits that can be applied in everyday life. 18 teachers highlighted immediate feedback as a result, and the same outcome was observed during face-to-face lessons when monitoring pupils/students. In terms of evaluation, teachers considered the main advantage of face-to-face instruction to be the focus on teaching and the subsequent assessment of pupils´/students' acquired knowledge. The most important phase in the educational process is the motivational phase—stimulating interest, desire, effort, and the drive to achieve, accomplish, and create something new (Song & Bonk, 2016). In this phase, the role of a highly qualified teacher is irreplaceable (Ruiz-Mallén et al., 2022).

In online education, 27 respondents highlighted time flexibility as a positive aspect, and 60% noted the possibility of repetition. However, many also reported that online education can lead pupils/students to be less focused on learning.

3.2 The Advantages and Disadvantages of both Forms of Education from Teachers' Perspectives

In the following section, we identified the advantages and disadvantages of both forms of instruction from the teachers' perspective. After completing the questionnaire, the factors influencing face-to-face education were classified as its advantages and disadvantages (Scheme 2):



Scheme 2: Advantages and Disadvantages of Face-to-Face Education in Chemistry at Primary and Secondary Schools.

Online education was appreciated for its time flexibility (27 respondents) and the possibility of repeating content (60% of respondents). However, teachers noted that online learning can sometimes lead to reduced pupils/student focus. Teachers reported the following advantages of online education (Table 1):

	Advantages	Disadvantages
Online education	flexibility	limited possibilities for experimentation
	resource availability	weaker pupil/student attention
	use of digital tools	technical problems
	even activities	uneven motivation

Table 1: Advantages and disadvantages of online education.

One of the key areas often underestimated yet with a significant impact on the long-term sustainability of the workforce and quality of life is the development of qualifications and practical skills. In line with these goals, education at primary and secondary schools is a crucial phase, during which fundamental connections are formed among knowledge, attitudes, and habits essential for students' future qualifications through creative activity (Ramadani et al., 2023).

3.3 The Effectiveness of Individual Forms of Education

In the third section, we compared the effectiveness of different instructional approaches in achieving educational objectives, based on teachers' responses. When comparing the two forms of instruction, it can be concluded that both face-to-face and online teaching have their advantages and disadvantages. Based on the results, respondents considered face-to-face instruction as the more effective form (70%). In line with the State Educational Programme (iŠVP) and considering the nature and objectives of the chemistry subject, the organisation of lessons was adapted to the number of students in each class. This ensured appropriate conditions for the proper implementation of teaching and fulfilment of performance and content standards (iŠVP).

Teachers noted that online instruction was less effective for achieving subject-specific aims when pupils/students:

- planned and conducted observations, measurements, or experiments (practical activities);
- developed manual, intellectual, and social skills through practical work while applying safety principles for handling chemicals;
- mastered and applied proper chemical safety procedures.

Most teachers considered face-to-face instruction more natural and suitable for chemistry, particularly for laboratory work, demonstrations, and practical experiments. Benefits included immediate interaction, better oversight of students' activities, and more effective feedback.

Online education was viewed differently. Its flexibility and access to diverse resources were appreciated, but the hands-on nature of chemistry posed practical limitations.

Overall, teachers regarded face-to-face instruction as more effective for most content areas, especially laboratory work, demonstrations, and handling chemicals and lab materials. Online learning was considered better suited for theoretical topics, review, and multimedia-supported learning.

3.4 The problems in Chemistry Teaching in both Forms of Education

In the penultimate part, we examined the problems encountered in teaching chemistry in both forms of education. Most teachers considered the face-to-face form (Table 2) more natural and suitable for teaching chemistry, especially given the need for laboratory work,

demonstrations, and practical experiments. Educators emphasised the possibility of immediate interaction, greater control over pupils' and students' activity, and more effective feedback provision.
Teachers evaluated distance learning (Table 2) ambivalently. Many of them appreciated, in particular, its ability to use modern digital tools. On the other hand, it was significant that perceptions of limitations were related to chemistry's practical nature.
When comparing the two forms, teachers found that face-to-face instruction is more effective for most subjects, especially for laboratory activities, demonstrations, and work with chemicals and laboratory materials. According to them, distance education is more suitable for theoretical topics, curriculum revision, and the use of multimedia aids.

Education	Advantages	Disadvantages
Face-to-face for	• direct guidance of laboratory exercises and experimental demonstrations, • personal guidance of students when working with chemicals and equipment, compliance with health and safety regulations, • immediate feedback, • better discipline and concentration of students, • pupil/student involvement, • easier solution of problem situations.	• time and space requirements of laboratory exercises, • limited material resources in some schools, • higher organisational requirements.
Distance form	• flexibility in teaching, • easy sharing of digital resources, • the possibility of using interactive applications, simulators and videos, • availability of materials for students outside of school.	• inability to conduct experiments, • weaker student motivation and reduced attention, • technical problems (internet, devices), • limited feedback and control, • worse knowledge assessment.

Table 2: Perception of face-to-face and distance learning from the perspective of educators.

3.5 Proposing Recommendations for Practice and Further Development of Innovative Teaching Methods

When recommending practice in chemistry education as a proposal for practice and the further development of innovative teaching methods, respondents offered several suggestions based on their own experience. Respondents mentioned possible combinations of face-to-face and distance learning (*blended learning*) as long as pupils/ students use correct procedures and techniques in practical activities, process and evaluate data obtained from coherent and disjointed texts, analyse problems, apply knowledge, formulate and verify hypotheses, and appropriately present professional knowledge and information. The optimal solution that teachers mentioned was a combination of both forms (*blended learning),* which uses the advantages of digital tools while maintaining face-to-face practical teaching.

If we consider the interpretation of what these results mean for the future of chemistry teaching, we can come to the following conclusions:

According to teachers, face-to-face education is more effective, especially for

- laboratory and practical topics,
- skills training,
- explaining complex concepts.

Distance education is suitable for

- theoretical topics,
- revision of the curriculum,
- use of multimedia aids.

Teachers perceive the most effective approach as a combined form (*blended learning*), which combines the advantages of both methods. This is also associated with considerations of the need for methodological innovations, the roles of digital tools, and improvements in teacher qualifications (Velempini et al., 2017).

Most respondents reported that face-to-face teaching felt more natural and enabled validation of knowledge through practical experiments. Immediate feedback was highlighted as a key benefit by 18 teachers, and similar results were observed in pupil and student evaluations of face-to-face classes. Teachers emphasised that the motivational phase – stimulating interest, engagement, and creativity – is crucial for learning and the role of a highly qualified teacher is irreplaceable (Song & Bonk, 2016; Ruiz-Mallén et al., 2022).

4 Conclusion

Currently, one of the main challenges for the sustainable development of education is the development of innovative forms and methods, accompanied by adequate professional qualifications of teachers. The results are in line with the findings of many current studies, which indicate that science subjects require direct manipulation of chemical substances and laboratory equipment and tools, which distance learning cannot fully replace. On the other hand, the online environment offers opportunities for innovation, such as virtual experiments, video demonstrations, and interactive quizzes, which can enrich traditional teaching. Both forms have their specificities, but in science subjects, the face-to-face format remains key. The results also point to the need to develop teachers' digital competencies and to systematically support schools in introducing modern technologies to develop innovative methods in chemistry teaching.

The survey showed that chemistry teachers prefer face-to-face education, mainly because of the subject's practical nature, the need for direct interaction with pupils and students, and the provision of better-quality feedback. However, distance education offers several additional advantages that can be effectively applied to selected topics, especially those of an abstract nature. However, distance education can complement face-to-face teaching by addressing theoretical issues and by using digital tools. Teachers identified several problems associated with distance education, in particular, low pupil/student motivation and technical difficulties. Nevertheless, they consider digital technologies an essential part of modern education. In the future, it is important to support the development of teachers' digital competences, to innovate teaching methods, and to create conditions for the effective combination of both forms of education. A promising approach seems to be combining both forms of education, which optimises the learning process and leverages the strengths of face-to-face and distance education.

Blended learning appears to be a promising approach to sustainable, modern teaching of science subjects, including chemistry. For future development, it is necessary to support innovations, methodological guidelines and further education of teachers in the field of modern teaching technologies.

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The Influence of Online Education on Students' Attention and Safe Teaching

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Abstract

This article examines the relationships among online education, students' attention, and safe teaching in vocational and technical subjects. Online education has become an established component of the educational process and has fundamentally transformed both knowledge acquisition and the organisation of technical and vocational instruction. The main question addressed is how the digital environment affects students' attention and what prerequisites are required to ensure that online teaching remains both safe and effective. The article analyses the benefits and risks of online education, attention-supporting techniques, and the didactic strategies employed by teachers of vocational subjects. Attention is conceptualised as a variable cognitive function that can be intentionally developed through pedagogical approaches, the regulation of digital technologies, and the creation of a safe learning environment. In line with current trends, the article highlights the importance of high-quality preparation for vocational teachers in digital instruction, their technological proficiency, and their role in shaping safe and structured learning practices.

Keywords: Online Education, Attention, Safe Teaching, Vocational Subjects, Digital

1 Introduction

Online education has, within just a few years, become an integral part of school practice and is no longer perceived as a temporary solution but rather as a stable model of the educational

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process. The COVID-19 pandemic significantly accelerated this transformation and simultaneously exposed limitations in the preparedness of schools, teachers, and students for changes in instructional modes (Adnan & Anwar, 2020). Research has shown that simply transferring traditional teaching methods to an online environment is insufficient, as the nature of cognitive processes, interaction patterns, and feedback mechanisms fundamentally changes (Mahyoob, 2020). Conversely, online education has also provided opportunities for flexibility, individualisation, and multimodal learning, all of which can offer considerable added value in vocational education.

The literature on safe educational environments consistently emphasises that learning is effective only when it takes place within a didactically safe and well-structured framework in which students clearly understand learning objectives and are able to orient themselves within tasks (Hanuliaková & Porubčanová, 2024). This requirement is even more pressing in the online environment, where students lose the natural anchor points of the physical classroom and their attention is exposed to a far greater number of competing stimuli. The teacher thus becomes not only a facilitator of content but also a regulator of the digital environment and a guarantor of safe instruction.

Particular demands are placed on teachers of vocational subjects, who must ensure the acquisition of complex technical procedures and practical skills in a digital environment. Research in technical and vocational education indicates that these teachers function as both interpretative and safety nodes: they transform technical concepts and technological processes into forms that students can understand, visualise, and apply safely (Bočková et al., 2023). At the same time, their workload increases, as they must adapt practical tasks to the online environment while maintaining safe and transparent learning conditions.

The social and organisational dimensions of education also come to the fore. Studies on the safety of school environments point to the importance of certainty, predictability, and relational stability as prerequisites for effective learning (Sirotová, 2025; Emmerová, 2025).

In the context of formative education at secondary schools, Tamášová and Zapletal (2022) demonstrate that an environment characterised by a positive climate, clear expectations, and transparent pedagogical communication is essential for the development of student responsibility and focus. These findings are fully applicable to online instruction, in which students need sufficient information not only about content but also about procedures and assessment criteria.

A crucial aspect of a safe environment is the management of attention, which in the digital environment becomes one of the most heavily taxed cognitive functions. Digital tools offer abundant resources and rapid feedback but simultaneously demand greater stimulus selection and more advanced metacognitive skills from students (Robinson & Cook, 2018; Mrázek et al., 2022). Maintaining attention cannot be left to chance or individual predispositions but must be an intentional part of pedagogical design.

2 Online Education and Its Didactic Specifics Headings

Online education is not merely a technical shift to a different platform but an intervention in the very structure of teaching. Several empirical studies confirm that online instruction must be conceived as a distinct pedagogical system that considers the different nature of interaction, motivation, and students' attention (Baticulon, 2020; Adnan & Anwar, 2020).

A fundamental prerequisite is a clear architecture of the learning process: explicit objectives, a transparent task schedule, and unambiguous communication of requirements. Without these elements, students experience increased cognitive overload, lose orientation in the curriculum, and their ability to focus on key components of the learning situation declines (Mahyoob, 2020).

Digital platforms such as Microsoft Teams or Google Classroom provide an appropriate framework for managing tasks, archiving materials, and offering feedback; however, their didactic potential depends on how the teacher structures and moderates the learning process. Research on safe environments indicates that students benefit from a stable, repeatable lesson structure that alternates between the exposition of new content, active engagement, and reflection (WHO, 2023; Hanuliaková & Porubčanová, 2024; Emmerová, 2025). In online learning, this structure often serves as the main guide, replacing the natural organisation present in a physical classroom.

In vocational subjects, the situation is even more complex because students must integrate theoretical knowledge with specific work procedures. The State Institute of Vocational Education (ŠPÚ, 2022) highlights that digitalised vocational education cannot rely solely on theoretical presentations but must also include tasks stimulating applied and problem-based thinking. Teachers are thus compelled to redesign traditional practical exercises into formats suitable for online learning—such as video demonstrations, simulations, case studies, or virtual laboratories. Although each of these solutions has limitations, when implemented well, they can support sustained attention and help students understand the sequence of steps in technical processes.

A further significant shift involves changes in interaction patterns. In face-to-face instruction, teachers can immediately react to non-verbal cues, address misunderstandings, and adjust the pace of the lesson. Online environments weaken these mechanisms—reactions may be delayed, visual feedback is limited, and monitoring each student's activity in larger groups becomes challenging. Research in technical subjects shows that delays or disruptions in feedback can lead to errors in mastering procedures and to a decline in focus (Bočková et al., 2023). Teachers must therefore purposefully plan checkpoints for verifying understanding and use varied forms of interaction—short questions, quizzes, chat responses, and reflective comments.

Online learning also shifts more responsibility for structuring the learning process to students. Whereas in face-to-face instruction teachers manage much of the organisational structure for students, online environments require learners to self-regulate their time, plan their activities, and evaluate their progress. This benefits students with strong self-regulation but poses risks for others, particularly at the secondary level (Mrázek et al., 2022).

Teachers of vocational subjects must therefore explicitly develop students' metacognitive skills—for instance, through reflective tasks, planning work steps, or maintaining learning journals.

A synthesis of these findings shows that online vocational education cannot be reduced to a simple technological shift. Instead, it requires a comprehensive redesign of didactic approaches. The teacher becomes the architect of the online learning environment, responsible for ensuring clear objectives, appropriate cognitive load, transparent organisation, and meaningful use of technology. Without a well-developed didactic concept, online teaching risks undermining attention, compromising safety, and reducing the overall quality of vocational education.

3 Safe Teaching in the Online Environment

A safe educational environment is currently conceptualised as a multidimensional framework encompassing physical, psychological, social, and didactic safety. Research on school safety emphasises fundamental prerequisites such as transparent organisation, clear behavioural rules, and consistent responses to risk situations (Emmerová, 2025; Kozubík, 2025).

In online learning environments, these principles are transferred into digital form: platform stability, clear working rules, civil communication, and data protection.

It is important to distinguish between technical and didactic safety. Technical safety includes secure access credentials, protection against inappropriate content, and reliable software. Didactic safety refers to a framework in which students understand expectations, have clear instructions, and receive sufficient support to complete tasks. Research on safe educational environments repeatedly shows that without clear structure and explanation of rules, students' uncertainty increases, leading to diminished attention and more risk-prone behaviours (Porubčanová, 2025; Hanuliaková, 2023).

These findings align with international studies demonstrating that the quality of distance education is determined more by organisation and communication than by technology itself (Adnan & Anwar, 2020).

In vocational education, safety has traditionally had a strong physical dimension—students work with tools, machinery, or materials, governed by clear safety protocols. Although this physical component may seem less prominent online, it takes on new forms. Vocational teachers must ensure that students understand risks even when viewing demonstrations through video or simulation. Moreover, teachers must guarantee the ethical and professional quality of digital materials and ensure that online tasks do not require students to perform unsafe interventions at home (Bočková et al., 2024).

The social dimension of safety is particularly fragile online. Studies on school climate demonstrate that feelings of acceptance, fairness, and predictable teacher responses significantly influence students' willingness to collaborate and communicate openly (Michvocíková, Malichová-Oríšková,2025; Tamášová & Zapletal, 2022).

In digital environments, these bonds can weaken as communication becomes more concise and less personal. Teachers must therefore intentionally create opportunities for interaction, questioning, and constructive feedback, ensuring that students perceive online lessons as safe spaces for learning and expressing uncertainty.

A particularly relevant risk is student overload. Research on online teaching reports that numerous tasks, multiple platforms, unclear deadlines, and inconsistent requirements across subjects often lead to feelings of chaos, weakening attention and motivation (Mahyoob, 2020). Authors focusing on safe environments stress that students learn effectively when expectations, deadlines, and assessment methods are transparent (Emmerová, 2025). For vocational teachers—whose tasks are often more complex and time-consuming—rigorous adherence to these principles is essential.

Comparisons of Slovak and international research (Porubčanová et al., 2025, 2023; Olejníková, 2025) indicate that a safe online environment results from the interplay of multiple factors: clear organisational structure, adequate technical support, civil communication, and professional teacher guidance. Without such coordination, online instruction risks fragmenting attention, weakening relationships, and reducing the quality of vocational education. In this context, the vocational teacher becomes the decisive actor whose approach can stabilise or destabilise the entire process of safe learning.

4 Students' Attention in Online Education and Pedagogical Strategies for Its Support

In psychological literature, attention is defined as a selective and sustained orientation toward relevant stimuli, which enables deeper information processing. In online education, this cognitive function is particularly strained because students are simultaneously exposed to learning content, technical interfaces, and numerous potential distractions. Robinson and Cook (2018) introduce the concept of *"stickiness"*, referring to the degree to which a student can remain engaged with a learning activity without shifting attention to other stimuli. Their research shows that the duration and quality of sustained attention are closely linked to task design, clarity of instructions, and the teacher's moderating strategies.

Mrázek et al. (2022) and Zelina (2018) empirically demonstrate that attention can be trained through techniques that explicitly develop students' self-regulation and metacognitive awareness. In the online environment, this translates into teaching students how to manage digital distractions, divide work into shorter blocks, monitor levels of fatigue, and intentionally schedule breaks. Without such support, students tend to fall into passive observation—formally attending the lesson while dividing their attention across multiple activities.

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In vocational and technical subjects, attention is essential not only for understanding theoretical content but also for following sequential procedures in practical tasks. Bočková et al. (2023) and Olejníková (2025) point out that teachers in technical disciplines must manage complex instructional processes that are demanding for students even in face-to-face settings. Online, these demands intensify: students must monitor screens, interpret verbal instructions, and mentally visualise processes that would typically be supported by multisensory experiences in a workshop or laboratory. Without appropriate scaffolding, attention declines rapidly, leading to superficial learning.

Digital distractions belong to the most significant challenges of online learning. According to Mahyoob (2020), notifications, parallel applications, and attempts at multitasking result in fragmented attention and reduced task performance—especially among students who lack advanced self-regulation skills. Although the digital environment often creates the illusion that multitasking is efficient, research (Magdadiová, 2025) consistently shows that task-switching reduces processing depth and increases error rates.

Pedagogical strategies designed to support attention must respond to these specific demands. Based on analyses of teaching practice, Impero (2023) recommends structuring lessons into shorter, clearly defined segments with frequent checkpoints and varied activities. Consistent with the recommendations of Mrázek et al. (2022), it is effective for teachers to explicitly teach planning routines, identification of personal distractors, and reflection on moments when attention lapses. In vocational subjects, these strategies can be integrated into content delivery—for example, planning the steps of a technical task serves both as attention training and as a professional skill-building activity.

Assessment also plays a key role. Robles and Braathen (2002) distinguish among traditional, alternative, and performance-based assessments. In vocational education, it is crucial to balance these forms in online contexts. Alternating tests, project assignments, practical demonstrations, and reflective activities increases variety and prevents monotony—one of the primary contributors to attention decline. For example, vocational teachers may combine short theory quizzes with video analyses of technical procedures and individual student reflections on the most challenging steps.

A synthesis of psychological and pedagogical perspectives demonstrates that attention cannot be viewed merely as an individual trait. It emerges from the interplay of personality predispositions, learning habits, and the quality of the learning environment. In a safe, well-structured online environment—where the teacher clearly defines objectives, processes, and working rules—students with weaker self-regulation abilities have far better chances of sustaining attention (Emmerová, 2025; Hanuliaková & Porubčanová, 2024).

In this context, the teacher of vocational subjects is a key agent whose didactic design determines whether the online environment becomes a support or an obstacle to students' attention and the development of vocational competencies.

5 Research Section

The research section is based on a partially modified design of the study by Bočková, Porubčanová, Procházka, and Gawrych (2023), which examined the workload and didactic challenges faced by technical subject teachers. In our study, the focus was placed on the relationship among online lesson organisation, students' attention, and vocational teachers' perceptions of educational safety.

Research Objectives:

1. To examine how vocational subject teachers assess students' attention during online instruction.
2. To ascertain how they perceive the safety of the educational environment in a digital context.
3. To identify which didactic strategies teachers consider most effective for maintaining student attention and ensuring safe learning processes.
4. To analyse the extent to which students' attention is associated with the clarity and organisation of online teaching.

The research involved 89 vocational subject teachers from Slovak secondary vocational schools, representing three disciplinary groups:

- Technical fields (46%)
- Gastronomy and hotel services (32%)
- Arts and crafts (22%)

The average length of teaching experience was 14.2 years.
A questionnaire was developed comprising three sections:

1. Online lesson organisation – clarity of instructions, transparency of tasks, and lesson structure ($\alpha = 0.87$).
2. Students' attention – perceived focus, responsiveness, and susceptibility to distraction ($\alpha = 0.81$).
3. Safe educational environment – clarity of rules, teacher availability, predictability, and communication culture ($\alpha = 0.84$).

All items were measured using a 1–5 Likert scale.

Key Findings

a) Students' attention in online lessons is highly variable.

Up to 72% of teachers reported that students were easily distracted during online instruction and required more frequent changes of activity. This aligns with Robinson and Cook (2018), who emphasise the short-term stability of attention in digital environments.

b) Clear lesson organisation predicts attention.

Regression analysis ($R^2 = 0.41$) showed that task transparency and clear instructions explain 41% of the variance in students' attention. These findings support claims by safety theorists (Emmerová, 2025; Zahoranská, 2025) that didactic certainty is fundamental to effective learning.

c) Sense of safety correlates with attention and orientation.

Teachers who reported higher availability to students also rated students' attention more positively ($r = 0.46$). This confirms the argument by Tamášová and Zapletal (2022) that clearly communicated expectations enhance student orientation and reduce stress.

Unlike face-to-face instruction, where teachers have natural control over the classroom environment, digital instruction shifts part of this responsibility to students, many of whom may lack metacognitive skills required for maintaining attention. The research shows that teachers most frequently adopt strategies such as:

- predictable and stable lesson structure,
- frequent comprehension checks,
- alternating shorter activity blocks,
- explicit articulation of each activity's purpose.

These practices were also identified as effective in the previous research by Bočková et al. (2023), forming the foundation of successful vocational pedagogy under challenging teaching conditions.

6 Discussion

The findings of this study confirm several conclusions from previous research on online education, educational safety, and attention in digital contexts. Clear lesson organisation emerged as the most significant factor influencing students' attention. This is consistent with international evidence indicating that transparency and clarity of tasks are among the strongest predictors of learning success in online settings (Adnan & Anwar, 2020; Mahyoob, 2020).

The correlation between a safe learning environment and attention is equally important. Authors writing on school safety (Porubčanová, 2025; Emmerová, 2025) emphasise that safe learning takes place in environments characterised by clear rules, predictable teacher responses, and civil communication. Our study confirms that these factors are essential for sustaining students' attention in online lessons.

The finding that frequent teacher interaction supports attention further reinforces the results of Bočková et al. (2023), who demonstrated that teacher availability helps reduce feelings of chaos and stabilises the learning process under demanding conditions. Interaction therefore functions as a protective factor against attention breakdown in digital environments.

From a pedagogical perspective, the results suggest that students' attention in online education is not primarily an individual predisposition but rather a systematic outcome of clear organisation, structured processes, and safe communication. Teachers of vocational subjects, who work with complex technical procedures, play a decisive role in shaping these conditions.

A well-designed online environment—characterised by clear expectations, transparent tasks, balanced cognitive load, and ongoing interaction—can significantly enhance students' ability to maintain attention, even when their self-regulation skills are underdeveloped. Conversely, when these didactic elements are weak, online instruction becomes fragmented, unsafe, and less effective in promoting vocational competencies.

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Current Trends in the Development of the Institutional Educational Environment

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Abstract

The paper examines current trends in the creation of institutional educational environments, with particular emphasis on the contemporary challenges faced by secondary schools. The theoretical synthesis highlights the need to reconsider the way schools create and organise their environments – physically, digitally, culturally and in terms of values. The analysis addresses key components of the educational environment from didactic, psychological, and technological perspectives. The aim of the paper is to identify the principal trends and compare the Slovak context with selected foreign initiatives. The paper also proposes recommendations for pedagogical practice, with a focus on well-being, and the creation of a supportive and safe school environment.

Keywords: Educational Environment, Social and Emotional Safety of the School

1 Introduction

The institutional educational environment has become one of the key areas of contemporary pedagogical research, as the quality of learning and the overall effectiveness of educational systems are increasingly associated with the characteristics of the physical, digital, social and emotional conditions in which learning takes place. Current European frameworks emphasise that the school is not merely a place for the transmission of knowledge, but a complex and dynamically evolving ecosystem that co-creates the cultural, value-based and relational contexts of learning and shapes processes of socialisation, motivation and students' psychosocial functioning.

Theoretical concepts grounded in ecological, systemic and constructivist approaches highlight that the educational environment represents an interconnected structure in which a change

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in one element – such as the digitalisation of teaching, individualisation of learning or increased diversity of student populations – generates transformations in other dimensions of the system. This perspective aligns with European strategic documents that stress inclusiveness, sustainability, democratic participation and the promotion of mental health as integral components of high-quality education.

At the same time, empirical findings increasingly demonstrate that the quality of the school environment is a significant predictor of academic achievement, student motivation, well-being and sense of belonging. The analysis of current trends in shaping the educational environment therefore requires an interdisciplinary approach that integrates pedagogical, psychological, sociological and organisational perspectives. The aim of this study is to identify key developmental tendencies in the field of institutional educational environments, outline their theoretical foundations, illustrate their manifestations in the European and Slovak context and propose their implications for educational research and teachers' professional development

2 Educational Environment as a Multidimensional and Dynamic System

The educational environment is defined in contemporary pedagogical theory as a multidimensional, variable and dynamically evolving system comprising physical, digital, social and emotional determinants that shape learning processes, socialisation and the overall personal development of learners (Leone, 2019; OECD, 2021). At the institutional level, the educational environment represents a complex framework encompassing the value orientations of the school, the quality of interpersonal interactions, the subjective sense of safety, as well as the social and didactic climate.

From the perspective of theoretical models, the educational environment can be interpreted through Bronfenbrenner's ecological systems theory (1979), which emphasises the interconnectedness of the various contextual layers influencing the individual. Similarly, theories of 'learning environments' (Fraser, 2015) highlight that the educational environment is not a mere sum of isolated factors but an interactional system that creates conditions for high-quality learning.

A change in one component – such as the digitalisation of teaching –generates modifications in other parts of the system (OECD, 2021), which is characteristic of complex adaptive systems (Davis & Sumara, 2006).

2.1 Components of the Educational Environment

In line with contemporary European concepts of 'learning environments', the educational environment can be understood as a multidimensional system comprising physical, digital, social and emotional (psychological) dimensions. These dimensions are interconnected and jointly determine the quality of the learning process, school climate and the well-being of both students and teachers (OECD, 2020; European Education Area, 2024).

Physical Environment

The physical environment includes the architecture of the school building, the layout and equipment of classrooms, lighting quality, acoustics, microclimate, and the availability of spaces for relaxation, individual work and cooperation. Research conducted as part of the OECD Learning Environments Evaluation Programme (LEEP) confirms that the quality of the physical environment – particularly natural light, acoustic comfort, air quality and flexible spatial arrangements – is associated with improved learning outcomes and higher levels of students' subjective well-being. Contemporary European approaches prioritise flexible, multifunctional spaces that enable differentiated instruction, small-group work and project-based learning (OECD, 2017; Eurydice, 2024).

Digital Environment

The digital environment comprises the technical infrastructure (computers, mobile devices, interactive boards, learning platforms) and the ways in which schools integrate technology into teaching and learning. European policy documents and analytical reports emphasise that what matters is not merely the level of equipment, but above all: the digital competences of teachers and students; the quality of pedagogical design of digital activities; the level of cybersecurity; the critical and ethical use of digital content (European Commission, 2023). Hybrid and online forms of learning extend the school environment into virtual spaces, increasing flexibility and personalisation, while simultaneously raising demands for supporting students from less stimulating backgrounds and ensuring equity of access (Eurydice, 2023).

Social Environment

The social environment consists of the network of relationships among students, teachers, school leadership, parents and the broader community. The concept of school climate, elaborated in the European context as part of inclusive and democratic education systems, highlights the importance of trust, respect, cooperation and student participation (European Agency for Special Needs and Inclusive Education [EASNIE], 2025). Research demonstrates that perceived support, fairness and openness on the part of teachers are key predictors of students' emotional experiences, motivation and school functioning (Bocchi, 2023; Martinelli, 2023).

Emotional (Psychological) Environment

The emotional/psychological environment relates to students' feelings of safety, acceptance, identity and meaningfulness of school life. European frameworks for school well-being (European Commission, 2024) conceptualise well-being as the integration of cognitive, emotional, social and physical dimensions of students' experience. According to Petlák (2025), as conditions and the world itself continue to change, the concept of well-being also evolves, and its meaning and significance are growing. Maslow's hierarchy of needs makes it clear that safety relates to a person's subjective feelings and the fulfilment of their need for security — a state in which they feel unthreatened, comfortable in a particular place or situation and within relationships with others, experiencing no negative emotions and maintaining a sense of personal identity as well as cooperation with others. The requirements for well-being arise from expanding knowledge about education and all aspects connected to it, but they are also a response to the dominance of scientism in schools, where students' emotions were pushed into the background. School atmosphere, communication practices, levels of empathy and psychological support are closely linked to school-related stress, anxiety and students' sense of belonging (Eurydice, 2023).

3 Trends in Shaping the School Environment – A Theoretical Synthesis

Contemporary pedagogical and didactic theory and practice increasingly demonstrate that the educational environment is no longer understood as a neutral 'backdrop' to instruction, but rather as an active agent influencing learning, socialisation and the psychological well-being of both students and teachers. Empirical findings from European comparative studies (TALIS, PISA, Eurydice, EASNIE) as well as national research highlight the need to systematically reconsider the ways in which schools design the physical, digital, social and value-based dimensions of their functioning.

Spatial Flexibility and Pedagogical Design
Traditional arrangements of desks in rows are increasingly being replaced by flexible spatial configurations that can be adapted to learning goals and student needs. In the European context, preferred solutions include variable layouts (circles, groups, learning zones), connections between classrooms and open spaces, and specialised zones (quiet spaces, project areas, community spaces). Findings from LEEP and related analyses show that such environments support collaboration, creativity and interactivity, and can contribute to improved PISA outcomes, particularly among students from less stimulating backgrounds (OECD, 2017, 2020).

Digital Transformation and Hybrid Teaching
The digital environment of schools in Europe is expanding rapidly through the adoption of LMS platforms, national educational portals and collaborative applications. Hybrid arrangements (combining in-person and online learning) enable individualised and asynchronous learning, while simultaneously increasing demands for the support of students at risk of digital

disadvantage. European documents emphasise the need to develop the digital competences of teachers and whole school teams, including the pedagogical use of technology rather than merely technical proficiency (Sipică & Toma, 2022; European Commission, 2023).

Well-being as an Integral Component of the Educational Environment

Among the most prominent trends is the shift from exclusively cognitive-oriented goals towards the integration of mental health and well-being into educational policy and school practice (Nozori, 2025).

The European Commission and the Expert Group on Supportive Learning Environments stress the whole-school approach, in which well-being is not an 'add-on', but a structural dimension of school life (European Commission, 2024).

A well-being-oriented environment includes physical elements (rest zones, relaxation and quiet spaces); psychological and social support (school psychologists, peer support, mentoring); a culture of respect, participation and safe communication.

European research confirms that a positive school climate and supportive relationships are associated with higher student motivation, lower absenteeism and improved learning outcomes (Bocchi, 2023; Martinelli, 2023).

Inclusivity and Universal Design for Learning

An inclusive educational environment is designed to be open and accessible to all learners regardless of their abilities, cultural or linguistic background, disabilities or socioeconomic status. European frameworks and EASNIE statistics emphasise the need for a supportive, caring and participatory environment that addresses the holistic needs of learners (EASNIE, 2025).

The concept of Universal Design for Learning (UDL) is increasingly applied in European educational policies, particularly in relation to diversity and equal opportunities. The environment should be designed in such a way that it does not require ex post adaptations but rather anticipates population variability from the outset (Eurydice, 2023).

Sustainability and "Green" Educational Environments

European documents on education for sustainability highlight that the school environment itself constitutes an important 'curriculum element' – physical infrastructure, greenery, and the management of energy and waste create a framework for environmental literacy and responsible citizenship (European Commission/Eurydice, 2024).

A sustainable educational environment includes green architecture (natural materials, energy efficiency, greenery); ecological programmes (waste sorting, water collection, school gardens); integration of environmental themes into everyday teaching.

Such approaches reinforce students' sense of meaningfulness in school life while simultaneously developing competences necessary for sustainable societal functioning (Petkou et al., 2025).

4 Research and Empirical Insights

4.1 Slovak Context

TALIS 2018 and the Professional Environment of Teachers

The international OECD TALIS 2018 study provided important data about teachers' perceptions of their professional environment across OECD countries, including Slovakia (OECD, 2020). For the Slovak context, particularly significant findings concern school climate and relationships, support from school leadership, professional collaboration among teachers and opportunities to implement innovative pedagogical approaches.

According to the national TALIS report, Slovak teachers more frequently than the OECD average perceive insufficient support, limited opportunities for participation in decision-making and a less developed culture of collegial collaboration (OECD & NÚCEM, 2020). These data suggest that the organisation and culture of the school environment in Slovakia may constitute a limiting factor for the development of innovative and inclusive teaching.

National Research on Well-being and School Climate (NIVaM)

In recent years, the National Institute for Education and Youth (NIVaM) has conducted several studies focused on student and teacher well-being as well as the quality of the school environment. Findings confirm a strong association between students' subjective well-being, the quality of interpersonal relationships, opportunities for rest and support at school and the degree of student participation in decision-making (NIVaM, 2023a, 2023b).

Among the most significant findings are:

1. *Relationships as a Key Indicator of Well-being*

Students who perceive their teachers as fair, supportive and open to communication report higher satisfaction with school, lower levels of stress and a greater willingness to cooperate. Conversely, experiences of ridicule, ignoring or lack of interest are associated with lower self-confidence and poorer emotional functioning.

2. *Physical and Social Conditions as Protective Factors*

The possibility to rest in a safe space, access to support services and aesthetically arranged classroom environments correlate with higher levels of student satisfaction and a lower incidence of psychosomatic difficulties.

3. *Student Participation and the 'Student Voice'*

Students who have a real opportunity to participate in decision-making (choice of activities, involvement in classroom and school structures) report higher subjective well-being and a stronger sense of meaningful connection to school.

4. *Risk Factors: Stress, Misunderstanding, Bullying*

Experiences of verbal, social or online bullying are associated with higher levels of stress, anxiety, psychosomatic symptoms and an increased risk of school absenteeism.

These findings align with European frameworks for supporting mental health and well-being in schools, which recommend systematic work on school climate, student engagement and multidisciplinary support (Ministry of Education SR, 2023).

Slovak teachers often perceive their professional environment as lacking support, with limited opportunities to participate in decision-making and an underdeveloped culture of collegial collaboration. Students who view their teachers as fair, supportive and open to communication show higher satisfaction with school and lower levels of stress. In contrast, negative experiences with teacher behaviour led to lower self-confidence and poorer emotional functioning. Physical and social conditions of the school also play an important role, particularly the availability of safe spaces for rest and access to support services. Aesthetically and functionally arranged classrooms increase student satisfaction and reduce psychosomatic difficulties. Risk factors such as stress, misunderstandings or bullying are associated with higher anxiety, psychosomatic problems and an increased risk of absenteeism.

Overall, research suggests that supporting students' mental health and well-being requires systematic development of a positive school climate, high-quality relationships and accessible support mechanisms.

4.2 International (European) Context

OECD LEEP Programme – Physical Environment and Learning Outcomes

The OECD Learning Environments Evaluation Programme (LEEP) focuses on assessing the quality of physical learning environments and their relationship to student outcomes and pedagogical practices (OECD, 2017).

LEEP has identified several key parameters of effective physical learning environments:

- lighting — with an emphasis on natural daylight,
- acoustics — reducing noise and disruptive stimuli,
- air quality and thermal comfort,
- flexibility and spatial zoning,
- aesthetics and visual clarity of the environment.

Findings indicate that modern, flexible and well-maintained environments contribute to improved student outcomes and are particularly significant for learners from socioeconomically disadvantaged backgrounds. OECD recommends that investments in infrastructure be linked to pedagogical design and that both students and teachers be involved in decisions regarding spatial modifications.

European Frameworks for Inclusion, Diversity and Well-being

Eurydice, OECD and EASNIE provide a framework for understanding how diversity, inclusion and well-being policies shape educational environments:

Promoting Diversity and Inclusion in Schools in Europe (Eurydice, 2023) analyses policies aimed at supporting learners with special educational needs, migrants, minority groups and students from marginalised backgrounds, emphasising the importance of a supportive climate and accessible resources.
Equity and Inclusion in Education (OECD, 2023) presents a holistic framework for the development of equitable and inclusive education systems and highlights the need for schools to respond differentially to the diverse needs of learners.
EASNIE (2025) underscores the importance of a supportive, caring and participatory school and classroom climate as the core of an inclusive education system.

European Guidelines for Mental Health and the Whole-School Approach
New EU guidelines for policymakers in the field of well-being and mental health in schools recommend a systemic, whole-school approach that integrates:

- school strategy,
- curriculum,
- teacher support,
- counselling and prevention services,
- participation of families and the wider community (European Commission, 2024).

This framework is aligned with conceptual models of school well-being that integrate the dimensions of climate, support, participation and emotional safety (Bocchi, 2023; Martinelli, 2023).

5 The Teacher as a Creator of Innovative Educational Conditions

The teacher plays a key and irreplaceable role in the process of education. The educational environment is shaped primarily by the teacher's professional activity, pedagogical competences, interpersonal behaviour, organisational strategies of teaching, and the ability to respond to the diverse needs of learners. The educational environment does not represent only the material and spatial framework of the classroom; rather, it constitutes a complex system encompassing the psychosocial climate, organisational structure of the educational process, digital learning conditions and the network of relationships among all actors in the school. In this context, the teacher acts as a central agent who shapes, coordinates and functionally integrates these components into a cohesive environment that supports learning and student development. In contemporary pedagogy, the teacher's role is understood holistically: the teacher is not only an expert on instructional content but also a creator of conditions for students' development, learning and well-being. The teacher supports the '21st-century learning environment' by implementing hybrid forms of instruction, project-based learning and collaborative learning spaces. Their approach must reflect current trends, societal needs and translate them into the design and creation of educational conditions.

As a creator of a safe and supportive environment, the teacher ensures students' physical and psychological safety. Through everyday actions, the teacher shapes the school climate—students who perceive their teacher as supportive and fair demonstrate higher self-esteem, lower levels of stress and greater interest in learning.

Hanuliaková and Lobotková (2023) conceptualise the teacher as a professional who, through didactic, communication and social competencies, creates a stimulating and supportive learning environment, motivates students and adapts instruction to their needs.

Antoniuk et al. (2023) further emphasise that a comfortable and safe learning environment emerges when the teacher intentionally promotes open communication, student participation and learner responsibility for their own learning.

As a facilitator of learning and motivation, the teacher fosters students' intrinsic motivation by providing appropriately challenging tasks, constructive feedback and meaningful opportunities for choice. They create conditions in which students perceive learning as meaningful and connected to real life. The teacher supports autonomy, competence and relatedness—the three basic psychological needs defined by Self-Determination Theory (Deci & Ryan, 2020).

As a model of social behaviour, the teacher demonstrates through their communication, conduct and conflict-management practices how to build relationships, collaborate and regulate emotions. They promote inclusion, mutual respect and a positive social climate. The psychosocial dimension of the environment places emphasis on safety, fairness and supportive relationships. Within this dimension, the teacher acts as a regulator of interactions, creator of norms and model of socially desirable behaviour. A positive climate characterised by trust, respect and recognition is a significant predictor of student engagement, well-being and academic success; conversely, a conflictual or inconsistent environment increases the risk of stress and school failure (Pasandalan & Cerado, 2025).

As a member of a professional community, the teacher collaborates with colleagues, exchanges experiences and contributes to the development of school culture. The teacher participates in decision-making related to the organisation of instruction and the school environment. Within partnership communication, they cooperate with parents and professional staff. The teacher's role is increasingly expanding to include coordination of collaboration with colleagues, school leadership and families. The teacher is perceived as a member of a professional community jointly responsible for the culture of the school and for establishing systemic conditions that support learning and the well-being of all students.

This aspect becomes particularly prominent in the context of inclusive and sustainable schools, where the educational environment is understood as a shared product of all actors, although the teacher remains its most visible representative in everyday practice (Mubaidillah, 2025).

From these perspectives, it follows that the teacher's role in the educational environment is not solely didactic but also strongly socio-psychological and organisational-professional. The teacher is a key actor who can shape an environment that supports learning, well-being, participation and student development. Without the teacher's intentional and responsible engagement in these aspects, the potential of the school remains unfulfilled. Ensuring such comprehensive pedagogical practice requires adequate support for teachers—professional development, collegial collaboration, opportunities for reflection, mental-health support and appropriate organisational conditions in the school (clear rules, fair management, participatory culture). A sustainable educational environment presupposes understanding the teacher's role as a complex professional mission.

5 Conclusion

The educational environment is a complex, dynamic and adaptive structure that conditions the quality of instruction, psychosocial well-being, motivation and the overall development of learners. Its systematic research and cultivation are essential within the European context for building inclusive, democratic and sustainable education systems. Given the multifaceted nature of the educational environment, pedagogical research must focus on developing valid tools for its diagnosis and evaluation (e.g., TALIS, CLASS, ECERS); examining the determinants of positive school and classroom climate; supporting teachers' professional competences—particularly in the areas of inclusion, ICT, differentiation and socio-emotional learning; and fostering teachers' professional learning through collaborative forms (Hargreaves & Fullan, 2012).

From a pedagogical-psychological perspective, the educational environment is closely linked to research on motivation, well-being, school coping and the prevention of risk behaviour (Ryan & Deci, 2020).

Contemporary European findings and national research clearly confirm that the educational environment is a key determinant of educational quality, well-being and social inclusion. The physical, digital, social and emotional components of the environment form a dynamic, interconnected system in which a change in one element influences the configuration of the whole. Trends such as flexible architecture, digital transformation, inclusive environments, whole-school well-being and sustainability highlight the need for systemic and long-term school development planning.

The Slovak context demonstrates that relationships, school culture, leadership style and the degree of student and teacher participation are of paramount importance. The future of schooling depends on its capacity to conceptualise the educational environment as an adaptive, inclusive and supportive space in which every learner can fully develop their competences, identity and well-being in alignment with the challenges of the 21st century.

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Increasing Students' Motivation to Study Technical Subjects through Changes in Assessment

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Abstract

Various findings indicate that low motivation among secondary vocational school students remains a primary challenge in the teaching of technical subjects. Many teachers assume that a change of the traditional assessment model, which relies on a numerical scale from 1 (excellent) to 5 (insufficient), could significantly enhance student motivation to study the technical subjects. This paper proposes an alternative evaluation system based on the accumulation of points, providing both a practical example and the results of its pilot implementation. Within this framework, negative motivation is mitigated as the teacher no longer primarily seeks to highlight the weaknesses or errors of a student. Instead, the system rewards achievements through the allocation of points. Furthermore, the responsibility for the final grade is transferred from the teacher to the student, who is empowered to determine their own final outcome based on performance.

Keywords: Secondary Vocational Education, Students Assessment, Motivation to Study the Technical Subjects

1 Challenges Related the Education Sector of Secondary Vocational Schools

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In relation to secondary vocational schools, a significant paradox currently exists. On the one hand, there is a clear national and societal requirement to support the further development of this education sector. This involves enhancing both the quantity and the quality of graduates to meet the demands of the labour market for a properly trained and qualified workforce. So, the main task of vocational schools is to focus on developing well-trained, motivated, higher-order skills, industry-responsive and globally competitive labour force which are needed in globalizing world (Marope et al., 2015).

From this perspective, secondary vocational schools are widely acknowledged as critical components of the national educational system. Conversely, within society, these institutions are often perceived as inferior and are frequently viewed as being intended for those with insufficient academic abilities or poor levels of attainment. Furthermore, there is a persistent lack of interest among the younger generation regarding study programmes that focus on technology and science (Pavelka et al., 2020; Azeem & Omar, 2019).

In the context of the system of vocational schools this can be partially influenced by two factors, which are insufficient infrastructure of the offered education and training and (Li, Zhou & Yuan, 2017).

In our view, the limited funding available for infrastructure should not be interpreted solely as a means of procuring technical equipment. This is particularly relevant as the existing facilities and training centres in these schools frequently lag behind contemporary industrial standards. Furthermore, investment is required for the continuing professional development of staff, whose current knowledge and skills may not always align with latest industry trends.

Establishing an appropriate infrastructure within the vocational education environment necessitates, among other factors, bringing education into closer alignment with industrial practice. This requires a flexible curriculum with updated content, the modernisation of teaching methodologies, and a refined system for the assessment of students. As the world outside the classroom evolves, educators are compelled to reconsider the strategies they employ when teaching subjects with a focus on technology. Or rather they should reconsider them and reevaluate their upgrading or changing, e. g., taking into consideration current job requirements, existing gaps between the world of work and the world of education, need to align learning objectives to social needs, and new demand in education due to globalization (Wieckenberg, 2014; Kwami & Manabete, 2022).

Science and technical subjects are often considered to be difficult and not interesting for students (Tomková, 2025). In studies conducted to uncover possible reasons for disinterest, students most frequently cited the difficulty of science subjects as a reason (Fančovičová & Kubiatko, 2015).

One challenge that teachers exhibit in teaching technical subjects is their inability to use befitting teaching methods for certain tasks. According to Modebelu and Duvie (2012) one of the most effective teaching styles is the one which is based on a combination of teaching techniques, knowledge of subject matter, enthusiasm for teaching and sensitivity to another's own characteristics. Similar findings resulted from a panel discussion with the staff of secondary vocational schools, mainly the ones focused on information technologies, the aim of which was to identify difficulty aspects of the vocational education and training, specifically to identify:

- what are the causes of difficulty in teaching technical subjects,
- what are the effective ways of motivating students to study technical subjects and how is it possible to maintain the motivation of students for a longer time, and
- what makes it possible to attract students´ attention more significantly in the teaching of technical subjects (Hašková, Danko, Pavera & Sałata, 2024).

One of the most significant findings emerged from the discussion among the panellists regarding the potential for motivating students to engage with the subject matter of required technical disciplines. This also encompassed the various methods through which student motivation could be sustained over an extended period. The initial responses from the panellists to these inquiries were somewhat sceptical; indeed, several participants suggested that the challenges addressed in these questions were largely Insoluble. However, as the discussion progressed, this initial scepticism diminished. The participants began to link potential solutions for student motivation to the overarching system of student evaluation. Several panellists described examples of successful outcomes following the discontinuation of traditional grading in specific subjects. This transition led to increased student motivation and consequently resulted in higher levels of academic attainment.

2 The Used Methods of Student Assessment: Why and How to Change Them

Motivating students to acquire new knowledge, skills, and experiences is an essential component of the professional responsibilities of a teacher. Regarding technical subjects, common methods for motivating students include encouraging active participation in various experimental activities and rewarding the mastery of specific tasks. Furthermore, students are often encouraged to engage in competitions or the development of projects related to the discipline. Other strategies involve highlighting the lives of prominent individuals who successfully pursued new knowledge or identified a solution to a problem, as well as those who encountered failure but persevered. However, teachers are increasingly struggling with student disengagement and are asking for ways to motivate students.
But they are asking not only for ways to motivate students, they also are asking about appropriate ways to motivate students more towards self-study, where the students would take responsibility for themselves, for their own learning. That is why we were interested by the finding, that emerged from the afore-mentioned discussion, namely that the low students´ motivation to learn could be associated with the way in which they are assessed, what would mean that the traditionally used system of students evaluation has rather demotivating than

motivating, or encouraging influence on them. We took into the consideration also the fact that students often complain about the unfairness of teacher evaluations. They feel that the final grade is not primarily in their hands, but in the hands of the teacher.

Regarding the traditional method of evaluating pupils through a numerical grading scale ranging from 1 (excellent) to 5 (insufficient), it is important to note that this system has a long historical tradition in Slovakia. This method of assessment was established by Maria Theresa, Queen of Hungary and Bohemia, who introduced the system alongside compulsory school attendance throughout the Austro-Hungarian Monarchy in 1774. Although numerous modifications have occurred over the subsequent two and a half centuries, the fundamental essence of the system has remained unchanged. Although the question is currently being raised on one side whether the evaluation of a student by grades is no longer outdated and experts have different opinions, everyone agrees on the fact that pupils and students should be assessed.

Within their teaching practice, teachers are faced with a dilemma regarding various approaches to assessment. They must consider what to evaluate, how to conduct such evaluations, and how these processes will influence their subsequent teaching as well as the progress of their pupils or students. It is now widely recognised that assessment constitutes more than mere classification. It serves multiple functions beyond simply providing information on the extent to which pupils or students have acquired specific knowledge or competences. In addition to this evaluative role, assessment is intended to facilitate student progress throughout the learning journey and to refine the ways that teachers work to ensure they remain as effective and beneficial as possible.

In our opinion, attempts to replace grading by means of verbal assessment have emerged from the recognition that the conventional system focuses exclusively on demonstrated learning outcomes. This existing model often fails to account for the diligence of pupils and students or the significant effort they have invested to achieve those results. Fair grading is always a question of what we consider fair. If we start from the student’s potential, we know the students have different potentials. Therefore, the grade does not express entirely fairly what a student knows.

Conversely, if grading is perceived as a form of feedback, it essentially serves to identify the current progress of a student on the path toward acquiring specific knowledge and skills. In certain subjects, it is possible to define precisely what a student must master, or rather which grade will be assigned based on a specific number of errors. For example, if a student makes fifteen errors in a dictation, this will result in a grade of five. That is relatively objective. But it is not always that simple, and mainly if assessing students´ learning achievements in technical subjects. That means that the question stated in the sub-title of this section “why and how to change the used way of assessment” applicable to every taught subject or learning unit, it is our view that this should certainly be considered in the context of technical disciplines.

3 Example of Good Practice in the Use of Alternative Student Assessment to Increase Study Motivation

In this study, we elected to replace traditional grading within selected technical subjects with a system based on a predetermined and fixed number of points. Consequently, a grade is only assigned to the student at the conclusion of the classification period. While this model initially appears to offer numerous advantages, these benefits were further confirmed during the experiment through both direct observation and feedback provided by the students. Under this system, the teacher no longer focuses primarily on identifying the weaknesses or mistakes of the student; instead, they reward the successes the student has achieved through the allocation of points. This assessment model effectively eliminates the possibility of continuous negative motivation for students.

One of the most important advantages of this type of assessment is that students have the final assessment in their own hands. In this way the responsibility for the final grade is postponed from the teacher to the students, who can determine for themselves the final grade they will receive at the end of the grading period based on the number of points they have earned. To ensure this system remains sustainable and accessible, it must be defined with the utmost simplicity. Consequently, the framework can be summarised by three fundamental rules:

1. Throughout a single classification period, which corresponds to one half of the academic year, a student can earn a maximum of 100 points. This total, representing 100 per cent of the available marks, is divided into the following categories *limited* and *unlimited* points. Approximately 80 points (80%) are *limited*. The remaining 20 points (20%) can be obtained in other ways and are referred to as *unlimited* points.

   The first category, defined as *limited points* is linked to mandatory assignments, written tasks, tests, and protocols. If a student does not achieve the maximum number of restricted points, they have the opportunity to compensate for this deficit only through the acquisition of unlimited points.

   So-called *unlimited points* can be obtained in different ways, but they are not related to obligatory assignments. This includes primarily voluntary homework, papers, oral answers, competitions, and different kinds of activities somehow related to the subject. There is no given maximum of the unlimited points, as their number depends solely on the approach, diligence and activity of the student himself. However, these points are somewhat more difficult to obtain, because for example, for one oral answer a student can obtain, for example, only 5 points, which in case of losing 10 points in a written work means at least 2 oral answers. The second aspect of the difficulty is that a student is "forced" to perform some his own activity during the whole assessed period, as to obtain a good assessment at the beginning of the period and then to remain passive in class is not enough to obtain a sufficiently good grading at the end of the assessed period.

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2. Every point earned is recorded and retained. All points, whether limited or unlimited, are aggregated to form a cumulative total., are added up. The teacher can only award positive points; reducing the number of the gained points is not possible. Points once earned by a student cannot be lost. The minimal sum of the gained points is 0.5 points. At the end of the assessed period grades are assigned according to the total number of the gained points as follows:

1	100 – 85 points	100% – 85%
2	84.5 – 70 points	84.5% – 70%
3	69.5 – 50 points	69.5% – 50%
4	49.5 – 30 points	49.5% – 30%
5	29.5 – 0 point	29.5% – 0%

3. Since in this method of assessment the teacher has practically no possibility to impose any punishments, and the teaching process is not only about learning, but also about upbringing, it was necessary to implement a certain form of "sanctions", or punishments, into this assessment system. While using this system already for a longer time, it has been necessary to resort to these sanctions only in several very exceptional cases. These “sanctions” are something like the awarding of so-called yellow cards. If a student receives 3 yellow cards, he loses the opportunity to collect further unlimited points. This may seem like a very weak punishment or sanction, but since unlimited points also include oral answers, it is impossible for such a student to enhance his final grade at the end of the year with an oral answer.

Following the pilot implementation of this alternative assessment system, it was necessary to resolve certain ambiguities. Consequently, the entire framework was refined based on the specific requirements and collective feedback of the students. It is therefore not a system that would be created and introduced in an authoritative manner, but was continuously created, modified and improved also based on the comments and suggestions of the students themselves. For example, one of the first unresolved questions which arose was what to do with the points that were obtained in addition, i.e. above the given limit of the obtained grade. In a common discussion with students as the fairest solution was decided to transfer all points earned to the subsequent period (the second half of the academic year) and at the same time to double the maximal number of the points earned in the second evaluated period to 200 points (100%). The final grading at the end of the second half of the academic year is then set as follows:

1	200.0 – 170 points	100% – 85%
2	169.5 – 140 points	84.5% – 70%
3	139.5 – 100 points	69.5% – 50%
4	99.5 – 60 points	49.5% – 30%
5	59.5 – 0 point	29.5% – 0%

Two significant consequences arise from the principles stated above. Firstly, it is essential for students to strive to accumulate as many points as possible during the initial assessment period. Secondly, if a student achieves a grade of two in the first half of the academic year, it becomes impossible for them to fail the subject overall, as they will have already secured 70 points toward their cumulative total. The situation is similar for a student who got during the first half of the academic year 60 points and has got a grade of 3 (good). Consequently, such a student gains the certainty that they will successfully pass the subject by the conclusion of the academic year, as they have already secured the required 60 points.

4 Conclusion

Unfortunately, many teachers continue to adhere to the convention that the only effective method of evaluating students is through the standard grading scale ranging from 1 (excellent) to 5 (insufficient). It is understandable that switching from one day to another to a completely different way of assessing would be very difficult, not only for teachers, but undoubtedly also for students and their parents.

The standard grading system has been used as a method for too long to be completely changed without any negative consequences. In addition to teachers, most parents often reject innovative assessment methods and cannot imagine them. Verbal assessment is insufficient for them, because they cannot use it to rank their children among their peers and compare the level of their results with the other ones.

From our perspective, however, this system seems to have number of advantages, which were confirmed to us either by means of our observations and experiences or by means of direct feedback from the students. In this system, negative motivation of students is not possible as the teacher no longer primarily looks for ways to point out the weaknesses and mistakes of the student, but on the contrary, rewards through the given points the successes that the student has achieved. Moreover, responsibility for the final grade is transferred from the teacher to the student, who can determine for himself the final grade he will receive.

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Quality Assurance of PLC Systems Teaching at Secondary Vocational Schools

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Abstract

Education in the field of PLC systems represents an important segment of the curriculum at secondary vocational schools, where students prepare for their future professional careers in the industrial sector. This paper addresses the challenge of how the appropriate quality of PLC systems teaching should be ensured in these schools. The authors present a methodology by which the quality assurance of PLC systems teaching can be supported. Furthermore, based on the results of applying the proposed methodology in practice, they formulate a proposal of measures to enhance the current quality of PLC systems instruction.

Keywords: Teaching PLC Systems, Vocational Education and Training, Quality Assurance of Teaching

1 Introduction

According to a study published by the Organization for Economic Co-operation and Development (OECD, 2024), Slovakia is one of the countries with the highest number of threatened types of employment. This is due to the rapidly increasing influence of Industry 4.0 on the global economy and the high dependence of the Slovak economy on production. Already, the first consequences of this phenomenon are evident, primarily in the form of a shortage of appropriately qualified labour. IT knowledge and skills are becoming increasingly

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crucial in most current industrial environments. Within the scope of the IT skills required by the labour market, PLC systems play an irreplaceable role as key elements of automation and the control of industrial processes. Knowledge and effective control of PLC systems are key factors for the competitiveness and success of industrial enterprises. This means that education in the field of PLC systems represents an important segment of education at secondary vocational schools, where students are prepared for their future professional activities in the industry sector (Hašková et al., 2023; Hašková & Zatkalík, 2020). However, with diverse programmes and approaches to teaching also come various challenges and questions regarding the unification of teaching content and compliance with state and school curricula.

The teaching process at secondary vocational schools is quite specific. This is mainly due to the structure of instruction, where students are taught in two-week cycles; the first week consists of theoretical preparation, followed by a week where they apply the acquired knowledge within practical vocational training. It is clear from the foregoing that teaching at this type of school is important not only from a theoretical perspective but, more importantly, from a practical one. Graduates of secondary vocational schools should be skilled technical experts who possess the theoretical knowledge necessary for the performance of specific work tasks. Taking into consideration the dynamics of the industrial environment, it is important to adapt the content of teaching permanently to the current requirements of employers and the needs of the labour market. Therefore, it is essential to analyse existing educational programmes constantly and ensure that they are in line with the needs determined by industrial enterprises.

Based on the foregoing, we decided to analyse the educational programmes of secondary schools at which the subject of PLC systems is taught, as well as employers' expectations regarding students' knowledge of PLC systems. Subsequently, we sought to identify possible shortcomings and suggest relevant improvements that would contribute to a more effective preparation of the students, reflecting the identified requirements of the industrial sector (Figure 1).

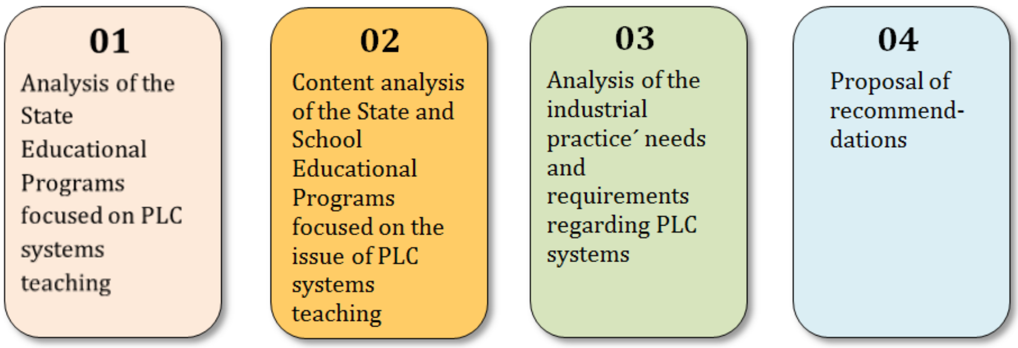

Figure 1: Concept of the methodology to support quality assurance of PLC systems teaching at secondary vocational schools.

2 Teaching PLC Systems at Secondary Vocational Schools

2.1 Analysis of the PLC System Issue Included in the State Educational Programmes of Selected Study Branches of Secondary Vocational Schools

State Educational Programmes for secondary vocational schools are issued and published by the Ministry of Education, Research, Development and Youth of the Slovak Republic. These are developed following negotiations with employers, school founders, and professional associations to ensure a nationwide reach, in co-operation with relevant ministries and in accordance with applicable legal regulations. The curriculum content prescribed within these State Educational Programmes is mandatory for the respective groups of study branches.

To identify the branches in which PLC systems are taught, the curricula of 27 groups of study branches were analysed (ŠIOV, 2010):

- physical and mathematical sciences
- metallurgy
- information and com. technologies
- technical chemistry of silicates
- food industry
- processing of leathers, furs and footwear
- printing and media
- transport, post and telecommunications
- agriculture, forestry and rural development
- economy and organization trade and services
- journalism, librarianship and scientific information
- art, and arts and crafts
- pedagogical sciences
- mining, geology and geotechnics
- mechanical engineering and other metal working production
- electrical engineering
- technical and applied chemistry
- textiles and clothing
- wood processing
- construction, geodesy and cartography
- special technical fields
- veterinary sciences
- legal sciences
- teaching
- physical culture and sport
- security services

Based on the comparative analysis of the State Educational Programmes for the specified study branches, it was found that the subject of PLC systems is included in the State Educational Programmes of only four study branches. These are: Mechatronics (within the mechanical engineering and metalworking production group), Electrical Engineering, Mechanic Mechatronic, and Computer Systems (all within the electrical engineering group).

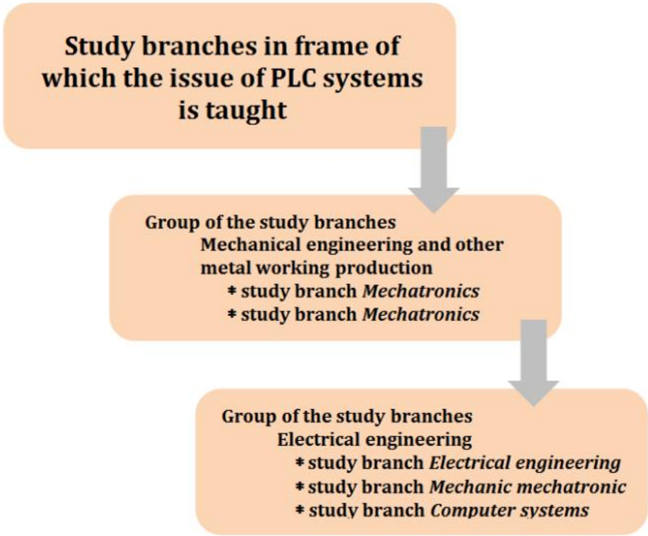

Figure 2: Findings resulted from the analysis of the State Educational Programmes focused on PLC systems teaching included in them.

2.2 Content Analysis of the PLC Systems Issue Included in the State and School Educational Programmes of the Relevant Secondary Vocational Schools

According to the State Educational Programme (ŠIOV, 2010), students (graduates) of the study branch *Mechatronics* are obliged to fulfil performance standards of the theoretical education, which are:

- to know how to explain the operating principles and applications of microcontrollers, robots, and PLC systems;
- to know how to write a simple program for controlling a logic circuit, microcontroller, robot, and PLC system;

and performance standards of the practical vocational training:

- to be able to program and diagnose operation of the PLC-controlled devices.

Within the scope of mechatronic systems control, the content standard requires students to acquire knowledge of the basics of algorithmicising and object-oriented programming, as well as microcontrollers, robots, and PLC systems and their programming. According to the State Educational Programme, students (graduates) of the study branch *Electrical engineering* are obliged to fulfil performance standards of the theoretical education, which are:

- to know how to apply microcontroller systems and PLCs for various methods of control and monitoring,
- additionally, in the amendment of no. 8 (2021), there is a requirement to know how to work with microcontrollers and microcomputers, to connect sensors to them, to

analyse and evaluate collected data, and to understand the basics principles of using PLC systems.

Within the scope of the performance standards for practical vocational training, there are no specifically defined performance standards with regard to PLC systems instruction. For the study branch Mechanic Mechatronic, no specific performance standards are defined which a graduate of this study branch should be able to fulfil. There is only a requirement to know how to characterise basic notions, construction, control systems, and the structure of industrial robots and manipulators, as well as their application in technical practice, the basics of their programming, and inter-operational and operational transport.

A similar situation exists in the case of the study branch Computer Systems. No specific performance standards for theoretical education are defined for graduates of this branch. Regarding the performance standards for practical vocational training, there is a requirement that a graduate of the study branch Computer Systems should be able to program PLC machines.

In Amendment No. 2, by which the State Educational Programme has been changed, sample curricula for professional subjects can be found. These propose to allocate one lesson to the topic of graphical tools for PLC programming within the subject Graphical Systems, taught in the Mechanic Mechatronic study branch. In the subject Basics of Industrial Informatics, taught within the Computer Systems study branch, it is recommended to address the use of LOGO! 230 RC, which is a compact PLC model produced by Siemens.

In the case of the subject Automation, taught within the Electrical Engineer Mechanic study branch, it is recommended that three lessons focus on PLC block diagrams, their internal structure, a comparison of modular and compact PLCs, and their areas of application. In Amendment No. 2, further subjects are recommended; for example, Measurement in Automation Technology has a recommended time allocation of five lessons aimed at remote measurement using PLCs.

Another recommended subject is Control Systems, with a suggested allocation of 12 lessons. The recommended topics include PLC systems, their classification, development, features and architecture, methods of programming, and examples of simple applications. For more complex PLC applications, a further 15 lessons are added. Finally, the subject Professional Training in Automation Technology is recommended within Amendment No. 2. This should address the unit on PLC systems over 140 lessons taught in the third year (covering everything from mounting to applications). In the fourth year, a further 98 lessons dealing with PLC systems in automation task management are recommended.

Amendment No. 4 extends the existing examples of the teaching curricula for the study branches Electrical Engineering – Automation Technology and Mechanic – Electrical Engineer. In the subject Electrical Measurements within the Electrical Engineering – Automation Technology branch, three lessons are recommended for the topic of remote measurement using PLCs. Furthermore, in the subject Control Systems, 12 lessons are recommended to address the subject of programmable logic controllers.

In the schedule of the subject matter for Programming of Automation Facilities, 49.5 teaching lessons are allocated in the second year for the acquisition of basic knowledge related to process control. In the third year, 60 teaching lessons are dedicated to the basic principles of programming programmable logic controllers, where it is specifically recommended to address the design of PLCs from various manufacturers, with a scope of approximately five lessons. In the third year, there is also the subject Vocational Training, with a time allocation of 147 lessons. These should focus on PLC programming, covering everything from workplace safety and PLC construction to various program applications (ŠIOV, 2010).

Based on the identified study branches within the scope of which PLC systems are taught (as defined by the State Educational Programmes), we contacted 20 secondary vocational schools throughout Slovakia. These institutions offer the study branches Computer Systems, Mechanic – Electrical Engineer, Electrical Engineering, or Electrical Engineering – Automation Technology. The purpose was to ascertain which model series and manufacturers they have integrated into their PLC instruction, and whether they would provide their school educational programmes regarding this specific subject matter.

Regarding the model series and their manufacturers, it was found that all the schools surveyed use the S7-1200 model from Siemens. However, the additional model series used differ from one school to another. Among those identified were various model series from manufacturers such as Elsaco, Eaton, Allen-Bradley, Mitsubishi, and Festo. An overview of the other types of PLC models used by the schools (alongside a list of the schools at which each model is utilised) is presented in Figure 3.

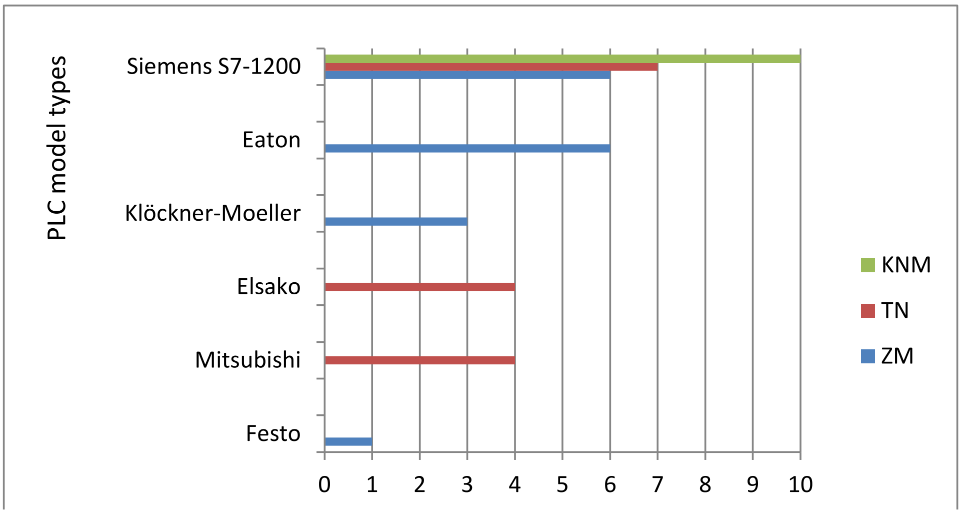

Figure 3: Findings resulted from the content analysis of PLC systems teaching within the selected sample of the secondary vocational schools.

Legend to Figure 3: KNM – Secondary Engineering School in Kysucké Nové Mesto
TN – Secondary Vocational School in Trenčín
ZM – Secondary Polytechnical School in Zlaté Moravce

A comparative analysis of the obtained school and State Educational Programmes revealed no significant differences in the methods used to teach PLC systems at the schools concerned. School curricula (School Educational Programmes) appear to correspond to the recommended state curricula (State Educational Programmes) and are fairly consistent in their content and objectives. Consequently, based on the information obtained, it can be concluded that the schools maintain a similar approach to teaching PLC systems and are relatively uniform in their teaching methodologies and the PLC models utilised (Kuna et al., 2020).

2.3 Analysis of the Needs and Requirements of Industrial Practice Regarding PLC Systems

Frequently, there is a fundamental difference between what students learn at school and what is required of them when they enter the workforce. Consequently, we conducted a survey of industrial enterprises located in the Levice region. Analysis of the survey results clearly indicated that the companies utilised a wide range of PLC models from various manufacturers, such as Siemens, Rockwell, Mitsubishi, and Beckhoff. This broad scope of PLC models is related to the preferences of technical equipment suppliers, who often favour specific types based on their expertise and experience. Additionally, the variety is influenced by the relocation of existing facilities, which frequently contain older PLC models.

Within the operations of the surveyed industrial enterprises, several positions require PLC knowledge. According to the level of expertise required, these positions can be categorised into three main groups:

- *Positions requiring only basic knowledge*: These are usually positions for maintenance and production technicians. It is necessary to ensure that these individuals have an overview of the daily functioning of the machinery. They must be able to perform basic non-electrical diagnostics of the devices, allowing them to identify simple faults and potential problems in the operation of the equipment. Furthermore, a basic knowledge of PLCs is important for setting reasonable and feasible requirements for the maintenance department, thereby ensuring the efficient upkeep and operation of the machinery.
- *Positions requiring diagnostic knowledge:* These are roles for maintenance staff with an electrotechnical focus, specialising in the diagnosis and repair of machinery. Electricians with many years of experience in the industrial sector usually occupy these positions. As shown by the survey, it is common practice for new workers to be sent for PLC training, as the knowledge they gained as pupils in secondary school may be insufficient. This applies not only to young graduates, but also to older workers and those who have transitioned to maintenance from other positions where they did not come into contact with PLC units.
- *Programming work:* These are employees in the positions of PLC programmer or electrical maintenance lead, whose work includes not only diagnostics but also

advanced programming activities. Their task is to solve complex problems associated with PLC systems and ensure their effective functionality. The programming activities of these workers do not always include programming an entire line from the ground up, but rather the modification or supplementation of existing program code as required. In the event of a need for deeper diagnosis or more complex code changes related to line reconstruction, external experts specialising in PLC systems programming are often utilised. In addition to their programming activities, these employees are also obliged to provide training for other workers responsible for PLC diagnostics. Their task is to transfer their knowledge and experience to other team members so that they possess the necessary skills to effectively solve problems related to PLC technology.

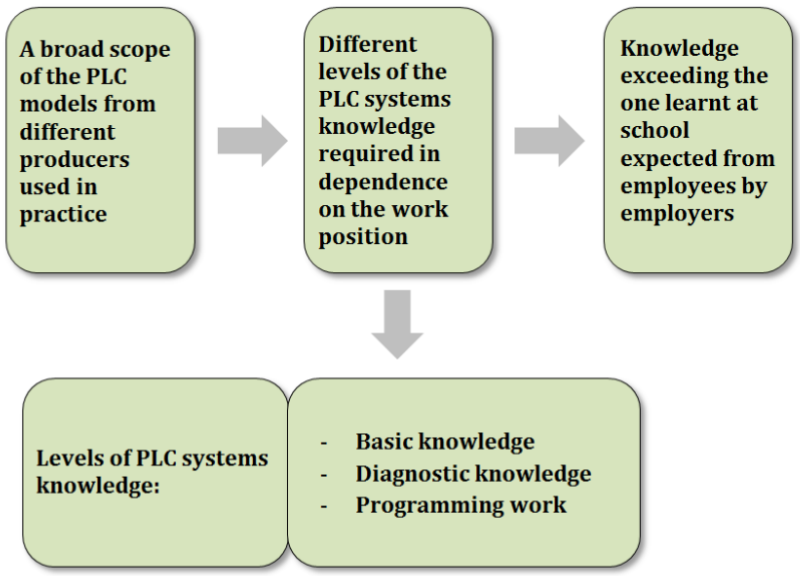

Figure 4: Findings resulted from the survey of the needs and requirements of the industrial practice regarding PLC systems.

3 Suggestions to Quality Assurance

Currently, many PLC systems manufacturers offer their own software tools for programming their systems. One such example is Siemens, which provides a wide range of software solutions for various PLC systems. To enhance PLC systems instruction at secondary vocational schools and ensure its quality, the following measures are proposed.

LOGO! Beginning with their simplest series, LOGO! is often referred to as a programmable relay; although this type is part of the sample educational programmes for the field of Computer Systems, our survey results indicate that it is rarely encountered in practice. This

type is configurable using LOGO! Soft software, which allows for the creation of programs for simple automation tasks.
S7 300/400: Here is the review of this section with the necessary changes for British Academic English, ensuring the tone is formal and technically accurate.

Revised Section
The LOGO! series is followed by the S7-300 and S7-400 ranges, which are programmable using Step 7 software. While this software is still taught and used in schools, it is encountered less frequently in practice, as modern PLC systems belong to newer model series that are not fully compatible with Step 7. Nevertheless, Step 7 remains an important tool for programming older PLC systems and is an essential element of educational programmes aimed at PLC programming.
TIA Portal: In addition to software tools such as Logo soft and Step7, a further fundamental element in modern PLC programming is Portal (Totally Integrated Automation) is Portal (Totally Integrated Automation). This integrated development environment allows programming, configuration and diagnosis of various PLC systems, including the latest series such as S7-1200/1500. The TIA Portal provides a comprehensive automation environment and is the preferred tool for many industrial applications. Through this platform, it is possible to create and test programs, monitor PLC system operations, and diagnose real-time faults. Given the increasing prevalence of the TIA Portal in industry, it is essential that students have access to this software and gain practical experience with it during their vocational education. Educational programmes should include TIA Portal instruction to ensure that graduates are prepared for modern industrial requirements and can effectively integrate into the working environment.
These software tools are necessary for the efficient programming and configuration of PLC systems; proficiency in their use is essential for students pursuing careers in automation and process control within industrial enterprises. It is vital that the educational programmes of secondary vocational schools include not only theoretical knowledge of PLC systems but also practical experience with these software tools. This ensures that students are prepared for the challenges of the industrial sector.

4 Conclusion

Updating the curriculum is necessary to ensure that students have access to the latest software tools and technologies used in industry. However, given the wide range of software solutions from various PLC manufacturers, it is difficult to create universal educational programmes or curricula that cover all possible tools and technologies.
It is important to note that School Educational Programmes should be developed with regard to the needs of the particular school and local industry. Consulting with experts in this field

may be useful when creating or updating these programmes to ensure that their content is relevant and aligned with current industrial requirements and trends.

While focusing on hard skills is undoubtedly a primary task, schools should not overlook the development of students' soft skills, as their importance in the labour market is continually growing. However, it is also important that employers accept this long-term strategic view and do not insist on requirements for School Educational Programmes based solely on their immediate needs.

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Sources and Manifestations of Stress in the Professional Life of Teachers in Relation to Their Managerial and Key Competencies

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Abstract

In this article, we examine the sources of stress and their manifestations in teachers' professional lives, with particular attention to their managerial and key competencies. Special emphasis is placed on the identification of stressors that teachers encounter on a daily basis and on the impact of these stressors on professional performance. The teaching profession places substantial demands on teachers' personalities, which play a decisive role in managing workload and require a range of key personal attributes and competencies necessary for effectively coping with demanding situations.

In contemporary educational contexts, it is essential to systematically monitor and map the sources and manifestations of stress experienced by teachers. Awareness of stress symptoms is valuable not only for teachers themselves but also for a wider professional and administrative audience, as it enables more effective adaptation to challenging situations and supports the efficient management of teaching activities.

Keywords: Stress, Sources of Stress, Manifestations of Stress, Teacher Work-Related Stress, Key Competencies

1 Introduction

The teaching profession has long been regarded as one of the occupations associated with a high level of psychosocial burden. Teachers are confronted on a daily basis with dynamically changing conditions, increasing societal expectations, and rising performance demands, all of which significantly affect their work-related well-being and professional stability. In addition to their educational responsibilities, teachers are required to possess a wide range of

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managerial, communicative, and social competencies necessary for the effective management of the teaching process, the creation of a stimulating learning environment, and the handling of diverse pedagogical situations. Considerable demands are also placed on their ability to organise time, demonstrate empathy, make decisions, and manage conflicts, each of which may be influenced by prolonged or intense exposure to stress.

Stress, in particular, reduces the effectiveness of key teaching competencies, disrupts pedagogical communication, and may contribute to a decline in the quality of the educational process. It is therefore important to systematically examine the ways in which stress-related factors influence the performance of teachers' professional competencies and affect their ability to adapt to demanding situations. Understanding these relationships represents a significant step towards the development of preventive and intervention strategies aimed at supporting professional satisfaction, mental well-being, and the long-term sustainability of the teaching profession.

The aim of this article is to emphasise the importance of understanding the sources of stress and their manifestations in teachers' professional lives, particularly in relation to their managerial and key competencies.

2 Stress in the Professional Life of Teachers

The theory of stress was first developed by Hans Selye, who defines stress as "a non-specific, stereotypical response of the organism, occurring as a so-called general adaptation syndrome, which is characteristic of the stress reaction regardless of the type of stimulus" (1966, cited in Macháč & Macháčová, 1991, p. 10).

Lazarus and Folkman (1984, in Baumgartner, 2001) created the transactional definition of stress, which is based on the study of interactions between the individual and the environment. Stress is defined as "a particular relationship between the person and the environment that the person perceives as taxing or exceeding his or her personal resources and threatening his or her well-being."

According to Selye, stress can be characterized as negative, i.e., distress, and positive, i.e., eustress. Both eustress and distress manifest physically in similar ways. From a health perspective, the impact of stress depends mainly on its intensity and frequency of occurrence. "The term distress is commonly used today to describe a situation of subjectively experienced threat for an individual, accompanied by often significantly negative emotional symptoms" (Křivohlavý, 2001, p. 171). Eustress, on the other hand, can occur when people voluntarily engage in challenging or risky situations, such as in sports performance (Křivohlavý, 2001).

The teaching profession is one of the most demanding occupations. Teachers must cope with both time-related and psychosocial pressures. Throughout their careers, teachers encounter various stressful situations that can negatively affect their professional life. During their teaching activities, they are exposed to a wide range of stressors, from demanding work tasks and concerns about poor workplace relationships to fear of job loss and long working hours, which include both classroom teaching in the morning and preparing lessons, correcting didactic tests, and assessing students' mastery of the curriculum in the afternoon.

By its nature, the teaching profession is highly psychologically demanding, and the mental load continues to increase, which can lead to teacher stress and, subsequently, to burnout syndrome (Petlák & Baranovská, 2016, p. 48).

Průcha, Walterová, and Mareš (2003, p. 262) define teacher stress as "stress related to the performance of the teaching profession, the main sources of which, according to empirical research, are: students with poor attitudes toward work and disruptive behaviour, rapid changes in educational projects and school organisation, poor working conditions including limited personal prospects for career advancement, time pressure, conflicts with colleagues, and the perception that society undervalues the teacher's work. When a teacher is under stress, it reduces the quality of their performance by decreasing job satisfaction and motivation, and it negatively affects relationships with students in the classroom."

Kyriacou (2001) modifies his definition of teacher stress as a complex of interactions and relationships among personality traits, coping mechanisms, and the environment.

In numerous domestic and international studies on teachers' workload, it has been observed that at least one-third of respondents consider the workload associated with their professional duties to be very high, even extreme, and significantly greater than the demands of their life outside of work.

2.1 Managerial and Key Competencies in the Working Life of a Teacher

The teaching profession places significant demands on the personality of the teacher, who also plays an important role in coping with workload. This fact should be considered already during the selection of candidates for the teaching profession, who should possess personality traits that lead to more effective stress management.

A teacher must be a person who does not immediately succumb to stress, 'panic', or react impulsively, but rather searches rationally and meaningfully for optimal solutions, whether in relation to students, parents, colleagues, or school leadership (Petlák & Baranovská, 2016, p. 36).

Holeček (2001) identifies, from dozens of traits, those associated with the work of a teacher, which can also serve as a kind of stress barrier. These include the teacher's attitude toward themselves, their work, others, values, and willpower traits.

More recent studies identifying characteristics of an effective teacher include the study by Polka (2006), which lists: good prior academic performance, communication skills, creativity, professionalism, pedagogical knowledge, thorough and appropriate assessment of students, self-development and lifelong learning, personality, talent or subject knowledge, and the ability to provide exemplary models.

Holeček (2001) also emphasises special teacher skills, which include didactic skills, pedagogical tact, expressive abilities, organisational skills, and the capacity for reflection.

Professional competencies of teachers include subject-matter expertise, pedagogical-psychological competencies, social and communication competencies, and managerial and organisational competencies.

Key areas of professional competencies include:

- Subject-matter competencies, which generally involve mastery of the curriculum, the ability to plan lessons, prepare appropriate teaching materials, and assess students' performance.
- Pedagogical-psychological competencies, which include understanding students' developmental, motivational, and emotional characteristics, identifying their needs, and adapting teaching to individual abilities.
- Social and communication competencies, which enable effective communication with students, parents, and colleagues, creating a supportive environment, managing conflicts, and building trust-based relationships.
- Managerial and organisational competencies, which involve classroom management, time management, organising teaching and activities, and effectively solving problems and conflicts.

Each country independently determines professional competencies for teachers. In Slovakia, these are defined by the Ministry of Education, Science, Research, and Sport of the Slovak Republic. Accordingly, pursuant to Section 41, par. 3 of Act No. 138/2019 Coll. on Pedagogical and Professional Employees and on Amendments to Certain Acts, as amended, the Ministry has issued professional standards aligned with the level of education for individual categories, subcategories, career levels, and career positions of pedagogical and professional staff.

A professional standard consists of a set of professional competencies that create the competency profile of a pedagogical employee.

They are organised into three areas and describe the professional activities of the pedagogical employee:

- Student Area – includes professional competencies aimed at understanding the student in the educational process.
- Educational Process Area – includes professional competencies focused on planning, preparation, implementation, and assessment of education, aimed at student development.
- Teacher Area – includes professional competencies related to the teacher's profession, improving their pedagogical and didactic expertise, cooperating with the school community, and contributing to the development of the school or educational institution.

Each professional competency is defined by the required knowledge (a set of information necessary for performing and correctly evaluating tasks within the competency) and skills (abilities acquired through practical experience).

2 Sources and Manifestations of Stress in the Working Life of a Teacher

2.1 Sources of Stress in the Working Life of a Teacher

Stress is not experienced uniformly by all individuals, as the intensity of stress perception depends on a range of factors. Our resilience to stress also fluctuates according to our biological rhythms – daily, monthly, yearly – and variations in performance and endurance. People with low self-esteem and limited social support are more likely to experience both psychological and physical symptoms of stress. Many domestic and international authors have studied the sources of stress in the professional life of teachers.
Kyriacou (2012, pp. 154–155) identifies the following factors as sources of teacher stress: students with inappropriate attitudes and low motivation for work, disruptive students, general indiscipline in the classroom, inadequate working conditions (school building and classroom facilities, school funding) including personal prospects for career advancement, frequent changes in educational projects and school organization, time pressure, conflicts within the staff, and a sense of being undervalued by society.

Holeček (2001), in his research on stressors in the teaching profession, identified seven factors that most frequently occur in the teaching environment:

1. Work overload of teachers
2. School management by higher authorities
3. Problematic students
4. Unmet need for self-realisation (frustration)
5. Problematic parents
6. Inadequate school-working environment
7. Problematic colleagues

The study by Žitniaková Gurgová and Behúňová (2017) identifies the most frequent teacher stressors using a non-standardized, self-developed questionnaire. Their sample consisted of 50 respondents from seven primary schools in the Považská Bystrica district. The authors found that the most common sources of teacher stress were frequent legislative changes, the presence of students with special educational needs, and the social valuation of the teaching profession. Other frequently mentioned sources of stress included salary conditions, holding multiple roles, and perfectionism. Conversely, the least stressful factors were relationships within the teaching staff, maintaining pedagogical documentation, and the relationship with superiors.

For comparison, Brenneman's research (2015 in Petlák & Baranovská, 2016), conducted in the USA with 30,000 teachers, found that the greatest sources of workplace stress for teachers were:

- Implementation of new procedures without proper training or integration into professional development – 71% of teachers
- Negative portrayal of teachers and school staff in the media – 55% of teachers
- Unclear and unpredictable work expectations – 47% of teachers
- Salary – 46% of teachers
- Lack of decision-making opportunities – 40% of teachers
- Fear of job loss – 32% of teachers
- Lack of opportunities for personal growth and promotion – 28% of teachers
- Physical exertion – 22% of teachers

According to Grecmanová (2007), there are circumstances that make teaching more difficult, including: large class sizes, addressing individual student differences, students with special educational needs, teacher unpreparedness to work with them, pressure to cover the required curriculum, and increasing demands from higher levels of schooling.
Other sources of teacher stress identified by Grecmanová include:

- Teachers do not have time to rest even during breaks (due to supervision duties, preparation of teaching materials),
- Teachers must fulfil tasks related to membership in subject committees, managing classrooms, or maintaining specialized teaching rooms,
- Teachers must cope with extensive administrative work,
- Lack of feedback – feedback is important for teacher motivation and can come from colleagues, management, school inspection, parents, and students,
- Inadequate recognition of teachers' work – sometimes teachers are criticized rather than praised, which can lead to reduced self-confidence,
- Teachers do not have any moments of rest during the school day.

3.2 Manifestations of Stress in the Working Life of a Teacher

Stress manifestations can be observed in three main areas: physiological, psychological, and behavioural. Most people are able to recognise when they are 'under stress', that is, when stress is influencing them. However, determining the intensity of stress is more difficult. The level of stress can be assessed based on the number of stress symptoms and their severity.
Insomnia, sudden mood changes, headaches, loss of appetite, alterations in daily routines, restlessness, sadness, depression, irritability, and aggression are all signs of increasing stress and signal the need for teachers to pay greater attention to stress-inducing factors present in the teaching profession (Zelinová – Zelina, 2007, pp. 121–122).

According to Míček and Zeman (1997), the following stress symptoms can be categorized into physiological, emotional, and behavioural domains.

Short-term manifestations	**Short-term manifestations**
Dry mouth	Increased blood pressure
Sweaty palms	Fatigue
Heart palpitations	Exhaustion
Rounded shoulders	Headaches
Muscle cramps in limbs	Stomach aches

Table 1: Physiological Symptoms of Stress.
(Author: Míček, Zeman,1997, s.16 – adapted by the author)

Acute symptoms	**Chronic symptoms**
Feeling nervous	Frustration
Negative thoughts	Depression
Self-doubt	Poor concentration
Rapid thinking	Feeling of loneliness
Slow thinking	Feeling of helplessness
Feeling excited	

Table 2: Emotional Symptoms of Stress.
(Author: Míček, Zeman, 1997, p. 18 – adapted by the author)

Impatience
Tearfulness
Forgetfulness
Raising one’s voice
Increased restlessness
Frequent urge to smoke
Frequent urge to overeat
Anger

Table 3: Behavioural Symptoms of Stress.
(Author: Míček, Zeman, 1997, p. 18 – adapted by the author)

According to Smetáčková (2020), additional manifestations of stress include cognitive symptoms, which encompass difficulties with concentration, forgetting important tasks, feelings of being overwhelmed, and an inability to solve tasks effectively. Overall, stress in teachers manifests in a complex manner – physically, psychologically, and behaviourally – and these manifestations often overlap. Early recognition of symptoms and the implementation of appropriate stress management strategies are therefore crucial for maintaining work well-being, professional development, and the quality of teaching performance.

4 Sources and Manifestations of Stress in the Working Life of a Secondary School Teacher

Research Aim

Based on the above considerations, we formulated the following research problem:

Which factors and manifestations of stress most affect teachers at selected secondary schools in the Nové Mesto nad Váhom district?

In connection with this research problem, we defined the following objectives:

1. To identify which stressors, affect secondary school teachers in the Nové Mesto nad Váhom district.
2. To determine the most common symptoms of stress and the areas in which these stress manifestations occur.

Subject of the Research

The subject of our research primarily concerns secondary school teachers. From the various categories of pedagogical staff, we included general education teachers, vocational subject teachers, and practical training instructors in the study. The research sample consists of teachers of students from different study and vocational programmes, with varying lengths of teaching experience, ranging from recent graduates to teachers of retirement age.

Research Questions

Based on the research objective, we formulated the following research questions:

1. What stressors most frequently affect the work of secondary school teachers?
2. What are the most common manifestations of stress among secondary school teachers?
3. Which area of stress manifestation occurs most frequently among secondary school teachers?

Characteristics of the Research Sample

To obtain a larger sample for observation, we contacted several secondary schools in the Nové Mesto nad Váhom district. The study included teachers from the Secondary Vocational School of Trade and Services, the M.R. Štefánik Grammar School, the Secondary Industrial School in Nové Mesto nad Váhom, and the Secondary Industrial School in Stará Turá.

The respondents were aged between 25 and 65 years. The sample included teachers with a minimum of one year of teaching experience.

4.1 Results of the study

In total, 86 respondents participated in our study, of whom 65 were women (75.6%) and 21 were men (24.4%). By category of pedagogical staff, the study included 42 (48.8%) teachers of general education subjects, 33 (38.4%) teachers of specialized subjects, and 11 (12.8%) vocational training instructors.

For the purposes of our research, we divided the sample according to teaching experience into two categories described by J. Průcha (2005): novice teachers ('pedagogical start' – 1 to 5 years of experience) and expert teachers ('pedagogical stabilisation' – more than 5 years of experience). The study included 67 (77.9%) expert teachers and 19 (22.1%) novice teachers.

Length of Teaching Experience	**Absolute Frequency (n)**	**Relative Frequency (%)**
Beginner Teacher	19	22.1
Expert Teacher	67	77.9
Total (N)	86	100

Table 4: Respondents by Length of Teaching Experience.

Within the variables, we decided to compare teachers also in terms of the Category of Teaching Staff.

Category of Teaching Staff	**Absolute Frequency (n)**	**Relative Frequency (%)**
Teacher of General Education Subjects	42	48.8
Teacher of Specialized Subjects	33	38.4
Vocational Training Instructor	11	12.8
Total (N)	86	100

Table 5: Respondents by Category of Teaching Staff.

Most Common Stressors Affecting Secondary School Teachers

The first research tool, which we used in a modified form in our questionnaire, is the methodology of the Romanian authors O. Clipu and A. Boghean (2015), originally titled '*Occupational Stress Perception Questionnaire*'.

The authors examined stressors among 150 Romanian kindergarten teachers. From the original 25-item scale, Žitniaková, Gurgová, and Behúňová (2017) selected fifteen items and retained the 5-point rating scale (1 = 'not stressful' to 5 = 'extremely stressful').

In our study, we adapted this methodology to allow us to investigate the frequency of individual stressors among secondary school teachers. Five items were replaced with new ones to better reflect the topic and the specifics of the sample under study.

The final set of stressors was created based on theoretical knowledge of stress and stressors from the professional literature, while also being adapted to the specifics of researching stressors among secondary school teachers.

In terms of frequency, the stress factors most commonly reported by teachers in their work are:

1. Low student motivation – 52% of teachers
2. Lack of interest from students – 51% of teachers
3. Student indiscipline – 49% of teachers
4. Inadequate financial recognition of teachers' work – 47% of teachers
5. Increasing number of students with special educational needs – 46% of teachers
6. Low social status of the teaching profession – 44% of teachers
7. High administrative workload – 42% of teachers

Questionnaire Item	Mode	Median	Mean	SD
A lot of administrative work	4	4	3.57	0.95
Increasing number of students with special educational needs	4	4	3.53	0.96
Low social status of the teaching profession	4	4	3.73	0.97
Increasing number of students in the classroom	3	3	2.87	0.96
Relationships within the teaching staff	3	3	2.64	1.01
Problematic parents	3	3	2.91	0.97
Low student motivation	4	4	3.70	0.82
Psychological demands (constant monitoring, evaluation)	4	4	3.64	0.89
Insufficient material equipment and resources for teaching	3	3	3.17	0.95
Time pressure	3	4	3.60	0.92
Inadequate financial recognition of teachers' work	4	4	4.05	0.78
Frequent changes in the State Educational Programmes	4	4	3.72	0.82
Responsibility for the safety and health of others	5	4	3.84	1.03
Lack of interest from students	4	4	3.60	0.77
Student indiscipline	4	4	3.37	0.82
Teaching in classes with very diverse levels of student knowledge	3	3	3.28	0.84
Low opportunities for professional growth	2	2.5	2.65	0.94
Lack of support from school management	2	2	2.08	0.89

Table 6: Statistical Differences in the Frequency of Stressor Occurrence.

Given the values of the statistical parameters (see table 6), we can conclude that the responses are fairly consistent across the entire sample of respondents and there are few so-called outliers.

Most Common Signs of Stress in Secondary School Teachers

As another research tool, we used the standardised questionnaire by C. Hennig and G. Keller (1996) with 24 statements covering physical, emotional, psychological, and social symptoms of stress, measured on an interval scale from 1 (never) to 5 (always). This questionnaire also provides the option to determine the overall level of stress susceptibility.

By summing the values across all four areas of stress symptoms, a number corresponding to a certain stress profile is obtained.

Rank	Questionnaire Item	Mode	Median	Mean	SD
1	I have trouble concentrating. (P)	2	2	2.36	0.79
2	I have no joy in my work. (E)	2	2	2.48	0.99
3	I feel discouraged. (E)	2	2	2.17	0.99
4	I feel physically exhausted. (F)	3,5	3	3.20	1.04
5	I lack the desire to help problematic students. (S)	2	2	2.14	0.88
6	I have problems with my heart, breathing, digestion. (F)	3	2	2.36	0.98
7	I doubt my professional abilities. (P)	2	2	2.22	0.95
8	I am prone to illnesses. (F)	2	2	2.45	0.96
9	I avoid professional conversations with colleagues. (S)	1	2	1.62	0.68
10	I make mocking remarks about students and their parents. (P)	1	1	1.30	0.59
11	I feel helpless in conflict situations. (E)	3	2	2.35	0.90
12	Frustration from schoolwork disrupts my private relationships. (S)	2	2	2.16	0.96
13	My professional growth and interest in the field are lagging behind. (P)	2	2	2.19	0.97
14	I am internally dissatisfied and nervous. (E)	2	2	2.48	1.06
15	I feel tense. (F)	2	2	2.60	1.10
16	I limit teaching only to conveying the curriculum. (S)	2	2	1.91	0.84
17	I am thinking about leaving the teaching profession. (P)	1	2	2.31	1.14
18	I suffer from a lack of recognition and appreciation. (E)	2	2	2.50	1.06
19	I sleep poorly. (F)	3	3	2.67	1.08
20	I avoid participating in further education. (S)	1	2	1.86	0.95
21	I fear losing track of developments in my field. (P)	2	2	1.72	0.71
22	I feel scared. (E)	1	2	1.79	0.97
23	I suffer from headaches. (F)	2	2	2.26	1.20
24	Whenever possible, I avoid conversations with students. (S)	1	1	1.48	0.68

Table 7: Stress Manifestations among Secondary School Teachers by Frequency of Occurrence of Individual Manifestations.

Based on the calculated average values of individual stress manifestation items, the most frequently reported manifestation among secondary school teachers is physical exhaustion. The least frequently reported stress manifestations were avoiding conversations with students and making mocking remarks about students and their parents. The statistical parameters again indicate good consistency in the respondents' answers.

Explanations:
F = Physical domain of stress impact
E = Emotional domain of stress impact
P = Psychological domain of stress impact
S = Social domain of stress impact

Rank	Area of Stress Impact	Mean
1	Physical Domain	2.59
2	Emotional Domain	2.29
3	Psychological Domain	2.02
4	Social Domain	1.86

Table 8: Stress Symptoms among Secondary School Teachers by Specific Areas of Impact.

Based on the average values obtained from respondents for the different areas of stress impact, it appears that the overall level of stress manifestations among secondary school teachers is relatively balanced. The values suggest that, despite the presence of stressors, most teachers exhibit good overall bodily equilibrium and the ability to recover, indicating their relative resilience to the negative effects of stress and their capacity to cope with daily work demands.

5 Conclusion

In the first research question, we found that secondary school teachers consider the most frequent stress factors in their work to be low student motivation, lack of interest and indiscipline on the part of students, inadequate financial recognition of teachers' work, the increasing number of students with special educational needs (SEN), low social status of the teaching profession, and a high administrative workload. These factors collectively create significant psychological pressure on teachers and negatively affect their well-being, motivation, and teaching effectiveness.

Students with low motivation and lack of interest often disrupt the educational process, requiring teachers to exercise greater patience, flexibility, and the application of individualized approaches or creative teaching methods. The growing number of students with SEN further increases demands on teaching, as it requires differentiated approaches, careful activity planning, and often the presence of an assistant to ensure quality education for all students.

Inadequate financial recognition, low social status of the teaching profession, and high administrative workload additionally contribute to feelings of frustration and demotivation, draining energy that could otherwise be devoted to direct teaching and student support. The combination of these factors thus significantly contributes to occupational stress and increases the risk of burnout among secondary school teachers.

Within the framework of the second research question, secondary school teachers identified the most frequent manifestations of stress as physical and psychological exhaustion, increased susceptibility to illnesses, headaches, and inner tension. These manifestations are closely linked to the demands of teaching, the high responsibility for the educational process, and the strain resulting from administrative duties, working with problematic students, and constantly adapting to legislative or organizational changes.

Based on the calculated average values of individual items, physical exhaustion emerged as the most pronounced manifestation of stress among secondary school teachers. This result indicates that occupational stress often affects teachers not only psychologically but also physically, potentially impacting their overall well-being and ability to effectively conduct teaching. Conversely, the lowest-rated stress manifestations included avoiding conversations with students and making mocking remarks about students or their parents, suggesting that teachers generally maintain professional behaviour and strive not to express negative emotions toward either students or parents.

Overall, the results highlight physical and psychological strain as the main indicators of occupational stress, while also considering broader implications for teachers' health and the quality of the educational process.

Based on our research findings, we can confirm the conclusions of several authors that the teaching profession is among the highly stressful occupations. Secondary school teachers face a combination of psychological, physical, and administrative burdens that may lead to occupational burnout, decreased work motivation, and negative effects on teaching quality. These findings emphasise the need for systematic support for teachers from schools, society, and relevant state institutions to minimise the negative impact of stress on teachers and promote their well-being and the effective education of students.

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All learning paths lead to knowledge

Perceptual Differences Toward Women Professionals in the Field of Information Technology Among Male and Female Students

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Abstract

The persistent underrepresentation of women in the field of Information Technology (IT) continues to raise questions about gender perceptions and their influence on career choices, workplace dynamics, and educational experiences. This study examines the perceptual differences regarding women professionals in IT among male and female university students. Using a mixed-methods approach, data were collected through a structured questionnaire and follow-up interviews conducted with undergraduate students enrolled in IT-related programs. The analysis examined attitudes toward women's competence, leadership, and contributions to technological innovation, as well as perceptions of gender equality and career advancement opportunities in the IT sector. Findings reveal significant gender-based differences: female students generally express more favourable and equitable perceptions of women in professional roles, while male students demonstrate greater adherence to traditional gender stereotypes. These perceptual gaps highlight the ongoing influence of social and cultural factors on how future IT professionals perceive gender roles in the technology sector. The study underscores the need for educational interventions that promote inclusivity, challenge gender bias, and foster a more supportive environment for women pursuing IT careers.

Keywords: Gender Perceptions, Women in Information Technology, Gender Bias, Gender Equality, Professional Competence, Inclusivity in Education

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1 Introduction

Over the past few decades, the field of Information Technology (IT) has become a cornerstone of global economic growth, innovation, and social transformation. Despite its rapid expansion, the participation of women in IT remains disproportionately low compared to their male counterparts. Numerous studies have highlighted the persistent gender gap in both educational and professional contexts within the technology sector, where women often encounter barriers such as gender bias, limited representation, and restricted access to leadership roles. These disparities not only hinder women's professional advancement but also limit the diversity of perspectives essential for technological innovation and inclusive design.

Perceptions about women's roles and competencies in IT play a critical role in shaping this gender imbalance. Students in higher education, particularly those enrolled in IT-related programs, represent the next generation of technology professionals. Their attitudes toward women in the field can significantly influence the inclusivity of future workplaces and the overall image of IT as a gender-neutral discipline. Understanding how male and female students perceive women in professional roles in IT, therefore, provides valuable insight into the social and cultural factors that perpetuate or challenge existing stereotypes.

While previous research has explored general gender attitudes in STEM fields, there remains a need for focused examination of perceptions within the specific context of IT. This study aims to address that gap by analysing and comparing the perceptions of male and female university students toward women professionals working in the IT field. Through this investigation, the research aims to identify prevailing stereotypes, assess the extent of gender-based perceptual differences, and highlight potential strategies for fostering a more equitable and inclusive environment in technology education and careers.

2 Literature review

The Information Technology (IT) sector continues to demonstrate a significant gender imbalance, despite sustained efforts to promote diversity and inclusion over the years. Women remain underrepresented in IT education, research, and professional environments, particularly in leadership and decision-making roles (Bian et al., 2017; UNESCO, 2021). This disparity is largely attributed to enduring stereotypes that associate technological competence and innovation with masculine characteristics (Cheryan et al., 2017). Such perceptions often deter women from pursuing education and careers in IT and contribute to the "leaky pipeline" effect, wherein women exit the field at various stages of their professional journeys.

Recent European studies have echoed these findings. Miština (2024) emphasises that recognition of women's achievements in science and technology remains limited, reinforcing systemic barriers and undervaluing women's intellectual contributions. Similarly, Miština and Široká (2025) observed that students' attitudes toward women in science and technology are often shaped by cultural expectations and educational practices, which can either reinforce or challenge gender bias. Their research highlights the importance of awareness-raising initiatives in academic institutions to foster greater gender sensitivity among future professionals. Perceptions of women in IT are deeply intertwined with broader societal norms and gender roles. Studies reveal that both male and female students internalise cultural narratives about gendered competence in technology, which can influence self-efficacy, career aspirations, and interpersonal dynamics within educational settings (Master et al., 2016; Sax et al., 2018). Male students often exhibit more traditional perceptions of gender roles in computing, while female students tend to display higher awareness of inequalities and greater support for inclusivity (Wang & Degol, 2017).

Miština and Široká (2025) found that female students generally demonstrate stronger support for women's participation in science and technology fields, associating gender equity with innovation and collaboration. Their results align with Dasgupta and Stout's (2014) findings that exposure to female role models and inclusive learning environments positively influences students' perceptions of women in technical domains. Furthermore, Cheryan et al. (2015) note that cultural stereotypes often manifest visually and symbolically, for instance, in classroom design or media representations of computer scientists, and these subtle cues can shape students' sense of belonging. The persistence of such stereotypes underscores the necessity of critical pedagogical strategies that address gender bias at both institutional and societal levels.

Educational contexts play a decisive role in shaping students' understanding of gender in technology-related fields. Early socialisation and the cultural framing of computing as a male-dominated pursuit continue to influence students' choices and confidence levels (Charles & Bradley, 2009). Institutions can either reinforce or counteract these patterns depending on curriculum design, representation of female educators, and exposure to inclusive narratives (Cheryan et al., 2015). In this regard, recent research has highlighted the transformative role of digital tools and artificial intelligence (AI) in fostering gender awareness and critical thinking.

Pondelíková and Luprichová (2024) demonstrated how AI-assisted reading comprehension activities can enhance gender sensitivity among students by encouraging reflection on historical and cultural representations of women. Similarly, Luprichová (2025) showed that integrating AI-powered tools in higher education not only improves students' historical understanding but also deepens their awareness of gender perspectives and societal biases. These studies suggest that technology, when thoughtfully integrated, can become a medium for challenging gender stereotypes rather than perpetuating them.

While significant progress has been made in examining gender disparities in STEM, there remains a shortage of focused research addressing perceptions of women professionals in the IT field. Existing literature tends to emphasise participation rates or performance indicators rather than the underlying perceptual and attitudinal factors that shape gender inclusion (Miština, 2024; Sax et al., 2018). Understanding how male and female students conceptualise women's roles in IT is therefore critical for predicting future workplace dynamics and promoting equitable professional cultures.

This study draws upon *Social Role Theory* (Eagly, 1987) and *Gender Schema Theory* (Bem, 1981) as theoretical foundations. Social Role Theory posits that perceived gender differences stem from the societal distribution of roles and expectations, while Gender Schema Theory explains how individuals internalise and reproduce these cognitive frameworks. Together, these theories provide a lens for interpreting how students' beliefs about gender and technology intersect.

Building on the insights of Miština and Široká (2025), this research aims to contribute empirical evidence on how educational and cultural factors influence gender perceptions in IT, ultimately informing strategies to foster inclusivity, recognition, and gender equity in the technology domain

3 Methodology

The principal aim of this study was to explore and compare perceptual differences toward women professionals in the field of Information Technology among male and female university students. The research examines how gender and academic orientation influence students' attitudes, beliefs, and stereotypes regarding women's roles, competencies, and contributions to the IT profession. The objectives are to identify and analyse gender-based differences in perceptions, examine how students' disciplinary backgrounds affect their understanding of gender equality in professional contexts, and assess the extent to which social, cultural, and educational influences shape these perceptions within the Slovak higher education environment. The study further seeks to contribute empirical findings to the ongoing academic discussion on gender inclusivity in science and technology education.

The subject of the research comprises the perceptions of bachelor's students toward women working in and shaping the development of IT. The analysis focuses on two contrasting groups at the University of Ss. Cyril and Methodius in Trnava, Slovakia: students of Applied Informatics at the Faculty of Natural Sciences, representing a technical and predominantly male environment, and students of English Language and Culture in Specialised Communication at the Faculty of Arts, representing a humanities-oriented and predominantly female environment. This comparison allows for an examination of how disciplinary culture and gender composition influence students' attitudes toward women professionals in technology.

The research sample included bachelor's students from both faculties during the academic years 2024/2025 and 2025/2026. In the Applied Informatics program, there were 79 male and 6 female students in 2024/2025, and 81 male and 8 female students in 2025/2026. Conversely, the Faculty of Arts enrolled 71 female and 13 male students in 2024/2025, and 83 female and 16 male students in 2025/2026. The strong gender asymmetry within both faculties mirrors the broader gender segregation in academic disciplines: technology-oriented fields remain male-dominated, whereas humanities and language studies attract predominantly female students. This structural imbalance also represents an inherent limitation of the research, as it reduces statistical comparability between male and female subgroups while simultaneously reflecting the authentic demographic realities of Slovak higher education.

A mixed-methods design was employed, integrating both quantitative and qualitative approaches to capture a comprehensive view of students' perceptions. The quantitative component consisted of a structured questionnaire containing Likert-scale and multiple-choice items that measured attitudes toward women's participation, leadership, and competence in IT. The data were analysed using descriptive and inferential statistics to detect differences across gender and academic orientation. To complement the quantitative findings, a qualitative component was implemented through semi-structured interviews and open-ended questionnaire responses, allowing for deeper exploration of students' reasoning, experiences, and underlying beliefs. Thematic analysis was applied to identify recurring patterns and narratives, thereby enriching the statistical results with interpretive insights. This methodological combination enables triangulation of data, enhancing the validity and depth of the findings, and aligns with the interdisciplinary character of the research that bridges gender studies, education, and information technology.

Despite its comprehensive design, the study acknowledges several limitations. The most significant constraint arises from the pronounced gender imbalance within both faculties, Applied Informatics being predominantly male (over 90%) and the Faculty of Arts predominantly female (around 85%). This uneven distribution may influence both the nature of social interaction within academic environments and the respondents' perceptions of gender roles. Moreover, as the research focuses exclusively on one Slovak university, the findings cannot be generalised to other national or international contexts without caution. Finally, while the mixed-methods approach provides depth, it also introduces potential interpretative bias, particularly when analysing qualitative data drawn from demographically uneven groups.

All participants took part voluntarily and were informed about the purpose and confidentiality of the study. Ethical principles of anonymity, informed consent, and data protection were strictly observed in accordance with the research ethics guidelines of the University of Ss. Cyril and Methodius in Trnava.

4 Research results

The analysis of students' responses revealed clear perceptual differences toward women professionals in the field of Information Technology, shaped by both gender and academic orientation. Quantitative results from the structured questionnaire were supported by qualitative insights derived from interviews and open-ended questions, which provided a more nuanced understanding of the students' attitudes and reasoning.

4.1 General attitudes toward women in IT

Across the entire sample, the majority of respondents expressed a generally positive view of women's participation in IT; however, the degree of positivity differed significantly between faculties and genders. Students from the Faculty of Arts demonstrated notably stronger support for women in IT than those from Applied Informatics. As shown in Table 1, 84% of Arts students agreed or strongly agreed that women possess the same level of technical competence as men, compared with only 59% of Applied Informatics students.

Field of study	Agree/Strongly Agree	Neutral	Disagree/Strongly Disagree
Applied Informatics	59%	27%	14%
Faculty of Arts	84%	12%	4%

Table 1: Students' perceptions of women's technical competence in IT.

A chi-square test confirmed that these differences were statistically significant ($p < .01$), suggesting that academic orientation and disciplinary culture play a considerable role in shaping gender-related attitudes.

A further breakdown by gender revealed that female students, regardless of faculty, tended to evaluate women professionals more positively. Among male students in Applied Informatics, 41% agreed that women contribute equally to technological innovation, compared with 78% of female students from the same program. Female respondents from the Faculty of Arts displayed the highest support overall, with 90% affirming the importance of women's leadership in technology. Figure 1 illustrates these differences, showing a clear gender gap in perceptions of women's leadership potential in IT-related contexts.

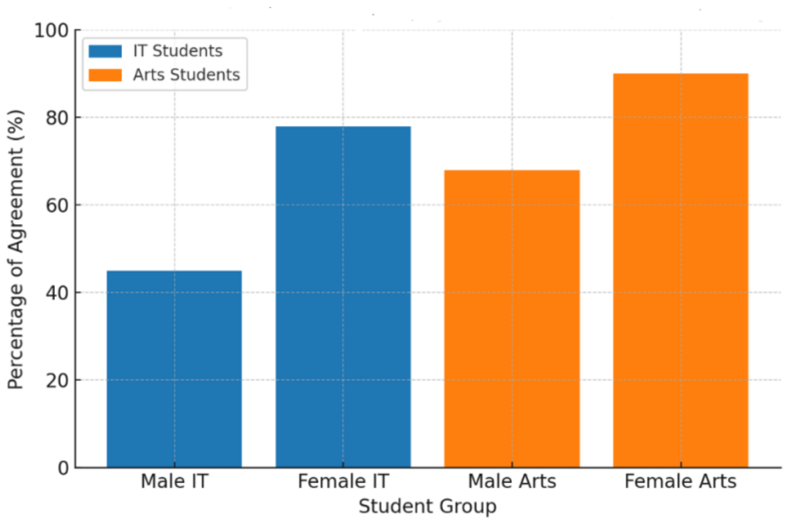

Figure 1: Percentage of agreement with the statement "Women are equally capable of leadership in IT fields".

It shows notably higher agreement among female students, especially those from the Faculty of Arts, and lower agreement among male students in Applied Informatics, clearly visualising the perception divide across gender and discipline. These results highlight a consistent gender gap, with female respondents expressing significantly higher support for gender equality than male respondents. The responses also indicate that male students within technical disciplines tend to evaluate women's success through a performance-based lens, often separating competence from issues of representation or discrimination.

4.2 Influence of academic context

Disciplinary orientation emerged as a major determinant of perception. Students from humanities-oriented programs generally displayed higher levels of empathy and critical reflection on social inequality, likely influenced by coursework involving language, culture, and communication (Luprichová, 2025; Pondelíková & Luprichová, 2024). Conversely, Informatics students exhibited more pragmatic and skill-based views, often evaluating professional competence through measurable performance rather than social context. Table 2 summarises differences in students' mean responses across key perception dimensions, measured on a five-point Likert scale (1 = strongly disagree, 5 = strongly agree).

Perception Dimension	Applied Informatics (M)	Faculty of Arts (M)	Overall Difference
Technical Competence of Women	3.62	4.34	0.72
Leadership Ability of Women	3.48	4.41	0.93
Gender Equality in IT Careers	3.19	4.09	0.90
Existence of Gender Bias in IT	3.23	4.18	0.95

Table 2: Mean Scores on Key Perception Dimensions

The mean differences across all categories were statistically significant ($p < .05$). The pattern indicates that students from the Faculty of Arts consistently express stronger awareness of gender inequality and greater support for women's professional advancement in IT, whereas Applied Informatics students maintain more neutral or traditional attitudes.

4.3 Perceptions of barriers and gender bias

When asked about the barriers women face in IT careers, both groups recognised gender bias as a persistent problem, though the perceived intensity of such bias varied. Approximately 72% of Arts students identified structural discrimination as a key obstacle, compared to 45% of Informatics students. Male students from the IT fields were more likely to attribute women's underrepresentation to personal interest rather than systemic inequality, echoing findings from Sax et al. (2018) and Miština (2024), who observed similar tendencies among male respondents in science and technology disciplines.

Qualitative data from interviews revealed recurring themes related to cultural expectations and socialisation. Many male Informatics students described IT as "a naturally male field," citing early exposure to technology as a gendered experience. In contrast, female Arts students often emphasised the need for representation and role models, expressing the belief that "visibility of successful women in IT would inspire others."
These qualitative insights align with Dasgupta and Stout (2014) and Miština and Široká (2025), who both stress the role of role models and inclusive education in reshaping gender perceptions.

4.4 Qualitative insights

The qualitative analysis reinforces the quantitative findings. Thematic analysis of qualitative responses revealed four dominant themes: (1) gendered socialisation and early exposure to technology, (2) underrepresentation and visibility of women professionals, (3) the influence of academic culture on perceptions, and (4) shifting attitudes through education. Students from the Faculty of Arts frequently discussed gender as a social construct, connecting women's underrepresentation in IT to broader systemic and cultural issues.
In contrast, Informatics students often framed the topic in terms of individual interest or meritocratic values, downplaying structural factors. Some notable quotes illustrate these contrasts:

> *"I think women can succeed in IT if they are truly passionate and hardworking, but not everyone is naturally drawn to it." (Male IT student, 2025)*
> *"IT has* always *been seen as a man's world. It's not about skill, it's about culture." (Male IT student, 2025)*
> *"Equal opportunity isn't just about competence. It's about the environment. If the environment feels unwelcoming, fewer women will join." (Female IT student, 2025)*
> *"Some men think gender doesn't matter in tech. But that's easy to say when you're not the one being doubted." (Female IT student, 2025)*
> *"The issue is not ability but encouragement. Women need to see they belong in these spaces." (Female arts student, 2025)*
> *"If we saw more women teaching IT or leading projects, it would normalise their presence." (Female arts student, 2025)*
> *"Interest doesn't develop in a vacuum. If girls never see women in tech roles, how can they imagine themselves there?" (Female arts student, 2025)*
> *"The media shows male hackers and male programmers. No wonder kids assume tech is a guy thing." (Male arts student, 2025)*
> *"If more movies or games had women programmers, it would normalise seeing them in real workplaces." (Male arts student, 2025)*

> *"It's not discrimination. It's just that fewer girls are really interested in coding."*
> *(Male arts student, 2025)*

These statements mirror findings by Master et al. (2016) and Cheryan et al. (2017), who documented how belongingness and identity strongly influence women's engagement in STEM, as well as support the assumptions of Social Role Theory (Eagly, 1987) and Gender Schema Theory (Bem, 1981), showing that social expectations and institutional environments continue to shape students' perceptions of gender roles in technology. The differences observed here suggest that educational context and disciplinary framing significantly affect students' interpretations of gender inequality in technology.

5 Synthesis and discussion

The findings of this study highlight the complex interplay between gender, academic orientation, and disciplinary culture in shaping students' perceptions of women professionals in the field of Information Technology. Although students across both faculties generally acknowledged women's competence in IT, the nuances of their responses reveal persistent gendered assumptions and differing interpretive frameworks that influence how women's roles in technology are conceptualised. These differences reflect not only individual attitudes but also the broader social and educational environments in which these students are embedded.

A central finding concerns the contrast between students enrolled in the Faculty of Arts and those studying Applied Informatics. Humanities students, regardless of gender, demonstrated a consistently higher awareness of structural inequalities and were more likely to perceive gender bias as a significant factor influencing women's participation in IT. Their responses suggest that the reflective and discourse-oriented nature of humanities education promotes sensitivity to issues of identity, representation, and social justice. Exposure to discussions of power dynamics, cultural narratives, and critical theory likely equips these students with conceptual tools for interpreting gender disparities not merely as matters of personal choice but as outcomes of socialisation and institutional constraints.

In contrast, students of Applied Informatics tended to adopt a more individualistic and meritocratic lens, often attributing women's lower participation in IT to differences in intrinsic interest rather than systemic barriers. This perspective aligns with well-documented trends within STEM fields, where students are socialised to value quantifiable performance and technical proficiency, sometimes at the expense of recognising the broader cultural and institutional factors that shape access and participation.

The prevalence of such views among male Informatics students, in particular, corresponds with the findings of Cheryan et al. (2017) and Sax et al. (2018), who observed that male STEM students frequently interpret gender inequality through a depoliticised framework that minimises structural bias.

Quantitative data reinforce these disciplinary contrasts. Arts students consistently rated women's technical competence, leadership potential, and equality of opportunity more highly than Informatics students. The gender gap was most pronounced among male IT students, whose lower levels of agreement suggest that they may more readily internalise traditional gender schemas associating technological expertise with masculinity. This pattern is consistent with the predictions of **Gender Schema Theory** (Bem, 1981), which posits that individuals interpret new information through culturally embedded cognitive structures. For many male Informatics students, these schemas appear to frame IT as a "male domain," a perception often reinforced by their immediate learning environment, which is overwhelmingly male.

Conversely, female IT students, although greatly outnumbered, expressed attitudes far more aligned with those of the female and male students in the Faculty of Arts. Their responses frequently underscored both competence and belonging while also acknowledging the pressure associated with navigating a minority position. These students often articulated a dual consciousness: confidence in their abilities accompanied by heightened awareness of subtle biases, stereotypes, or unequal expectations. This reflects findings from Dasgupta and Stout (2014), who argue that underrepresented groups in STEM frequently develop social and cognitive strategies to cope with stereotype threat while simultaneously advocating for more inclusive environments.

The interviews further reveal the interpretive dichotomy between faculties. Male Arts students often contextualised gender inequality within a broader socio-cultural framework, drawing connections between representation, media narratives, and professional identity. Their language reflected the academic vocabulary of the humanities, terms such as "stereotypes," "symbolic barriers," and "visibility", indicating that disciplinary training shapes not only perceptions but the very discourse through which students articulate their understanding of gender. Meanwhile, male Informatics students favoured vocabulary centred on "interest," "effort," or "ability," reflecting a culture that prioritises individual performance metrics over structural analysis.

These findings offer strong support for Social Role Theory (Eagly, 1987), which asserts that gender stereotypes arise from observations of social roles, particularly occupational patterns. In a faculty where women are scarce and technical roles are normalised as male roles, students naturally infer gendered divisions of competence and interest. In contrast, in a humanities environment with strong female representation, students encounter a wider array of gender-role models and learning contexts that problematize reductive assumptions about gender and ability.

An important interpretive insight emerging from this study concerns the role of higher education as both a site of social reproduction and potential transformation. The study's context, a university with sharply gendered disciplinary demographics, mirrors broader societal patterns and contributes to the perceptions students internalise. Yet the results also suggest that curricular design and pedagogical practices can mitigate or challenge gender bias.

Students in the Faculty of Arts clearly benefit from educational content that foregrounds issues of identity, representation, and social power. Integrating similar reflective elements into IT curricula, through interdisciplinary modules, gender-awareness training, or the inclusion of women IT professionals as lecturers and mentors, could foster more nuanced understandings among technical students.

It is also significant that, despite the noted differences, students across faculties expressed a belief that gender diversity benefits IT. Even male Informatics students who maintained more traditional views acknowledged the value of diverse perspectives in innovation and problem-solving. This shared recognition suggests that conversations around inclusion are possible across disciplinary boundaries and that interventions aimed at reducing bias may find receptive audiences in both contexts, though, perhaps, for different reasons.

Finally, the strong gender asymmetry in both participating faculties constitutes both a limitation and an interpretive lens. While the imbalance complicates statistical comparisons and generalizability, it simultaneously provides a realistic depiction of the environments students navigate daily. These environments shape the “gendered landscapes” of their academic experiences, reinforcing the need for institutional policies that address representation both symbolically and structurally.

The findings underscore that perceptions of women in IT are deeply rooted in gendered cultural norms and academic environments. While progress is evident, particularly among female and humanities students, notable gaps persist, especially within male-dominated technical fields. Addressing these gaps requires not only curricular innovation but also institutional commitment to fostering inclusive learning cultures, promoting female visibility in IT, and encouraging interdisciplinary understanding of gender and technology.

6 Recommendations

The study demonstrates that a complex interplay of gender, disciplinary identity, and educational culture shapes perceptions of women professionals in Information Technology. Students from the Faculty of Arts expressed consistently more egalitarian and inclusive attitudes toward women in IT, while those from Applied Informatics, particularly male students, displayed more traditional, meritocratic, and sometimes stereotypical interpretations.

These findings highlight the extent to which academic environments and gender representation within them influence students’ beliefs and expectations. Although the majority of respondents acknowledged women’s potential and competence, female IT students stood out as uniquely positioned and expressed strong confidence in women’s abilities. Still, they were simultaneously more attuned to subtle bias and the pressures of operating as a minority in a male-dominated field.

Their voices reveal both the resilience and vulnerability that accompany the experience of underrepresentation, underscoring the need for sustained institutional support.

Based on these findings, several key recommendations can be made:

1. **Increase the visibility of women in IT education.** Universities should prioritise inviting female IT professionals, researchers, and alumni as guest lecturers, mentors, or workshop facilitators to normalise women's presence and leadership in technology.
2. **Integrate gender-awareness content into technical curricula.** Short interdisciplinary modules or assignments focusing on representation, bias, and the social dimensions of technology may help technical students develop a broader, more reflective understanding of gender dynamics in IT.
3. **Strengthen support systems for female IT students.** Mentoring programs, peer support groups, and dedicated advising for women in technical fields could mitigate feelings of isolation and promote academic success.
4. **Promote cross-faculty learning experiences.** Collaborative tasks between IT and Arts students may foster mutual understanding and expose technical students to discussions of identity and representation, while giving arts students insight into the logic and language of technological fields.
5. **Encourage faculty development in inclusive teaching.** Lecturers in both faculties should receive training in gender-sensitive pedagogy and inclusive communication to ensure that learning environments are equitable and welcoming.
6. **Monitor and evaluate gender climate regularly.** Systematic data collection and student feedback can help identify emerging issues and track improvements in gender-related perceptions and experiences.

These recommendations aim to bridge the perceptual gaps observed in the study and to encourage institutional strategies that foster gender equity within both academic and professional spheres of Information Technology.

7 Conclusion

This research has examined perceptual differences toward women professionals in Information Technology among bachelor's students of Applied Informatics and English Language and Culture in Specialised Communication at the University of Ss. Cyril and Methodius in Trnava, Slovakia. Through a mixed-methods design combining quantitative questionnaires and qualitative interviews, the study revealed that students' gender perceptions are shaped not only by personal identity but also by academic culture and the gender composition of their respective study programs.

The Faculty of Arts students, both male and female, demonstrated a high degree of awareness of gender issues, frequently highlighting structural and cultural barriers that hinder women's participation in IT.

In contrast, students of Applied Informatics often interpreted gender disparities in IT as reflective of individual preferences or differences in interest rather than systemic obstacles.

This distinction suggests that academic environments and curricular focus significantly shape the conceptual frameworks students employ when thinking about gender and technology.
Female IT students provided particularly compelling insights. Despite their confidence in their own capabilities, they often reported experiences of being underestimated, overlooked, or positioned in ways that subtly reflect gendered assumptions. Their accounts lend strong support to existing research on stereotype threat and underrepresentation in STEM fields, demonstrating how gender dynamics manifest in everyday academic interactions.
Taken together, the findings emphasise the importance of addressing gender bias at both structural and instructional levels. While perceptions are gradually shifting toward greater inclusion, the persistence of gendered assumptions indicates that more targeted interventions are needed. By promoting visibility, fostering critical reflection, and cultivating inclusive educational cultures, universities can play a significant role in creating a more equitable technological future.

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All learning paths lead to knowledge

Reading Comprehension of Vocational Teachers in Slovakia: A Case Study

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Abstract

This case study explores the relationship between reading comprehension and critical thinking among vocational teachers in Slovakia, highlighting the role of these competencies in professional and pedagogical practice. Reading comprehension is essential not only for processing specialized texts but also for adapting information to diverse learning needs of students in vocational education. At the same time, critical thinking enables teachers to evaluate information, make informed decisions, and foster problem-solving skills in their learners. The study investigates to what extent vocational teachers demonstrate proficiency in both areas and how these skills support their teaching effectiveness. Attention is given to the influence of teaching experience, field of specialization, and continuous professional development. Findings indicate that strengthening reading comprehension and critical thinking is very much needed for improving instructional quality and preparing students for rapidly changing labour market demands. The study underscores the importance of targeted training programs and policy support in this context.

Keywords: Reading Comprehension, Vocational Education, Critical Thinking

1 Introduction

Nowadays, in the times of digital transformation, constant information inflow, and the rapid rise of artificial intelligence, information literacy has become the most important competency

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not only for everyday life but also for individuals' professional development. This ability is particularly important in the field of education, as teachers play a crucial role in shaping future generations. For vocational teachers, who face the demanding challenges of dynamic changes in their fields, information literacy is not only a tool for acquiring relevant information but also a means of critically evaluating and effectively using it in teaching.

Reading literacy, as a component of information literacy, is the ability to understand written text, work with it, and critically evaluate it in order to use it effectively in various life, academic, and professional situations. It includes not only decoding words but also understanding meaning, searching for and interpreting information, forming one's own conclusions, connecting the text with prior knowledge, and reflecting on or assessing its content and purpose. Sorting information has become a complicated issue today, as written text is no longer the exclusive domain of experts. Literary works are now published not only by renowned authors but also by individuals with questionable education or personal credibility. Especially the internet has therefore become a confusing space filled with false or misleading information, disinformation, unverified speculation, and half-truths.

One of the main challenges of today's education system is to ensure that teachers are able not only to receive information but also to understand, analyse, interpret, and apply it in ways that support the quality of instruction. Information literacy and especially reading comprehension in all its forms and dimensions, is inherently connected to critical thinking.

Critical thinking is an essential part of the professional competencies that teachers need to develop in order to assess the quality and reliability of information sources in an environment saturated with misinformation, innovate teaching methods, adapt instruction to the needs of modern students, and shape learners in a way that enables them to become information-literate and critical thinkers themselves.

1.1 Reading Comprehension and Critical Thinking

Reading comprehension (also known as reading literacy) represents an individual's ability to understand written text, interpret it, analyse and critically evaluate its content, and subsequently use this information effectively in various contexts of everyday life, learning, and work.

Key elements of reading comprehension are:

- Decoding – the ability to read words and sentences. Ability to read represents basic literacy. Without it, further education is impossible, but insufficient literacy does not imply low intelligence.
- Comprehension – understanding the meaning of words, sentences, and the text as a whole. A person should be able to understand the context of the read text.
- Interpretation – the ability to draw conclusions, identify main ideas, and recognize relationships between pieces of information.
- Critical evaluation – assessing the credibility, purpose, and relevance of the text.

- Application – the ability to use the acquired information for problem-solving, decision-making, or learning.

Reading literacy is a foundational competency for all educational processes of every individual. It influences not only the understanding of what is read but also the way information is searched for, the selection of relevant and reliable sources, the evaluation and use of information, as well as the presentation of one's own knowledge. Based on what reading literacy requires, we consider the process of text comprehension to be particularly significant (Borovská, 2015).

Better understanding of written text can be strengthened primarily in two ways:

1. By enhancing the comprehension process itself—setting a clear goal of understanding the text and practicing strategies that promote effective comprehension.
2. By working with pedagogical texts designed to support understanding, which, through gradually increasing levels of difficulty, help develop and expand our textual competencies (Gavora, 1992).

There are many strategies that promote effective text comprehension. We are talking about skills and approaches that enable readers to actively process, understand, and apply the information contained in a text (Harvey & Goudvis, 2024):

Before reading the text: activation of prior knowledge and experiences

- Prediction: Based on the title, pictures, or introduction, the reader tries to find out what the text will be about.
- Setting a purpose: Becoming aware of why the text is being read (e.g., to obtain information, understand a situation, solve a problem, etc.).
- Personal experiences and knowledge: Activating prior knowledge based on past experiences related to the topic.

During reading: monitoring the state of comprehension

- Self-correcting: If the reader does not understand, they go back, reread the sentence or paragraph, slow down, or use other sources to clarify the information. Sometimes there is a need to solve focusing problems.
- Visualizing: Creating a mental image of what has been read.
- Questioning: Thinking about what is happening, why it is happening, what will happen next, what the author is trying to say, etc.
- Highlighting and note-taking: Underlining key words, writing notes in the margins. Reader tries to identify main ideas.
- Paraphrasing: Summarizing in one's own words what has just been read.

After reading: processing and using information

- Summarizing: Expressing the main idea or storyline of the text.
- Discussion: Talking about the text – supporting deeper understanding and confronting different perspectives.
- Mapping or diagrams: Creating a mind map or diagram to visualize relationships, main characters or key ideas.

- Application: Using the information in practice (e.g., assembling something according to instructions, changing behaviour, solving a problem).
- Self-assessment and self-reflection: Evaluating what we have learned and what we found difficult.

Reading comprehension is inevitably connected with critical thinking. It is not easy, however, to define what critical thinking really is (Kosturková, 2016). Most definitions of critical thinking claim that it is a competency that encompasses multiple abilities and skills. Critical thinking comprises the mental processes, strategies, and representations people use to solve problems, make decisions, and learn new concepts (Sternberg, 1996). Critical thinking is a higher order cognitive skill, which includes reasoning, making analyses, inferences, and evaluations (Facione et al., 1995; Liu, Frankel and Roohr, 2014). For example, Paul (1992) proposed a model of 35 components of critical thinking (9 affective strategies, 16 cognitive macro-skills, and 9 cognitive micro-skills).

According to Ruisel (2008), critical thinking is a synonym for the quality or comprehensible thinking, which includes motivation for challenge, knowledge of critical thinking abilities, training of structure to facilitate transfer between contexts, and metacognitive monitoring. Nowadays, when we access many pieces of information primarily through social media and with the help of artificial intelligence, critical evaluating of information has become a must not only in our professional but also in our personal life.

Reading comprehension is not only the foundation stone of other literacies but also the essential base of critical thinking. Without the ability to comprehend written (or spoken) text, it is difficult for an individual to draw sound logical conclusions or orient themselves within today’s information chaos.

1.2 Reading Comprehension of Students and Teachers

The purpose of reading is comprehension which means getting meaning from written text. Without comprehension, reading is just a frustrating, pointless exercise. It is no exaggeration to say that how well a person develops the ability to comprehend what they read has a profound effect on their entire lives (Anderson et al, 1985; Teaxas Educational Agency, 2002). Over the past few decades, research has revealed a great deal of information about how readers get meaning from what they read and procedures for developing the skill. Nevertheless, the results of reading literacy assessments remain alarming.

A 2010 study conducted in Slovakia found that the reading comprehension of university students is low, and this concerning situation calls for a revision of teaching approaches already at the elementary and secondary school levels (Gavora & Matúšová, 2010). Similar results have been reached by other studies researching students and teachers as well (Kosturková 2013, 2014).

Data on reading literacy — whether in Slovakia or across Europe — are still fairly concerning. Although the field of reading literacy research is extensive and compelling, its central aim remains clear: to foster meaningful improvement. Despite the considerable attention devoted to reading comprehension and critical thinking, improvement has not yet followed.

In the current assessment cycle (PISA 2022), the scores of 15-year-old students in Slovakia fall below the OECD average. A similar result can be observed in the other two assessed areas. In both reading literacy and scientific literacy, the performance of Slovak students remained below the OECD average, just as in previous cycles. As in previous cycles, PISA 2022 recorded a significant proportion of Slovak 15-year-old students in the so-called at-risk group (that is, students who do not reach even the basic level of skills and knowledge in the assessed domain), and this occurred in all three assessed areas. The percentage of Slovak students achieving the highest performance level in mathematics literacy is 7.3%. Compared to 2018, when 10.7% of Slovak students reached the highest level, this represents a significantly lower result. In the other two areas—reading and science literacy—changes were also recorded in the share of top-performing students. In reading literacy, the percentage decreased from 4.6% in 2018 to 3.4% in 2022 (a statistically significant difference), while in science literacy it increased from 3.7% in 2018 to 4.3% in 2022 (the difference is not statistically significant, meaning it remains at the same level as in 2018) (OECD, 2023).

Slovakia achieved a score of 447 points in reading literacy, while the OECD average was 476 points. As in all previous cycles, Slovak students' performance in reading literacy in PISA 2022 remained below the average of participating OECD countries. Countries with performance comparable to Slovakia include Chile, Malta, and Serbia. Among OECD countries, significantly lower average results than Slovakia were recorded by students from Greece, Iceland, Mexico, Costa Rica, and Colombia. Compared to 2018, when reading literacy was also the main assessed domain, the average performance of Slovak students in this area decreased by 11 points, which represents a statistically significant difference (OECD, 2023ab; NIVAM, 2023a).

The National Institute for Education and Youth (NIVAM) has been implementing, on behalf of the Ministry of Education, Research, Development and Youth of the Slovak Republic, a national project titled International Assessment of Key Competencies of Adults - Programme for the International Assessment of Adult Competencies (PIAAC) since August 2018. The project is co-funded by the European Union through the support of the European Social Fund and the European Regional Development Fund under the Human Resources Operational Programme. As part of this project, research is being conducted on the competencies of teaching staff and students of teacher-training programs in Slovakia in the areas of reading literacy, mathematical literacy, and problem-solving using ICT (information and communication technologies). NIVAM carries out this research using the international assessment tool Education and Skills Online (PIAAC Online) developed by the OECD (NIVAM, 2023b).

The final report of the International Assessment of Adult Competencies (PIAAC) 2023 for Slovakia states that the average score across all participating countries in reading literacy was 260 points. Adults in Finland achieved the highest average score (296 points), while very high average scores above 280 were also achieved by adults in Japan, Sweden, and Norway. Adults in other countries, including Slovakia (254 points), scored significantly below the OECD average. The score in Slovakia was significantly lower than in Germany and neighbouring Czechia, comparable to Austria, France, and Croatia, and higher than in Hungary, Spain, Italy, and Poland (NIVAM, 2024).

Abroad, it is common for the development of reading comprehension and critical thinking to be an integral part of education in many scientific disciplines, and with the numerous classes and exercises that students complete during their studies, their critical thinking and reading comprehension improve (Ballová Mikušková, 2019). Critical thinking provides us with independence, protects us against unsubstantiated information, fraudsters, manipulation, and similar threats. However, it must be actively trained (Ballová Mikušková, 2019).

Kosturková (2013, 2014) proposed possible measures already ten years ago, but they have been implemented in practice only partially. She identified the main cause of this unsatisfactory situation primarily in the prioritization of encyclopaedic knowledge over critical thinking in education. The ability to think critically is considered a key competency of the 21st century; therefore, among other recommendations, she also suggested strengthening lifelong education for teachers with this focus.

2 Material and Methods

Based on a decade of research and the latest findings from PISA and PIAAC assessments, this case study evaluated the ability of vocational teachers at Slovak secondary vocational schools to comprehend basic instructions concerning the payment for tutoring students during their practical training.

Participants in the supplementary teacher training program at the Slovak University of Agriculture (SUA) in Nitra complete a practice training (so-called observation and listening practice) in the second year of their studies. The purpose of this practice is to observe vocational subject teachers at work and to pay attention to their interaction with students so that trainees become capable of independently managing the teaching process during their final teaching practice. These teachers serve as mentor teachers for the students and are compensated for their work. In order for the arranged payment to be paid, we must obtain their personal data. Each mentor teacher who agrees to cooperate with SUA in Nitra receives detailed instructions on how to complete this information (Figure 1).

The study was conducted from October 2024 to February 2025 as part of the supplementary teacher training program at SUA in Nitra. A total of 58 mentor teachers from secondary vocational schools in Slovakia participated in the research, including 11 men and 47 women. To preserve anonymity, we do not report their teaching qualifications, the schools in which they work, or any additional data collected. All mentor teachers were asked to send the completed and signed document to the University Counselling and Support Centre at SUA in Nitra, along with their telephone number and email address. We then contacted them to request additional necessary information for health and social insurance, including pension-related details.

Figure 1: Detailed instructions for mentor vocational teachers.

3 Results and Discussion

Over the course of five months, we collected responses from all 58 mentor teachers. Before that, however, we received 35 phone calls and 7 emails with questions regarding how to complete the required document.

The most frequently asked questions concerned the address to which the document needed to be sent (the address is listed both on the university website and at the bottom of the document that was completed). Other questions we received included:

- the number of hours to indicate when supervising two or more students,
- which date should be entered,
- whether it is necessary to list the full names of all students who completed the practice,
- whether proof of old-age or disability pension must be provided.

We answered all questions posed by the respondents. Nevertheless, the number of fully and correctly completed documents submitted to the workplace was only 27. A total of 31 documents contained one or more incorrectly filled items or completely missing information. A detailed analysis is presented in Figure 2.

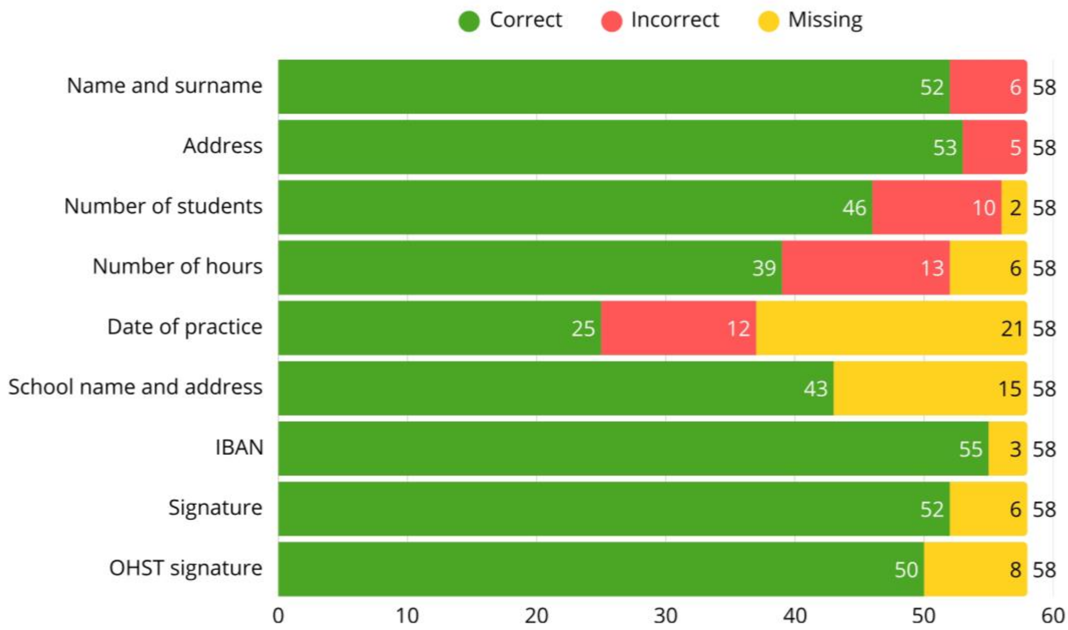

Figure 2: Number of correct, incorrect and missing data in completed documents from teachers.

From the responses obtained, we can infer results similar to those reported by Dole et al., (1991), Gavora et al. (2010), Kosturková (2013, 2014), and others, as well as findings from the International Assessment of Adult Competencies (PIAAC) (2023). Given that fewer than half of the submitted documents were completed correctly and in full and considering the types of questions asked by the mentor teachers, we may assume that the teachers did not read the instructions and the document with sufficient comprehension. The factors influencing this process should be the subject of further research (e.g., the level and ability to maintain concentration while reading and the conditions under which the document was completed, possible specific needs of the teachers such as specific learning difficulties, stress-related factors, and others).

4 Conclusion

Reading comprehension is insufficient not only among pupils and students, but also among teachers, which represents a major problem in the educational process. If a teacher is not able to understand written and spoken word, they may be more vulnerable to false information and more easily succumb to propaganda or develop fear of things that have until now been taken for granted (e.g., scientific knowledge). As a result, they will not be able to adequately prepare students for working with information or for the labour market. Therefore, it is now more important than ever to structure lifelong learning in such a way that activities are oriented toward the current digital information era, information literacy, and critical thinking.

We also agree with Kosturková (2013, 2014), who proposes measures to improve reading literacy and critical thinking. We believe that these measures are equally applicable to lifelong teacher education. To improve reading literacy, it is advisable to shift the type of educational activities so that encyclopaedic knowledge and memorization do not dominate; instead, education should rely more on workshops, discussions, and the use of modern active-learning methods. Project-based and problem-based learning are also essential, as well as problem analysis, development of soft skills such as communication, cultivated expression, and conflict resolution, training in flexible thinking, training in constructive criticism, and linking theory with practice. A considerable amount of further research is needed to examine the impact of social media on human cognitive functions and emotional experience.

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Students' and Teachers' Digital Practices In and out of the CLIL Classroom in Slovakia

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Abstract

This study examines and compares the digital literacy practices of students and teachers engaged in Content and Language Integrated Learning (CLIL) in Slovakia. Drawing upon data from two national-level surveys—the Digital Literacies Student Survey (DLSS) and the Digital Literacies Teacher Survey (DLTS)—the research investigates the ways in which both cohorts access, utilise, and perceive digital technologies both within and beyond the classroom environment. Quantitative data derived from 38 student respondents and four in-service CLIL teachers revealed notable discrepancies in digital engagement, tool usage, and perceived competence. Whilst students reported high levels of informal digital activity—predominantly via mobile devices and social media platforms—teachers exhibited a more cautious and moderately integrated approach towards the use of digital instruments within CLIL lessons. The findings highlight a generational and pedagogical gap in digital literacy application, with implications for teacher training, curriculum design, and strategic policy development. Recommendations emphasize the need for enhanced professional development and the alignment of instructional practices with students' existing digital competencies to support effective bilingual education.

Keywords: Digital Literacy, Bilingual Education, Extramural Practices

1 Introduction

Digital technologies have fundamentally transformed the mechanisms through which young people communicate, learn, and engage with society, engendering complex multilingual and multimodal networks that extend beyond the institutional confines of the school. Students

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routinely navigate digital practices such as gaming, social networking, and online content creation across various languages and platforms. These extramural practices – activities occurring outside formal education – offer authentic language exposure and foster informal learning processes (Sundqvist & Sylvén, 2016; Benson, 2021).

For learners in bilingual and Content and Language Integrated Learning (CLIL) environments, such experiences often provide their most sustained interaction with the target language. However, teachers ‘understanding of how these digital engagements connect to classroom learning remains limited. Research in applied linguistics and educational technology increasingly highlights the linguistic potential of these out-of-school practices. Studies demonstrate that online gaming, social media, and creative digital production can enhance vocabulary, pragmatics, and motivation (Reinhardt, 2019; Sauro & Zourou, 2019; Lee & Dressman, 2018).

Yet, teachers frequently perceive these activities as recreational rather than education (Henry et al., 2018; Brevik, 2020), leading to a misalignment between students ‘lived experiences and classroom practices in CLIL contexts – where content and language objectives are intertwined- this gap limits teachers ‘ability to connect students ‘informal linguistic resources to formal curricular goals (Vnučko & Klimova, 2023; Vnučko et al., 2024). The growing presence of artificial intelligence (AI) in students’ daily routines introduces further complexity. Learners increasingly interact with translation tools, chatbots, recommendation systems, and generative AI platforms that support creativity, problem-solving, and information retrieval in multiple languages (Ammar et al., 2023; Lin & Warchauer, 2023).

However, many teachers remain uncertain about how to meaningfully incorporate AI into their instruction, reflecting broader tensions between technological innovation and pedagogical awareness (Reinhardt, 2020). In CLIL this is particularly significant because AI can serve as both a linguistic and cognitive scaffold, supporting disciplinary discourse and multimodal meaning-making.

These developments intersect with the concept of Critical Digital Literacies (CDLs) – the ability to evaluate, interpret, and produce digital content with an understanding of its ethical, social, and epistemological implications (Hobbs, 2017; Pangrazio, 2019; Godhe, 2019). CDLs extend beyond functional digital skills to include critical awareness of bias, authorship, and information construction. For CLIL educators, this is especially relevant because developing bilingual disciplinary literacies requires not only language proficiency but also critical engagement with how knowledge is represented in digital media (Hüttner et al., 2025).

Yet, empirical studies show that most teachers continue to approach digital technologies instrumentally, focusing on technical operation rather than reflective or critical engagement (Calvani et al., 2012; Tour, 2017). The extent to which CLIL teachers recognize and integrate students ‘everyday digital and AI practices remain underexplored.

Recent European research has begun to document this gap between students ‘digital lives and classroom practice (Brevik, 2020; Llinares & Morton, 2023). However, few studies have compared teacher perceptions with student self-reports, particularly regarding AI-mediated literacies. Understanding this relationship is essential for developing pedagogies that align with learners ‘authentic linguistic environments and for preparing teachers to integrate digital and AI literacies into CLIL instruction. Accordingly, this study investigates how CLIL teachers perceive students ‘extramural digital and AI-mediated practices, how these perceptions align with students ‘self-reported experiences, and how such practices inform instructional design.

1.1 CLIL and Disciplinary Literacy

CLIL integrates subject and language learning, promoting both linguistic and cognitive development (Coyle et al., 2010). The field has evolved from emphasizing methodology to focusing on disciplinary literacies-the ways in which language and multimodal resources construct knowledge within subject areas (Llinares & Morton, 2023; Morton, 2020). Research indicates that bilingual classroom discourse supports disciplinary reasoning when teachers explicitly scaffold how students use language to build conceptual understanding (Nikula, 2017; Llinares & Morton, 2023). The Bilingual and Multilingual Disciplinary Literacies (BMDL) framework (Hüttner et al., 2025) further situates CLIL at the intersection of content, language and mediational resources, positioning digital tools as central to meaning making. Nevertheless, most empirical studies focus on classroom discourse rather than how digital mediation or out-of-school practices influence disciplinary learning.

1.2 Teacher Cognition and Technology Integration

Teachers ‘beliefs, experiences, and institutional contexts critically shape how technology is used in classrooms (Ertmer & Ottenbreit-Leftwich, 2010; Tour, 2017). Despite positive attitudes, teachers often employ digital tools in limited, presentation-focused ways (Prestridge, 2012; Petko, 2012). In CLIL, such patterns affect the balance between content and language, as many teachers still prioritize content delivery over linguistic mediation (Llinares & Morton, 2023). Moreover, teachers often underestimate students ‘extramural learning and fail to link informal practices to curricular objectives (Brevik, 2020). This disconnect can lead to the exclusion of authentic digital experiences that could enrich disciplinary engagement. Extramural digital learning-learners ‘voluntary engagement with digital media outside formal instruction-has been shown to enhance linguistic and motivational outcomes (Sundqvist & Sylvén, 2016).

Participation in gaming, social networking, and online creative communities supports communicative competence and confidence (Henry et al., 2018; Lee & Dressman, 2018). Studies also link digital gaming to positive attitudes toward English and increased lexical use (Vnučko et al., 2023, 2024).

However, connections to academic achievement remain unclear. Such informal experiences often shape linguistic identity and self-directed learning (Sockett & Toffoli, 2012; Benson, 2021), yet they are rarely recognized in classroom discourse (Lai & Gu, 2011).

For CLIL, leveraging these authentic digital practices could enhance motivation and disciplinary learning, provided teachers have the awareness and pedagogical tools to do so. Integrating critical digital literacies within CLIL can strengthen both linguistic and disciplinary learning by promoting analytical engagement with digital sources. However, empirical work exploring this intersection remains scarce. Technology adoption is mediated by teacher confidence, institutional support, and beliefs (Inan & Lowther, 2010) which may explain why AI tools are still rarely embedded in CLIL practice despite students 'growing familiarity. Recent frameworks, propose broadening CLIL to encompass digital and multimodal literacies (Llinares & Morton, 2023; Hüttner et al., 2025).

As students increasingly construct knowledge within multilingual and AI-mediated environments, CLIL educators must expand their literacy repertoires to encompass critical, digital, and AI-mediated forms of meaning-making. This study addresses this emerging pedagogical necessity by analysing how teachers perceive and integrate students' digital and AI-mediated practices, thereby bridging the conceptual and practical dimensions of CLIL in the digital age.

2 Slovak Context

This paper presents the national findings for Slovakia from the pan-European study conducted by CLILNetLe Working Group 4 (WG4). The overarching goal of the CLILNetLE Action (CA21114) is to investigate bi/multilingual disciplinary literacies (BMDLs) in Content and Language Integrated Learning (CLIL) contexts. The WG4 study focused specifically on digital practices that CLIL learners and teachers engage in both during lessons and in their spare time, and the influence these activities have on students ´bi/multilingual disciplinary literacies. The Slovak report aims to provide a detailed and nuanced picture of students 'digital literacies, their CLIL experiences, and the factors influencing their engagement with digital technologies. In Slovakia, CLIL, which stands for Content and Language Integrated Learning, has been promoted since 2001. However, there is no specific educational strategy or formal regulation from Slovak educational authorities to support its implementation. Consequently, CLIL is implemented voluntarily by school management or individual teachers, leading to an unclear count of schools suggesting that CLIL learners developed better linguistic communicative skills compared to non-CLIL peers, though content knowledge was not assessed, and the project was not continued.

The implementation of CLIL in Slovakia relies heavily on the capacities of school management and the availability of competent teachers. While educational authorities promote and support CLIL, mainly at the lower-secondary and secondary levels, they offer no direct support or regulation in the didactic and professional preparedness of teachers for CLIL. Therefore, pre-service teacher training for CLIL is gradually anchored into the curricula of four Slovak universities (Nitra, Bratislava, Trnava, and Prešov), and in-service teachers usually develop their didactic skills based on personal or professional interest. Given this context, the Slovak investigation sought to capture comprehensive data on students´ digital literacy skills, practices, and experiences, as well as teachers ´engagement with digital tools for developing disciplinary literacies.

2.1 Methodology

This study utilized two complementary instruments developed by CLILNetLe WG4: the Digital Literacies Student Survey (DLSS) and the Digital Literacies Teachers Survey (DLTS) (Ghamarian, Neville, Segura, Smit, 2024). The DLSS aimed to investigate digital practices CLIL learners engage in outside education in English or other CLIL target languages. The DLTS aimed to investigate digital practices and resources used in school-based CLIL teaching. Both surveys were administered online via the Qualtrics platform, which facilitated multilingual distribution. The DLSS was administered in Slovakia between March and April 2024. The target participants were students aged 10-19. Data collection focused on bilingual schools and schools providing CLIL education at lower secondary and secondary levels in several locations, including Nitra, Bratislava, Sučany, Martin, and Prievidza. Participants were recruited through teacher training school networks, social media outreach, and collaboration with educational institutions. A total of 38 student participants responded to the survey. The DLTS was undertaken between February and April 2024. The target group for the DLTS survey were CLIL teachers working with learners aged 11 to 21. Schools were selected based on availability and willingness to cooperate, often utilizing existing networks of teacher trainers who work with pre-service and in-service teachers. Challenges in gathering data included participants´ reluctance to take part due to limited time capacity. Only four valid responses were collected from Slovak teacher participants.

3 Results

The Slovak report presents the results of this national dataset (Kovacikova, Bagalova, 2024). The results section is structured based on the findings from both the DLSS (students) and DLTS (teachers) datasets for Slovakia. The results section is structured based on the findings from both the DLSS (students) and DLTS (teachers) datasets for Slovakia.

3.1 Digital Literacies Student Survey (DLSS) Findings

The DLSS captured participants across a diverse age range, with the largest group of respondents aged 9–10 and 11–13 years old. Most respondents were female (**68%**). A majority of students reported having parents/carers with a master's degree (N=15), followed by upper secondary (N=9) and post-secondary levels (N=7), with no respondents claiming primary level education for their parents. Students reflected Slovakia's multilingual environment, reporting the use of multiple languages at home, primarily Slovak (N=35), followed by English (N=6), Czech, and Hungarian (N=5). The **main language of schooling was Slovak** (N=21), followed by English (N=14) and Hungarian (N=3). **English was overwhelmingly identified as the main CLIL language** (N=35), followed by Hungarian (N=2) and German (N=1). The most common CLIL subjects were Natural Sciences (N=12) and Social Sciences (N=11), followed by Arts, Languages, and Philosophy (N=8). Regarding CLIL instruction objectives, the average student perspective suggested a tendency towards **"language and subject contents,"** with the mean score being 60.38% (on a 0-100 scale where 100% is entirely content-related), indicating that lessons were **balanced towards both language and content learning**. Moreover, the average scale for the extent of CLIL language use was 88.63%, suggesting that lessons were significantly oriented towards multilingual use.

3.2 Digital Literacies Teacher Survey (DLTS) Findings

The DLTS involved four teacher respondents (N=4). The majority were female (N=3), with one choosing the 'other' option. In terms of language background, 3 respondents identified as monolingual and 1 as bilingual. The teachers reported an **average teaching experience of 16 years** (ranging from 5 to 26 years) and an average of **4.75 years of CLIL teaching experience**. Three of the four respondents claimed to have received training in CLIL, primarily through specialized courses within a larger program, followed by professional development. The main CLIL languages taught were English (N=3) and German (N=1). Two respondents taught Language and Communication in CLIL, while one taught Arts and one taught Health Care.

Teachers' perceptions of CLIL lesson objectives varied, with the mean rating (48.5%) suggesting that objectives leaned towards **language and content integration**. Regarding language use in CLIL lessons, the average score was 63.25% (on a 1-100 scale where 100% is solely CLIL language). Two teachers claimed they mostly used the CLIL language (88% and 91%), while two claimed their lessons were more multilingual (35% and 39%).
Teachers reported that they spent an average of **17.5 minutes per lesson** using digital technologies (ranging from 15 to 20 minutes).

3.3 Use of Digital Tools and Perceptions (DLTS)

The teacher's responses indicated a significant reliance on certain digital tools in their main CLIL language practices, such as **social media, instant messaging, video streaming, and online research platforms**. This indicates these tools were integral for CLIL teaching. Tools like **multiplayer games and VR & AR technologies** showed lower usage frequencies. Regarding technology relevance, all respondents tended to think that using technology outside the classroom was beneficial for developing bilingual and multilingual disciplinary literacy skills. This is reflected in a high mean score of **79** (on a scale where 100 meant the highest benefit for developing disciplinary literacy skills). For the statement, 'Students' disciplinary literacy skills improve when incorporating technology into CLIL teaching,' all three respondents who answered somewhat agreed. Most teachers perceived the use of technology by students as **'Quite important'** or **'Moderately important'** for CLIL lesson planning.

3.4 Critical Digital Literacies at Teachers and Students

Students highly valued spare-time activities that supported CLIL learning. Most activities were perceived as either 'Important' or 'Moderately Important'. Specifically, activities related to digital engagement, such as **using educational apps, watching educational videos, and participating in online forums**, were frequently marked as 'Important' for enhancing language and content learning. Most respondents (N=33) claimed to access the internet daily. Students reported facing challenges, including those related to limited internet access at school and potential issues with teachers' digital technology skills. For example, 7 students reported problems with **parents and limited internet access at school**, and 5 students identified teachers as being sometimes problematic within digital technology skills. Regarding Critical Digital Literacies (CDLs), three out of four teacher respondents were **aware of the concept**. Of those aware, reported frequency of use of CDLs in CLIL teaching varied, with one valid response ranging from 'slightly less frequent' to 'often' across the mentioned CDL strategies.
The findings highlight that CLIL teachers in Slovakia generally view technology as critical for pedagogical strategies and believe it supports students' disciplinary literacy development, despite varying levels of adoption of newer or student-centred technologies like VR/AR.

4 Conclusion

The findings of this study reveal a clear generational and pedagogical divide in how students and teachers in Slovak CLIL contexts engage with digital technologies and develop digital literacies. While students demonstrate high levels of digital fluency and regularly engage in diverse extramural practices, such as social networking, gaming, and online content creation-teachers tend to adopt a more cautious, instrumentally oriented approach within formal CLIL classrooms. This discrepancy suggests that students´ informal digital competencies remain an underutilized resource in bilingual education, limiting opportunities to connect their authentic linguistic and multimodal experiences to curricular learning.
The results also underscore that, although teachers recognize the potential of digital tools to support disciplinary literacies, their implementation remains fragmented and often dependent on individual initiative rather than systematic support. The low integration of advanced or student-driven technologies such as virtual and augmented reality indicates that digital practices are still largely confined to traditional, presentation-based formats. Furthermore, while awareness of Critical digital literacies (CDLs) and AI-mediated learning is emerging, these concepts have yet to be embedded into classroom routines or teacher training frameworks in Slovakia. To bridge the existing gap, teacher education programs should prioritize the development of critical and pedagogical digital literacies, equipping

educators with both theoretical understanding and practical competence to integrate students´ everyday digital experiences into CLIL instruction. Institutional policies and national strategies are also needed to provide structured professional development and sustained support for technology-enhanced bilingual education. By aligning teaching practices with students´ evolving digital realities, CLIL can more effectively foster bilingual disciplinary literacies that prepare learners to navigate multilingual, multimodal, and AI-mediated environments.

Ultimately, this study highlights that the future of CLIL in Slovakia, and more broadly across Europe, depends on rethinking the digital dimension of bilingual education. Integrating informal digital practices, fostering critical awareness, and embracing innovation are key to ensuring that CLIL pedagogy remains responsive to the complex literacies that define contemporary learning.

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Pedagogical Strategies for the Development of Critical Thinking, Communication Competences and Empathy in Managing the Professional Doctors´ Education

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Abstract

The cultivation of critical thinking, communication skills, and empathy are fundamental pillars of contemporary educational management. Consequently, it is essential to evaluate pedagogical strategies that facilitate the development of these core competencies within medical education. This paper examines active and experiential learning methodologies, reflective practice, professional collaboration, and the integration of innovative technologies. Furthermore, emphasis is placed upon the significance of assessment, self-reflection, and the ethical-psychological dimensions of a clinician's professional evolution. The objective of this study is to underscore the necessity of an integrated educational model that synthesises clinical erudition with humanity, empathy, and professional responsibility toward patients.

Keywords: Critical Thinking, Communication Skills, Empathy, Management, Doctors´ Education

1 Development of Cognitive and Affective Competencies in Medical Education

Medical education can be considered a professional and systematic process of training both future doctors in a university setting and other healthcare professionals within further and

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higher education environments. This educational framework encompasses the acquisition of the knowledge, skills, attitudes, and values essential for professional practice.

European directives place significant emphasis upon the Continuous Professional Development of healthcare practitioners, and Slovakia aligns with these international standards. Their goal is to renew knowledge, skills and abilities in order to maintain the safe and effective performance in the medical doctor and other health professionals, and at the same time, to strive to keep up with current development and trends.

The development of cognitive and affective competencies is one of the basic aims of modern medical education. The cognitive area includes abilities such as analytical thinking, problem solving, critical, but also clinical decision-making and the application of theoretical knowledge in practice. Their development is supported by methods such as problem-based learning, case study analysis or simulations of clinical situations, which lead students, doctors and medical staff in general in the process of regular professional development to independence and critical thinking.

Affective competencies, such as empathy, communication skills, self-reflection and ethical decision-making, represent the emotional and value-based aspect of the medical profession. Their development requires pedagogical approaches that combine knowledge with personal growth. The integration of cognitive and affective skills allows educating doctors who combine professional erudition with humanity and the ability to understand the patient holistically.

Gurňáková et Marcinechová (2021, p. 8) state that: *"The needs of practice lead, especially abroad, to the formulation of protocols and to the creation of specific training programs in communication, which are based on principles proven in other areas of medicine"* (Gurňáková, Marcinechová, 2021, p. 8).

1.1 Critical Thinking as a Basis for Decision-making

As stated by Grecmanová et al. (2000, p. 13): *"Critical thinking is primarily active and independent reasoning, conditioned by the following abilities: understanding information and its thorough examination, comparison of ideas with other opinions and claims, seeing facts in context, using all levels of thinking processes, taking a position and taking responsibility for it"* (Grecmanová et al., 2000, p. 13).

Critical thinking forms the basis for decision-making and thus enables objective analysis of information, evidence evaluation and selection of the most appropriate solutions based on rational arguments, as opposed to assumptions or emotions. Every person who applies critical thinking in his/her life is able to distinguish between facts and opinions, verify sources of information, foresee the consequences of his/her decisions and take into account different perspectives on the problem.

In the context of medicine, critical thinking plays a key role, because doctors´ decisions directly affect the health and life of a patient. Critical thinking often allows doctors to connect scientific knowledge with clinical experience and evaluate diagnostic data. This brings a practical ability

to weigh the risks and benefits of treatment and make ethically responsible decisions. In a broader sense, critical thinking represents a tool for professional reflection and for a guarantee of high-quality decision-making process management in all fields, where complex information and consequences for people are worked with. The development of critical thinking also has its irreplaceable place in medical education, at all educational levels.
Bodoríková et al. (2023, 153 – 154) state that: "*Topics regarding students' critical thinking still raise many questions among teachers, gradually leading them to a changed view of teaching, enabling them to see the teaching process in broader contexts, to realize the essence of educational situations and to find ways to solve them*" (Bodoríková et al., 2023, 153 – 154).

1.2 Communication Competences as Part of Professional Identity

Communication competencies represent a comprehensive complex of knowledge, skills and attitudes that enable a person to communicate effectively, clearly and in a cultured manner. Consequently, these competencies encompass the ability to convey information accurately, engage in active listening, demonstrate interpersonal understanding, and adapt communicative strategies to specific contexts and objectives.
Communication competencies encompass both verbal and non-verbal expression, the capacity for active listening, the demonstration of empathy, and the ability to interact assertively and ethically, whilst maintaining respect for the individual needs of the patient. The cultivation of these skills necessitates systematic education throughout a clinician's professional tenure; furthermore, such training should constitute an intrinsic component of both undergraduate medical curricula and subsequent Continuous Professional Development.
The author Rustici (2019) states that while in ordinary interactions the information exchange takes place almost seamlessly and smoothly, in a situation where strong emotions are activated, where a lot is at stake, or where conflict endangers the quality of the mutual relationship, it is very important to pay special attention to the way of communication and its interpretation by the people with whom a person communicates (Rustici, 2019).
Veselá (2021) complements Rustici when she mentions that in both, team communication and communication with the patient, the following rule applies: what is meant, may not be said, what is said, may not be heard, what is heard, may not be understood, what is understood, may not be done, and what is done, may not be done correctly (Veselá, 2021).

1.3 Empathy as a Key Value of the Medical Profession

Empathy is the ability to empathize with other people's experience, to understand their feelings, thoughts, and situation – and to respond to them with respect, understanding, and compassion. It does not just mean "feeling the same," but to perceive the other person from their perspective, while maintaining distance and acting with respect for their needs.

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According to Goleman (2017), the meaning of empathy is to understand the interests and emotions of other people. It is mainly the ability to see the situation from their point of view. It is respect for differences in the feelings and opinions of other people (Goleman, 2017).
Doctor´s empathy is a specific form of empathy that refers to the ability of a healthcare professional to perceive, understand, and respond adequately to the emotional and psychological state of the patient, while maintaining professional distance and objectivity.
As Baštecká et al. (2009) state, empathy is the ability to sensitively perceive and understand the patient's inner world, including his/her subjective feelings and meanings. It is accompanied by emotional involvement and sincere interest in the other person, while in communication, the healthcare professional continuously and tactfully demonstrates his/her understanding (Baštecká et al., 2009, p.326).

2 Pedagogical Strategies and Recommendations for Effective Learning

In contemporary medical education, emphasis is increasingly placed not only upon the acquisition of clinical knowledge but, crucially, on the development of the personal and social competencies of both undergraduate medical students and postgraduate practitioners. Modern clinical practice urgently necessitates experts who possess the capacity for critical reflection, effective communication, and an empathetic response to the multifaceted needs of the patient.
Duchovičová et al. (2018) state that the development of evaluative thinking is achieved by gradual and systematic practice and development of partial evaluative skills. These skills include distinguishing between fact and opinion, identifying key and relevant information in the curriculum, formulating conclusions and generalizations, asking meaningful questions, structuring content according to the goals and different taxonomic levels, as well as recognizing relationships between cause and effect (Duchovičová, et al., 2018).

2.1 Active and Experiential Learning

Active and experiential learning within medical education represents a pedagogical approach wherein knowledge acquisition occurs through direct participation, practical experience, and critical reflection, rather than through the passive reception of information via traditional lectures. The objective is to support cognitive, practical and affective competencies, thereby equipping future doctors with the necessary skills to navigate complex, real-world clinical scenarios.
In the contemporary era, it is essential to prioritise medical education in the field of communication competencies as a fundamental component of strategic quality management

within healthcare. This should be delivered through the framework of Continuous Professional Development (CPD) to ensure the sustained enhancement of clinical standards. The opportunities in modern medical education are innovative approaches, active and experiential learning, which mainly consist of solving real or model problems from clinical practice. It is appropriate to include activating methods of education, such as brainstorming, problem-based learning, role-playing and the like into the framework of education and professional training.

Frk (2005) states that the final goal of the educational program should be to transfer the content of the curriculum to working performance. It is therefore necessary to ensure the consistency between the content of the curriculum and the content of the real work situations and the presence of practical situations in education. It is also necessary to verify whether the general principles have been correctly understood and to ensure a supportive environment for education (Frk, 2005, pp.96–99).

2.2 Reflection on Core Competencies and Feedback

Reflection upon core competencies, combined with structured feedback, enables clinicians to consciously evaluate their knowledge, skills, and attitudes, thereby identifying specific areas for development. This process facilitates the advancement of clinical, communicative, and empathetic proficiencies, enhances clinical decision-making, and underpins a commitment to lifelong professional growth.

As Blaško (2013) states, there is no universally valid definition of competence. Various experts from the fields of pedagogy, sociology, philosophy, psychology and economics have tried to define this concept. They agreed that key competences must be necessary and beneficial for the individual and the entire society.

If a person is to be competent in a certain area of life, it is necessary for him/her to achieve a certain level of education. (S)he must both, master these abilities and skills and at the same time, be able to effectively apply them in practice. Therefore, as Belz et al. (2011) state, competencies for a given activity can be understood as an individual's ability to handle a certain situation, an assigned task or a profession (Belz et al., 2011).

2.3 Support for Lifelong Learning and Management of Professional Identity

An integral part of a doctor's profession are communication and interpersonal skills that allow building trust, effectively informing the patient, and at the same time, managing challenging ethical or conflict situations. Teamwork, interdisciplinary cooperation, and respect for the diverse values and needs of patients are also essential.

Professional identity management is a process by which individuals consciously form, develop, and maintain their professional identity – that is, a set of values, attitudes, knowledge, skills, and behaviours that characterize their professional role and the way they present themselves in their professional community. In the medical environment, communication is the basis for quality management of doctors' attitudes toward patients.

According to Kristová (2002), communication is a universal phenomenon of human society and a direct regulator of the level of interpersonal relationships. At the same time, it can be considered a basic condition for the existence of every social system. No social group can exist without communication; it contributes to ensuring social contacts and interpersonal relationships and is also a means of social integration of an individual into a group (Kristová, 2002).

Communication has an irreplaceable function in the doctors´ work and in the healthcare profession in general. Overall, medical professions require a complex set of professional and personal qualities and constant readiness for further personal and professional development.

2.4 Recommendations for both Pedagogical and Medical Practice

Pedagogical strategies for the development of critical thinking, communication competencies and empathy in medical education should mainly connect theory with practice. It is also very important to support active, reflective and experiential learning. Methods that create simulations of clinical situations, problem-oriented learning, discussions and reflective diaries that develop the ability of students and trainees of educational programs to analyse, argue and make decisions are considered very effective methods. An important part of doctors´ education is systematic and objective feedback with an emphasis mainly on the development of communication skills through training and simulated interviews. Training in empathy through reflection on patient experiences and ethical discussions is also necessary. In medical practice, these principles are applied through several kinds of educational activities, mainly mentoring, supervision, interprofessional cooperation and lifelong learning.

Reflective practice and constructive feedback help doctors improve their professional and personal competencies and lead to ethical and empathetic care focused on the satisfaction of both, patients and healthcare professionals.

3 Conclusion

In Slovakia, the development of critical thinking is embedded within the National Educational Programme as a core component of cognitive competencies. This priority is integrated across many educational domains and subjects. In alignment with the strategic objectives and tasks that foster critical thinking, diverse pedagogical methodologies, formats, and instructional tools are deployed. These are specifically designed to encourage the active engagement of students and to cultivate their capacity for independent reasoning.

Critical thinking is defined as the capacity to independently analyse, evaluate, and creatively synthesise information to facilitate rational and ethically grounded decision-making. Within an educational context, it fosters a profound understanding of the subject matter, promotes autonomy, and enhances problem-solving capabilities. In a pedagogical sense, it serves as a vital instrument for reflection and the iterative refinement of the instructional process. Its development is primarily facilitated through discourse, problem-based learning, collaborative projects, and the analysis of case studies. Ultimately, the cultivation of critical thinking engenders personal autonomy, professional responsibility, and a commitment to lifelong learning.

Critical thinking and communication are interconnected, because clear and logical expression requires the ability to think, analyse and argue. Through communication, critical thinking is expressed also externally – it allows a person to effectively defend opinions, to respond to arguments and to be involved into a meaningful dialogue.

Communication between a doctor and a patient plays a key role in providing quality health care. It is the basis for building trust and an effective therapeutic relationship, which affects the patient's willingness to cooperate, share important information and adhere to recommended treatment. Clear, empathetic and professional communication contributes to more accurate diagnosis, reduces patient stress and anxiety and increases his/her satisfaction with health care. At the same time, it acts as a preventive means against misunderstandings, conflicts and complaints. Therefore, in the context of modern healthcare, communication is not considered a supplement, but an integral part of clinical practice and doctor´s professional competencies.

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AI and Its Use in Educating Students in Occupational Health and Safety (OHS) within the Dual VET System in Slovakia

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Abstract

Occupational health and safety (OHS) represents a key component of vocational education and training, particularly in the dual VET system, which links theoretical instruction in school with practical training at the employer's workplace. This paper analyses the implementation of OHS principles in Slovak vocational schools, focusing on the legislative framework, stakeholders' responsibilities, and the integration of OHS content into teaching. OHS education plays an essential role in preventing accidents, fostering responsible work behaviour, and building a culture of safety among future professionals.

The paper also examines emerging opportunities for using artificial intelligence (AI) to modernise and enhance OHS training. AI-supported tools – such as adaptive learning systems, automated knowledge assessment, predictive analytics for risk identification, and VR/AR simulations – enable personalised learning, safe practice of high-risk scenarios, and more efficient fulfilment of safety requirements for both schools and employers. These technologies can significantly improve students' understanding of OHS principles and increase the effectiveness of dual VET.

Although a standalone OHS subject is not commonly included in Slovak vocational school curricula, OHS content is typically incorporated into vocational subjects or delivered through thematic units and mandatory training. Effective implementation of OHS principles requires

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close cooperation between the school, employer, and student, contributing to safer learning conditions and better preparation of graduates for the labour market.

Keywords: Occupational Health and Safety (OHS), Artificial Intelligence, Dual VET, Vocational Schools, Legislation

1 Introduction

The dual VET system is based on linking theoretical instruction at school with practical training directly at the employer's workplace (Madzinová, 2018; Krásna, Barnová, & Gabriš, 2019), where students perform various work-related tasks that may involve risks of injury or threats to their health. This results in high demands on ensuring safe working conditions for students. Occupational Health and Safety (OHS) is an integral part of vocational education and training – not only in terms of creating a safe environment for students during theoretical instruction and practical training, but also in developing work habits that students will apply in future employment (Lajčin et al., 2020). Moreover, implementing OHS principles in dual VET is not merely a legal obligation, but above all a crucial tool for fostering students' responsible attitudes toward work, preventing injuries, and building work habits aligned with the principles of a safety culture, mainly because students are being trained for professions that inherently involve certain risks.
When implementing knowledge associated with the field of occupational health and safety, several requirements emerge. First of all, a practical application of OHS principles within the dual VET system requires close cooperation among all involved parties – the school, employers, and students. A key role is played by coordination between theoretical training, which focuses on recognising risks, understanding safety rules and legal regulations (delivered within specific vocational subjects or taught as a separate subject), and practical training, where students apply these principles in real work environments. High-quality OHS education contributes not only to student health and safety but also to enhancing the quality of vocational training, improving graduates' readiness for labour market requirements, and fostering responsible behaviour among all stakeholders.

2 Legislation Related to Occupational Health and Safety

The legislative framework governing OHS in Slovakia comprises several legal acts that define the responsibilities of employers, schools, students, and other stakeholders. These regulations aim to ensure that vocational school students – whether participating in the dual VET system or not – are trained in safe, health-preserving environments and are not at risk of injury or damage to their health. The most significant regulations include:

1. Act No. 124/2006 Coll. on occupational health and safety and on amendments and supplements to certain acts, which is the fundamental OHS regulation. It outlines employer and employee duties, OHS training requirements, risk prevention principles, and safety responsibilities during practical training.
2. Act No. 355/2007 Coll. on protection and development of public health and on the change and supplement to some acts as amended by subsequent provisions specifies obligations related to workplace health protection, including workplace environment evaluation and provision of protective equipment.
3. Act No. 311/2001 Labour Code regulates safe working conditions for employees and students in practical training, including special provisions for young workers.
4. Act No. 61/2015 on vocational education and training and on the change and supplement to some acts, is crucial for all VET schools, as it requires OHS and fire safety (FS) training before students begin practical training as well as ensuring compliance throughout the training period.
5. Act No. 314/2001 Coll. on fire protection as amended, requiring schools to maintain fire safety documentation, provide training, and conduct evacuation drills.
6. Decree No. 147/2013 Coll. on ensuring safety and health protection during construction work and related tasks, and on qualifications for certain job activities, which specifies safety requirements for construction-related activities – these are also relevant for dual VET training, school workshops, and specialised classrooms.
7. Decree No. 223/2022 Coll. on primary schools, which defines the principal's responsibilities for student safety and accident reporting.
8. Decree No. 224/2022 Coll. on secondary schools and its amendments, which references OHS only indirectly in § 5.
9. Government regulation no. 395/2006 Coll. on minimum requirements for the provision and use of personal protective equipment at work, specifying minimum workplace safety standards, including lighting, temperature, noise, ergonomics, and protective equipment – with a special focus on young workers and students.

3 OHS in the Dual VET System in Slovakia

Despite OHS being a mandated component of vocational training, there is no dedicated compulsory subject titled "OHS" across all vocational fields. Nonetheless, schools may include it within their curriculum using discretionary hours. In practice, OHS is frequently integrated into vocational subjects, structured as a thematic module, or delivered in blocks. In some study programmes (e.g., technical, electrical, construction, chemical, medical), it is a separate thematic unit with its own assessment.

A significant advancement in this area is the introduction of the study programme 3965 M Occupational Health and Safety, included among specialised technical programmes (Decree No. 287/2022 Coll. on the system of fields of education for secondary schools and on the material scope of application to the fields of education), which prepares students for OHS positions in industrial settings (Vančo & Zemánková, 2025).

Theoretical OHS instruction focuses on legal and organisational foundations, risk recognition, employee rights and duties, labour relations, legislation, injury prevention, ergonomics, and environmental protection. Practical training includes safe work procedures, use of protective equipment, machine and tool handling, fire safety, and prevention measures.

For dual VET students, OHS training is tailored to the employer's workplace conditions, including communication with responsible persons and OHS documentation. Employers must provide initial and recurring OHS and FS training, maintain training records, and ensure professional supervision of student activities.

4 Potentials of AI in OHS within the Dual VET System

In recent years, AI-based technologies have increasingly influenced education (Adel, 2024). Artificial intelligence, now a standard part of modern schooling, can also be meaningfully applied to OHS training. It provides opportunities to modernise and streamline the educational process (Shen et al., 2024) while helping schools and employers mitigate risks associated with practical training in the dual VET system.

AI's potential lies in its ability to analyse large datasets, predict hazardous situations (Fiegler-Rudol et al., 2025), personalise learning, and support prevention. Its implementation can significantly enhance student safety by making OHS content more accessible and engaging, while also supporting institutions in fulfilling legal obligations and strengthening safety culture.

AI-based solutions can support OHS in several areas:

- AI can monitor all students' training processes, including compliance with safety procedures and tracking injuries or training records, as well as student behaviour (Çela et al., 2025).
- Educational tools, such as adaptive learning platforms (Prasetya et al., 2025), VR/AR simulations of hazardous scenarios, and intelligent testing systems that provide instant feedback can increase the quality of training and make it more appealing to students.
- Workplace safety technologies, including IoT sensors that monitor environmental factors (temperature, noise, pollutants), detect dangerous patterns in student behaviour, and provide early warnings, can increase safety as well.

5 Conclusion

Occupational Health and Safety is an essential component of vocational education and training in vocational schools (Gabrhelová et al., 2020). In dual VET, where practical training takes place directly at employers' workplaces, compliance with OHS standards is even more critical. Its implementation is indispensable for preventing injuries, protecting student health, and developing safe work habits among future employees.

Ensuring effective OHS requires close collaboration among schools, employers, and students to connect theoretical learning with workplace reality. Legislative requirements must be accompanied by systematic integration of OHS into the educational process, continuous monitoring, and regular updates of training content. Introducing a dedicated OHS subject could further improve safety and the quality of vocational preparation.

In this context, emerging technologies – particularly artificial intelligence – offer additional opportunities to strengthen OHS education. AI-supported tools, including adaptive learning systems, automated assessment mechanisms, predictive analytics for identifying risk factors, and immersive VR/AR simulations, can personalise instruction, enable safe practice of high-risk scenarios, and support schools and employers in efficiently meeting safety requirements. These innovations can enhance students' understanding of OHS principles and improve the effectiveness of dual VET.

Ultimately, high-quality OHS training – especially within dual education – is an investment in protecting health, improving workplace culture, and preparing graduates for the demands of the labour market.

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All learning paths lead to knowledge

Curiosity-Driven Change: Evaluating AI Tools and Teacher Preparedness in Slovak VET

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Abstract

This article explores the readiness of Slovak vocational education and training (VET) teachers to integrate artificial intelligence (AI) into their practice, as part of the Erasmus+ project VETAssIst – Artificial Intelligence as VET Teacher Assistant (No. 2024-1-HU01-KA220-VET000253387). Building on earlier tool evaluations, the study analyses national findings from interviews and questionnaires that reveal stark contrasts between AI pioneers, teachers who actively experiment with tools like ChatGPT, Canva, or Copilot, and non-pioneers, who remain cautious due to lack of training, infrastructure, or institutional support. A key outcome of the project is the evaluation of 37 AI tools across categories such as chatbots, lesson design, assessment, collaboration, and media creation. Tools like Padlet, Fobizz, Miro, and Microsoft Copilot stood out for their pedagogical relevance and ease of use. While many tools offer free access, concerns persist about data privacy, limited non-English functionality, and reliance on premium features. In response to these gaps, the project has developed a modular training programme to be piloted in autumn 2025, aimed at equipping VET teachers with AI literacy, ethical awareness, and practical skills. The article argues that a structured, context-sensitive approach, combining professional development with critical reflection, is essential for responsible AI adoption in Slovak VET schools.

Keywords: Artificial Intelligence, Vocational Education and Training (VET), AI Literacy, Teacher Readiness, Educational Technology

1 Introduction

Artificial intelligence (AI) is increasingly influencing teaching and learning worldwide, offering new possibilities for personalisation, material creation and administrative efficiency (Tan, Cheng, & Ling, 2025; Moroianu, Iacob, & Constantin, 2023). Research shows that teachers'

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confidence, digital skills and institutional support strongly determine whether AI becomes a meaningful part of everyday practice (Granström & Oppi, 2025). These issues are particularly relevant in vocational education and training (VET), where teachers must respond to technological change while supporting diverse learners and industry-linked curricula (Cedefop, 2022; Jeon, 2025).

In Slovakia, discussions around AI in education are growing, yet empirical insights from the VET sector remain limited. Recent work by Pondelíková (2025) shows that AI tools can enrich university teaching and enhance students' engagement, but similar evidence from VET is still lacking. The Erasmus+ project *Artificial Intelligence as VET Teacher Assistant* (VETAssIst) aims to address this gap by exploring how AI can support VET teachers' work and by developing training resources that reflect their needs and levels of readiness.

This study therefore examines how Slovak VET teachers perceive AI, what motivates or discourages them from using it, and how the experiences of active AI users ("pioneers") differ from those of teachers with limited AI engagement. By addressing these questions, the paper contributes to understanding the conditions necessary for responsible and effective AI integration in Slovak VET.

2 Theoretical background

2.1 AI in VET and Teacher Readiness

Artificial intelligence (AI) has become a significant driver of change in teaching and teacher professional development. Recent systematic reviews show that AI is mainly used to personalise learning, automate routine tasks (e.g., grading, feedback), and generate analytics that can guide instructional decisions (Tan & Cheng, 2025). In vocational education and training (VET), these functions are closely tied to labour-market demands: AI is used to simulate authentic workplace scenarios, monitor practical skills, and support practice-oriented learning pathways (Ghosh & Ravichandran, 2024; Jeon, 2025).

A growing body of VET literature emphasises that the impact of AI depends strongly on teacher agency. Studies on emerging technologies in VET argue that AI, along with VR, robotics and other tools, can enhance engagement and skills development only when teachers have the competences and time to redesign tasks and assessments, and when infrastructure is reliable (Ghosh & Ravichandran, 2024; Jeon, 2025). Research on AI-supported teacher teams in Chinese vocational schools similarly highlights the need for institutional strategies, intelligent training platforms and supportive evaluation systems if AI is to contribute to "high-quality development" rather than remain a series of isolated pilots (Yao, 2025).

Across education systems, teacher readiness has emerged as a key predictor of whether AI is actually taken up in classrooms. A large-scale Estonian survey (N = 3,848) found that teachers who already use AI tools report significantly higher readiness and perceived usefulness, whereas non-users most often cite lack of knowledge, guidance and infrastructure as reasons for not adopting AI (Granström & Oppi, 2025). Complementary work using a compartmental mathematical model conceptualises teachers as moving between states such as "unaware", "aware", "adopter" and "discontinued user". The model suggests that adoption can be fragile: without sustained support, some teachers revert from adopters to non-users, which underlines the importance of long-term resource provision and professional development rather than one-time initiatives (Ayanwale et al., 2025).

These findings resonate with qualitative and review studies showing that teachers often fall into two broad groups: early adopters or "pioneers", who experiment with AI, and non-pioneers, who remain hesitant due to limited training, ethical concerns or perceived misalignment with curriculum demands (Tan & Cheng, 2025; Jeon, 2025). In VET, this divide may be even sharper, because teachers must track both educational and technological developments in specific sectors (e.g., manufacturing, logistics, health care). The Slovak context discussed in this article aligns with these international trends and allows a more fine-grained analysis of how pioneers and non-pioneers position themselves toward AI tools in VET practice.

2.2 AI Literacy, Competency Frameworks and Professional Development for VET Teachers

As AI becomes embedded in education systems, there has been a shift from viewing AI use as an individual teacher choice towards conceptualising AI literacy and competencies as part of professional standards. AI literacy is generally understood as a combination of knowledge, skills and attitudes that enable individuals to use AI tools critically, understand how they work, recognise their limitations and societal impact, and make responsible decisions about when and how to rely on them (OECD, 2025).

At policy level, the UNESCO AI Competency Framework for Teachers (AI-CFT) defines 15 competencies across five dimensions: human-centred mindset, ethics of AI, AI foundations and applications, AI pedagogy, and AI for professional learning (UNESCO, 2024). The framework stresses that AI should strengthen rather than replace teachers, and that educators need not only technical skills but also ethical awareness and reflective capacity to work within a "teacher - AI - student" triangle. Building on similar principles, the AILit Framework developed by the OECD and European Commission proposes AI literacy domains such as understanding, using, creating with and evaluating AI, again emphasising critical thinking and responsible use (OECD, 2025).

From a more bottom-up perspective, Filo, Rabin and Mor (2024) co-created an AI competency framework for teachers and students with practising educators. Their design-based study identifies competencies such as explaining AI mechanisms at a basic level, integrating AI into learning activities, exercising agency in co-creating value with AI, and addressing ethical issues explicitly in the classroom (Filo et al., 2024). This work underscores that AI competences must be contextualised in local school cultures, rather than imported as purely technical standards.

For VET, these generic frameworks meet the broader digitalisation strategies. European policy analyses argue that VET teachers need "dual" competences: the ability to integrate digital and AI tools into practice-oriented pedagogy and work-based learning, and the capacity to keep up with AI-driven changes in their occupational fields (Jeon, 2025; Cedefop, 2025). Reports stress that large-scale, sustained professional development (PD) and upgraded infrastructure are necessary to avoid widening gaps between well-resourced and under-resourced VET institutions.

Evidence from AI-related PD research supports this view. Tan and Cheng’s (2025) systematic review shows that brief, tool-centred workshops rarely change practice; more effective are modular programmes that combine technical training with pedagogical design and ethical reflection (Tan & Cheng, 2025). Studies of VET teacher teams similarly recommend collaborative PD models that build shared resources, intelligent training platforms and supportive evaluation mechanisms (Yao, 2025). Instruments such as readiness scales and AI-related self-efficacy measures are now being used to track how PD influences teachers’ willingness and capacity to work with AI over time (Granström & Oppi, 2025; Ayanwale et al., 2025).

Against this backdrop, the modular training programme developed in the VETAssIst project can be positioned as a context-sensitive attempt to translate international AI competency frameworks into the specific realities of Slovak VET: balancing technical tool use (e.g., chatbots, lesson-design tools, media creation) with pedagogical redesign, ethical awareness and differentiated support for AI pioneers and non-pioneers.

3 Project Context and Summary of AI Tool Evaluation

The Erasmus+ project *Artificial Intelligence as VET Teacher Assistant* (VETAssIst; Project No. 2024-1-HU01-KA220-VET-000253387) was launched to support vocational education and training (VET) teachers in adapting to the rapid spread of artificial intelligence (AI) in education. The project aims to strengthen teachers’ digital and pedagogical capacities by promoting AI as a supportive assistant in lesson planning, content creation, assessment, classroom interaction, and administration. The broader intention is not to replace educators, but to provide tools that reduce routine workload, encourage innovative practices, and support more inclusive and personalised forms of learning.

To support these aims, the project partners from Hungary, Serbia, Germany and Slovakia conducted a structured evaluation of **37 AI tools** to determine which applications are most suitable for VET contexts. The evaluation was carried out collaboratively across all partner institutions and focused on tools that were freely available or low-cost, user-friendly, and relevant for teachers across different vocational fields. The tools were grouped into several functional categories, including:

- *Chatbots:* ChatGPT, Microsoft Copilot, Perplexity, Pi, Claude, DeepSeek, Gemini, Grok AI

- *Collaboration and brainstorming tools:* Miro, Padlet, Jambot (Figma), Canva for Education
- *Lesson and content generators:* Fobizz, SchoolAI, MagicSchool, Eduaide, Curipod, TeachAid, Diffit, Twee, Roshi
- *Assessment creators:* Quizizz, Conker AI, Formative AI
- *Design and media tools:* Canva, Freepik, Adobe Firefly, Microsoft Designer, Gamma, AutoDraw

Several key insights emerged from the partner evaluation. **Chatbots** were identified as the most versatile category, offering support for designing lesson plans, creating handouts, drafting quizzes, summarising documents, and generating administrative communication. Collaboration platforms such as **Miro** and **Padlet** were highlighted for encouraging interactive brainstorming and group work - an asset for practical, project-based VET learning. Lesson-design platforms like **Fobizz** were appreciated for their comprehensive free access, while others (e.g., Eduaide, TeachAid, Twee) restricted generation volume or advanced features in their free versions. Assessment tools (such as Quizizz and Conker AI) enabled quick creation of quizzes and formative tasks, though usage caps were common. Media-creation tools like **Canva for Education** stood out for ease of use and strong support materials.
At the same time, project partners identified several barriers to sustainable use. Many platforms offered **limited free functionality**, often requiring mandatory registration or paid upgrades. **Language support** varied significantly: while tools like ChatGPT and DeepSeek handled non-English input effectively, other platforms produced inconsistent translations - a challenge for Slovak VET environments. Concerns were also raised regarding **data privacy**, **integration with existing learning management systems**, and the long-term reliability of free plans. Tools that offered clear tutorials and help resources, such as Canva and Formative AI, were perceived as easier to adopt, particularly for teachers with lower digital confidence.

The evaluation resulted in a curated, category-based overview of AI tools with strong pedagogical potential for VET. These findings informed the selection of tools to be showcased in upcoming project outputs, including a multilingual e-book and a modular online training programme. Importantly, the evaluation also highlighted areas where teachers may need additional support, such as ethical and privacy considerations, language-related challenges, and strategies for critically interpreting AI-generated content.
With this foundation in place, the project proceeded to examine how VET teachers themselves perceive AI. The next chapter therefore presents the methodological approach used to analyse interview data collected from Slovak VET teachers, both AI pioneers and non-pioneers, regarding their readiness, attitudes, and support needs in adopting AI tools.

4 Methodology

4.1 Research design

This study employed a **qualitative research design** using semi-structured interviews to explore how Slovak vocational education and training (VET) teachers perceive and use artificial intelligence (AI) in their pedagogical practice. The qualitative approach was chosen to gain an in-depth understanding of teachers' motivations, experiences, challenges, and expectations related to AI integration, and to allow meaningful comparison between two teacher groups: **AI pioneers** and **non-pioneers.** Semi-structured interviews enabled participants to express their views freely while ensuring consistency across interviews through a shared set of guiding questions.

The interview protocol was jointly designed within the VETAssIst project and focused on four thematic areas: (1) AI adoption and motivation, (2) practical use of AI in teaching, (3) institutional conditions and barriers, and (4) future perspectives on AI in VET.

4.2 Research Questions

This study was guided by the following research questions, which reflect the aim to understand how Slovak VET teachers perceive and integrate artificial intelligence in their professional practice and how these experiences differ between teacher groups:

RQ1: How do Slovak VET teachers perceive the opportunities and challenges associated with the use of artificial intelligence in their teaching practice?

RQ2: What factors motivate or hinder VET teachers in adopting AI tools for lesson preparation, classroom activities, and administrative tasks?

RQ3: How do the experiences, attitudes, and support needs of AI pioneers differ from those of non-pioneers in Slovak vocational education?

4.3 Participants – Research Sample

The research sample consisted of ten vocational education and training (VET) teachers from Slovak secondary schools. Participants represented a range of school types, including vocational secondary schools, industrial schools, specialised technical schools, and combined secondary schools. For the purposes of the study, teachers were categorised into two groups based on their self-reported experience and engagement with artificial intelligence tools: AI pioneers and non-pioneers.

AI Pioneers

The pioneer group comprised five teachers, predominantly women (4 women, 1 man), aged between 31 and 60 years. Their teaching experience ranged from 6 to 30 years. These teachers worked at schools specialising in electrical engineering, industrial informatics, information and digital technologies, agriculture, and services and hospitality. Subjects taught included:

- Programming, applied informatics, networking technologies, and technical graphics
- English language
- Slovak language and literature, biology
- Economic and IT-related subjects (e.g., project management, innovation and entrepreneurship)
- Digital communication and practical vocational training

This group represented a diverse set of disciplinary backgrounds, though with a notable concentration in technical and IT-oriented fields.

Non-Pioneers

The non-pioneer group also consisted of five teachers, all over the age of 41, with a predominance in the 51–60+ age range. All were women except one male participant. Their teaching experience varied from 4 to 33 years. These teachers were employed at schools specialising in electro energetics and industrial informatics, construction and geodesy, agriculture, and hospitality and food industry. Subjects taught included:

- Operating systems, server and network technologies
- Mathematics
- Economics, accounting, English language, physical education
- Chemistry and food-processing technologies
- English language

Compared to pioneers, the non-pioneer group also represented a wide range of vocational domains, with some overlap in technical specialisations but generally showing a stronger presence of traditional academic and vocational subjects.

4.4 Data Collection

Given the exploratory nature of the study, **semi-structured qualitative interviews** were selected as the primary data collection method. According to Creswell (2013), qualitative interviews are particularly suitable when the goal is to understand participants' experiences, perceptions, and meaning-making processes within their real-life contexts. This approach aligns with the study's aim to examine how Slovak VET teachers interpret the role of AI in their work, what motivates or constrains their adoption of AI tools, and how these experiences differ between AI pioneers and non-pioneers.

The interview protocol was jointly developed within the VETAssIst project and structured into four thematic sections:

- sociodemographic background;

– AI adoption, motivation, and challenges;
– practical use of AI in teaching and administration; and
– future perspectives on AI integration.

Interviews were conducted individually, either online or in person, depending on participant availability. Each interview lasted approximately 30–45 minutes. The semi-structured format ensured comparability across participants while allowing flexibility for follow-up questions and deeper exploration of relevant issues. All participants provided informed consent prior to the interview and were assured confidentiality and voluntary participation.

4.5 Ethical Considerations

The study adhered to the ethical guidelines of the VETAssIst project and the University of Ss. Cyril and Methodius in Trnava. No personal data were collected, and participants were assured of anonymity and confidentiality. Interviews were conducted only after obtaining explicit consent, as documented in the interview introduction. All data were stored securely and used exclusively for research purposes.

4.6 Data Analysis

All ten interviews, five with AI pioneers and five with non-pioneers, were analysed using reflexive thematic analysis (Braun & Clarke, 2006). The transcripts from both groups were reviewed repeatedly to ensure familiarisation, including the pioneer interviews from Prešov, Žilina, Nitra and Košice and the non-pioneer interviews from Nitra, Prešov, Trenčín and Košice. Initial codes were generated inductively and focused on recurring ideas such as teachers' motivations, perceived benefits of AI, barriers to adoption, ethical concerns, school-level conditions, and expectations for professional development. These codes were then grouped into broader thematic categories, which were compared across both teacher groups to identify convergences and differences. Themes were subsequently refined to ensure internal coherence and clear relevance to the research questions.
The final themes serve as the basis for presenting the findings in the next chapter, with explicit comparison between pioneers and non-pioneers.

5 Results

This section presents a thematic analysis of qualitative data gathered through semi-structured interviews conducted with Slovak vocational education and training (VET) teachers participating in the Erasmus+ VETAssIst project (Project No. 2024-1-HU01-KA220-VET-000253387). The interviews aimed to explore current practices, motivations, challenges, and contextual conditions shaping the integration of artificial intelligence (AI) in VET. The sample comprises two contrasting teacher profiles: AI pioneers, who actively experiment with AI tools, and non-pioneers, who demonstrate limited or hesitant engagement with AI.

5.1 Motivations for Engaging with AI

A clear divergence emerged between the two groups.

AI pioneers frequently described their motivation as rooted in professional curiosity, intrinsic interest in innovation, and the desire to streamline everyday tasks. Many highlighted a personal commitment to "keeping up with technology" and improving workflow efficiency. Their initial engagement with AI stemmed from informal experimentation, peer exchange, or participation in training opportunities.

In contrast, **non-pioneers** expressed a more distant interest in AI, typically influenced by media, colleagues, or general social discourse rather than active professional motivation. Their interviews reflected uncertainty, lack of confidence, and limited knowledge, which impeded further exploration despite a generally positive attitude toward technological progress.

5.2 Types of Tools and Extent of Use

The difference in AI adoption translated directly into tool usage.

Pioneers reported frequent use of generative chatbots (ChatGPT, Copilot, Perplexity), visual design tools (Canva, Adobe Firefly), and specialised educational platforms (Diffit, Curipod, Quizizz). They described using AI to create lesson plans, worksheets, exam materials, programming explanations, or project-based tasks. Some ICT teachers also used AI to support debugging or code explanation.

Non-pioneers demonstrated minimal use of AI beyond basic functionalities embedded in standard software (Microsoft 365, translation tools). When AI was used, it typically served simple tasks such as searching for information, summarising text, or generating images. Most non-pioneers emphasised that they do not feel sufficiently competent to integrate AI into teaching activities.

5.3 Pedagogical Applications and Classroom Practices

Among pioneers, AI was integrated into multiple dimensions of teaching practice. Teachers reported using AI for:

– generating differentiated materials for students with varying abilities,
– creating visual resources (diagrams, posters, illustrated explanations),
– developing quizzes and formative assessments,
– supporting project-based learning,
– preparing templates, rubrics, and administrative documents.

Some pioneers also experimented with student-facing activities, such as guided prompting, creative tasks, or demonstrations of AI-generated solutions, always accompanied by discussions of verification and reliability.
Among non-pioneers, pedagogical use remained sporadic. Teachers described limited experimentation and stated that they would require greater confidence and training before involving students in AI-supported tasks. Their classroom references to AI were mostly conceptual rather than procedural.

5.4 Perceived Outcomes and Added Value

Pioneers consistently emphasised the **time-saving** dimension of AI, explaining that AI "reduces preparation workload" and "quickly produces materials that would otherwise take hours." They also highlighted improved quality of learning resources and increased creativity in lesson design. Some pioneers observed greater student motivation when AI-supported visuals or interactive tasks were incorporated.
Non-pioneers acknowledged the theoretical advantages of AI but lacked concrete experiences to evaluate its value. Their expectations centred on potential time savings or new approaches to content delivery, yet these benefits remained mostly unrealised in practice.

5.5 Barriers to AI Adoption

Barriers differed substantially between the two groups.
Pioneers reported:

- the financial limitations of premium tools,
- uneven technical infrastructure,
- varying quality of Slovak-language output,
- the need to verify AI-generated information,
- lack of systematic training in advanced AI use.

Non-pioneers, however, described more fundamental obstacles:

- insufficient training and lack of step-by-step guidance,
- uncertainty about how to begin using AI,
- fear of misusing the technology or giving students incorrect information,
- concerns about plagiarism and students' over-reliance on automation,
- inadequate digital infrastructure in some schools.

Several non-pioneers noted that rapidly evolving technologies make it "difficult to keep up," reinforcing their reluctance to adopt AI independently.

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5.6 Institutional and Environmental Factors

The organisational context played a significant role in shaping teacher engagement with AI.
Pioneers frequently worked in environments that encouraged innovation or where digital technologies were well integrated into school culture. Some had colleagues who experimented with AI, creating informal support networks.
Non-pioneers tended to come from schools where digitalisation was inconsistent or where professional development opportunities were limited. They expressed a need for clear school-level strategies, more structured training, and leadership support before they would feel comfortable integrating AI into their teaching practice.

5.7 Ethical and Pedagogical Concerns

Ethical considerations appeared in both groups but were interpreted differently.
Pioneers showed an awareness of data privacy, academic integrity, and the need for verification of outputs. They tended to address these issues proactively, encouraging students to engage critically with AI content and emphasising responsible use.
Non-pioneers expressed stronger apprehensions. They feared that AI could reduce students' critical thinking, increase dependency, and facilitate plagiarism. Many stated that they lacked the competence to guide students in ethical use and therefore avoided AI altogether.

6 Discussion

The findings show a clear divide between Slovak VET teachers who actively use AI and those who do not. AI pioneers approached the technology with curiosity, confidence, and a desire to improve efficiency, which aligns with international research highlighting self-efficacy and openness to innovation as key drivers of early adoption. They used AI regularly for lesson planning, material creation, and administrative tasks, and reported benefits such as time savings and increased creativity. Non-pioneers, however, expressed interest in AI only at a general level and lacked the training or confidence needed for practical implementation. Their concerns, particularly about plagiarism, misinformation, and student dependency, reflect global debates on the risks of AI in education. The interviews also showed that school context plays an important role: pioneers often worked in digitally supportive environments, while non-pioneers described insufficient infrastructure and unclear institutional strategies. Both groups expressed a need for professional development, but at different levels of complexity. Overall, the results suggest that although Slovak VET teachers recognise the potential of AI, its integration remains uneven and depends on the interplay of teacher readiness, school conditions, and access to structured, practical training.

7 Recommendations

The findings indicate the need for differentiated professional development that recognises the varying levels of teacher readiness. Non-pioneers would benefit from introductory, practice-oriented training that allows them to experiment with AI tools in a guided and supportive environment, while pioneers require more advanced and subject-specific opportunities to deepen their expertise. Strengthening institutional support is equally important; schools should develop clear strategies for the pedagogical and ethical use of AI and create conditions that encourage experimentation and collaboration. Improving digital infrastructure would further help address disparities between schools and ensure that teachers can access and use AI tools effectively. Finally, both teachers and students should be supported in developing responsible and critical approaches to AI, with an emphasis on verifying information, understanding limitations, and engaging with AI outputs thoughtfully and ethically.

8 Limitations

This study is based on a small sample of ten Slovak VET teachers, which limits the generalisability of the findings. The data reflect self-reported experiences that may not capture the full complexity of classroom practice. Additionally, the rapidly evolving nature of AI means that teachers' perceptions and available tools may change quickly. Future research should include larger samples, quantitative components, and longitudinal perspectives to better understand how AI integration develops over time.

9 Conclusion

This study set out to explore three core questions: how Slovak VET teachers perceive the opportunities and challenges of using artificial intelligence in their teaching; which factors motivate or hinder the adoption of AI tools; and how the experiences of AI pioneers differ from those of non-pioneers. The findings show that while teachers generally recognise the potential benefits of AI, their readiness to use it varies considerably. Pioneers, driven by curiosity, digital confidence and supportive school environments, integrate AI into lesson planning, content creation and everyday tasks, reporting clear advantages such as time savings and improved material quality. Non-pioneers, on the other hand, face fundamental barriers including limited training, low confidence and concerns about ethical and pedagogical risks, which prevent them from moving beyond initial awareness. These differences confirm that successful AI integration in Slovak VET depends not only on individual motivation but also on access to appropriate training and supportive institutional conditions. Strengthening these areas will be essential for ensuring that AI becomes a meaningful and responsibly used component of vocational education.

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Factors Influencing Pre-Service English Language Teachers' Presentation Skills

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Abstract

Being able to express oneself verbally has been a sign of success since ancient Greece. However, expressing oneself accurately, speaking engagingly, and captivating an audience are skills that require continuous development. While some individuals possess an innate "orator", most find their speech influenced by various factors that impact their overall presentation skills. This research aims to ascertain which factors most significantly affect presentation skills in the university preparation of pre-service English language teachers. Although this topic has been studied before, there is a scarcity of data specific to Generation Z and their difficulties in proper self-presentation in a foreign language, particularly within pedagogical research. Besides observation and individual feedback, instruments like the Personal Report of Communication Apprehension and State Trait Anxiety Inventory provided a clearer understanding of students' overall condition.

Keywords: Generation Z, EFL, Presentation Skills, Factors

1 Introduction

Presentation skills, professional speaking, and public speaking are interconnected concepts focused on the ability to communicate effectively with an audience. Although each term may be used in slightly different contexts, they all emphasise the importance of delivering clear, engaging, and purposeful messages. Whether someone is presenting information in a workplace meeting, speaking as an expert in a professional setting, or addressing a general audience from a stage, the fundamental skills involved remain essentially the same.

In recent years, professional speaking has emerged as a popular career path. Like any profession, it entails a specific job description and necessitates extensive study, practice, and preparation, particularly in the field of education.

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In this paper, we will explore the role of professional speaking, its fundamental principles, and the factors that most significantly influence the outcome of a presentation. With a particular focus on the teaching profession, a small-scale research study has been conducted involving a sample of pre-service English language teachers in their first year at the tertiary level of education.
This research aims to identify which factors have the greatest impact on presentation skills during the university preparation of pre-service English language teachers. What are the most common factors that influence presentation effectiveness?

2 Professional Speaking

There are various types of professional speaking. Joanna Penn (2019) primarily explains them from a business perspective and categorises them as follows:

- Keynote or inspirational speaking
- Content speaking
- Workshop presentation and facilitation
- Master of Ceremonies (MC) or event Chair
- Chair of panel or panellist
- Reading or performing your own work

The objective of these events is to entertain, inspire, educate, or coordinate a range of occasions, whether conferences, special events, or everyday gatherings. Their duration can range from just a few minutes to full-day sessions. Additionally, the interaction between the speaker and the audience varies. While inspirational speakers, MCs, and readers typically dominate the speaking time, workshops, conference facilitation, and academic lectures often involve a more dynamic interaction, distributing the speaking time between the presenter and the audience or participants to enhance engagement with the content (Penn, 2019).
Professional speaking, often called public speaking, has one essential element in common: an audience. Regardless of the number of listeners or the level of interaction between the speaker and the audience, this element is crucial in the preparation for any speech. The term "professional" in professional speaking implies that effective speeches require thorough preparation and practice to be beneficial and successful.

The following subsections offer a brief overview of the speech preparation and delivery process to identify factors that may influence public speaking. This is important because public speaking is often cited as one of the leading causes of anxiety and one of people's greatest fears (Dwyer & Davidson, 2012).

2.1 Preparing for Speech

The key principles of preparation include understanding the audience, topic, purposes and central idea, finding materials, organising the outline, creating speaking notes, and practising (Gregory, 2018).

The crucial part of the preparation for presentations or speeches is to know the topic, audience, and objectives. In higher education, students encounter different types of presentations, where topics may be chosen by the student or assigned by the university instructor. From there, we consider the audience, typically consisting of fellow classmates and teachers, and thoroughly think about the objective of the presentation – whether it is to educate and inform, or to entertain and foster better relationships.

When the purpose of the presentation is to inform and educate, finding and studying appropriate materials is essential. We may gather information from various reliable sources, interview knowledgeable individuals, and draw upon our own experiences (Gregory, 2018).

Next, we organise the body of the speech, develop points, and arrange them in a visually appealing manner if using presentation slides as support. A clear introduction and conclusion must be formulated to prepare concise notes for the outline, allowing us to begin practising.

This stage of preparation is mostly individual. It involves the technical organisation of thoughts, which is generally not influenced by many external factors, considering that higher education students are familiar with the requirements for university studies Tucker & LeHew, 2020).

2.2 Delivering Speech

When delivering a speech, many elements come into play simultaneously. Ideally, we as presenters speak fluently and at an appropriate volume while maintaining eye contact and engaging with the audience. We use just the right number of gestures, and our posture is both comfortable and alert. We reference our notes effectively, speak from the heart, and utilize presentation tools, such as slides, appropriately. Our speech is clear, we avoid filler words, and our introduction and conclusion are confident (Gregory, 2018).

Unfortunately, during a speech, these elements can often be inconsistent. A speaker might have a softer voice, resulting in an overly quiet delivery. They may focus too much on their slides and notes, turning their back to the audience. Some presenters might use excessive gestures or rely on verbal fillers, which can disconnect the audience from their message. Additionally, poor posture, such as slouching shoulders, can convey a lack of enthusiasm. Even the opening and closing lines may come across as confusing or unclear (ibid).

3 Factors Influencing Presentation Skills

If we follow all the stages of preparing for a speech and pay attention to the elements of delivering it, the final outcome should be a successful, comprehensible, and engaging presentation. However, the reality is different as there are many factors influencing presentation skills.

3.1 Literature Review

Public speaking and the elements that contribute to an effective presentation have been discussed in research for many years. More recent studies, especially those published after 2016, have begun to explore how new generations of students—such as Generation Z—develop their presentation skills. While oral presentation ability remains an essential learning outcome in higher education, there is still ongoing debate about which learning conditions best support its development. Existing research suggests that factors such as personality traits, preparation, audience interaction, and language proficiency all play a major role in shaping students' presentation performance (Razawi et al., 2019).

For example, many students experience fear when presenting in English, particularly in EFL settings, which shows how closely language skills are linked to confidence during presentations (Algouzi et al., 2023). This fear is often reinforced by issues related to content preparation, delivery techniques, and moment-to-moment confidence often affacted by the anegagement of audinece, which together can increase overall anxiety (Alshiabani & Algraini, 2024).

From our own teaching experience in the Presentation Skills course, we have consistently observed that fear, anxiety, and stress are among the most common barriers students face when presenting. Our 2024 pilot study supports this observation, as do larger longitudinal studies conducted by researchers such as Tóth (2024) and Szyska (2024). Their findings highlight that emotional factors, especially anxiety, have a major impact on speaking and presentation performance. These pressures often lead students to rely heavily on their slides or scripts, a pattern frequently reported among EFL learners.

This connection between emotional state and language performance demonstrates the importance of creating supportive learning environments that reduce anxiety and help students build confidence (Octaberlina et al., 2022). Research further shows that personality traits, such as self-esteem, inhibition, and willingness to take risks, along with external conditions like preparation time or available support, also shape how successfully students communicate orally (Bata & Castro, 2021).

Overall, a variety of factors influence presentation performance. Some lie completely outside the speaker's control, others are partially shaped by both the speaker and the environment, and some depend entirely on the speaker's own actions and preparation.

4 Factors Influencing Pre-service English Language Teachers' Presentation Skills

4.1 Methodology

The aim of the research was to find out what factors influence pre-service English Language teachers' presentation skills and their perceptions of public speaking.
The research was conducted during the summer semester, i.e., 12 weeks in 2025, in the course Presentation skills, which is a compulsory course for students in the single major English Language and Literature teacher training programme.
The sample consisted of bachelor students in the first year of English language and literature teacher training programme. It was a mixed group of 11 students aged 18-19. The participants were an availability-based sample.
Full-time students must complete a total of 75 hours per semester, including 25 hours of in-class seminars. The course aims to teach students the fundamentals of creating and delivering presentations in English, fostering clear, well-structured performances, and confidently managing and presenting their work to an audience. Beyond practising presentation skills, the course also addresses critical thinking regarding information and text, effective audience communication, and strategies for managing anxiety.
As anxiety has played a significant role in speaking and presentation skills, as mentioned in chapter 2, the State Trait Anxiety Inventory (Spielberg, 1989), consisting of 20 self-report items on a 4-point Likert scale ranging from 1 - not at all to 4 - very much so, measures only state anxiety, which is a temporary state influenced by the current situation. The Personal Report of Communication Apprehension (PRCA-24), comprising 24 statements on a 5-point Likert scale from 1 - strongly agree to 5 - strongly disagree, assesses feelings about communication with others, with a focus on public speaking for the needs of this research (McCroskey, 2005).
To answer our research questions, observation and a non-formal anonymous questionnaire about their feelings, course expectation fulfilment, or other factors helped us form results.

4.2 Results

In the analysis of the State-Trait Anxiety Inventory, out of 12 students, 4 students exhibited high levels of anxiety with an average score of 49.3. Additionally, 3 students displayed low anxiety levels with an average score of 35, while 5 students had moderate anxiety levels, scoring an average of 44.2.
In terms of the Personal Report of Communication Apprehension, all 11 students scored between 51 and 80, indicating average communication apprehension. Moreover, upon further examination of questions 19 to 24, which pertained to their attitudes toward public

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speaking and their feelings when delivering a speech, all students scored above 14 and below 24, reflecting moderate apprehension.

By observing students' presentations and delivery, their reactions and self-assessments, and teacher feedback and recommendations, we have identified groups of factors that lie along a spectrum. On one end, there are factors that we cannot change, such as the topic, the audience, and innate traits connected to personality, like natural intelligence and tendencies toward anxiety.

On the opposite end, we find factors that can be controlled, such as preparation, practice, and the technical tools used. Somewhere in between these extremes is a combination of external influences and personal efforts, including language abilities, culture, family upbringing, education, and teacher support. These factors range from those we have little to no control over to those that depend entirely on our attitude and effort.

Students' feedback on the course was mostly positive, with participants indicating that it effectively improved their understanding of posture, boosted their confidence, enhanced their skills in working with presentation slides, and provided strategies for preparation. Despite these confidence gains, students expressed a desire to address further issues related to stress and anxiety, as consistently highlighted in the submitted questionnaires. Many respondents emphasised that both preparation and the audience significantly influence their anxiety levels. Notably, a few students mentioned that although the initial minutes of the presentation can be anxiety-inducing, this apprehension tends to decrease once they realise their audience consists mainly of friends and acquaintances.

Anxiety is a prevalent concern among students. Consequently, we sought to explore whether factors such as parental upbringing, educators' influence, and cultural context affect presentation skills. Responses varied; some students dismissed these factors as overly simplistic, attributing their experiences primarily to intrinsic personality traits. In contrast, a subset of respondents reported that support from family and reactions from teachers significantly influence their feelings of confidence or anxiety throughout their lives, extending beyond the context of presentation skills.

4.3 Limitations

Like the previous year, when we conducted similar research in the same course (Myjavec, 2025), we faced a limited number of students, which restricted the scope of our findings. It was beyond our control to influence the number of students applying for the course.

One limitation noted from our perspective was the low level of English language skills among participants, performing below B1 levels.

We believe that research with a small sample can function as a pilot study, which is valuable for guiding future research design and methodology to obtain more reliable results.

5 Conclusion

The aim of this research was to identify the factors that most significantly affect presentation skills in the university preparation of pre-service English language teachers. Previous research by Myjavec (2025) highlighted the role of anxiety in this context. Additionally, other studies from neighbouring countries have focused on anxiety and strategies to manage it in order to improve presentation skills (Tóth, 2024; Wu et. al, 2024).

In our small-scale research, we initially found that students tend to attribute challenges in presentation skills mainly to anxiety. Despite the results showing moderate anxiety levels and average communication apprehension, most students considered preparation to be a vital factor in mastering their presentations. Furthermore, as students practised and followed the course plan, they began to realise that preparation, a factor within their control, significantly helps to reduce feelings of anxiety. On the other hand, one uncontrollable factor, the audience, affects presentation skills and helps decrease their anxiety levels.

We want to emphasise that while presentation skills are not synonymous with teaching ability, they are highly important for pre-service English language teachers. The role of a teacher encompasses various responsibilities, including being a speaker, mediator, presenter, and facilitator, all of which are closely linked to effective oral presentation skills.

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From Needs Analysis to Training: Building AI Literacy Among VET Teachers in Slovakia

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Abstract

As Artificial Intelligence (AI) becomes increasingly integrated into education and the labour market, enhancing teachers' AI literacy has become crucial, particularly in vocational education and training (VET). Within the Erasmus+ project VETAssIst – Artificial Intelligence as VET Teacher Assistant (No. 2024-1-HU01-KA220-VET-000253387), we conducted a national online survey to examine Slovak VET teachers' experiences with and attitudes towards AI use in teaching and learning. Using a Google Forms questionnaire, we gathered responses from 208 teachers across various VET disciplines, complemented by 38 in-depth qualitative interviews. The findings revealed significant gaps in AI literacy, digital skills, and technical readiness, both at the teacher and institutional levels. Drawing on these findings, we created customised professional development sessions that helped teachers build digital skills and gain confidence in applying AI within their classrooms. So far, 78 VET teachers have participated in these training sessions. The paper highlights key outcomes of these initiatives, including improvements in teachers' ability to integrate AI tools into lesson planning, assessment, and classroom management. The study underscores the need for systemic support and sustained professional development to prepare VET educators, and indeed all teachers, for the challenges and opportunities presented by AI driven education.

Keywords: AI Literacy, Digital Skills, Vocational Education and Training (VET), Teacher Professional Development, Artificial Intelligence in Education, AI Training

1 Introduction

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Artificial Intelligence (AI) is reshaping education worldwide, including in Slovakia, where it presents both challenges and opportunities (Pondelíková, 2025). AI has strong potential to advance Sustainable Development Goal 4, which calls for inclusive, equitable, and high-quality education (UNESCO, online). As AI becomes embedded in daily life, schools must adapt by integrating digital and 21st century skills into their curricula (Gocen and Aydemir, 2020).

This shift requires well prepared teachers who can understand, evaluate, and responsibly implement AI tools. To address these needs, four universities - the Budapest University of Technology and Economics, the University of Bremen, the University of Novi Sad, and the University of Ss. Cyril and Methodius in Trnava – developed the Erasmus+ project **VETAssIst – Artificial Intelligence as VET Teacher Assistant** (2024-1-HU01-KA220-VET-000253387). The project explores how AI can support VET teachers in lesson planning, assessment, administration, and digital innovation. A key output is a comprehensive e-learning course offering practical guidance and examples of AI integration, while also examining opportunities, risks, and pedagogical implications.

This article reports on the Slovak pilot implementation of the course. It builds on earlier qualitative interviews with 38 VET teachers and a nationwide survey of 208 respondents. In October 2025, the first part of the pilot course was delivered in Prešov, Košice, and Banská Bystrica, with the second part planned as an online delivery. The analysis focuses on teachers' feedback from the initial sessions, which covered prompting, AI based text and image generation, AI assisted presentation design, and translation tools. The evaluation examines teachers' motivation to participate, their growing confidence in using AI tools, their suggestions for the next training phase, and shifts in their overall perceptions of AI.

2 Theoretical Background and Literature Review on the Integration of Artificial Intelligence (AI) in Vocational Education and Training (VET)

Artificial intelligence in education has gained considerable scholarly interest in recent years. While its integration into teaching and learning environments has been relatively gradual, current research indicates a steady expansion of AI's role, particularly through the adoption of virtual assistants and intelligent support systems. Yet, as Bates et al. (2020) note, AI remains a "sleeping giant" within the educational sector. Buckingham Shum and McKay (2018) similarly argue that the practical use of AI still falls short of its widely discussed potential. This discrepancy is often attributed to systemic challenges, including insufficient institutional structures, a shortage of trained personnel, and inadequate technological infrastructure (Ifenthaler, 2017). Despite these constraints, continuous technological advancements and growing investment in educational innovation suggest that the gap between AI's promise and its practical implementation may gradually diminish in the coming years. Recent bibliometric analysis by Prasetya et al. (2025) highlights growing research interest in the use of AI in VET. Their study confirms AI's potential to enhance accessibility, inclusivity, and equity in education, while also contributing to the United Nations Sustainable Development Goals (SDGs) 2030, particularly SDG 4 (quality education access), SDG 8 (decent work and economic growth), and SDG 9 (industry, innovation, and infrastructure).

Artificial intelligence is reshaping both labour markets and educational systems, placing vocational education and training (VET) at the centre of these transformations. As AI driven technologies redefine workplace expectations, VET providers must adapt the content and aims of initial and continuing training (Bükki et al., 2025). AI is therefore doubly relevant to VET, both as a core topic within vocational curricula and as a tool that can enhance teaching and learning processes (Attwell et al., 2020). Despite growing interest in AI's transformative potential, empirical research on its educational use, especially in VET, remains limited (Chiu, 2023; Deitmer et al., 2024; Seufert, 2024).

Survey data from the VETAssIst Erasmus+ project, administered in February 2024 among VET teachers in Hungary, Serbia, and Slovakia (Bükki and Manojlovic, 2024; Papp et al., 2024), revealed generally positive attitudes towards AI but showed that only a minority had begun integrating AI tools into their teaching. Bükki et al. (2025) identified two teacher groups: AI pioneers, who actively experiment with generative AI tools, and non-pioneers, who show interest but lack confidence, training, and institutional support. Complementary Serbian findings using fuzzy cognitive mapping indicate that strong institutional and technical conditions significantly boost teachers' motivation to adopt AI, while students' own use of AI further supports uptake (Papp et al., 2025). Collectively, these studies show that AI integration in VET depends not only on technological availability but also on organisational culture, teacher readiness, and sustained pedagogical support.

Research further highlights both the opportunities and challenges of implementing AI in VET. Çela et al. (2024) show that technologies such as VR/AR, machine learning, intelligent tutoring systems, IoT, robotics, gamification, and big data can personalise learning, strengthen skills development, and prepare students for an AI-driven labour market, while issues of algorithmic bias, data privacy, high costs, and unequal access remain. Leong (2025) likewise emphasises the potential of adaptive learning systems, tutoring platforms, virtual simulations, and robotics to align VET with industry needs, but also warns of the digital divide, gaps in instructor preparedness, and data protection challenges.

Luprichová's (2025) evaluation of 37 AI tools confirms these findings, showing that AI can support teachers through automation, personalisation, and increased engagement, yet concerns about reliability, accuracy, and equity call for systematic training and institutional guidelines. The importance of teacher preparedness is further demonstrated in Schmitt and Brutzer's (2025) design-based training, which combined theory on AI, ethics, and data protection with hands-on prompt-engineering tasks. Their results from 52 participants showed improved prompt-design and evaluation skills, though teachers requested more practice and structured support. AI integration in VET remains complex, shaped by technological, institutional, and pedagogical conditions. While AI offers significant benefits for everyday teaching, successful adoption requires adequate infrastructure, ethical safeguards, and sustained professional development. As VET systems respond to digital transformation, strategic investment in training, policy development, and evidence-based practice will be essential.

3 Introducing the VETAssIst AI Course Pilot for VET Teachers

A central aim of the VETAssIst project is to equip VET teachers to use artificial intelligence as a supportive digital assistant. Within this framework, AI is viewed as a tool that can aid routine and creative pedagogical tasks such as lesson planning, content creation, assessment design, student engagement, and classroom management. AI tools also enable more inclusive teaching by customising materials to diverse learner needs. The project, therefore, seeks to integrate AI into VET in a pedagogically sound, ethical, and practical way.

To achieve this, the VETAssIst Moodle e-learning course was developed as an eight-module professional development programme. Each module combines theoretical readings, demonstrations, and individual tasks, supplemented by optional materials and resources. The modules cover core areas of AI use in education: fundamentals of AI; AI-supported educational design; active learning; content creation and collaboration; tutoring support; AI-based assessment; development of students' AI literacy; teachers' professional and administrative use of AI; and ethical and policy considerations. Together, they build the knowledge, skills, and competencies needed for responsible AI integration, emphasising conceptual understanding alongside hands-on practice. Participants also receive access to AI tools, case studies, and step-by-step video tutorials. The course targets in-service VET teachers seeking to enhance their AI literacy and classroom practice, as well as pre-service teachers preparing for careers in VET. Because several modules are transferable, the course is also relevant to educators from other sectors, contributing to diverse peer learning.

In October 2025, the Slovak team launched the first in-person pilot implementation, using selected activities from modules most applicable to immediate teaching practice. The workshops introduced foundational AI concepts, demonstrated text- and image-generation tools, strengthened AI literacy, and, within one group, offered training in AI-supported video creation. Ethical issues such as responsible use, data protection, and identifying AI-generated content were integrated throughout. Across three workshops, 78 VET teachers participated, providing feedback that will guide further refinement of the course and its adaptation to Slovak educational needs.

4 Research Methodology

To evaluate the relevance, usefulness, and perceived impact of the pilot implementation of the VETAssIst course, a qualitative research design was adopted. Qualitative methodology was selected because it allows for an in-depth exploration of participants' experiences, perceptions, and motivations, which are essential for understanding how VET teachers interact with and reflect upon AI. According to McLeod (2023), qualitative research aims to explain how and why a particular phenomenon operates as it does within a specific context. This approach is therefore well suited to examining teachers' responses to AI supported professional development, their evolving attitudes, and the nuanced factors that influence their readiness to integrate AI into their teaching practice.

Qualitative inquiry is rooted in social sciences such as psychology, sociology, and anthropology. Methods commonly used within this paradigm, such as interviews, focus groups, observations, and content analysis, are designed to generate rich, detailed data that reveal complex social processes. Although qualitative findings may be more subjective and less generalisable, they offer an insider's perspective and can illuminate subtle dynamics often overlooked within more positivist, quantitatively oriented research (Denscombe, 2010). Qualitative descriptions also help identify potential relationships, causes, effects, and developmental trajectories, providing a deeper understanding of lived experiences and emergent educational practices (Pondelíková, 2023).

In alignment with these methodological assumptions, data for the presented study were collected through a set of open-ended questions administered to participants immediately after each workshop. These questions were structured into four thematic categories. The first category, **Motivation and Initial Expectations**, explored participants' reasons for attending the workshop and their hoped-for outcomes. The second category, **Perceived Benefits, Learning Outcomes, and Changes in Perception of AI**, focused on the most useful components of the workshop, the new knowledge or skills acquired, participants' plans to implement selected activities in their teaching practice, and any shifts in their perception of AI in education. The third category, **Content, Structure, and Practical Applicability**, examined the relevance and practicality of workshop activities, the adequacy of time allocation, and suggestions for additions, removals, or structural adjustments in future sessions. Finally, the fourth category, **Overall Evaluation of Quality and Organisation**, examined participants' assessments of strengths and weaknesses related to organisation, materials, interactivity, and lecturers' performance, and asked whether they would recommend the workshop to colleagues and how they would describe it concisely.

In total, 18 feedback responses were collected. Some were submitted by individual teachers, while others represented group responses, prepared by teachers working together based on their subject specialisation and the collaborative teams formed during the workshop activities. This combination of individual and collective feedback enriched the dataset and provided a multifaceted perspective on the workshop's perceived value and areas for improvement.

The collected responses were subsequently analysed using thematic content analysis, enabling the identification of key themes and actionable insights that can inform further refinement of the VETAssIst course.

5 Interpretation of the Research Results

Drawing on feedback from the pilot workshops, this interpretation examines how VET teachers perceived the relevance, usefulness, and practical applicability of the introduced AI tools. The findings reveal clear patterns in teachers' motivations, learning outcomes, and shifts in their attitudes towards AI integration in education. Together, these insights provide a deeper understanding of the factors that shape VET teachers' readiness to adopt AI in their everyday practice. Prior to the workshops, 38 interviews were conducted with secondary VET teachers, who indicated that they perceive artificial intelligence in VET as a useful supportive tool capable of enhancing teachers' preparation, enriching instruction, and facilitating students' access to information. They expect AI to simplify the creation of worksheets, tests, presentations, multimedia materials, translations, and supplementary learning resources, while also contributing to faster feedback, personalised learning, and increased student motivation.

Teachers believe that AI has the potential to enhance learning, support the visualization of complex content, and foster the development of digital competences. They also noted that AI may partially reduce administrative workload, particularly in test assessment and report generation, but only once its use is supported at the systemic level. At the same time, teachers are acutely aware of the associated risks. The most frequently mentioned concerns include the weakening of students' critical and logical thinking, reduced autonomy, increased dependence on technology, diminished personal interaction between teachers and students, as well as the risks of plagiarism and misuse of AI tools. They also warned of potential ethical issues, such as violations of copyright, insufficient verification of information, and threats to privacy. For these reasons, they consider it essential to establish clear rules for the use of AI, to ensure data protection, and to systematically cultivate responsible digital behaviour.

In terms of professional development, teachers expect long term, practice-oriented training during which they can experiment with a variety of AI tools, ranging from lesson planning and material generation to intelligent learning systems, text- and speech-processing tools, and testing platforms. The key competencies they consider necessary to acquire include critical evaluation of AI outputs, proficient use of digital tools, the ability to creatively integrate technology into instruction, and literacy in ethical, safety, and privacy-related issues. All respondents emphasised that AI should not replace the teacher. They expect technology to remain a supportive component, while the core role of the teacher, such as guidance, motivation, pedagogical decision making, and addressing diverse learner needs, remains inevitable. AI should complement teaching, not control it, and its use should be balanced, intentional, and meaningful.

In addition to the in-depth interviews, a nationwide survey was conducted in secondary VET schools, gathering responses from 208 teachers. The results indicate that nearly 70% of respondents are interested in AI related training, as their current use of AI is largely limited to chatbots. Specifically, 40% reported regular use, 33.7% use them only minimally, and 26.4%

do not use them at all (Figure 1). Moreover, almost 60% of teachers stated that they are unable to work with AI-based content-generation tools, 17.8% reported partial use, and fewer than 10% indicated proficient use (Figure 2).

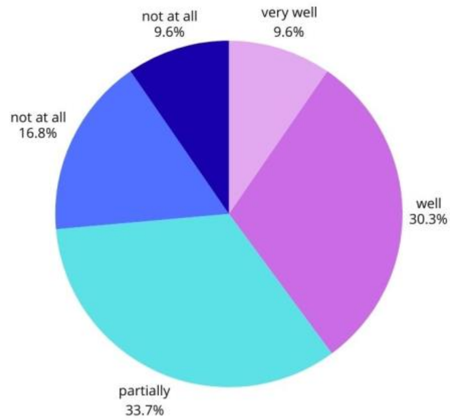

Figure 1: Teachers' ability to use chatbots.
Source: *own processing based on the obtained data*

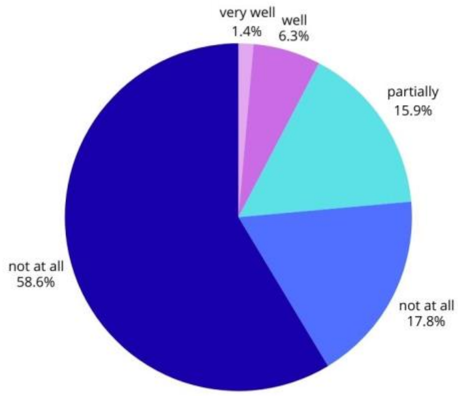

Figure 2: Teachers' proficiency in using AI tools designed for content generation.
Source: *own processing based on the obtained data*

At the beginning, we were interested in participants' personal **motivation** to attend such a workshop. Their motivations for attending the AI workshop were diverse, yet united by a strong interest in better understanding artificial intelligence and its potential in education. Several respondents highlighted the practical value of the training for their teaching practice, as illustrated by R6, who noted that the workshop "can be added not only to our professional portfolio but also used in our pedagogical practice." Many participants expressed the desire to acquire new knowledge about AI (R7, R13), with R11 explicitly stating the need "to find out how AI can be beneficial for me." Teachers also emphasised that AI has become a common part of students' daily lives; as R12 explained, "A huge number of students use AI, and we –

teachers need to know how to work with it so that we can guide them properly." Some motivations were professional or personal in nature, for example, R9 appreciated the opportunity to attend his "first in-person training" in a new job, while R17 stressed the wish "to keep up with young people in using modern technologies," and to make teaching more engaging. For several participants, the relevance and timeliness of the topic were important (R14), as was the rapidly evolving nature of AI, which, according to R15, requires continuous training. Overall, the findings show that participants were driven by professional development, the enhancement of digital competence, the need to adapt to a changing educational environment, and the desire to better respond to students' needs.

We were further interested in the **perceived benefits, learning outcomes, and changes in participants' perceptions of AI**. Participants identified a wide range of workshop components as particularly beneficial, with the majority highlighting the creation of presentations, especially through tools such as Gamma, as the most valuable aspect. For example, R1 stated that "the creation of presentations was the most beneficial, as it takes the most time in teachers' preparation," while R7 appreciated "the creation of presentations in Gamma." The possibility of generating and modifying images was emphasised by respondents such as R4, who noted that "the most beneficial part was generating images and creating presentations," and R10, who highlighted "image generation through precise instructions." Some participants, such as R15 and R16, stressed that all components were beneficial, with R16 describing the workshop as "highly relevant and applicable to every part of the educational process." Additional insights included enthusiasm for speaking avatars, with R18 noting that "the talking avatar was the biggest surprise and will make teaching easier." At the same time, R18 also reflected critically on AI's limitations, warning that "our creativity may disappear completely" and expressing concerns about how students' knowledge might evolve "when they no longer need to create, search, or explore."

These reported benefits aligned closely with the concrete learning outcomes described by participants, who indicated that they had gained practical skills in working with AI tools for teaching. Many respondents reported learning to create or improve presentations and generate visual materials, with several noting that they were using tools such as Gamma for the first time (e.g., R7). Others acquired new competencies in image generation, note creation, and advanced prompt formulation, as illustrated by R12 and R17, who planned to implement interactive activities such as *Say what you see* and *Which face is real* to enhance student motivation. Some participants were inspired to experiment further with creative tools, with R17 reporting the creation of talking avatars of authors using Vidnoz, which "received applause" from students. Several teachers also emphasised that the workshop deepened their understanding of how AI operates, broadened their awareness of available applications, and provided strong inspiration for integrating AI-supported tasks into future lessons.

Overall, teachers expressed clear intentions to incorporate these activities into their teaching practice, recognising their potential to enrich instruction and strengthen student engagement.

Participants reported increased confidence when working with AI tools. Most participants indicated feeling more secure or even “certain” in using AI (e.g., R2, R4, R6, R12, R15), while a few noted only slight improvement or felt they were still beginners (R1, R5). Only one participant stated that their confidence remained unchanged due to already having a strong foundation (R3).

One aim of the workshop was to influence teachers’ perceptions of AI in educational practice positively, and the responses indicate meaningful shifts in this direction. Respondents reported notable changes, most commonly viewing AI more positively as a supportive tool that can simplify teachers’ work and save time. Several teachers emphasised AI’s role as an assistant rather than a threat; for instance, R3 noted that they now “see it as a helper, not an enemy,” while R2 remarked that AI “does not have to be a bogeyman.” In addition, R1 stated that the workshop “confirmed my view that AI can be helpful and save time.” At the same time, some participants expressed a balanced or cautious stance. R12 explained that they no longer see AI as “avoiding responsibilities, but as a way to simplify work,” whereas R18 voiced concerns that AI may foster superficial learning: “If students receive information on a plate without effort, they won’t remember it.” Participants acknowledged AI’s potential benefits but also recognised the need for critical, guided, and responsible use.

The third area of our interest focused on participants’ **satisfaction** with the workshop’s content, structure, and practical applicability. Respondents expressed relatively few reservations regarding the workshop’s content, though several participants identified specific elements they considered less necessary. A few teachers felt that certain segments were allocated more time than needed. For example, R1 noted that “too much time was devoted to prompt engineering,” while R3 mentioned that the activity on distinguishing AI-generated and real images was less essential. Others pointed to the section on translation tools, which some viewed as redundant given their prior experience (R17). However, participants also acknowledged that these components were valuable for colleagues with different levels of expertise, with R12 emphasising that “some teachers explicitly needed this part.” Several respondents, such as R13 and R15, stated that they found all components useful, praising the workshop’s overall balance, pacing, and responsiveness to participants’ needs. Critical comments were minor and related primarily to time management rather than the relevance of the content. While most participants considered the time allocation appropriate, often describing it as “adequate” or “well planned”, a few noted small challenges. For instance, R4 suggested allowing more time to log in to tools to prevent confusion, and R15 mentioned experiencing reduced concentration in the afternoon due to the volume of new information.

Participants also suggested several ways to enhance future workshops, most commonly requesting more examples, new tools, and deeper practical training. A key theme was the desire for guidance on evaluating AI outputs, with R1 emphasising the need to learn “how to verify the information provided by AI.” Others expressed interest in expanding the range of demonstrated applications; for instance, R3 proposed including the AI tool NotebookLM, while R15 called for "more new applications" and even suggested creating a mini project for participants to submit for feedback. Several teachers highlighted the value of additional prompt-engineering practice for generating exercises, worksheets, and reading texts (R12). Regarding new topics, respondents most frequently mentioned test and quiz creation (R5, R17) and strategies for checking students' independent work in the age of AI (R11). Some also expressed interest in real-time interactive applications, as R18 described tools that allow students to generate content that appears instantly on a shared screen collaboratively. A few participants, such as R16, felt that the current scope was sufficient but trusted that future workshops would "always offer something new and relevant." In addition, respondents showed strong enthusiasm for broadening both the thematic focus and the practical depth of upcoming sessions.

The final part of the investigation focused on the overall evaluation of the **workshop's quality and organisation**, including participants' perceptions of its strengths and weaknesses, as well as whether they would recommend it to their colleagues. Respondents highlighted numerous **strengths** of the workshop, most frequently emphasising its interactivity, high-quality demonstrations, professional lecturing, and well-prepared materials. Many praised the instructors' expertise and supportive approach; for example, R5 noted the "human and professional approach, structure, and interactive demonstrations," while R12 described the lecturers as "excellent, with a highly enriching selection of activities and topics." The positive atmosphere and quality of communication were also repeatedly mentioned, with R4 valuing the "very pleasant manner of the lecturers and practical tasks," and R17 emphasising the "excellent atmosphere." A particularly detailed reflection was provided by R18, who described the workshop as "perfectly prepared and organised from the very first contact," praising the smooth communication, thoughtful logistics, and supportive guidance throughout. They highlighted the instructors' attentive assistance, "they carefully followed every step and directed us to the next one," and appreciated the friendly, non-judgmental environment in which participants felt welcomed and encouraged to contribute. The usefulness of demonstrations and materials was frequently underscored (R1, R2, R3), and R16 highlighted the "highly professional preparation," noting that the small group size fostered active engagement.

Although respondents were generally positive, they identified several **areas for improvement**, most of which related to technical limitations, time constraints, and group composition rather than the workshop itself. A recurring issue was weak internet connectivity and insufficient institutional equipment, as highlighted by R2 and R4, with the latter noting that limited time for some activities was caused by "inadequate technology and connection, which our institution failed to provide." Several participants suggested allowing more time for certain tasks (R1, R11, R14), while others pointed out that the heterogeneous skill levels within the group slowed the pace; R12 observed that they sometimes had to wait for colleagues who were "technically weaker," and R5 mentioned challenges arising from an "undisciplined and diverse group." Respondents also commented on instances of inappropriate behaviour during the workshop, with R3 noting that some colleagues "talked constantly, which was very distracting." Importantly, several participants recognised that the lecturers cannot influence the quality of participants' devices, the stability of the internet connection, or the varying levels of participants' technical skills, particularly since the workshops were conducted not in the lecturers' own facilities but in schools or other educational institutions hosting the event. A few respondents reported no weaknesses at all (R6, R7, R10, R15).

One of the clearest indicators of the workshop's success is that all participants stated they would **recommend** it to their colleagues, frequently emphasising its practical value and immediate relevance for teaching. Respondents appreciated the workshop's hands-on, practice-oriented approach. R10 highlighted the "focus on practice and prompting" and many underscored its usefulness for beginners, with R7 noting that it is ideal for those new to AI, while R5 stressed its importance for colleagues who "resist or fear" such technologies. Participants also praised its clarity and structure, describing it as "a good starting point and an excellent overview of tools" (R9) and "a way to make work easier and more attractive" (R12). The perceived benefits extended beyond mere recommendation. For example, R1 reported learning "how to use AI effectively so that you have more time for other responsibilities," and R12 remarked that the workshop "dramatically shifted my abilities and made my daily preparation 200% easier." Several respondents also valued the engaging and motivating atmosphere, as expressed by R7 ("you will have great fun"), R4 ("you will learn to use AI tools in a playful way"), and R5 ("efficient, practical, well-organised"). Additional endorsements highlighted its inspirational nature; for instance, R6 noted that "it will make their work easier and they should not resist it," while R14 added that "you might regret not attending." Overall, participants regarded the workshop as a highly beneficial and inspiring professional development opportunity that enriched their digital competencies, enhanced the efficiency of their teaching practice, and provided a motivating, interactive learning experience.

6 Evaluation of the Research Results

The research results show that the pilot implementation of the VETAssIst course effectively addressed the immediate training needs of Slovak VET teachers and offered practical, motivating experiences with AI tools. Qualitative feedback indicates that the workshops strengthened teachers' digital competencies, boosted their confidence, and increased their willingness to integrate AI-supported activities into their teaching. Participants particularly valued tools for text and image generation, presentation design, and prompt formulation, confirming that hands-on, application-oriented training aligns well with their everyday professional needs.

The workshops also contributed to more positive perceptions of AI. Many teachers began to view AI as a helpful assistant that saves time and simplifies routine tasks, while initial fears or scepticism diminished. At the same time, respondents demonstrated an awareness of potential risks, especially student overreliance on technology, weakened critical thinking, and superficial learning. Participants evaluated the workshops very positively, highlighting the lecturers' expertise, clear demonstrations, and supportive atmosphere. All stated they would recommend the training to colleagues. Nonetheless, several systemic challenges affected the experience, including unstable internet, limited equipment, and varying digital skill levels.

The pilot workshops achieved their goals and provided a solid foundation for developing AI literacy among VET teachers. The results, along with participants' suggestions, such as enhancing training on verifying AI outputs, creating tests, and designing assessments, offer clear directions for improving the next phase. The evaluation also underscores the importance of ongoing, practice oriented professional development and stronger institutional support for the sustainable integration of AI into VET.

7 Research Limitations

The study offers valuable insights into VET teachers' perceptions of AI, yet several limitations must be acknowledged. First, the research is based solely on qualitative data from open-ended questions completed immediately after the workshops. Although this method provided rich reflections, it limits generalisability. The dataset includes 18 responses, which is relatively small; however, several of these reflect the shared viewpoints of small groups rather than individual participants. Second, the findings were strongly shaped by contextual factors, as participants' experiences reflected not only the workshop content but also external conditions such as unstable internet, limited equipment, and varying levels of digital skills.

The results do not examine how teachers apply newly acquired skills over time, how their perceptions evolve, or what challenges emerge during classroom implementation. This gap will be addressed in the next phase of the project through additional quantitative data to better capture teachers' progress and the long-term impact of the training. Taken together, while these limitations restrict broader generalisation, they point to important directions for future research, including mixed-method designs, larger and more diverse samples, and longitudinal follow-up.

8 Recommendations

The research findings suggest several key recommendations for the sustainable integration of AI into vocational education and training. Teachers emphasised the need for ongoing, practice oriented professional development, particularly hands-on work with AI tools for generating materials, creating assessments, verifying outputs, and designing interactive activities.

Strengthening competencies in evaluating AI-generated content and ensuring ethical, responsible classroom use should remain a priority.

Participants also called for a broader thematic focus in future workshops, including AI-supported test creation, strategies for monitoring students' independent work, and advanced applications that enhance engagement and collaboration. Using authentic classroom examples and optional mini projects with feedback may further support practical transfer. Finally, the results highlight the importance of institutional and infrastructural support. Schools should invest in reliable technology and ensure access to necessary hardware, software, and connectivity. Clear institutional policies on ethical AI use, data protection, and academic integrity are essential for creating a safe and supportive environment for both teachers and learners.

9 Conclusion

The findings of this study demonstrate that the pilot implementation of the VETAssIst course represents an important step towards strengthening AI literacy among Slovak VET teachers and supporting their preparedness for the digital transformation of vocational education and training. The teachers' reflections clearly indicate that practical, hands-on AI training enhances their confidence, enriches their pedagogical repertoire, and motivates them to integrate innovative digital tools into their teaching practice. At the same time, the results underline the need for systematic professional development, adequate institutional support, and long-term monitoring of how AI related competencies are translated into authentic classroom practice.

In the broader educational context, the integration of AI aligns with contemporary shifts in teaching, learning, and evaluation. As Miština and Jurinová (2022) observe, the increasing use of information and communication technologies enables the adoption of new interactive multimedia forms of assessment, which corresponds closely with VET teachers' calls for more dynamic and meaningful ways of evaluating students' skills and knowledge. Moreover, AI driven changes in education reflect deeper societal transformations. At the core of these changes lies the evolving concept of digital identity, shaped by technologies that increasingly define human interaction, communication, and learning (Pecníková, 2018). These developments highlight the importance of cultivating not only technical skills but also digital awareness and responsibility among teachers and learners.

Given the expansion of new AI tools and the vast amount of information now available, the role of critical thinking becomes even more essential. As Javorčíková and Badinská (2021) emphasise, critical thinking empowers both students and teachers to evaluate information sources, establish hierarchies of relevance, identify plagiarism, and assess authors' credibility; competencies that are essential in an AI rich learning environment. Similarly, the linguistic dimension of AI integration cannot be overlooked. As Dančišinová (2022) notes, the knowledge of a foreign language must always be understood in relation to its purpose of use. English, as a global language of creativity, digital connectivity, and technological innovation, plays a central role in navigating AI applications. This was reflected in the training, where VET teachers learned not only to generate and analyse content but also to translate texts efficiently and accurately without being limited by language barriers.

To conclude, the study highlights that AI offers significant opportunities for innovation in VET. Yet its effective and responsible integration requires a balanced combination of technical skills, pedagogical reflection, ethical awareness, and critical judgment. The insights from the pilot workshops will guide the next phase of the VETAssIst course and help build a robust foundation for future research and professional development. By fostering teachers' competencies and confidence, the project contributes to ensuring that artificial intelligence becomes not a threatening force but a meaningful, supportive, and empowering component of vocational education and training.

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Challenges and Opportunities for Vocational Education Teachers in the Context of Social and Technological Change

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Abstract

This article analyses the challenges and opportunities faced by vocational education teachers in secondary schools within the context of ongoing social and technological transformation. It focuses on the impact of pedagogical innovation, digital tools, and organisational mechanisms on teacher professionalism and the quality of practical training. The theoretical and empirical sections of the study intersect current trends in vocational education with the everyday realities of teachers, culminating in recommendations aimed at increasing the effectiveness and relevance of practical teaching in secondary schools.

Keywords: Innovation; Competences; Modern Technologies; Professional Development; Vocational Education Teacher; Vocational Education

1 Introduction

Practical training represents a crucial component of vocational education - one highly dependent on technological developments, material conditions, and the teacher's didactic preparedness. Current social and technological shifts are transforming not only the nature of professional activities but also the qualification requirements expected of secondary vocational school students. The vocational education teacher thus enters the instructional environment as a professional who must ensure the acquisition of technological processes while simultaneously supporting the development of competences aligned with contemporary trends in industry and services. Their work is therefore shaped by the need for

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flexible reactions to change, the adaptation of teaching methods, and the integration of digital solutions into traditionally manual settings (Lobotková, et al., 2025).

2 Theoretical Background

Modern didactic concepts of vocational education Wyszynska and Andersson (2024), Szőköl and Gabrhelová (2024), emphasise a multidisciplinary connection between theory and practice, supporting students' adaptability in technologically adjusted working environments. Pecina and Krištofiaková (2021) define the vocational education teacher as a key professional and didactic 'element', integrating technological processes, work procedures, and situational learning into a coherent system of professional preparation. Their model highlights three crucial determinants of effective practical instruction:

1. the quality of material conditions,
2. the organisational structure of teaching, and
3. the teacher's didactic competence.

Among these, the teacher's ability to manage instruction under variable and technologically evolving conditions is currently the most exposed to external pressures.

Technological innovation, especially within the frameworks of Industry 4.0 and 5.0, is increasingly influential, reshaping manual activities, work processes, and labour market expectations. Research presented at technical conferences (Vulic et al., 2024) shows that digitalisation, sensor-based systems, automation, and virtual simulation environments demand a reconceptualisation of practical training, shifting emphasis from procedural memorisation toward analytical, diagnostic, and process-oriented thinking. The authors Barnová et al. (2024), Tamášová and Matušová (2021) also notes that digital environments heighten cognitive load, necessitating well-designed feedback mechanisms and differentiated tasks.

Theoretical models such as those by Timiras et al. (2024) demonstrate that technological transformation is not isolated; new soft skills have emerged as essential prerequisites for professional adaptation. Employer studies identify key competences needed at labour market entry: communication, teamwork, learning ability, analytical thinking, problem solving, and adaptability. These competences evolve in workplaces and thus must be embedded in practical instruction, where teachers address real or simulated problem scenarios. The observed disparity between employer expectations and student mastery, the so-called competence mismatch, adds further urgency to modernising vocational education.

Scholarship on vocational and technical education also references pedagogical adaptability, wherein traditional craft methods merge with digital technologies. IEEE research (2024) reports that augmented reality (AR), virtual reality (VR), digitisation, visualisation, and AI supported tools fundamentally change how students acquire workshop-based and vocational skills (Šimek, et al., 2024). Such technologies allow teachers to model risk situations that would be unsafe in real life while enhancing the precision and safety of training. Consequently, the teacher's role evolves, from instructor of manual procedures to curator of a digital learning environment who manages stimuli, directs attention, and regulates interaction with technology.

However, digital tools alone do not guarantee enhanced learning outcomes. Wyszynska and Andersson (2024), stress that their benefits manifest only when embedded within a clearly structured pedagogical design. Without such grounding, instruction risks becoming fragmented, cognitively overwhelming, and demotivating.

In the context of rapid societal change, the professional identity of the vocational education teacher becomes especially significant. Research (Sorensen, 2022; OECD, 2022) emphasises the teacher's role as mediator between technology and the world of work, requiring competences in digital didactics, technological integration, pedagogical reflection, inclusive teaching, and safe learning environments.

According to Bilčík and Bilčíková (2023), employers increasingly value 'green skills', competences related to sustainability, reflecting a shift toward circular, environmentally conscious economies. Their integration into practical training introduces new didactic challenges, particularly in engineering, electrical engineering, and gastronomy.

Recent research (Vochozka et al., 2023 a, 2023b) has shown suggest that vocational education must cultivate adaptive experts capable of addressing unpredictable problems and learning in technologically evolving environments. The teacher's role thus extends beyond transmitting skills. They must design learning situations that foster creativity, autonomy, responsibility, and safety.

Increasingly, didactic personalisation is also expected. According to IEEE (2024), AI enables the real-time identification of individual learning needs, adaptive pacing, precise error diagnosis, and personalised assignments. Teachers therefore influence not only *what* students learn, but also *how deeply* learning is internalised and transferred to practice.

Overall, contemporary vocational teachers face an interconnected set of didactic, technological, organisational, and value-oriented challenges (Voráč, Kopecký, 2021; Gawrych, 2022). Simultaneously, trends such as digitalisation, automation, sustainability, and labour market restructuring provide new opportunities for modernising practical training, improving its quality, and aligning education with current economic needs.

3 Methods

The methodological framework of this study combined content and comparative analysis of scholarly sources with the synthesis of data from recent empirical studies on practical training in Slovak and Polish vocational schools. The aim was to identify common determinants influencing the effectiveness of practical training in the context of social and technological change.

The quantitative sample consisted of 112 vocational education teachers from Slovakia and Poland, selected based on a minimum of three years' teaching experience, representation of diverse vocational fields (technical, service area, economic), and regional diversity. Data were collected through an electronic questionnaire. The qualitative component included nine semi-structured interviews with teachers from both countries, enabling deeper interpretation of their experiences, needs, and suggestions for improving pedagogical practice.

4 Results

The analysis of sources and empirical data highlighted several key determinants shaping the quality of practical training today.

1. Didactic preparedness of teachers

Several of the authors mentioned above stress the need for continuous updating of pedagogical and technological competences in response to the changing nature of work. In the research carried out, teachers reported that their ability to integrate new technologies directly influences instructional effectiveness.

2. Quality of material and technical equipment

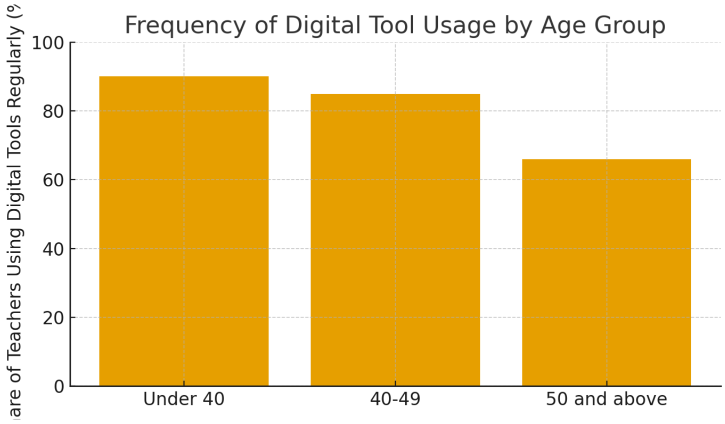
Functional workspaces, access to modern tools, and digital simulation environments enhance skill acquisition and improve safety. Schools that invest systematically in workshop modernisation demonstrate significantly higher student success rates.

3. Organisational mechanisms within schools

School culture, staff collaboration, and communication between management and teachers strongly affect the implementation of innovations. Teachers emphasised that management support is crucial for adopting new methods and digital tools.

4. Generational differences in digital tool adoption

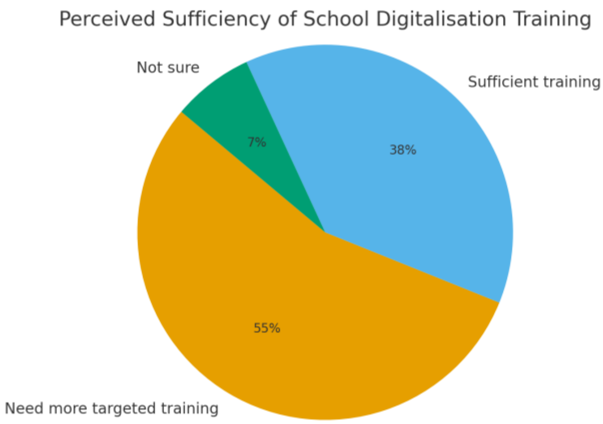
The youngest teachers (under 40) reported the highest usage of digital tools (92%). Usage declined among teachers aged 40–49 (85%) and was lowest in the 50+ group (66%).
These findings align with European studies indicating a generational gap in digital readiness (Vulic et al., 2024).



Graph 1: Frequency of Digital Tool Usage by Age Group.

5. Insufficient professional training in digital competence

Only 38% of teachers considered school provided digitalisation training adequate. A majority (55%) requested more targeted, practice based, and subject specific training. The remaining 7% were undecided. These results mirror findings from Timiras (2024), which stress the need for systemic and field-specific professional development.



Graph 2: Perceived Sufficiency of School Digitalisation Training.

5 Discussion

The findings indicate that practical training in vocational education is undergoing fundamental transformation. Technological innovation must be integrated into pedagogy in ways that reflect student needs and instructional goals. Successful innovation depends on the teacher’s willingness to adapt, their ability to work with digital tools, and the availability of methodological guidance and reflective professional spaces.

A major theme concerns balancing manual and digital learning components. While practical, hands-on experience remains irreplaceable, digitalisation offers enhanced opportunities for safe, repeatable, and detailed simulations that cannot be executed in real conditions. Vocational teachers thus gain opportunities to enrich traditional instruction with technological solutions, improving precision, engagement, and safety.

6 Conclusion

Practical training is increasingly shaped by rapid technological and social change. The vocational education teacher serves as expert, coordinator, and facilitator within this evolving landscape.

The findings show that effective practical training requires a combination of didactic preparedness, quality material resources, supportive school management, and the thoughtful integration of new technologies aligned with student needs.

The study highlights the pressing necessity for systematic professional development and the continuous modernisation of practical classrooms, ensuring that vocational education remains responsive to changing labour market demands.

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Artificial Intelligence as a Tool to Support Task Design in the Flipped Classroom

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Abstract

The flipped classroom model shifts the acquisition of new content to students' independent preparation, allowing contact time to be dedicated to active learning and practical application through creative tasks. The efficacy of this pedagogical approach depends on the quality of activities designed to foster the application of knowledge, skill development, and collaborative engagement. This paper examines the potential of artificial intelligence (AI), particularly generative models, as a tool for supporting the design of such tasks during the in-class phase. By exploring the utility of AI in developing problem-based scenarios, role plays, and project-based activities, the paper demonstrates how these technologies can assist educators in creating in-class experiences that are meaningful, engaging, and effective for university students.

Keywords: Flipped Classroom, Active Learning, Creative Task Design, AI in Education

1 Introduction

The higher education sector is undergoing a significant transformation, driven by both pedagogical innovation and emerging technologies. Amongst the most prominent and successful models to have emerged is the Flipped Classroom (FC). This model inverts traditional university pedagogy by shifting direct instruction and content delivery to a pre-class, independent student preparation phase, often via recorded lectures, readings, or interactive modules (Bergmann & Sams, 2012). This strategic shift is designed to liberate valuable in-class contact time, transforming it from a passive listening experience into a dynamic, active-learning workshop.

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However, the success of the FC model is entirely dependent on the quality and nature of these in-class activities. Simply removing the lecture is not enough. The freed-up time must be filled with meaningful, engaging tasks that foster peer instruction, problem-solving, and the deep application of knowledge (Baig & Yadegaridehkordi, 2023). This crucial time must be filled with creative tasks that foster the application of knowledge, the development of skills, and collaboration (Pšenáková & Pšenák, 2024).
This presents a significant pedagogical bottleneck. Designing these high-impact activities, such as problem-based scenarios, complex case studies, role-plays, and collaborative projects, is a non-trivial, time-consuming work (Schallert-Vallaster et al., 2021). It requires a different skill set than creating a traditional lecture and places a heavy burden on educators.

1.1 Artificial Intelligence as a Proposed Solution

Considering the pedagogical burden involved in developing rich, high-impact tasks for the flipped-classroom model, educators are turning to generative Artificial Intelligence (AI) as a promising aid. The advent of sophisticated large language models (LLMs) presents a new kind of "assistant" for teaching staff. For example, AI tools can serve as "a tool to support the design of creative tasks," thereby helping instructors navigate designer's block, accelerate the generation of diverse learning activities, and alleviate the time-intensive nature of task development (Pšenáková et al., 2023).
Beyond this specific claim, a growing body of work supports the notion that generative AI can play a meaningful role in instructional design and flipped environments. For instance, explore how LLM-driven flipped-classroom workflows allow teachers to generate peer-questioning tasks and flipped interactions in large classes (Tan, 2023). Other authors, examine how generative AI advances adaptive and personalized learning by enabling the rapid creation of tailored educational materials and task variants (Guettala et al., 2024).
Within this context, it may be argued that generative AI possesses the potential to function not merely as an isolated tool, but as a systematic support mechanism for educators seeking to design problem-based scenarios, complex case studies, role plays, and collaborative projects. In doing so, these technologies may alleviate the pressures placed upon academic staff, facilitate the creation of more dynamic and varied tasks, and shift the focus of instructional design from initial development toward curation, customisation, and facilitation.

1.2 The Research Gap and Objectives

While this potential is both clear and theoretically compelling, a significant gap remains within the empirical research. The educational community lacks sufficient objective data to compare the outputs of an AI-assisted design process with traditional, educator-developed tasks. This raises critical questions regarding whether AI-generated content meets the rigorous pedagogical standards required for the flipped classroom. Furthermore, it remains to be determined whether such technology defaults to lower order thinking, as some critics contend, or if it can genuinely facilitate the sophisticated, creative tasks essential for higher education.

This paper seeks to address this research gap by employing a quantitative comparative content analysis. The study examines a corpus of 20 tasks developed for a university-level statistics course: 10 designed by the course educator (Human Design; HD) and 10 produced by artificial intelligence (AI-Generated; AG). The research intends to address two primary questions:

1. Is there a significant difference in the quality of HD versus AG tasks based on the core pedagogical criteria of Application, Skills, and Collaboration?
2. Is there a significant difference in the cognitive level (as defined by Bloom's Taxonomy) of tasks designed by humans versus AI?

2 Literature Review

The Flipped Classroom model is an implementation of active learning approach (Bonwell & Eison, 1991). The foundational work by Bergmann and Sams (2012) in was quickly adopted by higher education, as it directly addresses the need to move beyond passive information transmission. The flipped classroom model is considered effective because it closely aligns with constructivist learning theories, which emphasize that learners actively construct their own understanding through experience and reflection rather than passively receiving information. This alignment has been repeatedly noted in the literature as one of the theoretical foundations of the flipped approach (Abeysekera & Dawson, 2015; Bishop & Verleger, 2013).

The in-class phase is where this learning is constructed. Research consistently shows that for an FC model to be effective, these in-class activities must be structured, challenging, and collaborative (Strayer, 2012). If students perceive in-class activities merely as conventional homework, motivation is likely to diminish, potentially leading to the failure of the model. Consequently, the onus on the educator to serve as a sophisticated designer of learning experiences is substantial.

2.1 Generative AI in Educational Design

The emergence of powerful generative AI, particularly LLMs like GPT-5, has created a new frontier in education. While much public discourse has focused on student use (and misuse), a significant and growing body of research examines AI's role as a tool for educators (Celik et al., 2022; Luo et al., 2025).

AI is being explored as a tool to:

- Generate formative assessment questions.
- Create diverse case studies and "real-world" problems.
- Differentiate instruction by creating variations of a task for different levels.

• Act as a "thought partner" or "sparring partner" for educators to brainstorm new teaching approaches.

Our previous research fit directly into this context, focusing on a high-leverage application using AI to solve the "task design bottleneck" of the Flipped Classroom (Pšenák et al., 2025).

The intersection of these two fields, FC pedagogy and generative AI, is new and largely theoretical. Most current literature consists of "how-to" guides, conceptual papers, and anecdotal reports. While optimistic, this body of work lacks the systematic, comparative analysis needed to validate its claims.

It is unknown if AI, when prompted, produces tasks of comparable quality to those designed by an experienced educator. Specifically, there is a concern that AI might excel at "superficial" content generation (Kwan et al., 2025) but struggle to create the complex, "Higher-Order Thinking Skills" (HOTS) tasks involving analysis, evaluation, and creation, which are the hallmark of an effective flipped classroom (López-Villanueva et al., 2024). This study directly addresses this empirical gap.

3 Methodology

This study employed a quantitative comparative content analysis of a task corpus (N=20). This methodology was selected as it provides a systematic and objective framework for evaluating the tasks against a predefined set of evaluative criteria (rubrics). The corpus was divided equally into two distinct groups to facilitate a between-groups comparison.

3.1 Corpus Development

A sample of 10 existing in-class activities was selected from the official repository of a university-level statistics course. These tasks were developed by the course instructor (an experienced educator) over the preceding five academic years and constitute a representative cross-section of the activities typically employed within the curriculum.

A corresponding set of 10 tasks was generated using a large language model (specifically, GPT-4). This process was carefully structured to ensure a fair comparison. For each of the 10 human tasks, we first identified its core learning objective (e.g., "Students will be able to perform and interpret a two-sample t-test").

This objective was then used in a structured prompt: "Act as an expert university-level statistics educator. Design an in-class, collaborative, problem-based scenario for a 50-minute flipped classroom session. The single learning objective for this task is: [Learning Objective]. The task should require students to work in small groups to produce a solution or interpretation."

This prompting strategy was designed to explicitly request the "creative tasks" that we advocate for.

3.2 Instrumentation and Coding

Each of the 20 tasks was independently scored by the same analyst using two instruments.
1. Pedagogical Rubric: A 3-point scale (0 = Absent, 1 = Partially Present, 2 = Clearly Present) was used to score three criteria:

1. Application: Measures if the task requires students to apply knowledge to a new scenario.

Score 2 (Clearly Present): Task requires application in a novel or real-world-like context.
Score 1 (Partially Present): Task is a straightforward procedural application.
Score 0 (Absent): Task is simple recall.

2. Skills: Measures if the task develops a specific technical or soft skill.

Score 2 (Clearly Present): Task explicitly asks for a skill demonstration.
Score 1 (Partially Present): Skill is implied but not required for the final product.
Score 0 (Absent): No skill development is included.

3. Collaboration: Measures if the task necessitates teamwork.

Score 2 (Clearly Present): Task requires a single, integrated group product or solution.
Score 1 (Partially Present): Task suggests discussion but is still completable alone.
Score 0 (Absent): Task is clearly designed for individual work.

2. Bloom’s Taxonomy: Each task was classified according to its highest-order cognitive skill, based on the revised Bloom’s taxonomy (Anderson & Krathwohl, 2001).

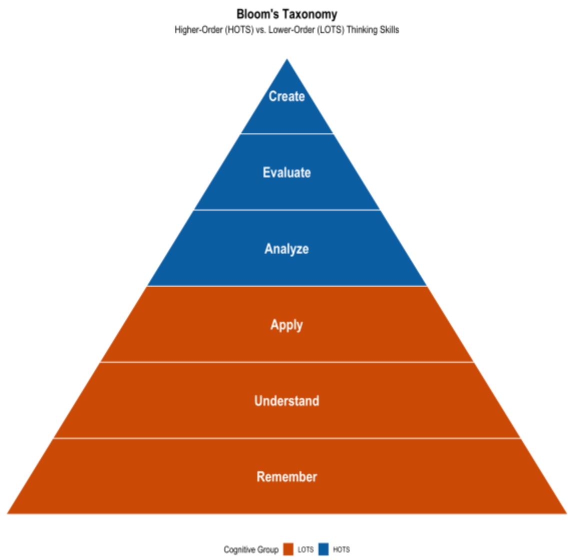

Figure 1: Revised Bloom’s Taxonomy (Anderson & Krathwohl, 2001).

For robust statistical analysis, these 6 levels were collapsed into two broader categories: Lower-Order Thinking Skills (LOTS) (Understand, Apply) and Higher-Order Thinking Skills (HOTS) (Analyse, Evaluate, Create). We excluded “Remember” as no tasks fell into this category.

3.3 Statistical Analysis

All data were analysed using R, which provides a flexible environment for statistical computing and reproducible research.
Rubric Data: The pedagogical rubric scores collected in this study are ordinal in nature and were obtained from a relatively small sample of participants. Given these characteristics, the assumptions for parametric tests (e.g., t-tests) were not met. Consequently, the non-parametric Mann-Whitney U test was employed to compare the distributions of scores for the dimensions of Application, Skills, and Collaboration between the HD and AG groups. This test is well-suited for ordinal data and small sample sizes, as it does not require the assumption of normality and compares the ranks of the scores rather than their raw values (de Winter & Dodou, 2010).
Bloom’s Taxonomy Data: To examine the distribution of cognitive levels across groups, a 2x2 contingency table was constructed with the factors Group (HD vs. AG) and Cognitive Level (LOTS vs. HOTS). Pearson’s Chi-squared test was then performed to determine whether the observed frequencies differed significantly from expected frequencies under the null hypothesis of independence. This analysis allows us to assess whether the groups differed in terms of the proportion of tasks targeting Lower-Order Thinking Skills (LOTS) versus Higher-Order Thinking Skills (HOTS). This approach ensures that both ordinal rubric data and categorical cognitive level data are analysed appropriately, providing a robust statistical foundation for comparing instructional outcomes between the two groups.

4 Results

The initial analysis of rubric scores showed that both groups produced high-quality tasks that were strong in applying knowledge and developing skills. The mean scores for Application (HD=1.9, AG=1.8) and Skills (HD=1.3, AG=1.5) were very similar.

Group	Mean Application	Mean Skills	Mean Collaboration	Count
HD	1.9	1.3	0.3	10
AG	1.8	1.5	1.8	10

Table 1: Summary of mean rubric scores by group.

The Mann-Whitney U tests confirmed this visual observation. There was no statistically significant difference in Application scores between the HD and AG groups ($W = 55, p = .58$). *There was no statistically significant difference in Skills scores between the HD and AG groups ($W = 41, p = .48$).
Both the human educator and the AI were equally proficient at creating tasks that required students to apply statistical knowledge and practice relevant skills. In sharp contrast to Application and Skills, the Collaboration metric showed a stark and significant difference. The mean score for the HD group was 0.3, indicating that the human-designed tasks were intended for solo work. The mean score for the AG group was 1.8, indicating that the AI-generated tasks were almost all explicitly designed as group activities. A Mann-Whitney U test found this difference to be highly statistically significant (W=6.5, p=.0004).
This result directly supports our prompting strategy. The AI, when asked to create collaborative tasks, was exceptionally effective at doing so, far surpassing the baseline tendency of the human educator.

4.1 Cognitive Level Analysis (Bloom's Taxonomy)

A primary concern was that AI might "dumb down" content. We analysed the cognitive level of all 20 tasks. The initial 6-level distribution was as follows:

Group	Remember	Understand	Apply	Analyse	Evaluate	Create
HD	0	1	3	3	2	1
AG	0	1	3	2	3	1

Table 2: Frequency of tasks by Bloom's Taxonomy level.

A Chi-squared test on this 2x6 table failed because the sample size was too small for the number of categories, with many cells having expected counts less than 5.
To resolve this, the categories were collapsed into Lower-Order Thinking Skills (LOTS) and Higher-Order Thinking Skills (HOTS), as described in the methodology. This produced a robust 2x2 contingency table:

Group	LOTS	HOTS
HD	4	6
AG	4	6

Table 3: Frequency of tasks by cognitive group (HOTS/LOTS).

The distribution was identical for both groups. Both the human educator and the AI produced a 60% majority of Higher-Order Thinking Skills tasks. A Pearson's Chi-squared test confirmed this visual finding, showing no statistically significant difference ($\chi^2(1) = 0, p = 1$).

This approach ensures that both ordinal rubric data and categorical cognitive level data are analysed appropriately, providing a robust statistical foundation for comparing instructional outcomes between the two groups.

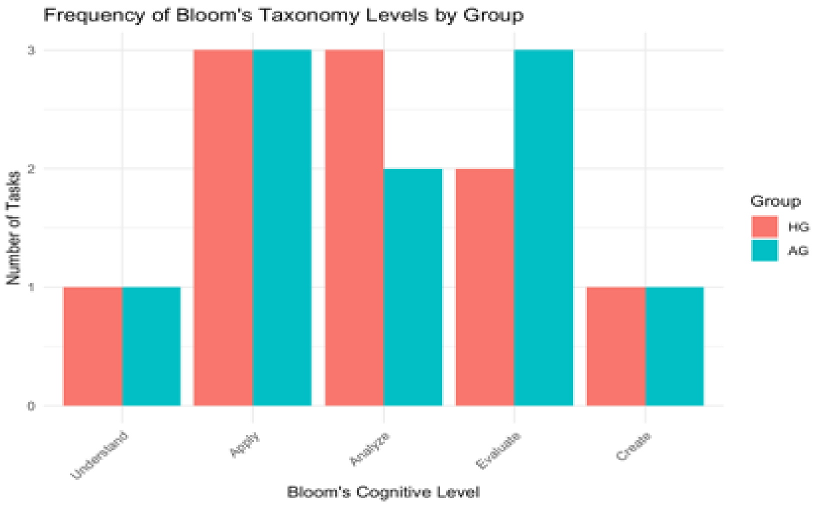

Figure 2: Frequency of Bloom’s Taxonomy Levels by Group.

Figure 2 illustrates that the overall distribution of tasks across different Bloom’s taxonomy levels is largely similar, with no statistically significant differences observed. This suggests that the Human-Designed and AI-Generated tasks were comparable in their cognitive scope, indicating that AI was able to produce tasks that closely mirror the intended complexity and variety of human-created tasks.

5 Discussion

The most valuable finding of the paper is AI’s profound and statistically significant strength in generating Collaboration tasks. The human-generated tasks, while pedagogically sound, reflected a common educator tendency of designing solo-work activities (Mean = 0.3). The AI, in contrast, consistently produced tasks (Mean = 1.8) that required group interaction, shared problem-solving, and a single group product.

This directly supports the proposal of this paper that AI can be used to design the “role plays,” “problem-based scenarios,” and “project activities” that are foundational to the FC model. The AI, unburdened by an educator’s established habits or the “worksheet” model of task design, appears to be an exceptional tool for breaking out of this solo-work paradigm.

Our second key finding refutes the common concern that AI may “dumb down” educational content. The AI-generated tasks were indistinguishable from the human-designed tasks in terms of pedagogical quality.

- There was no difference in requiring students to Apply knowledge or develop Skills.

• Crucially, there was no difference in cognitive demand. The AI was just as capable as the human educator at creating tasks that demand Higher-Order Thinking Skills.

This suggests that fears of AI defaulting to lower order, 'remember' or 'understand' tasks are unfounded, provided the AI is prompted effectively. Our methodology, which explicitly defined the learning objective and context, demonstrates that AI can operate at the higher levels of Bloom's Taxonomy.

5.1 Practical Implications for Educators

The practical implication of these findings is that AI should not be perceived as a replacement for the academic, but rather as a powerful "collaborative assistant". A proposed effective workflow for a contemporary educator employing the Flipped Classroom model is as follows:

1. The educator defines the learning objectives, the specific course context, and any relevant constraints.
2. The educator prompts the AI to generate a variety of creative structures for the in-class activity.
3. The educator then curates, adapts, and performs "human-in-the-loop" editing of the optimal AI-generated output, infusing it with specific domain expertise and an understanding of their students.

This model leverages AI's while retaining the educator's essential role as the pedagogical expert. It can save educators significant time in the design phase, allowing them to focus on the in-class facilitation.

5.2 Limitations and Future Research

This study has several important limitations:

1. Sample Size: The N=20 corpus is small and drawn from a single university course. The findings may not generalize to other disciplines, such as the humanities, or to other educational levels.
2. Single Coder: The use of a single coder for the full corpus could introduce bias.
3. Prompt Dependency: The quality of AI output is highly dependent on the quality of the prompts. Our structured-prompting method was effective, but different prompting strategies could yield different results.
4. Existing Tasks: The HD tasks were pre-existing. A different study design might involve an educator and an AI starting from the same "blank page" to design a task for the same objective.

Future research should expand this methodology to encompass a larger, multi-disciplinary corpus of tasks. However, the most critical progression involves moving from the design phase to empirical implementation. It is imperative that future studies deploy these AI-generated tasks within a live classroom environment to evaluate their impact on student engagement, the quality of in-class collaboration, and, ultimately, student learning outcomes.

6 Conclusion

This study demonstrates that generative AI can effectively support the design of complex, collaborative, and pedagogically sophisticated tasks within the flipped classroom model. The findings indicate that AI-generated tasks demonstrated equivalence to those developed by humans in relation to collaboration, skill development, and higher-order cognitive engagement. Consequently, these results challenge the prevailing concern that the integration of AI may "dilute" or simplify academic content.

The findings suggest a practical workflow wherein academics define core objectives, AI generates a diverse range of task options, and the educator subsequently curates and refines these outputs. This "human-in-the-loop" approach leverages the efficiency and generative capacity of AI whilst retaining the indispensable pedagogical judgement of the academic.

The limitations of this study include the restricted scale of the single-course sample, the reliance on a single-coder analysis, and the inherent dependency on prompt quality. Consequently, it is imperative that future research evaluates AI-generated tasks within authentic classroom environments across a broader range of disciplines. Such investigations are necessary to rigorously assess the impact of these interventions on student engagement, the quality of collaboration, and, ultimately, measurable learning outcomes.

In conclusion, artificial intelligence demonstrates considerable potential as a high-leverage instrument for addressing the "task design bottleneck" inherent in flipped learning. By facilitating the more efficient production of high-quality activities, these tools empower academic staff to overcome resource constraints without compromising pedagogical integrity.

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Programming and Technical Skills of Students Using a Microcontroller

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Abstract

The article presents an analysis of some research results. The research was conducted using a pre-test and post-test. The test was conducted before and after the practical part of the project, the aim of which was to verify the development of students' knowledge and skills in the field of BBC micro:bit microcontroller programming and technical skills. The testing focused on a basic understanding of the principles of the BBC micro:bit microcontroller, the ability to navigate the MakeCode environment, and the application of knowledge in solving simple tasks. The research was conducted at an elementary school and involved students in grades 5–9. Eighty-four students took the entrance test, and 65 students took the exit test after completing the course using specially designed teaching aids. The results indicate a positive impact of experimental teaching on the development of students' programming and technical skills.

Keywords: BBC Micro:bit, STEM Education, Elementary School

1 Introduction

Education in the 21st century requires a change in teaching approaches that reflects the modern needs of society and technological progress. The STEM concept represents an educational approach in which the fields of science, technology, engineering and mathematics are interconnected into a single coherent system that enables pupils to acquire knowledge through application, inquiry and practical problem solving. Within primary education, theoretical teaching without sufficient connection to practice still dominates, which may limit

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the development of pupils' ability to link knowledge across subjects and to understand its relevance in real life. Integrating microcontrollers into teaching represents an effective way to support interdisciplinary education. The BBC micro:bit microcontroller is a suitable tool for primary schools due to its simple design, the availability of sensors and intuitive programming in MakeCode. By incorporating real measurements into lessons, pupils can observe physical phenomena in practice, analyse the measured values and apply theoretical knowledge when solving problems. This type of instruction supports the development of practical technical skills, digital competencies and algorithmic thinking. As part of the research, a teaching intervention was designed that focused on the use of the BBC micro:bit microcontroller and several external sensors, through which primary school pupils measured water temperature and air humidity. The aim of the research was to quantify the impact of this experimental teaching method on pupils' knowledge of the software and hardware of the BBC micro:bit microcontroller. The research was conducted using a pre-test and post-test and focused on changes in the level of knowledge in programming and working with sensors.

2 The STEM Concept in Teaching

National policymakers in the field of education, along with educational institutions worldwide, are placing increasing emphasis on providing students with an education that reflects contemporary needs and labour market demands of the twenty-first century (Skinner, Saxton, Currie, Shusterman, 2017, p 2433–2459). Many contemporary school environments still fail to engage students effectively in learning, as they continue to rely on educational models that are more than half a century old (World Economic Forum, 2017, p 7-12). Most education at primary and secondary schools (ISCED 1–ISCED 3) continues to focus more on theory than on the application of theory in practice, and teaching is carried out in a way that does not strengthen links between individual subject areas (Nadelson, Seifert, 20217, p 221 –223).
Given the growing demand for a workforce with knowledge in the field of STEM education, national efforts in educational policy are intensifying worldwide. In the scholarly literature, the STEM approach to education is described in various ways (Bybee, 2013, p 1-7). For example, Vasquez, Comer and Gutierrez (Vasquez, Comer, Gutierrez, 2020, p 11-23) state in their publication that STEM education is an interdisciplinary approach to teaching and learning that removes the traditional barriers between the four disciplines of science, technology, engineering and mathematics and integrates them into relevant learning units that are applicable for students in real life.
According to Dugger (Dugger, 2020, p 2-5), STEM is an educational approach that aims to provide students with the ability to communicate in an interdisciplinary way, to work in teams, to think creatively, to engage in inquiry-based research, and to create and solve problems with an emphasis on integrating knowledge and skills from science, technology, mathematics and engineering into instruction based on engineering design (Kelley, Knowles, 2016, p 2-11). In the article A conceptual framework for integrated STEM education, the authors Kelley and

Knowles (Kelley, Knowles, 2016. p 2-11) describe the STEM approach in education as relating to teaching, learning and integrating the disciplines of science, technology, mathematics and engineering into science topics with an emphasis on solving modelled real-world situations and practical tasks. In this approach, students acquire key competencies and complex cognitive skills. These skills are necessary for creating meaningful connections in the processing of knowledge, which leads to interdisciplinary, meaningful understanding.

The authors Spelt, Biemans, Tobi, Luning and Mulder (Spelt, Biemans, Tobi, Luning, Mulder, 2009, 365-378) define interdisciplinarity as the ability to integrate knowledge from two or more disciplines to achieve cognitive progress in a way that would be impossible or unlikely when using the resources of a single discipline.

STEM education is perceived as an interdisciplinary approach that connects science, technology, engineering and mathematics into meaningful, reality-oriented tasks. Its aim is to develop teamwork, creative and critical thinking, problem-solving skills and the ability to integrate knowledge across disciplines. Interdisciplinarity is understood here as the integration of knowledge from several fields in such a way that it enables cognitive progress which a single discipline could not achieve on its own.

3 Microcontrollers

A microcontroller is a small computer system located on a single integrated circuit. Typical examples of such systems include Arduino boards or the BBC micro:bit. An embedded system is a computer with a specific, precisely defined function that is usually not designed to be reprogrammed later (e.g., engine control units, implanted medical devices, household appliances, etc.). Microcontrollers are particularly suitable for tasks such as reading data from sensors and implementing control algorithms, and it is important to realize that they are digital devices. To interface with the analogue world, they use digital-to-analogue conversion (DAC) to convert binary values into a real output voltage, and analogue-to-digital conversion (ADC) to convert an analogue input signal into digital data that the microcontroller can process.

The most used microcontroller platforms include the BBC micro:bit, Arduino and Raspberry Pi, while older types such as PIC microcontrollers may be suitable for alternative didactic approaches. Individual microcontrollers differ in size, available features, the ratio of functionality to size, software architecture, number of input–output (I/O) pins, power requirements, processing speed and other parameters (Lambert, 2017, p 4 - 7).

In this paper, we focus on the BBC micro:bit microcontroller. It is a small programmable microcontroller that combines several sensors and components: an LED display, buttons, an accelerometer, a compass, a temperature sensor and Bluetooth. It works in such a way that pupils create a program on a computer, tablet or smartphone (for example in the MakeCode environment using block-based programming), upload it to the micro:bit, and the device then executes the given commands it displays an animation, measures temperature, reacts to movement, controls external devices, etc.

The BBC micro:bit microcontroller is programmed in the MakeCode environment. MakeCode is a visual programming platform developed by Microsoft for easily creating programs for microcontrollers. It is intended primarily for educational purposes and enables block-based programming, where pupils intuitively assemble blocks in a way like a puzzle. The MakeCode platform runs directly in a web browser and does not require any software installation. Each block in a program represents a particular command or function, such as a measurement, a calculation, a condition or data display. In addition to the block interface, MakeCode also offers the option to switch to text mode in JavaScript or Python, which allows pupils to gradually transition to more advanced forms of programming. In the MakeCode environment, pupils can create interactive projects, work with sensors, LEDs, displays and other extension modules. The platform supports experimentation and provides immediate feedback the result of a program can be simulated directly in the browser or transferred to a real device via a USB cable.

For education in Slovak primary schools, the BBC micro:bit is suitable for several reasons:

- **Low entry barrier** – block-based programming is understandable even for younger pupils; they do not need prior coding experience.
- **Connection to real life** – pupils can create concrete projects (measuring classroom temperature, a pedometer, a simple alarm), which helps them better understand the purpose of programming.
- **Support for cross-curricular links** – the BBC micro:bit makes it possible to connect informatics with physics, technology, mathematics or science (measurement, experiments, projects).
- **Safety and availability** – the device is robust, safe to use and relatively affordable even for Slovak schools, and there is a large amount of teaching material available in Slovak.

This makes the BBC micro:bit a suitable tool for developing digital competencies, logical thinking, and interest in STEM fields in the first and second grades of elementary school.

4 The Research

We pursued the research objective by implementing an activity designed by us with the BBC micro:bit microcontroller. The activity, focused on measuring water temperature and air humidity using the BBC micro:bit and external sensors, was carried out with lower-secondary pupils in the subject of Technology as a model example of working with a microcontroller and sensors from the Smart home kit. Pupils worked in small groups (2–4 students) and built on a short introductory explanation by the teacher, who clarified the aim of the activity, reviewed the concepts of temperature and air humidity including their units, introduced the microcontroller, the sensors used, and the basic safety rules for working with electronics and water. In the first phase, in the computer lab, pupils created a simple program in the MakeCode environment which, in an infinite loop, read values from the sensors and displayed them on the micro:bit's LED display or in the serial monitor. In the second phase, they practically assembled the measuring circuit on an expansion board and carried out measurements of water temperature and air humidity under different conditions (cold/warm water, various environments in the classroom and its surroundings), continuously interpreting changes in the measured values. The final discussion focused on reflecting on the observed phenomena and on how the sensors and the microcontroller helped them better understand the behaviour of water temperature and air humidity in real situations.

The activity is aimed at developing pupils' ability to connect knowledge from multiple subjects, understand their interrelationships and use them when solving concrete tasks. Within this interdisciplinary approach, pupils use mathematical skills when processing measured data, physics knowledge when interpreting the results, and informatics skills when programming and visualising the data. At the same time, it fosters environmental awareness by having pupils monitor physical quantities related to phenomena in nature. This type of instruction can lead to a deeper understanding of the relationship between technologies, humans and the environment, which is one of the main goals of interdisciplinary education.

The Research sample

The research was carried out with primary school pupils in grades 5–9 who took part in instruction focused on block-based programming and working with sensors in the BBC micro:bit and MakeCode environments. A total of 84 pupils participated in the pre-test, with gender evenly distributed (50% boys and 50% girls). The same knowledge test was subsequently administered after completion of the teaching module as a post-test, in which 65 pupils responded, of whom 55.4% were boys and 44.6% were girls.

The difference between the number of respondents in the pre-test and post-test (a decrease of 19 pupils, i.e., approximately 22.6%) is due to a natural rate of attrition (absence at the second measurement, organisational reasons, non-participation in the entire module, etc.). The analysis of the results is therefore based on two partial samples: one for the initial knowledge level (N = 84) and the other for the final level (N = 65).

The pupils represent a typical lower-secondary school population becoming familiar with block-based programming and sensors through a practically oriented project. This target group is didactically relevant, as it is an age at which pupils first encounter programming, abstract thinking and the concepts of measuring physical quantities using sensors in a more systematic way.

Structure and content of the test

The research instrument was a knowledge test (a questionnaire with closed-ended items) that was administered at two time points as a pre-test and a post-test. The test consisted of multiple questions, but for the purposes of this article we used seven selected closed-ended questions focused on key areas:

1. *Block-based programming and working in the MakeCode environment*
    - What does “block-based programming” mean?
    - How can you test your program in MakeCode to find out whether it works correctly?
    - What is the purpose of the “repeat every” block?

These items verify whether pupils understand the basic nature of block-based programming (visual blocks instead of text-based code), the principle of simulation in MakeCode, and the use of timing/control blocks (periodic repetition of actions).

2. *Sensors, measurement and technical components*
    - Which of the following sensors is used to measure the temperature of a liquid?
    - What are the pins on the expansion board at the bottom of the board used for?
    - On what principle does the soil moisture sensor work?
    - What type of data does this sensor detect?

This group of items specifically examines understanding of the functions of sensors (temperature sensor, soil moisture sensor) and of the technical infrastructure (expansion board, connecting sensors via pins). Pupils must be able to match a sensor to the quantity being measured and understand that a sensor operates on a specific physical principle (e.g., a change in the electrical conductivity of soil as its moisture changes).
The content of the test is thus targeted at the cognitive level of understanding and basic application – the pupil should be able to explain concepts (block-based programming, simulation, timer), assign a sensor to its purpose, and interpret what a given sensor measures.

Item form and scoring
All items were designed as closed-ended questions with a single correct answer. Pupils selected their answer from the options provided.

- Each correct answer was scored with 1 point.
- Each incorrect answer was scored with 0 points.
- The total score for an individual pupil therefore ranged from 0 to 7 points.

The construction of the knowledge test was based on the objectives of the teaching module:

- to introduce pupils to block-based programming in the MakeCode environment,
- to develop understanding of sensors (temperature, soil moisture, etc.) and their use in controlling simple technical systems.

From a methodological perspective, this is a content-focused knowledge test that complements practically oriented instruction.

5 Pre-test and Post-test Evaluation

After summing all correct answers across items, pupils in the pre-test answered correctly 207 times out of 588 possible responses, which corresponds to an average success rate of approximately 35.2%. In the post-test, we recorded 195 correct answers out of 455, i.e. an average success rate of approximately 42.9%.

The average proportion of correct answers per item thus increased from 35.2% (pre-test) to 42.9% (post-test), which represents:

- an average increase of 7.7 percentage points,
- a relative improvement in the average success rate of approximately 22% (≈ +21.8% relative to the baseline value).

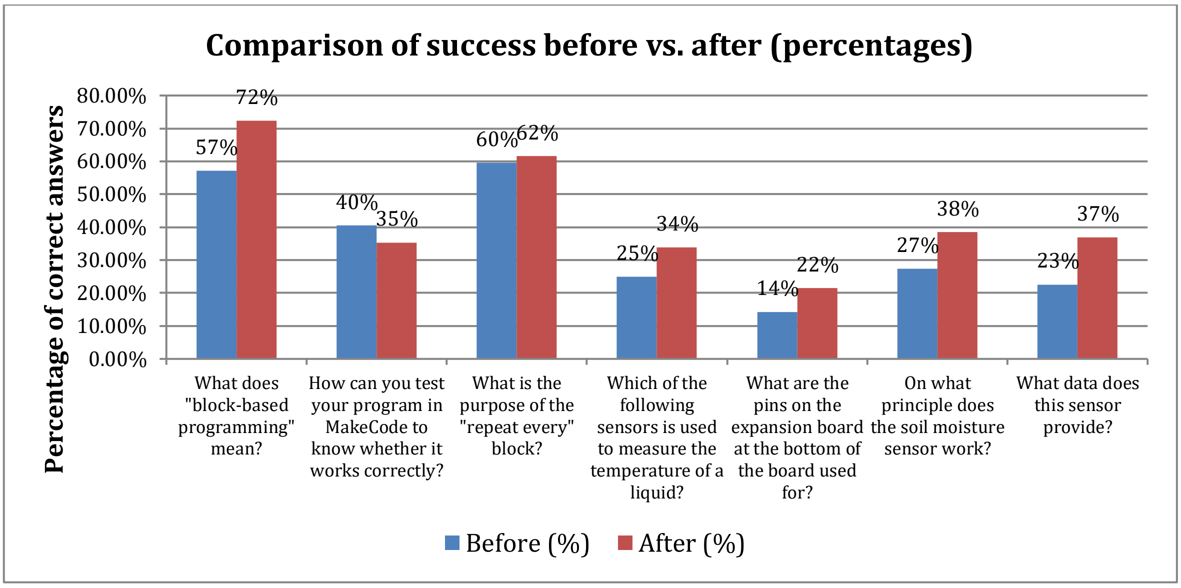

Figure 1: Comparison of pre-test and post-test results.

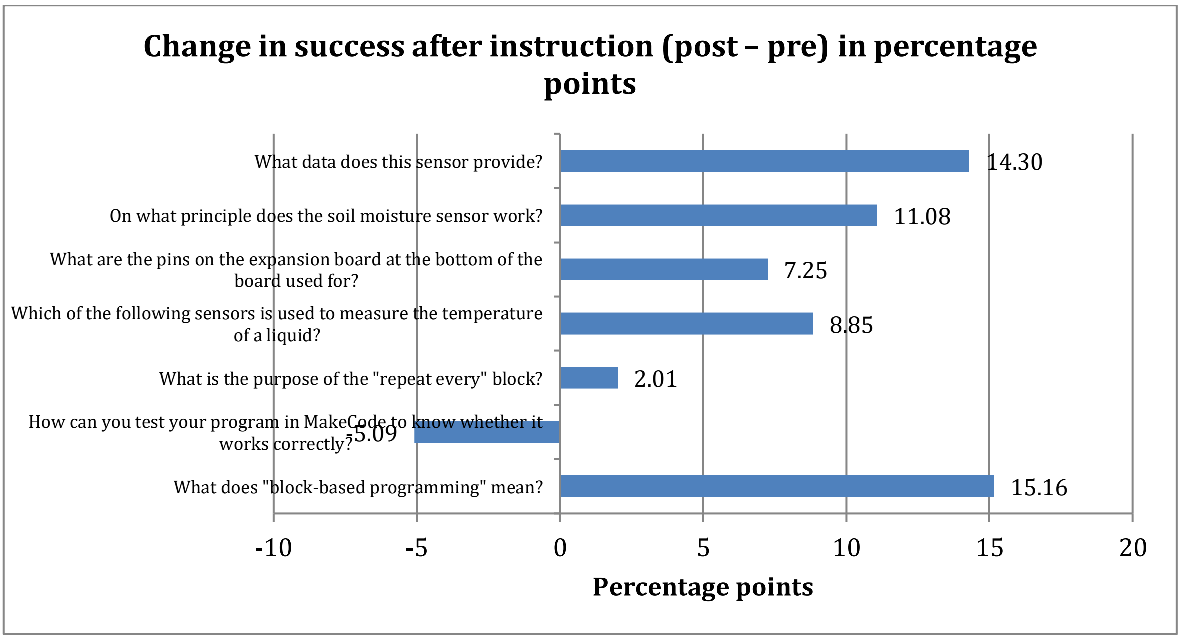

Figure 2: Representation of the change in pupils' success rate in percentage points.

In Figure 2, the change in success after the instructional intervention is shown in percentage points, with a mean value of 7.65 percentage points. This means that a typical item showed a slight shift towards higher success. However, the spread between items is relatively large (from –5.09 to +15.16 percentage points), which suggests that some concepts were learned much more strongly than others, while in one item there was even a slight deterioration.

Area 1: Block-based programming in MakeCode

Definition of "block-based programming"

The first item examined whether pupils understand the basic concept of block-based programming.

- Pre-test: 48 out of 84 pupils answered correctly, which represents 57.1%.
- Post-test: 47 out of 65 pupils answered correctly, i.e. 72.3%.
- Change: +15.16 percentage points.

This is the highest increase among all items. The initial level of understanding was already relatively good in the pre-test (more than half of the pupils), but after the intervention the proportion of pupils with the correct answer increased substantially. The effect can be characterised as small to medium (Cohen's h ≈ 0.32), which, given the short intervention, represents a favourable outcome. From a didactic perspective, this suggests that working with concrete examples in the MakeCode environment, visual blocks and program demonstrations effectively supported conceptual understanding of what block-based programming is.

Testing a program in the MakeCode environment

The second item focused on the process of testing a program, i.e. checking whether it works correctly.

- Pre-test: 34/84 pupils, i.e. 40.5% correct answers.
- Post-test: 23/65 pupils, i.e. 35.4%.
- Change: –5.09 percentage points.

This is the only item that shows a slight deterioration. However, the effect is small (Cohen's h ≈ –0.10), which indicates stagnation rather than a dramatic decline. Compared to the other items, it appears that while pupils relatively well grasped the conceptual side of block-based programming, the practical procedure for testing a program remains unclear for part of them. In the future, it would be appropriate to include more activities in which pupils consciously verbalise the testing procedure and compare different options (simulator, physical device, step-by-step debugging).

Function of the "repeat every" block

The third item focused on the concept of a timing loop (the "repeat every …" block).

- Pre-test: 50/84 pupils, i.e. 59.5% correct answers.
- Post-test: 40/65 pupils, i.e. 61.5%.
- Change: +2.01 percentage points (Cohen's h ≈ 0.04).

Success was already relatively high in the pre-test and increased slightly after the intervention. The change is minimal – it rather confirms that the concept of repeatedly executing commands at regular intervals was already familiar to some pupils at the outset. From a pedagogical point of view, this area does not seem to represent as pronounced a bottleneck as some of the more technical aspects of sensor work.

Summary for the area of block-based programming

If we average the success rates of the three programming-related items, we obtain:

- Pre-test: on average 52.4% correct answers,
- Post-test: on average 56.4% correct answers.

The average increase in this area is therefore approximately 4 percentage points. Overall, this means that pupils already had a relatively good intuitive understanding of the basic principles of block-based programming at the beginning, and the intervention further slightly strengthened it, especially regarding the definition of the concept of "block-based programming". From a didactic perspective, it is necessary to define and elaborate more precisely the procedural steps related to testing a program.

Area 2: Sensors and hardware components

The remaining four items concern the specific soil moisture sensor and the related hardware (expansion board, pins, type of signal). The initial success rate in this area was markedly lower than in programming, which reflects pupils' more limited prior experience with electronic hardware.

Identification of the soil moisture sensor

The fourth item (choosing the correct sensor from the options offered):

- Pre-test: 21/84 pupils, i.e. 25.0% correct answers.
- Post-test: 22/65 pupils, i.e. 33.8%.
- Change: +8.85 percentage points, small effect (Cohen's h ≈ 0.19).

After the project, pupils were better able to identify which hardware component is the soil moisture sensor, but even after the intervention the success rate remains at only about one third. This may also be due to the complex names of sensors composed of numbers and letters; pupils may not have remembered these names correctly.

Function of the pins on the expansion board

The fifth item asked about the purpose of the pins on the expansion board:

- Pre-test: 12/84 pupils, i.e. 14.3%.
- Post-test: 14/65 pupils, i.e. 21.5%.
- Change: +7.25 percentage points, small effect (Cohen's h ≈ 0.19).

This is the item with the lowest absolute success rate in both the pre-test and the post-test. Although the direction of change is positive, most pupils still do not clearly understand what the individual pins are used for. From a didactic point of view, this points to the need for more explicit visual labelling and step-by-step explanation of their function.

Operating principle of the soil moisture sensor

The sixth item examined whether pupils know the basic physical principle on which the sensor operates:

- Pre-test: 23/84 pupils, i.e. 27.4%.
- Post-test: 25/65 pupils, i.e. 38.5%.
- Change: +11.08 percentage points (Cohen's h ≈ 0.24).

The increase is more pronounced than for the identification of the sensor or understanding the function of the pins. This suggests that the explanation of the physical and technical principle (change in conductivity at different soil moisture levels or another mechanism) was didactically effective, but it is still a concept with which about 60% of pupils have difficulties. At primary school level, this already represents somewhat more abstract content that may require more experimental activities.

Type of output data from the sensor

The seventh item examined what kind of data the sensor provides:

- Pre-test: 19/84 pupils, i.e. 22.6% success rate.
- Post-test: 24/65 pupils, i.e. 36.9%.
- Change: +14.30 percentage points, small to medium effect (Cohen's h ≈ 0.31).

This is one of the items with the most pronounced relative improvement, although the absolute success rate remains moderate. The result suggests that after completing the activity, pupils had a much clearer idea of what kind of data the sensor provides.

Summary for the area of sensors and hardware

The average proportion of correct answers in this area was:

- Pre-test: 22.3%,
- Post-test: 32.7%.

The average increase thus reaches approximately 10.4 percentage points, i.e. higher than for the programming items. At the same time, however, the absolute success rate remains lower than for block-based programming: even after the intervention, only about one third of pupils answered correctly. From a didactic perspective, this means that the intervention was able to improve understanding of sensors and hardware more markedly, but this is an area in which pupils started from a very low baseline level and would probably need more time, repetition and visual support to achieve a similar level of confidence as in programming.

The analysis of the seven items of the knowledge test shows that the implemented educational activity led to:

- an overall slight increase in the average success rate (from 35.2% to 42.9%, i.e. +7.7 percentage points),
- a more pronounced improvement in sensors and hardware (≈ +10.4 percentage points),
- a more modest improvement in block-based programming (≈ +4 percentage points),
- the greatest gains in defining basic concepts (block-based programming, type of data provided by the sensor),
- and persistent difficulties in procedural and hardware-related details (testing the program, function of the pins on the expansion board).

From the perspective of effect size, most items show small effects (Cohen's h approximately 0.19–0.32), which is to be expected for a one-off or short-term intervention at primary school level. The exception is the item on testing a program, where the effect is slightly negative and points to the need to revise the didactic design of this part of the content.

Verification of results based on age

When evaluating the data, we also focused on the pupils' results by age. We were interested in whether pupils' age influenced the knowledge acquired.

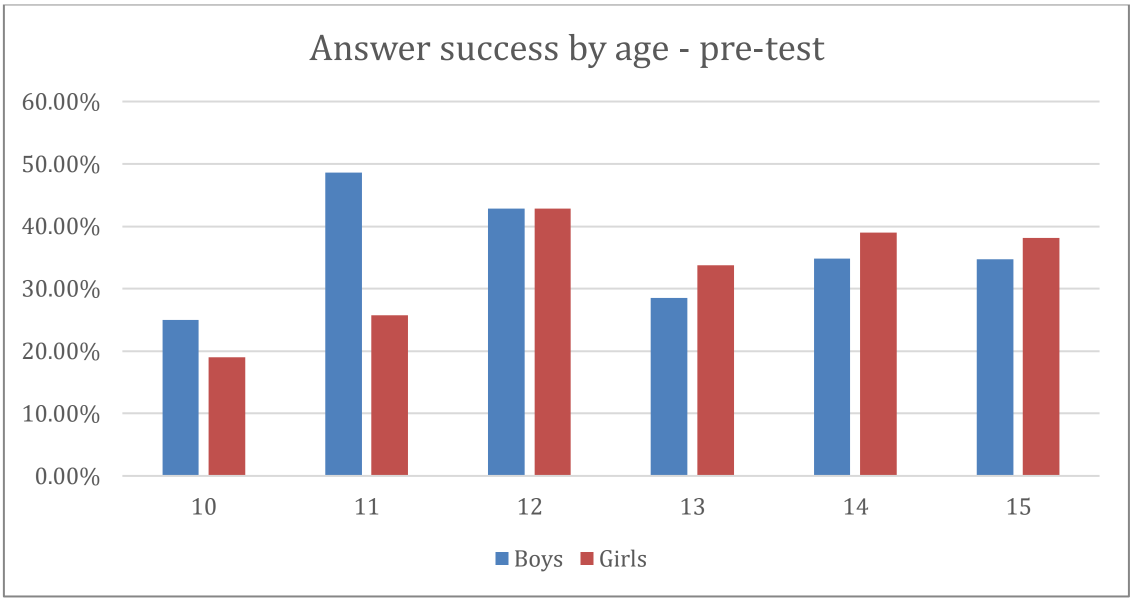

Figure 3: Success rate of pupils' answers by age in the pre-test.

In the pre-test, the success rate of answers ranges approximately between 20–50%. We do not observe a simple linear trend of "the older, the better"; rather, there is a local maximum around 11–12 years of age:

- **10 years:** boys achieve a success rate of about one quarter of correct answers, while girls are even lower (below 20%). At this age, boys thus have a slight advantage, but the overall level of knowledge is low.

- **11 years:** this is the group with the highest success rate for boys in the entire pre-test (almost 50%), whereas girls are only at about one quarter of correct answers. A pronounced gender asymmetry in favour of boys is evident here.
- **12 years:** boys and girls achieve very similar performance (around 40–43%). This is the only age category in which the genders are practically equal in the pre-test.
- **13–15 years:** among older pupils, success rates range around 30–40%. In these age categories, girls have a slight advantage: their bars in the graph are systematically a few percentage points higher than those of boys.

The pre-test thus suggests that:

- in the lower grades (10–11 years), boys are somewhat more successful in the tested knowledge,
- from around age 13 onwards, performance gradually shifts in favour of girls,
- there is no simple increasing trend between age groups, which may be related to differences in prior experience with the topic and differences between classes.

Distribution of success rates in the post-test

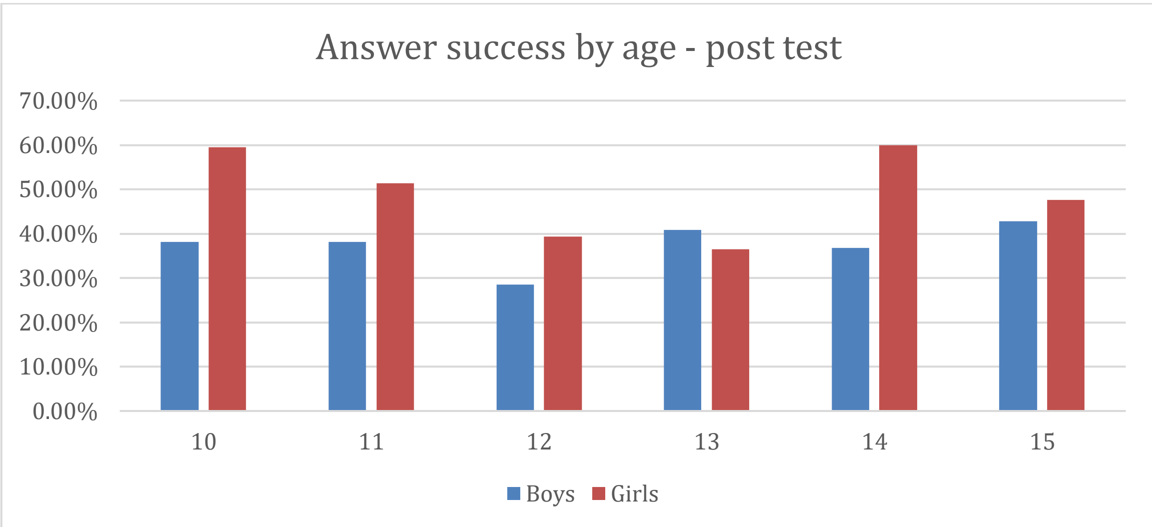

Figure 4: Success rate of pupils' answers by age in the post-test.

In the post-test, the overall level of knowledge shifts upwards – most bars are higher than in the pre-test, especially for girls. The spread of values ranges approximately between 30–60%.

- **10 years:** boys improve to roughly 40%, while girls reach almost 60%. The difference between genders after the intervention is very pronounced in favour of girls.
- **11 years:** boys slightly decrease to around 38%, whereas girls improve to approximately 50%. The original advantage of boys from the pre-test shifts in favour of girls.

- **12 years:** after the intervention, boys have a lower success rate (around 30%) than in the pre-test, while girls are slightly above 40%. Here too, after instruction there is a clear shift in favour of girls.
- **13 years:** in one of the few groups, boys are more successful after the intervention (around 40%) than girls (just under 40%). However, the difference is considerably smaller than among 10- or 14-year-olds.
- **14 years:** boys remain approximately at the pre-test level (around 37%), while girls improve markedly to about 60%. This is the largest observed gender difference in favour of girls.
- **15 years:** both boys and girls improve their results (boys to approximately 43%, girls to almost 50%), with girls maintaining a slight advantage.

The post-test thus clearly shows that girls benefited from the intervention more strongly than boys in most age categories. Gender differences, which in the pre-test were rather small and local (except for 11-year-olds), increase considerably after instruction in some ages (10, 11 and 14 years) in favour of girls.

Changes between the pre-test and post-test

When comparing the two graphs, several patterns can be identified:

1. **Overall trend of improvement**. In most of the age × gender combinations, the post-test bar is higher than in the pre-test, which indicates an overall positive effect of instruction. The exceptions are some groups of boys (especially 12-year-olds), where success rates decreased after the intervention.
2. **Strong effect among younger girls**. Among 10- and 11-year-old girls, there is a shift from low values (around 20–25%) to levels above 50%. This is the most pronounced relative increase in the entire dataset, which may suggest that project-based work with technologies activated a new interest in this group and supported rapid acquisition of basic concepts.
3. **Heterogeneous effect among boy.** Boys in most age categories show only a modest increase (e.g. 10, 13, 15 years), and in some cases stagnation or decline (11, 12, 14 years). This indicates that the intervention was not uniformly reinforcing for boys, and its effectiveness may be moderated by prior experience, motivation, or the way of working in classes, particularly.
4. **Change in the pattern of gender difference.** Whereas in the pre-test gender differences are often small and in the lower grades even in favour of boys, after the intervention the pattern changes: girls outperform boys in almost all ages except 13 years. This may mean that the implemented way of working is relatively more inclusive for girls and better supports their confidence in technical tasks.

From the results it can be concluded that the educational intervention leads to an overall increase in success rates in the tested knowledge. It has a particularly strong positive impact on girls in the younger and middle grades. At the same time, it changes the profile of gender differences from a slight advantage of boys in the lower grades in the pre-test to a prevailing advantage of girls after instruction.

6 Conclusion

The research findings indicate that a one-off experimental teaching intervention focused on working with the BBC micro:bit microcontroller and sensors in the MakeCode environment led to a modest but pedagogically meaningful improvement in pupils' knowledge. The average success rate in the knowledge test increased from 35.2% in the pre-test to 42.9% in the post-test, with a higher gain observed in sensors and hardware than in block-based programming. This suggests that a practically oriented activity involving real measurements and data interpretation can foster understanding of basic technical concepts, even when pupils start from a low baseline level.

In the area of block-based programming, pupils already possessed relatively good intuitive understanding of the basic concepts before the intervention, and the instruction further strengthened this understanding, particularly regarding the definition of "block-based programming." The procedural dimension, especially testing and debugging programs in the MakeCode environment, remained a weaker point. In the area of sensor work and hardware, the findings confirmed that pupils initially had very limited experience; after instruction, however, there was a noticeable increase in success rates on items focused on the operating principle of the soil moisture sensor and the interpretation of measured data, although the overall level of knowledge remains moderate.

The analysis of results by age and gender showed that the activity particularly benefited girls, who, after instruction, achieved higher success rates than boys in many age categories. This suggests that project-based work with a microcontroller can contribute to reducing traditional gender gaps in technical and programming domains and represents an inclusive approach for a broader spectrum of pupils.

At the same time, the results highlight certain limitations of the intervention. It was a relatively short teaching module, without a control group and with a natural drop in the number of respondents between the pre-test and post-test. For future work, it appears promising to expand the number of thematic blocks, include longer-term projects, and elaborate more thoroughly the didactic design of those areas in which pupils experienced the greatest difficulties (program testing, functions of hardware components). Despite these limitations, it can be concluded that the BBC micro:bit represents a suitable tool for developing basic programming and technical competences among lower-secondary pupils in the context of STEM and interdisciplinary education.

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Using Generative AI to Evaluate Pre-Service Teachers' Project-Based Learning Designs

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Abstract

This paper presents an innovative application of generative artificial intelligence to the evaluation of project-based learning (PBL) lesson preparation by pre-service teachers of vocational subjects. Using a system prompt grounded in the Gold Standard PBL criteria (Larmer, Mergendoller, & Boss, 2015), the AI analyses project quality in terms of intellectual challenge, authenticity, student voice and choice, reflection, critique and revision, and public product, with particular attention to the development of critical thinking and problem-solving skills. The evaluation process includes criterion-based commentary, identification of strengths and areas for improvement, and the provision of constructive feedback to students. The primary aim is to support the development of key professional competencies among future teachers and to enhance their ability to design meaningful and effective project-based instruction. The paper further discusses the pedagogical benefits, limitations, and ethical considerations associated with this approach.

Keywords: Artificial Intelligence, Project-Based Learning, Lesson Design Evaluation, Gold Standard PBL, Pre-Service Teachers, Vocational Education, Feedback, Didactic Reflection

1 Introduction

Throughout history, humans have sought to improve their living conditions through the development of tools and technologies, primarily aimed at reducing the physical demands of labour. Historical analysis reveals several periods marked by fundamental transformations in production processes and modes of work, commonly referred to as industrial revolutions. The

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most recent, the Fourth Industrial Revolution, extends beyond automation and robotization to include the integration of advanced information technologies into production systems. In the context of increasing automation and robotization, concerns have emerged regarding potential job displacement (Oosthuizen, 2022). At the time, creative work was generally considered less vulnerable to such changes; however, this assumption has been challenged by the rapid advancement of artificial intelligence. Artificial intelligence is based on people's efforts to describe and simulate learning processes (Zirar, 2023), (Ahmmed et al., 2024). People have long sought to develop various algorithms capable of solving different problems (Zirar et al., 2023). This effort is currently manifested in the form of artificial intelligence, the core of which is based on processes that we may not be familiar with and are therefore unable to describe.

On the one hand, we can view artificial intelligence as something that can threaten us and potentially take away jobs based on creativity. On the other hand, however, if we learn to use artificial intelligence, it can significantly increase the efficiency of our work. Artificial intelligence is here to stay, so we need to learn how to use it and take advantage of it. This also applies to the educational process. (Zirar, 2023), (Zirar et al., 2023), (Ahmmed et al., 2024).

2 Defining and Contextualizing Artificial Intelligence

According to a survey conducted by Ipsos in collaboration with Vodafone, up to 87% of students use AI tools at home or at school. In addition, 74% of students consider it important to have teachers who understand AI and know how to work with it in class. Students use artificial intelligence to make lessons more attractive (33%), to make it easier to work in unpopular subjects (23%), to support learning in favourite subjects (22%), develop skills instead of purely theoretical knowledge (17%), improve grades (16%), individualize teaching (15%), or personalize assignments (10%). (Ipsos, 2025)

The National Pedagogical Institute of the Czech Republic also covers the issue of artificial intelligence within the field of digitization in education. Teachers can find a wealth of information here on how artificial intelligence works, selected legislative aspects of its use in the educational process, how to use artificial intelligence in teaching, and much more, including answers to frequently asked questions (Šnajdrová, 2025). Teachers can also find inspiration on the Artificial Intelligence in Schools Czech web portal (Artificial Intelligence in Schools (AI in Schools)).

Teachers use artificial intelligence as inspiration for their teaching and for creating teaching materials in the form of various teaching resources. However, teachers can also use artificial intelligence to assess students, most often in connection with providing feedback on students' written work. According to the above-mentioned research, 53% of students think that grading using AI is fairer than grading by teachers. On the other hand, 48% of young people fear that if AI is used for assessment, some students may be discriminated against. (Ipsos, 2025)

The use of artificial intelligence for student assessment is therefore considered risky by the students themselves. In addition to them, the EU AI Act (Regulation - EU - 2024/1689 - EN - EUR-Lex) also considers the use of artificial intelligence for assessment to be risky. It thus regulates the use of artificial intelligence for assessment only as a basis for teachers, who will then carry out the final assessment independently. This approach is similar to that mentioned by Harari in his book Nexus regarding the use of artificial intelligence in the judiciary to prepare the basis for judgments. If the use of artificial intelligence is part of such an important process, the people affected by the consequences of this process are entitled to an explanation and review of the results of this process. (Harari, 2025)

In the previous section, we mapped out the broader historical and technological context—from moments of fundamental change in manufacturing to the current phase, which we refer to as the fourth industrial revolution—and then focused on the role of artificial intelligence in the transformation of work, production, and creativity. In this chapter, we will move closer to the school and educational environment: we show how AI technologies are actually reflected in school and student activities, including the use of AI tools, their perception by students and teachers, and the legal and ethical aspects of their use in assessment. (Yue Yim, 2024), (Wang et al., 2024), (Ruiz Viruel et al., 2025)

This transitional phase integrates a macro-level perspective on technological change with a micro-level perspective focused on a specific educational context. The following section presents the research component of the study, outlining the methodology and research design. It builds on the technological and educational insights discussed in the preceding chapters and proposes a framework for examining the application of generative artificial intelligence in the educational process, specifically within project-oriented learning. This approach ensures that the empirical investigation is grounded in both technological and educational theory while remaining relevant to school practice and the professional needs of teachers.

3 Methodology

The primary objective of the methodology is to examine the applicability of a system prompt for generative artificial intelligence (GenAI) in evaluating the preparation of project-based teaching by students of vocational subjects. The study investigates whether GenAI can provide relevant, consistent, and educationally valuable feedback.

Sub-goals:

- Compare how different genAI tools (chatbots) interpret the same prompt and how their outputs differ.
- Compare outputs from genAI with expert (teacher) evaluation.

Research questions:

- Which areas of PBL are best developed in projects?
- What is the degree of agreement between AI evaluation and teacher evaluation?
- How do the outputs of different AI tools differ when using the same prompt?

3.1 The System Prompt for Evaluating Project-Based Teaching Preparations

In the system prompt we have created, genAI expert plays the role of a project teaching expert who specializes in evaluating projects according to the “Gold standard PBL” described in the book by Larmer, Mergendoller & Boss (2015). The expert's goal is to evaluate the project preparations sent by the teacher and provide constructive feedback.

At the beginning of the conversation, the user is prompted to upload the project preparation. GenAI then reads the preparation in detail and evaluates it according to seven criteria corresponding to the seven Gold standard PBL, by Larmer, Mergendoller & Boss (2015):

- Challenging Problem or Question,
- Sustained Inquiry,
- Authenticity,
- Student Voice & Choice,
- Reflection,
- Critique & Revision,
- Public Product.

For each criterion, genAI adds a detailed comment on how well the criterion is implemented in the project preparation (not just whether it is mentioned or not). GenAI will also list the strengths and weaknesses of the project preparation, including recommendations for improvement. Finally, it will classify the project preparation according to one of four levels of PBL gold standard implementation:

1 = Meets the Gold Standard,
2 = Meets with minor reservations,
3 = Partially meets,
4 = Needs significant improvement.

The implementation of the seven Gold Standard PBL ensures that projects will be challenging, engaging, complex, and interesting for students, leading to beneficial educational outcomes. At the same time, according to Larmer, Mergendoller & Boss (2015), the goal of project-based learning is for students to develop not only key knowledge and understanding, but also “21st-century skills” such as critical thinking/problem solving, collaboration, and self-management. The system prompt designed for various genAI conversation tools (chatbots) is designed to consider the theory of project-based learning according to Larmer, Mergendoller & Boss (2015) and to ensure that the resulting preparation and implementation of projects in teaching are of high quality. Evaluating projects before their implementation in real educational practice allows for the correction of planned projects, thereby contributing to higher quality project-based teaching. GenAI includes a million experts with a million areas of expertise who can supplement the teacher's evaluation with valuable comments.

3.2 System Prompt Testing Process: Input Data, Outputs, Comment Types

The system prompt is tested on a sample of 10 didactic preparations for project-based teaching created by students of practical teaching and specialized subjects as part of a project-based teaching course.

Each PBL plan is evaluated by genAI using the created system prompt. From the available genAI tools, the chatbots ChatGPT, Gemini, Claude, Copilot, and Perplexity were selected. At the same time, the plans were evaluated in parallel by experts—two teachers of the Vocational education, Practical Teaching and Vocational Subjects study program. The evaluation results were compared to determine how different genAI tools interpret the same prompt and how their outputs differ, including a comparison with the output from experts.

The implementation of Gold standard PBL (Larmer, Mergendoller & Boss, 2015) was evaluated on a scale of 1 to 4:

1 = Meets the Gold Standard – Criteria are fully and exceptionally met; the project is inspiring and demonstrates deep understanding;
2 = Meets with minor reservations – Criteria are mostly met, but there are small shortcomings or opportunities for improvement;
3 = Partially meets – Criteria are only partially met, significant improvement is required;
4 = Needs significant improvement – Criteria are not met or are minimally met; the project requires major revision.

The strengths and weaknesses of the projects were evaluated verbally.

3.3 Methodology of Verbal Assessment Analysis

The verbal assessment analysis procedure is shown in Figure 1 and began with the collection of all verbal assessments into an MS Excel spreadsheet for simple tabular coding, where the source of the assessment (genAI vs. teacher) was noted.

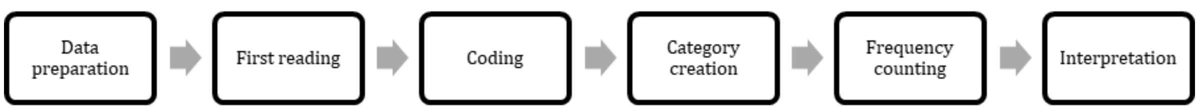

Figure 1: Word evaluation analysis procedure.

After thoroughly reading the evaluations, sentences or parts of sentences with the same meaning were identified and a code was assigned to these units of meaning. The codes were created inductively (they gradually emerged from the data/text of the evaluation). The codes were then sorted by similarity into 12 semantic categories, see Table 1.

The assessments were then reread, this time with the aim of determining how many assessments fell into each category (frequency) and whether the assessment was listed as a strength or weakness. Frequencies were recorded separately for individual evaluators (genAI vs. teacher) and by group (strengths vs. weaknesses).

The data was organized into a clear frequency table and supplemented with excerpts from the evaluations as illustrations for each category. The resulting data was then interpreted in terms of existing contrasts between evaluators and the most common strengths and weaknesses.

Codes	Category
Real world, practice, authenticity, community, real problem, client	1. Authenticity and connection to the real world
Professional context, professional skills, professional profiling, practice, professional standards	2. Professional relevance and professional development
Interconnection of fields, interdisciplinarity, integration of theory and practice	3. Interdisciplinarity and interconnection of areas
Autonomy, freedom of decision-making, creativity, own ideas	4. Student autonomy and creativity
Social impact, community, civic dimension, social responsibility	5. Social and community impact
Clear structure, good management, quality planning, criticism & revision, Gold Standard	6. Quality of pedagogical design
Reflection, feedback, evaluation, critical thinking	7. Reflection, critical thinking, and evaluation
Student involvement, motivation, enthusiasm, engagement	8. Student motivation and engagement
Lack of research, superficial work, instructions, little discovery	9. Weak inquiry process
No output, non-public project, weak presentation	10. Weak public product (public output)
(Non)demanding in terms of materials, teaching aids	11. Demanding material requirements
Great, excellent, no comments	12. Overall evaluation: excellent

Table 1: Conversion of code to semantic categories.

4 Results

The point scores according to the seven Gold Standard PBL criteria (C1–C7), including the strengths and weaknesses of the projects, are shown in Table 2 (teachers did not explicitly evaluate the strengths and weaknesses for each criterion, but only for the project as a whole). Of all the AI tools, the chatbot Gemini (mean value 1.36 points) received the most positive evaluation (1 = Meets the Gold Standard – Criteria are fully and exceptionally met, the project is inspiring and demonstrates deep understanding), followed by Perplexity (mean value 1.46 points) and Copilot (mean value 1.75).

On the other hand, the most critical were the Claude chatbot (mean value is 2.50 points) and ChatGPT (mean value 1.88 points). Claude and ChatGPT evaluated all criteria with reservation and saw room for improvement in each (especially in criteria C5 Reflection and C6 Criticism and Revision).

The average overall rating from all AI chatbots was the same as the average overall rating from the two teachers (mean value 1.79 points).

	ChatGPT	Copilot	Gemini	Perplexity	Claude	genAI average	Teacher
C1 - Challenging Problem or Question	1,9	1,4	1,3	1,8	3,0	1,88	1,6
C2 - Sustained Inquiry	2,3	2,3	1,1	1,5	2,9	2,02	2,05
C3 - Authenticity	1,0	1,0	1,0	1,0	2,1	1,22	1,35
C4 - Student Voice & Choice	2,0	2,0	1,5	1,5	2,6	1,92	1,65
C5 - Reflection	2,7	2,4	1,6	2,1	3,3	2,42	2,35
C6 - Critique & Revision	2,8	2,6	2,2	2,1	3,1	2,56	2,05
C7 - Public Product	1,3	1,5	1,7	1,1	2,0	1,52	1,45
Strengths and weaknesses for each criterion? (1 - yes/0 - no)	1,0	0,8	0,44	0,6	1,0	0,77	X
Average rating (1 - 4)	**1,88**	**1,75**	**1,36**	**1,46**	**2,5**	**1,79**	**1,79**

Table 2: Results of the analysis of the average point rating of PBL gold standards.

All evaluators, including teachers, agree that the best-fulfilled criterion in student projects is C3 Authenticity. This means that the projects are realistic and connected to professional practice and the local community.

Overall, the criteria C7 Public Product and C1 Challenging Problem or Question are also positively evaluated. This means that the projects have a clearly defined public output (often a presentation or exhibition) and are defined at the outset by a meaningful question or address a real problem (with the exception of the chatbot Claude, which was the only one to rate this criterion as insufficient = 3 points, criticizing the absence of an explicit formulation of the central question of the project).

The weaknesses of the projects across all evaluators are criteria C6 Critique & Revision, C5 Reflection, and C2 Sustained Inquiry. According to the evaluation, the projects are short, without in-depth research, mostly lacking a systematic feedback cycle, and the reflection is formal, without real self-reflection by the students.

The differences between the AI and teacher evaluations can be interpreted as teachers tending to evaluate slightly more positively. The average AI evaluation score ranges from 1.36 to 2.50 points, while teachers evaluate an average of 1.79 points. Overall, however, a comparison of the project scores shows that AI can serve as a valid first stage of evaluation.
AI provides comparable assessment results to those of teachers. By combining both approaches, a comprehensive evaluation of PBL preparations can be obtained. AI can quickly and consistently assess the formal aspects, while teachers provide a deeper pedagogical interpretation.

4.1 Results of the Verbal Assessment Analysis

Table 3 summarizes how genAI and teachers describe the strengths and weaknesses of student projects in individual semantic categories. For each category, it shows the proportion of positive and negative mentions and their ratio. Table 3 shows where the genAI and teacher evaluations agree and where they differ.

Category/Evaluator	**GenAI**			**Teachers**		
	Number of strong ratings (+)	**Number of weak ratings (-)**	**Ratio (+/–)**	**Number of strong ratings (+)**	**Number of weak ratings (-)**	**Ratio (+/–)**
Authenticity and connection to the real world	**96%**	0%	96%	**55%**	20%	35%
Professional relevance and professional development	**70%**	0%	70%	**20%**	0%	20%
Interdisciplinarity and connection between areas	60%	0%	60%	10%	0%	10%
Student autonomy and creativity	34%	48%	-14%	15%	20%	-5%
Social and community impact	26%	0%	26%	10%	0%	10%
Quality of pedagogical design	46%	8%	38%	0%	0%	0%
Reflection, critical thinking, and evaluation	20%	**82%**	-62%	20%	**60%**	-40%
Student motivation and engagement	20%	**48%**	-28%	0%	0%	0%
Weak inquiry process	0%	**40%**	-40%	0%	**45%**	-45%
Weak public product (public output)	0%	30%	-30%	0%	5%	-5%
Material resource requirements	0%	0%	0%	5%	5%	0%
Overall rating: excellent	0%	0%	0%	30%	0%	30%

Table 3: Comparison of strengths and weaknesses identified in project evaluations.

Higher percentages in the genAI columns indicate that chatbots tend to identify and explicitly name more strengths (and weaknesses) than teachers and overall evaluate projects more optimistically and "generously" (in the case of strengths) and more strictly (in the case of weaknesses). Teachers, on the other hand, are more selective, i.e., they highlight only those aspects that they consider truly significant, which is why their verbal assessments are reflected in lower percentages in the table.

The verbal evaluation confirms the conclusions of the point evaluation. The projects are particularly strong in relation to reality and professional practice (Gen AI marked as a strength in 96% and 70% of evaluations, respectively, and by teachers in 55% and 20%, respectively). On the contrary, the most problematic areas from the perspective of both evaluators are reflection and the process of inquiry (GenAI marked as a weakness in 82% and 40% of evaluations, respectively, and by teachers in 60% and 45% of evaluations, respectively). GenAI also mentions a frequent lack of motivation and internal engagement (48%). The teacher does not comment on this area.

An interesting difference emerges in what the individual evaluators focus on. GenAI places relatively strong emphasis on "Quality of pedagogical design" (positive ratio +38%) and systematically identifies the formal qualities of projects, while the teacher does not single out this category and focuses more on the process and impact of learning. In addition, the teacher is the only one to include the category "Overall rating: excellent" (+30%), which shows that, in addition to the sub-criteria, he also considers the holistic impression of the project, its educational potential, including an assessment of the students' overall work.

4.2 Nature of the Evaluations Generated by Individual Chatbots

All tested chatbots evaluated projects according to a similar pattern: for each criterion, they described the status of the project preparation, listed its strengths and weaknesses, and in most cases added a final summary, including the level of fulfilment of the Gold Standard PBL.

ChatGPT produced concise, factual, and quickly generated evaluations (approximately 2–3 pages) that combined a description, pros, cons, and recommendations for each criterion and concluded with a clear summary of strengths and weaknesses.

Claude produced the longest and most detailed texts (4–8 pages), with extensive elaboration on strengths and weaknesses, but at the cost of significantly longer generation times.

Copilot provided more concise, clear evaluations (1.5–2 pages), with a clear summary of the criteria and a brief final overview; recommendations were rather rare.

Gemini combined factual comments with visual clarity (bold highlighting, bullet point summaries), and the outputs were of medium length (approx. 2.5–3 pages) and quickly generated.

Perplexity opted for compact paragraphs combining description, strengths and weaknesses, and recommendations, concluding with a brief summary and Gold Standard PBL level (2–3 pages, quick generation).

5 Conclusion

A comparison of generative artificial intelligence (GenAI) and teachers indicates that AI is well suited for rapid, structured assessment, whereas teachers remain essential for evaluating the depth of pedagogical processes and student development. GenAI demonstrates sensitivity to formal aspects of project quality, such as design, authenticity, and relevance, while teachers are better positioned to capture procedural and pedagogical dimensions, including the learning process and the extent of student engagement in project preparation. The integration of both perspectives therefore provides a multidimensional understanding of the quality of project-based teaching preparation. GenAI can function as a tool for efficient, criteria-based evaluation aligned with the Gold Standard PBL framework, while teachers contribute indispensable interpretative insight into how projects support student learning in practice.

All examined chatbots were able to provide structured evaluations consistent with the Gold Standard PBL criteria; however, they differed in the level of detail, length, and emphasis of their recommendations. For practical application in school settings, tools that balance clarity, conciseness, and actionable feedback—particularly Gemini, ChatGPT, Copilot, and Perplexity—appear most suitable. In contrast, systems producing excessively lengthy and time-consuming outputs, such as Claude, may be less practical for routine use.

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The Use of Animations in the Educational Process

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Abstract

Appropriate instructional illustrations represent active elements in the educational process and play a significant role in supporting learners' understanding of subject matter. Animated visualizations may be used in traditional classroom instruction, distance learning environments, or blended and flipped classroom models. The visual impact of animations can function as a motivational factor while simultaneously supporting individual learning pace, which is an important consideration in contemporary education.

Although numerous ready-made animations are available online, they are not always freely accessible and are often limited by language, level of detail, or relevance to specific instructional objectives. In some cases, available materials may be either overly simplified or excessively complex for a given topic. Consequently, the creation of custom-made animations may offer a more effective solution. Recent developments in artificial intelligence have introduced new possibilities in this area, as AI-based tools can generate animations either from textual input (e.g., ChatGPT, Copilot, AskGPT, Claude) or through specialized animation platforms (e.g., RunwayML, Kaiber, NVIDIA Omniverse).

Keywords: Animation, Education, Artificial Intelligence

1 Introduction

Visual instruction represents an important component of the educational process and, when used appropriately, plays a significant role in supporting learners' understanding of subject matter. One commonly used form of visual instruction is animation. Animations are widely employed not only in media, marketing, and video games, but also in educational contexts. In education, they can be used to illustrate natural phenomena and processes, such as the water

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cycle, animal life cycles, chemical reactions, and electrical circuits, as well as to support the comprehension of mathematical concepts, including functions and geometric transformations. Similar applications can be identified across a wide range of subject areas. Animations may be integrated into traditional classroom instruction and also play a significant role in distance learning environments, such as e-learning, as well as in blended learning models, including the flipped classroom. According to Vécsey (2020), the use of animations in the educational process is already common practice. Several studies confirm that students who participated in teaching supplemented with animations achieved better results than control groups. (Islam et al., 2014; Liu a Elms, 2019; Shreesha a Tyagi, 2018; Tani, Manuguerra a Khan, 2022; Teplá, Teplý a Šmejkal, 2022).

The use of animation in educational contexts is often so widespread that it may go unnoticed. The visual effects of animations can function as motivational elements within the educational process and may also support individualized learning pace. These considerations suggest that animations play, or have the potential to play, a significant role in education. However, their instructional effectiveness depends on appropriate and purposeful use within the curriculum. Vécsey et al. (2020) address the question of when static images or animations should be employed in instructional design. According to their findings, attention should be paid to factors such as cognitive load, selective visual perception, learners' prior knowledge, spatial perception, and the temporal characteristics of the instructional content.

2 Creating Digital Animations

Numerous ready-made animations are available online for use by teachers; however, they are not always freely accessible, and some are language specific. In addition, existing materials may be incomplete, overly detailed, or unsuitable for a particular instructional topic. Fully customized animations are generally produced only through the creation process undertaken by the educator. According to Towler (2023), the process of developing scientific animations should include the following steps: writing a script, creating a voice-over, storyboarding the script, illustrating the storyboard, animating the illustrations, obtaining feedback on the draft, and producing and delivering the final animation.

When creating your own animations, especially when using AI tools, this procedure may no longer be strictly valid. For example, we can compose a real animation according to certain templates and based on pre-animated objects or characters. In some cases, the animation may not even contain an audio channel.

According to the method of creating animation, we could divide it into three groups: stop-motion (e.g. using a series of photographs, plasticine, paper), digital and traditional (e.g. cartoon). Below we will only deal with digital animations.

Of course, there are many software programs suitable for creating digital animations, but working with them is usually time-consuming.

Such tools include, for example: Pencil2D, Synfig Studio, OpenToonz, TupiTube for 2D-animations, and Blender, K-3D pre 3D animácie. A revolutionary change in this area can be brought about by artificial intelligence-based tools that can create animations based on text input (e. g. ChatGPT, Copilot, AskGPT, Claude etc.), as well as specialized tools developed specifically for this purpose (e. g. RunwayML, Kaiber, NVIDIA Omniverse etc.).
The following chapter illustrates how simple animations can be generated using the generative artificial intelligence tool M365 Copilot. Although these tools are not specifically designed for animation creation, they can still produce meaningful outputs. Other AI tools have been developed for this purpose and may yield more refined results. M365 Copilot was selected for this study due to its widespread availability within the educational system as part of MS Office 365 Education.

3 Methodology

Artificial intelligence can support the understanding of learners' questions and requirements, allowing educators to address specific learning needs. Interactions with AI-based conversational assistants generate variable responses, which may lead to divergent outcomes in the learning process. The present study aims to explore the potential of contemporary AI tools in educational practice. To this end, available AI applications suitable for the creation of animated educational materials were examined, with consideration of established best practices and the selection of multiple illustrative case studies. These case studies, which exemplify the implementation of new pedagogical procedures, were subjected to qualitative analysis commonly employed in educational research.
As an illustrative case study, this work presents a method for integrating information technology, cloud-based APIs, AI, and software applications incorporating built-in generative AI tools.
Another case study involved iteratively providing instructions to a conversational assistant with the objective of generating image-based animations, while considering the associated cognitive load.
Based on the analysed case studies, several paradigms were identified. Animation provides a visualisation of a dynamic phenomenon, when it is not easily observable in real space and time scales (Betrancourt, 2005). Ginns tries to point out that presenting instructional materials using a combination of an auditory mode for textual information, such as spoken text, and a visual mode for graphical information, such as illustrations, charts, animations, etc., will be more effective than presenting all information in a visual format, such as printed text with illustrations, charts or animations (Ginns, 2005). The success of education using animations is investigated using various methods, e.g. eye movement tracking. Increasing number of physics education researchers are using eye tracking to learn more about physics learning by analysing students' visual attention (Hahn & Klein, 2022).

When deciding whether a static or animated approach to a topic is more effective for educational purposes, it is important to consider the recipient's prior experience with animation as a medium and their spatial abilities (Vécsey, 2020).
Another issue becomes the use of materials that are intellectual property. OpenAI and other large technology firms focused on developing generative AI models have claimed their use of text protected under copyright is permissible under United States “fair use” doctrine (Stark, 2024).
A certain level of attention-grabbing in education can be the attribution of human behaviour to inanimate objects, avatars, natural phenomena, plants, animals, etc., which we refer to as anthropomorphism (e. g. Sad Mac icon indicated a problem with the computer at startup.). Anthropomorphism is defined as the attribution of human characteristics, emotions, and behaviours to animals or other non-human things (including objects, plants, and supernatural beings). It involves interpreting nonhuman entities in terms of human traits, such as emotions and intentions (Nikolopoulou, 2023).

4 AI-Generated Animations

To understand functions, we use a familiar diagram, according to which we imagine a function as a machine that processes input values according to the function's prescription (see Figure 1) and then displays the result at the output. The animation accurately illustrates this process by processing various input values.

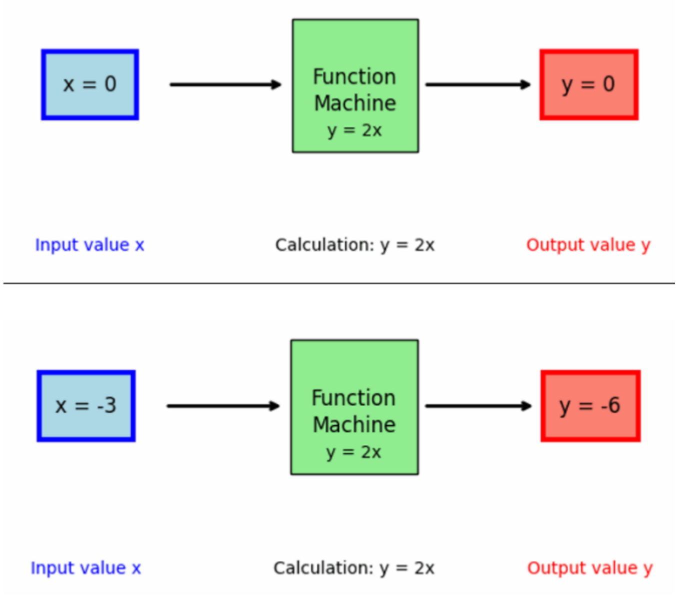

Figure 1: Animating the Function y = 2x. (Created by M365 Copilot)

Figure 2 also shows a very simple animation that aims to present the process of photosynthesis. The image clearly shows leaves, the sun, and arrows with hatched fills attached to them, symbolizing the so-called moving light rays. These light rays indicate the direction of movement and thus add dynamism and animated character to an otherwise static image.

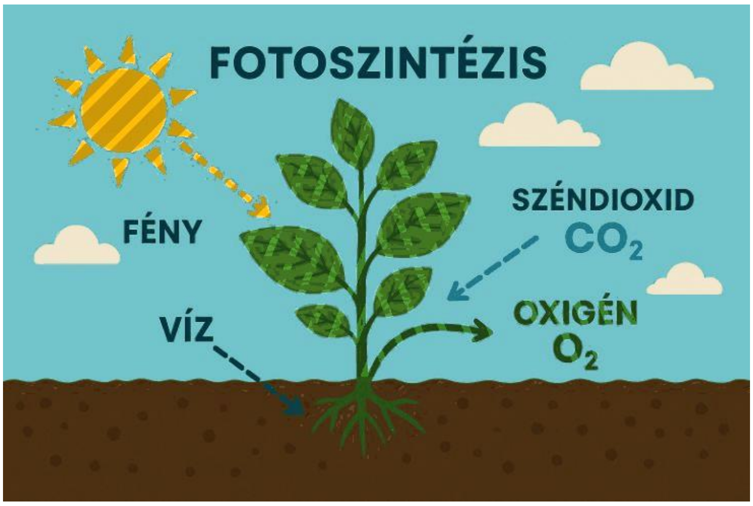

Figure 2: Animation of Photosynthesis. (Created by M365 Copilot)

Figure 3 shows an animation used to illustrate the Riemann integral, which approximates the area under the curve of the function $f(x) = x^2$ on the interval [0, 2]. Using the so-called lower sum method, i.e. by adding the contents of the rectangles, the value of the integral is approximated. The animation clearly shows that with an increasing number of rectangles; the approximation becomes more accurate.
On the interval [0, 2], the volume of the body that is created by rotating the function $y = x^2$ around the x-axis is further investigated. The sought volume is approximate using the method of disks, i.e. as the sum of the volumes of the individual disks (see Fig. 4).

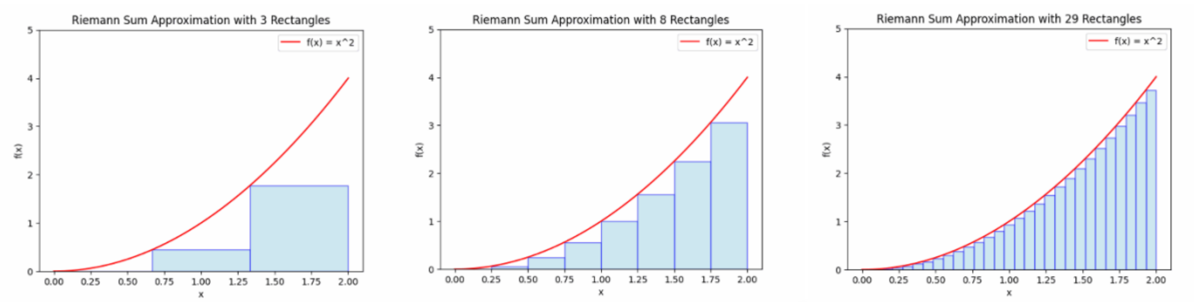

Figure 3: Lower Riemann Sum. (Created by M365 Copilot)

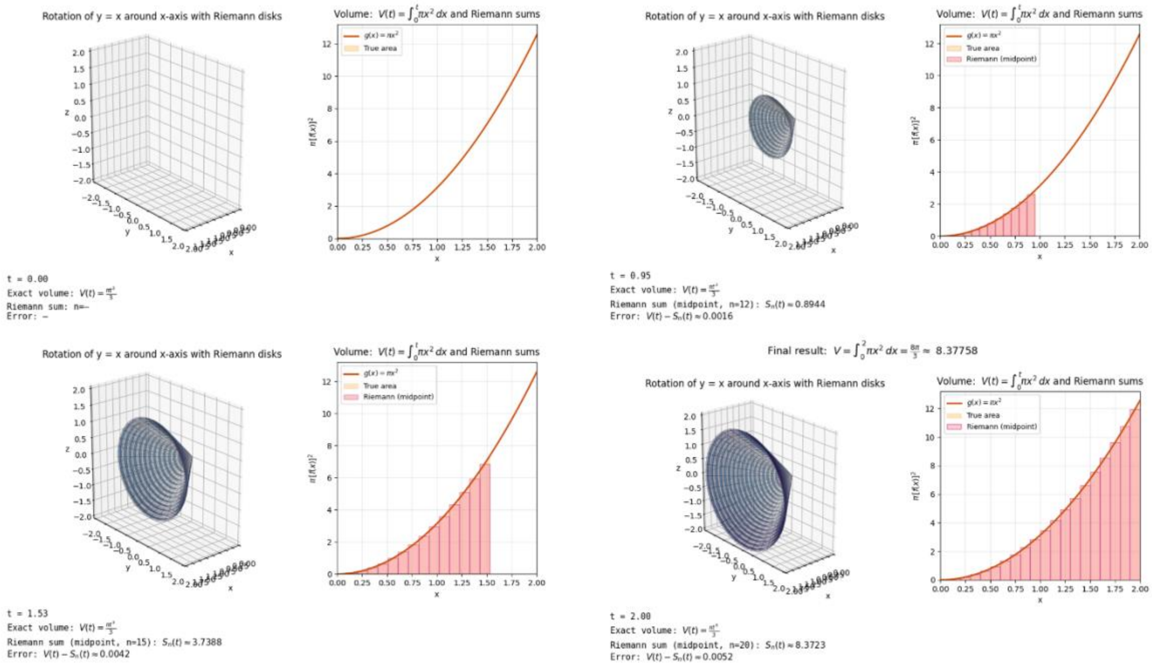

Figure 4: Volume of a Solid of Revolution. (Created by M365 Copilot)

Figure 5 shows an animation of a volcano eruption. We generated the individual frames (image sequences) using the 2.5 Flash model in Google Gemini. Although it generates images, this version (free version) cannot combine them into a GIF or a video file. We could have combined the images using various video editing software, or for example using M365 Copilot.

Figure 5: Animation of a volcanic eruption.

The following case presents the application of AI in the preparation of educational material according to Figure 6. We use AI to convert text to an mp3 audio file. To create interactive educational material, we used the Internet cloud application Visual Paradigm Online using its visual materials, namely diagrams. Subsequently, the production of the diagram was animated and recorded as a screen in Windows. The accompanying text of the animation was formulated in English. The conversion of the written text was provided by the Applio application based on the principle of using the AI method Text-to-Speech. We ensured the integration of text and video sequences with the standard Adobe Premiere tool, but we also recommend using other tools e.g. Pinnacle Studio, DaVinci Resolve, Shortcut or MS

ClipChamp. However, in a higher version of the cloud application Visual Paradigm Online, it is also possible to apply directly built-in AI to create various visual materials. Figure 7 shows a schematic representation of the creation of animated educational material using AI.

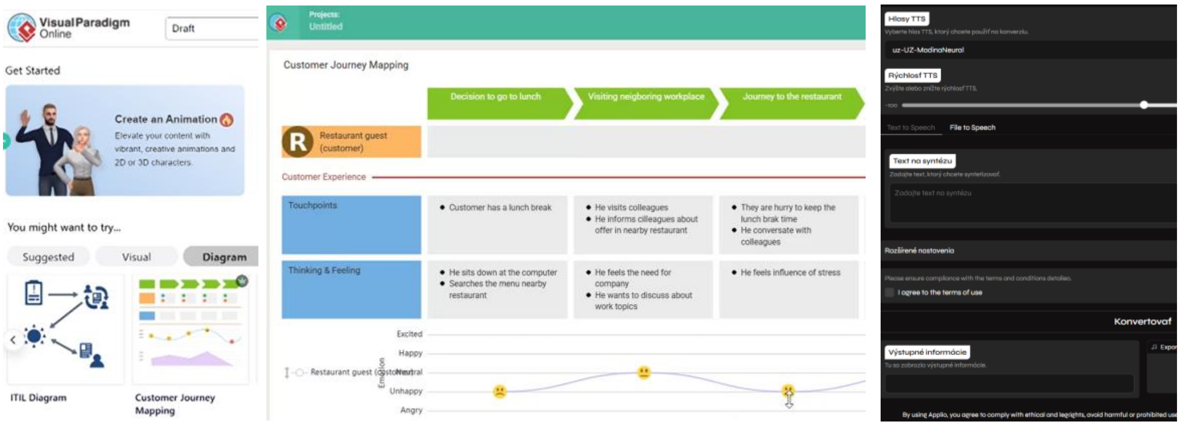

Figure 6: basic elements of creating a video and audio sequence (Own elaboration, 2025)

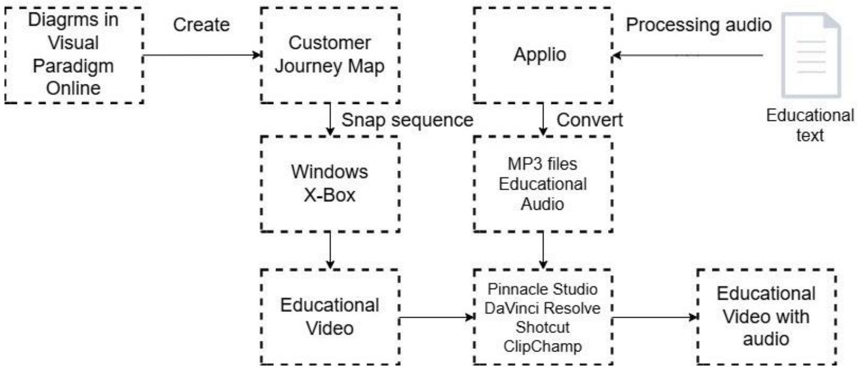

Figure 7: Scheme for creating animated educational material. (Own elaboration, 2025)

5 Surveying Student Attitudes

We investigated the opinions of student of Preschool and Elementary Education study programme on their attitudes towards the use of animations in education, their experiences with creating animations, the suitability of animations in subjects, their self-assessment of digital competencies, their experiences with AI, the most suitable tools for the work of a teacher, difficulties experienced using digital tools, and what problems they find in using AI in education. We investigated the research questions using a questionnaire with a total of 12 questions, of which 3 questions related to information about the student. We prepared the questionnaire as a pilot survey. We examined multidimensional questions using a Likert scale (number 3) and subjected them to multidimensional analysis using the Sourcetable API. We evaluated the remaining six questions by expressing the percentage of responses and using qualitative analysis.

Table 1 presents the results of the Factor Analysis of Question 1, What is the attitude of students towards creating animations? Based on the scores of students' answers in the range of 1-5, we used factor analysis to identify two factors that we consider to be students' attitudes.

Factor 1	Factor 2
Applying experiences with creating animations during teacher training (High practical value – 3.90)	Animations introduce motivating effect (Strongest agreement – 3.93)
Preferring animations created by own (Self-creation valued – 3,86)	Help animations to better understand learning material (Moderate agreement - 3.45)
Afraid of too much time and technical knowledge (Some concerns exist- 3.38)	Using animations made by AI based tool (Lowest but still positive – 3.21)

Table 1: Attitude of students towards creating animations.

In the Table 2 we present the results of students' answers to question 2, Please indicate your experience with applications that enable the creation of animations. We expressed the students' experience as a percentage.

Stop motion (e.g., clay, paper, photo series)	14%
Digital (e.g., PowerPoint, Canva, Vyond, Animaker, etc.)	24%
Handdrawn / manually created	7%
AIbased (e.g., using ChatGPT, Copilot, Pika Labs, Animoto, etc.)	0%

Table 2: Experiences with animation tools.

In the table 3 we introduce answers of students to question 3, What subjects students recognise using of animations. Students see the greatest use of animations in subjects Natural sciences, Kindergarden activities, and in English as a foreign language.

During kindergarten activities	66%
Mathematics	31%
Hungarian language and literature	48%
Slovak language and literature	34%
English as a foreign language	55%
Local history	38%
Natural sciences	69%

Table 3: Using animation in subjects.

Table 4 introduces the results of the factor analysis to question 4, How students evaluate their digital competencies according to arranging options. Based on students' response scores ranging from 1 to 5, we used factor analysis to identify two main factors that moderate students' views of digital competence.

Factor 1	Factor 2
I would be able to integrate digital tools into pedagogical work. (Excellent - 0.48)	I know and use educational digital platforms e.g., Kahoot, LearningApps. (Excellent - 0.35)
I confidently use word processing programs. (Excellent - 0.47)	I consciously manage online data protection and security. (Very Good - 0.35)
I can create digital learning materials. (Excellent - 0.34)	I can create digital learning materials. (Excellent - 0.34)

Table 4: Students' digital competencies.

Table 5 presents an analysis of question 5, What do you think about your knowledge and use of AI tools. Based on the students' response scores on a scale of 1–5, we used factor analysis to identify two main factors that moderate students' views on how they would use AI knowledge.

Factor 1	Factor 2
I understand how AI-based educational tools (e.g., ChatGPT, Quizizz AI) work.	I consider it important to address ethical issues of AI in teacher training.
I am able to critically evaluate AI-generated content.	I would gladly use AI tools in my future pedagogical work.
I have used AI content generation tools for learning or creating teaching materials.	I have used AI content generation tools for learning or creating teaching materials.

Table 5: Using AI knowledge.

Table 6 shows the answer to question 6, Which digital tools or applications do you find useful in education? Students also use an interactive whiteboard, a data projector, and the Canva design package in their education.

The Canva	7%
Cell phone	3%
Google Translator	3%
Photo math	3%
Interactive table	10%
Data projector	7%
Word wall	3%
Educational application	3%
ChatGPT	3%
Kahoot	3%
Other	3%

Table 6: Use of digital tools in education.

In question 7, we asked What difficulties have you experienced when using digital tools? Students indicated that they lacked knowledge about the effective use of digital tools, mentioned freezing applications when creating animations, limiting work by the presence of ads, The demanding requirement for knowledge and practice, and expressed concern about technical problems.
In question 8, we asked about experiences with using AI. We found that students had experience with the generative AI ChatGPT. Students used ChatGPT for searching and refining, for making suggestions and recommendations, and for generating ideas.
In Table 7, we analyse question 9. What problems or risks do you see in using AI in education?

Students give the greatest weight to the following questions:
Children forget to think independently and leave everything to artificial intelligence.
The negative impact of AI, regardless of how it is used, whether in education or in everyday life.
The answer is not always correct, especially in literature.
Excessive use of artificial intelligence when the student passively completes assigned tasks.
Children are also present on many internet platforms at home, so I don't think artificial intelligence should play a big role in education.
Students should be able to think without artificial intelligence, stay creative, create new things, write correctly, etc.
I agree with stricter rules when using AI.

Table 7: Obstacles (problems and risks) using AI in education.

6 Conclusion

Animations play a significant role in education, particularly in the areas of visualization, motivation, and support for individualized learning pace. Based on the examples presented, educational animations can be developed using both traditional tools and artificial intelligence. In this study, the M365 Copilot tool was employed; although it is not specifically designed for animation creation, it can generate educational content, albeit with variable success depending on the specificity of prompts. The use of such tools is widespread in educational institutions, highlighting their potential for instructional purposes.
The flipped classroom approach aligns particularly well with animated content, as it enables learners to acquire knowledge in advance and actively engage with the curriculum during instruction. It is essential for educators to select tools deliberately, considering student needs and pedagogical objectives. Accordingly, animation should be considered not merely as a technical resource but as a pedagogical method that can enhance learning. Future research should explore strategies to maximize the educational potential of animation effectively and appropriately.
This study presents two cases of animation creation. The first involved generating animations directly using generative AI, while the second explored the use of AI for simulating human

voice and integrating it with video sequences. As described in the methodology, the creation of educational materials was informed by established paradigms of good practice.

In the pedagogical process of developing animated educational materials, attention is given to spatial reasoning, cognitive perception, and mentalization abilities. The following paradigms are considered particularly important: cognitive load, eye tracking, fair use of textual content, and anthropomorphism.

Exploratory development work indicated that students perceive animations as motivating and useful tools for learning, particularly in natural science subjects, early childhood activities, and language acquisition. However, students reported challenges, including limited experience in creating animations, concerns regarding time requirements and technical skills, and a tendency to over-rely on artificial intelligence. Ethical considerations and responsible use of AI were also identified as key concerns. Effective integration of animations and AI in education therefore requires targeted training, technical support, and clear guidelines for use.

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All learning paths lead to knowledge

New trends in Teaching the Subject of Information Society

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Abstract

This paper explores emerging trends in the teaching of the subject *Information Society*, highlighting how rapid technological developments and societal shifts are reshaping educational approaches. The study examines key pedagogical innovations, including the integration of artificial intelligence (AI), blended and hybrid learning environments, mobile and immersive technologies, and an increased emphasis on digital, media, and information literacy. It also addresses the growing importance of teaching ethical, civic, and critical perspectives on digital life, data use, and online communication. These trends reflect a broader shift from traditional, skills-based instruction toward learner-centered, interdisciplinary models that prepare students for active participation in a digitally connected world. The paper concludes by identifying the challenges educators face—such as digital equity, teacher training, and curriculum relevance—and offers recommendations for adapting teaching practices to meet the needs of the 21st-century information society.

When enrolling in a course, it is essential to address learners' initial motivation, the evaluation and classification of individual modules, and the process of familiarization with the curriculum. For teachers to guide students in using the internet as part of the learning process, they must first develop strong ICT and digital literacy competencies. This includes acquiring the ability to understand and explain fundamental concepts related to ICT and digital technologies, use computers and digital devices effectively, work with datasets and textual materials, create and interpret tables, charts, and figures, manage databases, develop presentations, and obtain, share, and communicate information. Furthermore, teachers should be able to use the internet proficiently, manage email communication, and create digital content such as web pages, blogs, and vlogs.

Keywords: Different Learning, Innovative Teaching Methods, Information Society

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1 Introduction

In the 21st century, the rapid advancement of digital technologies has fundamentally transformed the way individuals' access, process, and share information. As societies become increasingly interconnected and data-driven, the concept of the "information society" has emerged as a central theme in understanding modern social, economic, and cultural dynamics. Teaching the subject of the information society is therefore more important than ever, as it equips learners with the critical skills and knowledge needed to navigate and contribute to a world shaped by information and communication technologies (ICTs).

However, traditional approaches to teaching this subject are no longer sufficient in addressing the evolving realities of digital life. Emerging technologies, shifting digital literacies, and new societal challenges demand updated pedagogical strategies. Recent trends in education—such as interdisciplinary learning, project-based approaches, integration of real-world digital tools, and a stronger emphasis on ethical and societal impacts of ICT—are reshaping how the information society is taught across different educational levels.

This paper explores recent trends and innovations in the teaching of the *Information Society* as an academic subject. It examines how contemporary educational practices are adapting to the complexities of digital transformation and considers the implications for both educators and learners in preparing for an increasingly digital future.

2 Quality of Education

Using the concepts of quality and efficiency are indeed very frequent, but often, without a clearer definition. Especially with the introduction of globalization, the concept of quality occurs in virtually all areas of human activities, including education. Education is a service provided by an educational institution. Firstly, it is important to note to whom this service is intended and what its purpose is. Furthermore, it is imperative to understand that learning cannot be assumed clearly as an economic standpoint. The level – quality of education may be evaluated, but more subjectively, qualitatively than objectively and measurably, continuously and long term. The specific of higher education is its 'optional nature' (Szőköl, 2016).

Key Indicators of Quality Education

1. **Trained and Motivated Teachers**: The presence of well-trained, competent, and motivated educators is essential. Teachers must also be equipped with ongoing professional development opportunities.
2. **Relevant Curriculum**: The content taught must reflect real-world challenges, be culturally relevant, and prepare students for both local and global citizenship.
3. **Safe and Inclusive Learning Environments**: A supportive atmosphere — free from discrimination, bullying, and violence — is critical for effective learning.

4. **Access to Learning Resources**: Quality education requires access to books, technology, and modern tools that facilitate deeper understanding and engagement.
5. **Student Engagement and Learning Outcomes**: Measuring not just attendance but the actual outcomes — such as literacy, numeracy, critical thinking, and emotional intelligence — is essential.

In education the term quality (quality management) refers to several elements, mostly to:

- **The educational system** constitutes a fundamental factor in a country or region's overall development. Its quality is determined by clearly defined goals and educational philosophy, the content and structure of education, principles of governance and financing, the inclusion of children, youth, and adults, the accessibility of qualifications, and the flexibility and openness of the system. Enhancing the quality of a national educational system requires international comparability of performance, which can be achieved through participation in large-scale international assessments such as PISA and TIMSS.
- **School (school facility):** As discussed above, the level of educational quality—shaped by factors such as declining student populations, competition for enrolment, and per-pupil funding—is critical to the sustainability of schools. Each school should therefore develop and implement its own quality management system that governs all institutional processes and involves all members of the school staff.
- **Teaching process:** The teaching process is the most important of all processes at school and therefore its quality is a crucial element for the quality of schools. The quality of the teaching process in the subjects they teach can also increase the individual teacher (group of teachers) if the school has still not implemented quality management.
- **Learning of pupils and students:** The quality of learning of pupils and students is the culmination of efforts to increase the quality of education. The aim should be to make pupils, students acquire rational ways of learning - learning competences, to be aware of their preferred learning style and implement it, as well as metacognition and meta-learning to implement an in-depth approach to learning. The result should be a strategically focused student, someone, who wants to take responsibility for managing their learning, which is learned, and can manage their own learning, which is able to optimize their learning in school, out of school and after their school era. Such pupils and students have the greatest chances of success in the current, constantly and rapidly changing world, because they will be more successful in lifelong learning (Horváthová, 2011).

3 The Concept of the Information Society

The concept of the Information Society refers to a type of society in which the creation, distribution, and manipulation of information has become the most significant economic, cultural, and political activity. It's a central theme in modern social theory, media studies, communication, education, and digital policy.

Dimensions of the Information Society

1. Economic – Rise of IT industries, digital markets, remote work, and gig economy
2. Educational – Digital learning, lifelong learning, digital literacy, and open access to knowledge
3. Social – Online communities, social media, digital identities
4. Political – E-government, digital activism, cyber-surveillance, and digital rights
5. Cultural – Global cultural exchange via digital media, remix culture, digital storytelling
6. Ethical – Issues around privacy, surveillance, misinformation, algorithmic bias, digital divide

Criticisms and Challenges

- Digital Divide: Not everyone has equal access to information or technology (locally or globally)
- Surveillance & Data Privacy**:** States and corporations have unprecedented control over personal data
- Information Overload & Misinformation: The abundance of content can lead to confusion or manipulation
- Inequality: Benefits of the information society are not evenly distributed—both economically and socially
- Algorithmic Control: Algorithms shape what people see, buy, believe—raising ethical and democratic concerns

Relevance in Education: In education, teaching about the information society means:

- Understanding how information is created, distributed, and controlled
- Teaching digital literacy**,** media literacy**,** and critical thinking
- Preparing students to participate ethically**,** safely**,** and effectively in a digital world
- Reflecting on the social impacts of technology on work, identity, culture, and democracy

From a social perspective, the information society is characterized by the growing role of informatics and information and communication technologies as a major economic force. These technologies shape and transform the entire social system and facilitate the emergence of new social, supraclass, and supranational structures, thereby fundamentally altering the mechanisms of social development.

Challenges of the information society and further directions of development have been the subject of several papers at the international and national level. The following ones have an important role within the frame of documents of national character:

- Policy of Informatizing Society in the Slovak Republic for the years 2022 – 2025 with a view to 2030.
- National Action Programme of Society Informatization
- Millennium – National Programme of Education in the Slovak Republic for the next 15 to 20 years (10-13)

The main benefits of the information society are:

- making available the usage of information sources and their tools by the public,
- expansion and improvement of means of services and entertainment,
- promotion of education,
- new opportunities for the application of human creative abilities, as well as the employing of handicapped people in life through "teleworking"
- increasing of cultural traditions and identity of regions,
- more efficient state administration,
- more effective management of enterprises, improving competitiveness, facilitating of connection between the manufacturer, service provider and the customers themselves,
- new services in the telecommunications and new markets in the field of software,
- more effective health care.

Information Society was firstly taught at the Trnava University in winter semester of the academic year 2024/2025. Since the subject of Information Society was not included in the accredited programs, the content of the course was divided into several subjects.

Most of the topics were included in the basic subject of Information and Communication Technologies, taught in the first years of education at the Faculty of Education of the Trnava University in Trnava. Part of the topics appears in the continuing subject of Information and Communication Technologies II. The subject of Informatics is taught only one semester at the Faculty of Education so only four modules of Information Society are taught by means of presentations. Individual modules were evaluated based on tests, which had to be passed by all the students as the procedure within the exam. Tests were carried out in the LMS environment of Moodle, where the teacher could exactly evaluate the different parts and process the percentage of success.
Thematic unit on e-learning has found its place in the subject Didactics of Informatics, which is an organic part of the Master Teacher Training program. Thematic unit on legal standards of information society forms a part of the subject called Law and Ethics in the Use of Information and Communication Technologies.

Course: Developing information literacy
From our previous experience of working with students and execution of subjects in the first years, it shows that students come to college with ever-improving skills of ICT. Not always,

however, are these skills sufficiently comprehensive and are usually associated only with general information literacy. Our aim is to develop these skills in students and shape subject information literacy.

The course will take the form of e-learning as part of the subject Information Society. Since we believe it is necessary to convey the students the following information as soon as possible, we have chosen Information Society as a reference subject, due to its concentration on first-year students on the Faculty of Education.

The course is made up of five modules. Modules that are used as a proposal for teaching e-learning courses have specifically defined instructions for studying introduction, module objectives, content and performance standards, instructional text, summary, auto-test, additional literature, conclusions, and bibliographical references (Szőköl, 2010).

Individual modules are completed with a self-test summarizing the discussed curriculum. After the successful completion of this test, students will be able to advance to the next module. At any timeframe of the program, students will be able to use electronic consultations (Szőköl, 2010).

The study support of each module is divided and structured so that the acquisition of knowledge and the creation of knowledge by the study participants work with maximum efficiency. Efficiency lies mainly in the fact that the study participants can fully engage in the study of the educational content because it is not constrained by directed learning, as the study text includes features allowing rapid and accurate autoregulation. Participants in the study, after applying for the subject (course) receive the study materials.

4 Results and Discussion

The questionnaire included four teacher competences that are closely related to internationalization of education:

Communication in foreign languages, digital competence, interaction skills, and *cooperative skills*. The averages for each listed competence were calculated from the questionnaire. We can conclude that none of the listed competences reached worse than 3 points average – this means that the respondents consider them at least as important or higher.

Communication in foreign languages is based on the ability to understand, express, and interpret concepts, thoughts, feelings, facts, and opinions in both oral and written form in an appropriate range of societal and cultural contexts (in education and training, work, home, and leisure) according to needs. Competence in foreign languages requires knowledge of vocabulary and functional grammar and an awareness of the main types of verbal interaction and registers of language. Knowledge of societal conventions and the cultural aspect and variability of languages is important. Essential skills for communication in foreign languages consist of the ability to understand spoken messages, to initiate, sustain and conclude conversations and to read, understand and produce texts appropriate to the individual's needs. A positive attitude involves the appreciation of cultural diversity, and an interest and curiosity in languages and intercultural communication European Communities (2007).

Digital literacy involves the ability of confident and critical use of IST (Information Society Technology) for work, leisure and communication. It is underpinned by basic skills in ICT: the use of computers to retrieve, assess, store, produce, present, and exchange information, and to communicate and participate in collaborative networks via the Internet European Communities (2007). Using ICT can be easily and quickly connect with people from abroad and so consult with experts or obtain new information to learn. However, the information is mostly not available in national language.

Interaction skills are a part of interpersonal skills. Interpersonal interaction is a communication process that involves the exchange of information, feelings and meaning by means of verbal and non-verbal messages, between two or more persons (teacher and children, or teacher and others). Children learn and develop by interacting with teachers, each other, family and other persons. Adults who are respectful listeners and keen observers, who are prepared to negotiate, who change their practice, and who make meaning with children are those who are most responsive to them. They know the children well, are sensitive to their current level of understanding, know their interests and intentions, and pitch activities and experiences which are just beyond what they can currently do and understand so that they can extend their learning. Their interactions promote children's learning and development and help children to reach their full potential (Ugrai, 2020).

Cooperative skills are a skill set everyone needs to be able to cooperate effectively – i.e. work with others in a collective, non-hierarchical, democratically managed organizational structure. The cooperating teacher has the greatest and longest-lasting influence on not only the student teaching experience but also the aspiring teacher's growth and development long after student teaching has ended (Benedek, 2015).

In our research of all monitored key competences, teacher competences, skills, knowledge and other attitudes *communication in the mother tongue* reached the highest preference. Similarly, it was ranked first in the competence survey provided by Szőköl (2016) conducted by practicing teachers in Hungary. Overall, we found that our results and results by Szőköl (2016) in terms of the most preferred teaching competences are very similar.
Only three competences reached the average value of 4.5 points: *communication in the mother tongue, ability to take responsibility* and *expertise*. Similarly, *interaction skills* and *cooperative skills* got high scores in our questionnaire as well (Tab. 1).
However, the lowest value (3.21 points) in our survey was achieved by *mathematical competence and basic competences in science and technology* – even though this competence also belongs to key competences. Although the preference for *digital competence* is higher

than *mathematical competence and basic competences in science and technology*, but it is also very low, on the 33rd place in the ranking of all forty observed key competences, teacher competences, skills, knowledge and other attitudes. In the list of eighteen competences published by Bendíková (2014) *digital competence* is ranked in 16th place with 3.65 points.

Basic statistical evaluation of four selected teacher competences of the research is presented in Table 1.

Key competences, teacher competences	Maximum	Minimum	Range	Modus	Mean	Variance	Standard deviation	Median
Communication in foreign languages	5	2	3	4	3.73	0.70	0.84	4.00
Digital competence	5	2	3	3	3.56	0.62	0.79	3.50
Interaction skills	5	2	3	5	4.41	0.52	0.72	5.00
Cooperative skills	5	2	3	5	4.31	0.54	0.73	4.00
Sample size: 4	**5**	**2**	**3**	**4.25**	**4.01**	**0.59**	**0.77**	**4.10**

Table 1: Statistics on four selected teacher competences.

Key competences, teacher competences	Maximum	Minimum	Range	Modus	Mean	Variance	Standard deviation	Median
Sample size: 40	**4.58**	**3.21**	**1.37**	**4.20**	**3.90**	**.14**	**.37**	**3.86**

Table 2: Statistics of observed forty teacher competences.

Key competences, teacher competences	Answers				
	1 Unnecessary %	2 Less necessary %	3 Important %	4 Very important %	5 Indispensable %
Communication in foreign languages	0.00	7.50	30.00	45.00	17.50
Digital competence	0.00	6.25	43.75	37.50	12.50
Interaction skills	0.00	1.25	10.00	35.00	53.75
Cooperative skills	0.00	1.25	12.50	40.00	46.25

Table 3: Preference of four selected teacher competences.

Table 3 shows the distribution of response preferences of the four selected teacher competences.

The reasons why should occur internationalization and modernization of teacher training programmes: students obtain updated information and knowledge and not are burdened with data and knowledge not essential to their future life. Graduates succeed in today's world and be competitive in the labour market; are not only educated but also are confident and independent; become able to work creatively, solve unforeseen situations but also to cooperate with others regardless of whether it is a fellow citizen or foreign.

5 Conclusion

In conclusion, the evolving nature of the information society demands a corresponding transformation in how it is taught. Traditional approaches that focused primarily on technical skills are no longer sufficient. Instead, contemporary pedagogy must emphasize critical thinking, media and digital literacy, ethical awareness, and the social impacts of information technologies. The integration of artificial intelligence, immersive technologies, hybrid learning environments, and student-centred methods reflects a growing recognition of the need to prepare learners for active, informed, and responsible participation in a digitally interconnected world. These new trends not only enhance engagement and accessibility but also promote lifelong learning skills crucial for navigating rapid technological and societal change. However, successful implementation requires continuous teacher training, updated curricula, and a commitment to digital equity. As the information society continues to evolve, education must remain agile—responsive not only to technological developments but also to the complex human, cultural, and ethical dimensions that shape how information is created, shared, and understood.

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All learning paths lead to knowledge

Reflection on the Teaching Practice Experience of Students of Teacher Education Programmes

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Abstract

The purpose of this study is to examine in detail the reflections on pedagogical practice of undergraduate student teachers. The intention is to explore students' reflections on their pedagogical practice at its various stages, the factors influencing these reflections and students' self-reflection in the context of their future teaching profession. A qualitative research methodology was employed. Data were obtained through content analysis of written reflections of pedagogical practice experiences. Data analysis was conducted using the grounded theory method, which involved three phases: open coding, axial coding, and selective coding. The study population consisted of 143 students of teacher education programmes at the Faculty of Education, Comenius University in Bratislava, who carried out their pedagogical practice in the academic year 2023–2024. The analysis of reflections revealed key concepts and their interrelationships in students' thinking about pedagogical practice. This paper contributes to the understanding of the impact of reflective pedagogical practice on students' thinking about their future profession. The results suggest that reflective pedagogical practice is important for the professional development of student teachers and the linking of theoretical knowledge with practical experience. The study highlights the role of supervising teachers as role models who significantly shape the professional identity and motivation of future teachers.

Keywords: Pedagogical Practice, Self-reflection, Pre-Service Training, Professional Development of Teachers, Supervising Teacher

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1 Introduction

Pedagogical practice can be seen as an activating and motivating factor in the process of undergraduate preparation of future teachers, also as a self-realization factor for the discovery of individual personalities and at the same time as an environment suitable for the application of theoretical education, in which the relationship with pupils, future colleagues and the teaching profession is developed (Čelinák, 2007).

According to the research of several authors (Eraut, 1994; Píšová, 2005; Kasáčová, 2005; Korthagen, 2011; Kosová, Tomengová 2015), from all their theoretical knowledge, teachers actually use only a certain part of it, it is the knowledge that has been sufficiently integrated with their personal experience and through reflection has become the dominant theoretical interpretations of practice. The research-supported theory of the interrelationship between theoretical and practical knowledge demonstrates that the condition for their interconnection and the gradual transformation of students' professional action and professional thinking is the reflective nature of pedagogical practice, which is based on the socioconstructivist theory of knowledge and learning (Korthagen, 2011; Petríková et al., 2021). This places a demand on both pre-service and in-service teacher education to place practical training through reflection at a new qualitative level (Kosová, Tomengová, 2015).

The competence to reflect on one's own practice and teaching, which is considered a core competence for professional growth, is part of the professional standards for the teaching profession in many countries (Spilková, Tomková, 2010), while the concept of reflective practice is simultaneously becoming the most widely used model for designing the practical preparation of future teachers in higher education (Petríková et al., 2021).

2 Context of the Research and its Objectives

Reflective pedagogical practice is crucial for student teachers as it enhances their professional development, bridges the gap between theory and practice and promotes a deeper understanding of the educational process. Reflective practices, such as journal writing and the use of other reflective tools, enable student teachers to critically analyse their experiences, develop competence in dealing with challenging situations and shape their professional identity. As a reflective practitioner (Schon, 1983; 1987), the student engages in reflective thinking, which often has its origins in doubt, hesitation, and embarrassment, in situations that lead to new inquiry, through recalling relevant experiences (Spalding, Wilson, 2002). Key benefits of reflective pedagogical practice include:

Professional development: completing a reflective practice placement is an important step for student teachers in their professional development journey. It is an opportunity to develop new knowledge and competencies in teacher candidates by encouraging critical reflection on their experiences in a real school setting. Taking a reflective approach to pedagogical practice

as a fundamental starting point, the constructivist model of teacher education considers the student as the main actor in their professional growth and co-creator of their professional identity (Vermunt, Verloop, 1999; Slade et al., 2019; Boris, Ekiugbo, 2021).
Improving reflective skills: The ability to reflect on one's own actions is an essential competency expected of future teachers. It is a competence related to personal growth, self-development, and self-improvement of the future professional within the educational process. Tasks such as reflective journals in teacher education programmes support the development of reflective habits in future teachers (Barber, 2020). Teachers are expected to be able to implement reflective teaching, the essence of which is that they return to what has taken place in the classroom, review it, and based on this, suggest strategies for optimising elements of the educational process.
Forming teacher identity: Reflective pedagogical practice also helps students of teacher education programmes to form their professional identity. It provides an opportunity to develop a relationship with the teaching profession (Segalo, Dube, 2022; Anand, Gangemi, 2023).
In addition, reflective competence as a metacognitive competence also promotes students' awareness of their own process of becoming a teacher (Kasáčová, 2004).
Collaboration and mutual learning: reflective practice often involves sharing experiences with classmates, which can lead to shared learning. This mutual interaction is beneficial for the development of new knowledge and approaches to the educational process (Velasquez et al., 2023).
Linking theory and practice: Reflective practice serves as a bridge between theoretical knowledge and practical application, allowing student teachers to apply what they have learned in their college studies to real-world classroom settings. This helps them to understand the complexities of the educational process and thus to recognize the needs and characteristics of students, as well as the difficulties they may encounter in the future (Smith, Lev-Ari, 2005; Anand, Gangemi, 2023).
Improvement in teacher competencies: Engaging in reflective practices allows students to improve their competencies essential to the educational process, such as communication, lesson planning, and assessment (McDuffie, 2004; Zahid, Khanam, 2019).

3 Methodology

The aim of the research was to map in detail the reflections of the pedagogical practice of students of teacher education programmes at the bachelor's degree level. We continuously defined the focus of our analyses by formulating the following research questions.
What are students' reflections on pedagogical practice at its various stages?

How and what determines students' thinking before, during and after the pedagogical practice? What are students' reflections on themselves as future teachers in the context of reflecting on their experience of pedagogical practice?
For this study, a qualitative methodology was chosen. Content analysis of written texts, specifically selected parts of students' teaching practice portfolios—namely, written reflections on teaching practice experiences—was used as the method of data collection. We followed the grounded theory method for data analysis, and the process of analysis, in accordance with this theory, consisted of three phases, namely concept formation (open coding), searching for theoretical relationships between concepts (axial coding), and selecting a central concept and formulating a theory (selective coding) (Gavora, 2007; Řiháček el al., 2013).
The study employed a closed sample, consisting of students of teaching study programmes at the Faculty of Education, Comenius University in Bratislava (n = 143; 113 women, 30 men), who carried out their pedagogical practice in the 2023–2024 academic year. The practice was observation-based, conducted in primary or secondary school settings under the guidance of a supervising teacher, comprising 20 precepting lessons followed by methodological analyses of the observed lessons. The object of the observed-oriented type of pedagogical practice was structured observation of school reality and subsequent methodological analyses of the observed lessons with the supervising teachers. The pedagogical observation was more narrowly focused on the educational aspects of the educational process. The output was a portfolio of pedagogical practice, one of the components of which was the students' reflection on their pedagogical practice. A homogeneous purposive sampling design was used, with the criterion for selecting participants being their similar experience of pedagogical practice (Gavora, 2007).

4 Results

The following text focuses on the key themes and their interrelationships that emerge from analyses of student teachers' reflections on pedagogical practice at each stage of its progression, namely the entry, progression and exit phases.

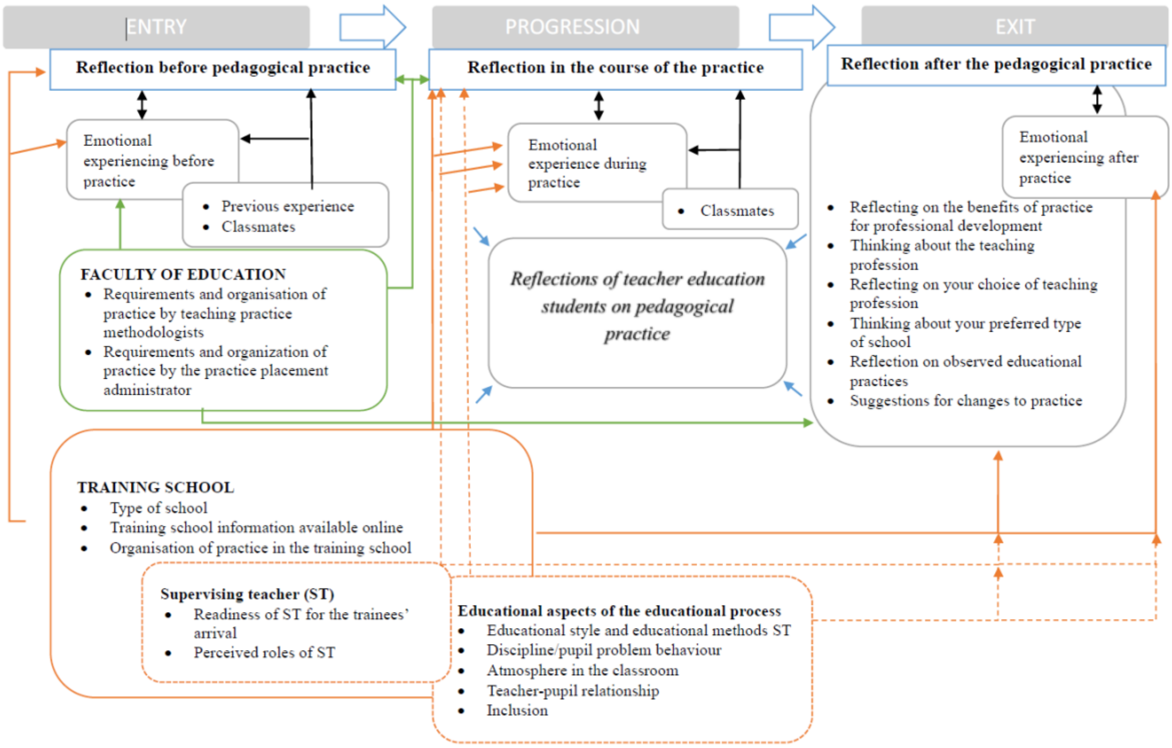

Figure 1: Map of concepts and their contexts in the context of student teachers' reflections on pedagogical practice.

How and what determines students' thinking about teaching practice in its different phases is graphically illustrated by Figure 1. Thinking about practice before it was undertaken was based on a variety of sources. Initially, students formed their ideas about what to expect through a briefing session with the practice methodologists and the practice administrator at the Faculty of Education, where they were familiarised with the requirements for successful completion of the practice. Reflection was further saturated by information available online about the training school, previous pedagogical practice experience and information conveyed by upper year students. Expectations were also notable determined by the prevailing discourse about 'today's' children: *"...before the placement I had expectations that it would be a week full of chaos and shouting..."; "...before first arriving at the school I was full of expectations and fears about whether a week at school would put me off the teaching profession"; "...what the children and teachers would be like and whether it would put me off a profession I was still unsure about".*

Initial thinking about practice was in a mutually conditioning relationship with the emotional experience of the impending experience. The relationship between emotions and cognitive processes is reciprocal, that is, it is not only cognitions that influence emotions, but emotions also influence cognitive processes (Zibrínová, Birknerová, 2015). Before and at the beginning of the practice, in retrospect, students described different emotional experiences of positive or negative valence, often involving ambivalent experiences of the incoming experience (fears, uncertainty, curiosity, positive expectations...).

The organisation of the practice in the training school notable determined the students' experience of the practice at the beginning but also throughout its course. At the beginning of the practicum, students often reflected on the need to be welcomed and accepted in the school. The personal welcome, introduction to the school and the initial organisational instructions to the practice from the school management proved to be particularly important. The SUPERVISING TEACHER occupied a special place in the organisation of the practice. Supervising teachers were a central category in the reflections, significantly determining not only the students' emotional experience of the practice, but also their overall reflection on it. Supervising teachers were identified at the beginning of the practicum as those who, through their helpful, empathetic, and friendly approach, helped students to reduce experienced tensions, fears, or stress. Students particularly praised the preparedness of the supervising teachers for their arrival and the welcoming way they were received.
Within the context of the category of supervising teacher, the perceived role of the supervising teacher was identified as a significant sub-category. Based on the students' thoughts from the portfolios, we consider the following perceived roles of the supervising teacher:

Supervising teacher as support. Students perceived the supervising teachers primarily as emotional support, not only at the beginning of the practice, when many described experiencing slight tension, uncertainty, fears about the upcoming experience, but also during the whole experience. They were often perceived as those who, with their empathic approach, were able to alleviate possible fears and insecurities and promote an overall positive atmosphere during the practice. The supervising teacher is the one who facilitates the whole course of the practice, accompanies and supports the student during the practice, is ready to answer questions, to help him/her..., is friendly, helpful, receptive, empathetic towards the students...
Supervising teacher as a role model, inspiration. One of the most frequently reflected benefits of the practicum was the opportunity to observe teachers with different educational styles, applying different educational methods, which many students perceived as an inspiration for their future teaching practice.
Supervising teacher as a source of information. The supervising teacher was reflected by many as the one who conveyed the necessary information about the course of the practice, was the person who "guided" the students into the practice with the necessary information and provided a lot of other information related to the teaching profession during the following days.
Supervising teacher as a consultant. The opportunity to have conversations with teachers after class helped them to better understand some of the phenomena observed during the educational process. The mutual conversations were deeply inspiring and motivating for some in the context of their future profession.
Supervising teacher as a facilitator of pedagogical thinking. This role was perceived by some students who had the opportunity to interview a supervising teacher about how they

perceived their profession as a teacher. Which inspired and motivated many on their future career path as a teacher. In the context of the educational aspects of the educational process, the DISCIPLINE of the students emerged as a significant theme in the reflections, the very occurrence and manifestations of which were interesting for the students, as it emerges as a significant theme in their reflections on their profession in the future. Reflecting on this - "What will my pupils be like?" - emerges in the reflections even before the actual practice: *"...what the children will be like and whether it will put me off a profession I was still unsure about."* In addition to the phenomenon of problem behaviours themselves, students observed and analysed the teachers' educational approach in managing them, which, based on their own reflections, became a role model or, on the contrary, a negative example.

The concepts obtained and their interrelationships allowed us to pursue further analyses in several directions. In the next step, we decided to narrow the analysis to how teaching practice influences students' thinking about themselves in the role of future teachers - ME AS A FUTURE TEACHER. Based on the previous analyses, we chose thinking of oneself as a future teacher after the internship as a central concept that can be easily linked to the other concepts. Thus, we formulated a more specific research question: *What are students' reflections about themselves as a future teacher in the context of reflecting on their pedagogical practice experience?*

Reflecting on oneself as a future teacher featured prominently in the students' reflections after the placement. The students confronted their expectations and previous ideas before starting the internship with their current ones after the internship. For some, the new experience was a confirmation of the expected and of their previous ideas, an encouragement and motivation on the path to teaching, for others it was an opportunity to reflect on whether to stay on the path of teaching, and for others it was even a source of change in thinking about themselves as a future teacher. From the reflections, it appears that thinking about oneself as a future teacher was determined by observations of the supervising teachers during the education process and subsequent interviews with them. Do I want to be that kind of teacher too? Reflections on the teaching profession and on oneself as a future teacher were also influenced by observations of pupils' behavioural manifestations and their interactions with teachers. Even before entering the practice, students asked themselves the question - "What are today's pupils like?" The issue of discipline appears to be significant in their reflections on teaching, it is one of the concerns regarding the teaching profession that they perceive even before the actual practice. Also evident in the reflections is the link between the theme of discipline and that of trainee teachers as role models for managing undesirable pupil behaviour. Reflecting not only on whether I too want to be such a teacher, whether the model presented is worthy of emulation, but also on whether I want to work in that type of school. Do I want to be a primary school teacher where managing pupil behaviour appears to be more challenging than in a secondary school? Not only previous attitudes towards the teaching profession, but also the immediate experience of the observed pedagogical realities determined the students' thinking about the teaching profession, and this thinking about the teaching profession is immediately reflected in the thinking about themselves as future teachers (see Figure 2).

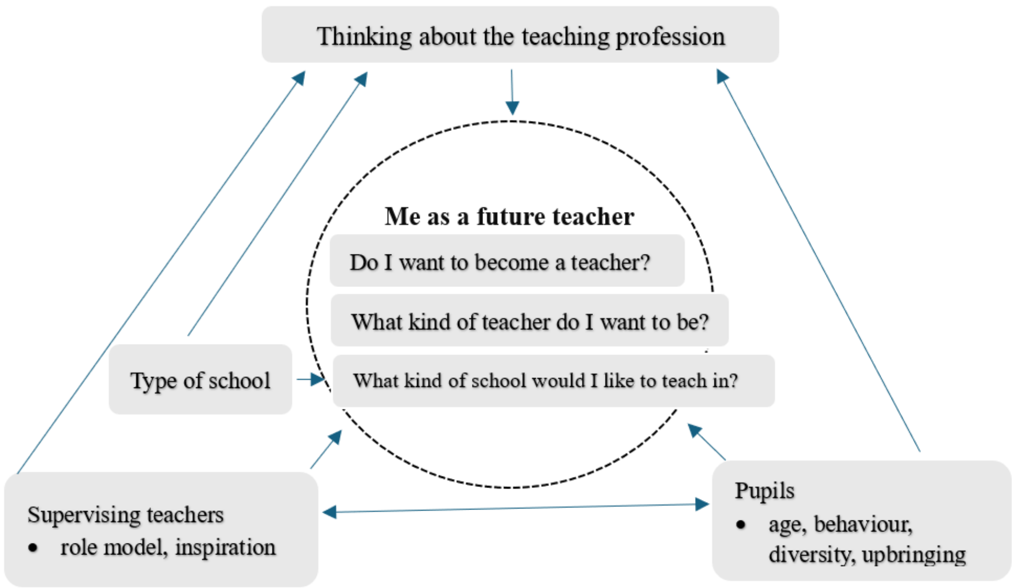

Figure 2: Students' consideration of themselves as a future teacher as a central concept.

Identified key themes arising from analyses of reflections on the central concept – self as a future teacher:

1. Reflecting on the teaching profession is the starting point for reflecting on oneself as a teacher. The following lines of reflection emerged from the reflections.

- The difficulty of the profession: students perceive teaching as a psychologically demanding profession, often justifying this by the fact that teachers are often confronted with unpredictable situations in their work, they are faced with a difficult task in the context of the diversity of pupils, their specific behaviours or needs.
- The responsibilities and challenges of teaching: it is a profession of great responsibility. Teachers are not only transmitters of knowledge but also shapers of the personalities of new generations. It is not just a profession but a mission.
- Respect and admiration for the profession: after completing their internship, students express greater respect, some even admiration, for the teaching profession and recognise its importance in educating future generations. "...I now have even more respect for the teaching profession, also based on the situations I have witnessed"; "After the internship, I perceive the profession with even more humility and admiration for anyone who chooses to pursue it."

Reflecting on the choice of teaching profession.

- Confirmation of the decision to become a teacher: many students were confirmed by practice in their initial decision to become teachers. Despite the awareness of the difficulty of the profession in contact with the reality of pedagogical practice, this group of students still feels motivated to pursue a career as a teacher. "Although there was a lot of negative student behaviour, it did not deter me from becoming a teacher." This sense of affirmation emerged repeatedly, with students often pointing out that the experience had given them a clearer picture of their future profession. Supervising teachers appear to be notable in the affirmation of career choice. "This teacher's approach motivated me personally to persevere in my decision to become a teacher."
- Increased motivation and enthusiasm for the teaching profession: for several students, the practice even further strengthened their initial conviction to
- "My attitude towards the teaching profession is even more positive and stronger". For several students, the practical experience has even aroused enthusiasm for teaching.
- Decision support: a smaller group was represented by students who, although attending a teacher education programme, are not yet firmly convinced of their choice to study teaching, describing their choice of university and future profession ambivalently. For some, the field experience has tipped the scales of decision-making towards the teaching profession, while for others it has further deepened their ambivalent feelings. "I am not sure that my choice of college is the field I want to pursue. Because through this experience, I have come to realize that the job of a teacher is really demanding and carries a huge responsibility for children."

Thinking about preferred type of school.

- Preference for type of school: experience also determined the preferred type of school in which students would like to work in the future. Several preferred to work with older pupils in secondary school, while some felt more motivated to work with younger children. "The practice has made me sure that if I am going to teach, it will be only in secondary school. I'm not saying I couldn't do it in primary school, but it would be more mentally challenging for me".
- Change of opinion: the practice has influenced the opinions of several students who had previously rejected the idea of becoming a primary school teacher, but after positive experiences with younger pupils are considering this option, which was a surprise for them themselves. "Although I thought I would never want to teach in primary school, this experience has made me open to the possibility," one student remarked; similarly, another said, "My attitude has changed slightly. I think that even with younger pupils, it's all possible." In this way, the internship opens the door to new possibilities and perspectives that might otherwise remain undiscovered by the students.

- Primary school is more about upbringing: another interesting aspect arising from reflections on practice in the context of preferred school type was the reflection that pedagogical activity in primary school is much more focused on upbringing than many had previously realised. This view of the educative aspect of the educational process is fundamental to the formation of future teachers, who are not only transmitters of knowledge but also educators of future generations.
- Finally, students' reflection on the overall contribution of teaching practice to their professional development as a future teacher cannot be omitted. They described the experience of the observed pedagogical reality as:
- An enriching practical experience: the internship was perceived as an opportunity for professional growth, a chance to gain valuable experience from the observed educational reality.
- Opportunity for linking theory with practice: the practice helped to link theoretical knowledge with real situations in schools, which is considered by the students to be very important for their future practice as teachers.
- Awareness of the importance of college preparation for the future profession: the practical experience fostered students' understanding of the college for their future profession as teachers.

A source of motivation for further study.

- Source of inspiration and role models: students were inspired by the approaches of the supervising teachers and gained new ideas on how to deal with educational situations in the context of pupil diversity. The practicum allowed them to observe, compare and evaluate different educational practices of several teachers, which enabled them to reflect on their own educational practices that they would prefer in their future practice.
- Overall, it appears that supervising practice has a major influence on student teachers' thinking about their future profession and their decision to become teachers. At the same time, it has also fostered an awareness of the importance of theoretical preparation at university and its connection to practice. For further professional growth, it was reflected by many students as an enriching practical experience, inspiration and motivation for further studies, the source of which was primarily named by the supervising teachers. Supervising teachers appear to have the potential to notable support and motivate practising students on their professional development journey.

5 Discussion

At a time when teaching practice is an integral part of the preparation of future teachers, it is essential to pay attention to the processes that shape their professional development. An analysis of student teachers' reflections on their pedagogical practice reveals that this process has a profound influence on their reflections on their own professional identity and their future profession. Reflections, as part of teacher education, also provide valuable information about how students think about the challenges facing the teaching profession.
One of the key findings of the analyses is that reflective pedagogical practice helps students to connect theoretical knowledge with practical experience. Our findings support the research findings of other authors who suggest that reflective practice serves as a bridge between theory and its practical application in the real-world conditions of a particular school classroom; it is an opportunity for students to apply what they learn, mostly theoretically, during their undergraduate preparation. Linking theory to practice helps them better understand the complexities of the educational process (Smith, Lev-Ari, 2005; Anand, Gangemi, 2023).

Students' reflections also suggest that pedagogical practice is an opportunity for them to self-reflect and develop their professional competencies. Students learn to critically analyse their experiences, which enables them to identify areas for improvement and thus develop their teaching competences. According to Barber (2020), reflective journals and other reflection tools are effective means of promoting the development of reflective habits in future teachers. In this way, students become active participants in their learning process and take responsibility for their professional growth. Reflective teaching practice has the potential to develop the reflective skills of teacher trainees, which, given the dynamics of the school environment and the ever-changing needs of students in the future teaching profession, are essential; it is a competence that will enable them to adapt and respond effectively to the challenges that await them in their professional lives. As Korthagen (2011) confirms, the ability to reflect on one's own practice is a core competency that enables teachers to adapt to changing conditions in the school environment.
The issue of professional identity and professional decision-making was also an important topic of reflection. Our findings show that students ask questions about their professional preferences after completing their internships. They consider to what extent the internship has affirmed or, on the contrary, "discouraged" them from the teaching profession. These reflections are in line with the ideas of several authors, according to whom reflective pedagogical practice helps students of teacher education programmes to shape their professional identity and is an opportunity for forming a relationship with the teaching profession (Segalo, Dube, 2022; Anand, Gengmei, 2023).

Supervising teachers have emerged as important actors in the professional development of teacher trainees, contributing to the formation of their professional identity. Their empathetic approach, ability to provide support and willingness to share their professional experiences contributed to creating a positive atmosphere during the practicum, resulting in students feeling accepted and motivated. According to several authors, role models and mentoring are particularly significant in teacher education (Segalo, Dube, 2022; Anand, Gengmei, 2023). Students who had the opportunity to observe and interact with supervising teachers who were an inspiration to them were more likely to be affirmed in their decision to become teachers.

Ultimately, pedagogical practice is not only an opportunity to develop professional competences, but also to shape the personal and professional identity of future teachers. Support from supervising teachers, as well as opportunities for reflection and critical evaluation of their own experiences, are key to successfully linking theoretical education to practical teaching activities. The practical experience of pedagogical practice contributes to teacher students becoming motivated, competent and self-reflective professionals who are prepared to meet the challenges of a changing educational environment.

6 Limits

Although quality researchers often select their research participants "purposively", i.e. based on their chosen criteria and availability, as we did in our selection, it is more typical for the grounded theory method to follow the principle of theoretical sampling. Where the researcher gradually expands his or her selection of participants based on emerging concepts during the analysis. However, due to the nature of the research material and the impossibility of re-entering the field, we worked with a closed sample. At the same time, we are aware that the data obtained would have been more valid had it been obtained through the application of multiple research methods of data collection. In this paper, we present only the results of the content analysis of the written products, but our broader analyses of reflections on pedagogical practice included analysis of interviews with research participants in the colloquia. The interviews conducted support the theory derived from the content analysis of the written products. However, the scope of this paper did not allow inclusion of these interview analyses in the results.

7 Conclusion

The process of student teachers reflecting on their teaching practice is essential for the personal and professional growth of future teachers who are trying to find their place in the dynamic and challenging environment of education. These reflections are particularly important for students as they gradually form their ideas about their future profession, reflecting on their own professional aspirations and preferences.

Analysis of the reflections shows that pedagogical practice strongly influences student teachers' decisions to become teachers. For many students, pedagogical practice has reinforced a positive attitude towards teaching and strengthened their determination to face the challenges inherent in the profession. They see teaching not only as a profession but also as a mission that requires responsibility, empathy and commitment. Supervising teachers occupy a substantial place in the reflections. Their empathetic approach to students, support and willingness contributed to creating a pleasant atmosphere during the practice. Their approach and role models have been an inspiration to many students, and for many it was the approach of the supervising teachers that was the source of affirmation of their decision to become a teacher.

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Evaluation of a Workshop as a Form of Continuing Professional Development for Primary Education Teachers in the Context of Developing Students' Manual Skills

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Abstract

The development of students' manual skills in primary education is a key competency, important not only for their personal growth but also for their future career development. Despite this, a noticeable deficiency in these skills exists, contributing to declining interest in traditional craft and technical fields. This situation underscores the need for continuous professional development to enable teachers to effectively foster students' practical skills. The aim of this article is to evaluate a workshop focused on promoting manual skills as a form of lifelong professional learning for primary school teachers. The research focused on analyzing the opinions of participants who completed the workshop, which were gathered through a questionnaire survey. The survey results revealed that this form of professional development was perceived as highly effective and relevant. Teachers expressed satisfaction with the connection between theory and practice and confirmed that they plan to implement the knowledge and skills gained in their teaching practice. The data suggest that practical workshops constitute a valuable and necessary component of continuing professional development for teachers, potentially contributing to the enhancement of students' manual skills in Slovakia.

Keywords: Workshop, Manual Skill, Teacher

1 Introduction

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In 2023, a new school reform was adopted in the Slovak Republic, representing a significant step towards the modernization of the educational system (Vzdelávanie 21. storočia, 2025a). Starting from the 2026/2027 school year, the new national curriculum will be implemented in all primary schools, beginning with the first grade. The main goal of the reform is to shift from a transmissive model of education, based on the transfer of knowledge, to a competence-based model focused on developing complex skills, creative thinking, and the holistic potential of each student. The reform also emphasizes the student's active approach to learning and their participation in the process of discovering knowledge.

One of the identified issues is the low level of student engagement in science subjects, which are often perceived by learners as unattractive and insufficiently connected to real life (Franco, 2025; Oujezdecký & Nagyová, 2016; Lagria & Pañares, 2023). Students frequently fail to recognize the practical value of theoretical knowledge, which leads to a loss of motivation and reduced interest in learning. As Asykin and Agustin (2023) state, learning through direct experience, observation, and practical activity significantly contributes to a deeper understanding of the concepts taught and increases the joy of learning. The reform also reflects the need for digitalization in education and the integration of modern technologies into the teaching process (Vzdelávanie 21. storočia, 2025b).

Within current educational trends, which are often focused on developing cognitive abilities and digital competencies, it is essential to emphasize the importance of manual activities as a fundamental part of the educational process. Wójciková (2021) highlights that motor activity represents a key developmental stimulus. The development of fine and gross motor skills in primary school students should not be seen merely as a supplementary activity but as a fundamental element that supports cognitive, emotional, and social development. This process is closely related to neurobiological maturation and significantly influences the overall learning potential of the child.

2 The Importance of Manual Activities in Education from the Perspective of Student Personality Development

Research in the field of neuroscience highlights a strong connection between motor skills and cognitive functions (Grissmer et al., 2010; Diamond, 2000; van der Fels et al., 2015). Diamond (2000) demonstrated a causal relationship between motor activity and the development of cognitive abilities, emphasizing that both processes are inseparably linked. Activities such as manipulating objects, cutting, drawing, gluing, or modeling stimulate brain areas responsible for spatial perception, problem-solving, and memory processes.

The development of fine motor skills, such as proper pencil grip or precise cutting, directly affects the level of graphomotor abilities, which are essential for developing writing skills. Insufficiently developed manual skills may manifest as poor coordination, slower writing speed, and reduced legibility, which can lead to student frustration. Van der Fels et al. (2015)

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state that fine motor skills, bilateral coordination, and timed motor performance show the strongest relationship to cognitive abilities.

Manual activities such as working with clay, wood, or textiles contribute to the comprehensive development of a student's personality. They allow learners to express themselves creatively, implement their own ideas, and strengthen their sense of competence through the completion of a tangible product. This process fosters self-confidence, increases intrinsic motivation, and contributes to the development of a positive attitude toward learning.

At the same time, these activities have a significant social and emotional dimension. Collaborative creative projects develop teamwork, communication, empathy, and conflict-resolution skills. They teach students to accept mistakes as a natural part of the learning process, thereby fostering psychological resilience and perseverance.

The integration of manual activities into teaching should therefore be seen as an essential component of a modern educational system. This is not a return to traditional forms of instruction, but rather an innovative approach that acknowledges the connection between body and mind as a key aspect of the holistic development of every learner.

3 Workshop for Primary Education Teachers Focused on Developing Manual Skills

International experience from successful school reforms shows that a key prerequisite for the successful implementation of changes in the educational system is the systematic support of teachers and their continuous professional development (Zimmerman, 2006; Kim, 2024; Brundrett & Dunca, 2011; Vzdelávanie 21. storočia, 2025b). The effective implementation of reform measures requires the development of methods for teachers' professional growth and the adjustment of their university-level teacher preparation programs (MŠ SR, n.d.).

Primary education teachers face the challenge of responding to the changing needs of students, who, because of digitalization and changes in daily lifestyles, have fewer opportunities to develop manual skills through natural activities, such as play or creative tasks at home. Therefore, ongoing professional development through workshops, seminars, and practical courses is crucial for maintaining and expanding teachers' professional competencies.

In a questionnaire survey conducted among 216 primary education teachers, 70% of respondents (152 teachers) expressed interest in a workshop focused on developing students' manual skills, as they consider these skills insufficient. Among the interested teachers, 136 (63%) indicated their willingness to participate in the workshop, and 28% preferred in-person learning.Based on the survey results, the workshop was designed to include five activities focused on working with technical materials: paper, cardboard, natural materials, wood,

textiles, and modeling compounds. Interest in working with plastics was the lowest (24%). The 10-hour workshop was held on a Saturday to accommodate employed teachers.
The aim of the workshop was to expand teachers' methodological repertoire with new material-handling techniques that can be directly applied in teaching, thereby contributing to the effective implementation of the goals of the school reform. At the end of the session, participants evaluated the content, organization, and practical applicability of the workshop.

4 Evaluation of the Workshop Questionnaire

The opinions of the participants of the workshop focused on developing manual skills of primary education pupils were collected through a questionnaire distributed immediately after the educational activity via the Google Forms platform. The questionnaire contained six closed-ended and one open-ended item. The closed-ended questions were evaluated on a five-point Likert scale, where 1 represented the highest possible score (maximum satisfaction) and 5 represented the lowest score.

The open-ended question allowed respondents to express their comments, suggestions, and recommendations regarding the content and implementation of the workshop. Respondents were asked the following questions:

Q1. Did the workshop meet your expectations?
Q2. Was the content focus of the workshop beneficial for your personal development?
Q3. Were the activities suitable for application in your teaching practice?
Q4. Was the time allocated to each activity appropriate?
Q5. Do you consider the workshop beneficial in terms of acquiring new knowledge and skills?
Q6. Would you participate in a similar workshop in the future?
Q7. Please write your comments and opinions about the workshop you attended.

The results of the responses to the first question (Q1) showed that 89% of participants stated that the workshop met their expectations (see Figure 1). The highest level of satisfaction was expressed by in-person participants (97%), while among the online participants, satisfaction reached 86%. Average satisfaction (rating 3) was reported by 11% of respondents, with 14% of online participants and 3% of in-person participants selecting this option. No respondent indicated that the workshop did not meet their expectations. The identified differences between the groups exceeded 10%, suggesting statistically significant differences between the evaluations of the in-person and online forms of the workshop.

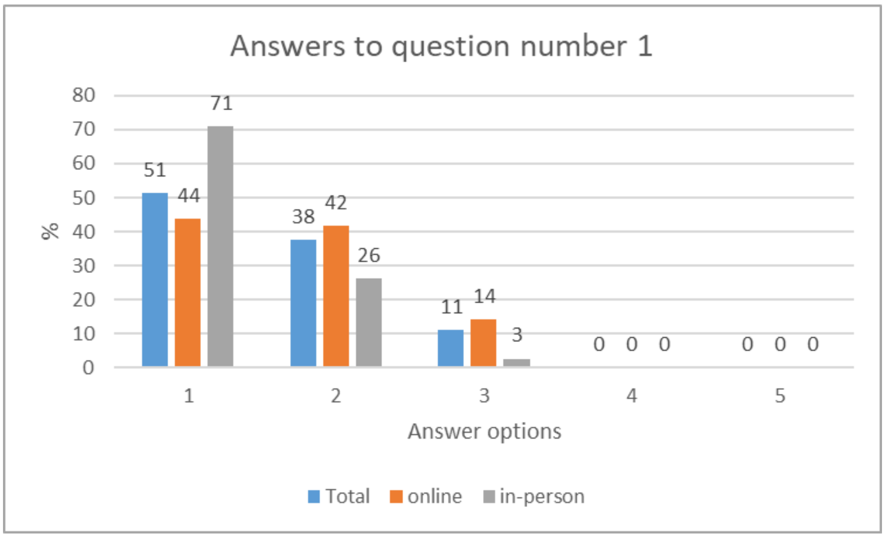

Figure 1: Fulfilment of Participants' Expectations.

In the second question (Q2), we examined the extent to which the content focus of the workshop was beneficial for the participants' personal development (see Figure 2). The highest rating (1) was chosen by 56% of respondents, with a 21% higher proportion recorded among in-person participants. A rating of "2" was selected by 37% of respondents, indicating an overall high level of satisfaction. The results also show that online participants (41%) more frequently chose a slightly lower rating compared to in-person participants (26%), which may be related to the limitations of the distance-learning environment and a lower opportunity for interactive engagement in the activities.

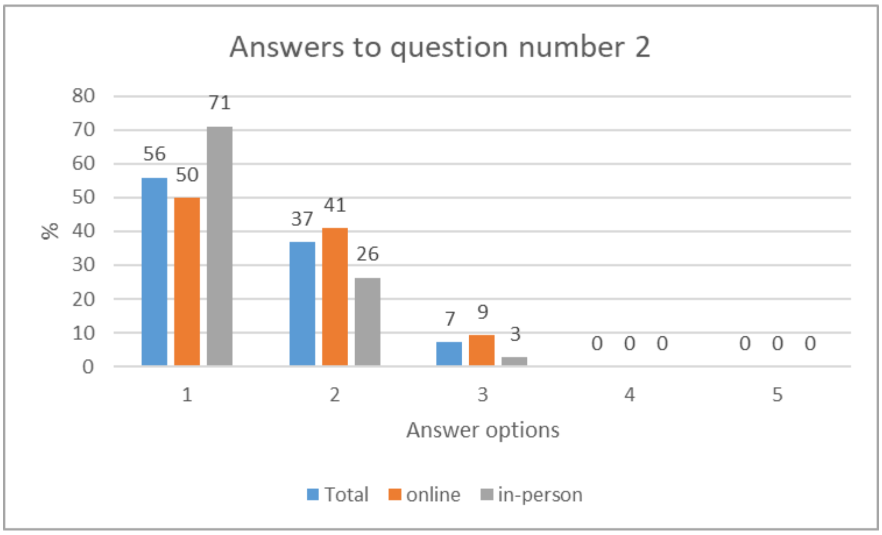

Figure 2: Contribution to Personal Development.

Question Q3 focused on assessing the suitability of the activities for application in pedagogical practice – Figure 3. The results showed that 97% of respondents considered the implemented activities suitable for classroom application (54% chose rating 1 and 43% rating 2). Only 3% of participants rated the suitability of the activities as average (rating 3). None of the in-person participants gave a rating lower than 2. These results suggest that participants perceived the workshop as a methodologically and practically useful tool for professional development.

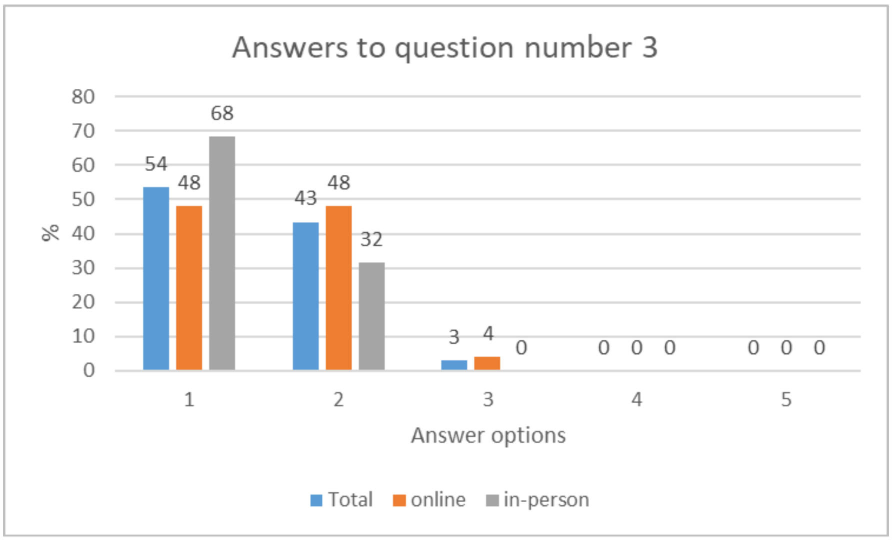

Figure 3: Suitability of Activities for Pedagogical Practice.

For Question Q4, which focused on the adequacy of time allocated to individual activities, significant differences were observed between the groups. Option 1 (full satisfaction with time) was selected by 84% of in-person participants, but only by 20% of online participants (Figure 4), representing a 64% difference. Respondents from the online group most frequently chose ratings 2 (44%) or 3 (36%). These findings indicate that the online format was perceived as less time-efficient, likely due to technical limitations, lower interaction dynamics, and reduced opportunities for direct observation of activity details.

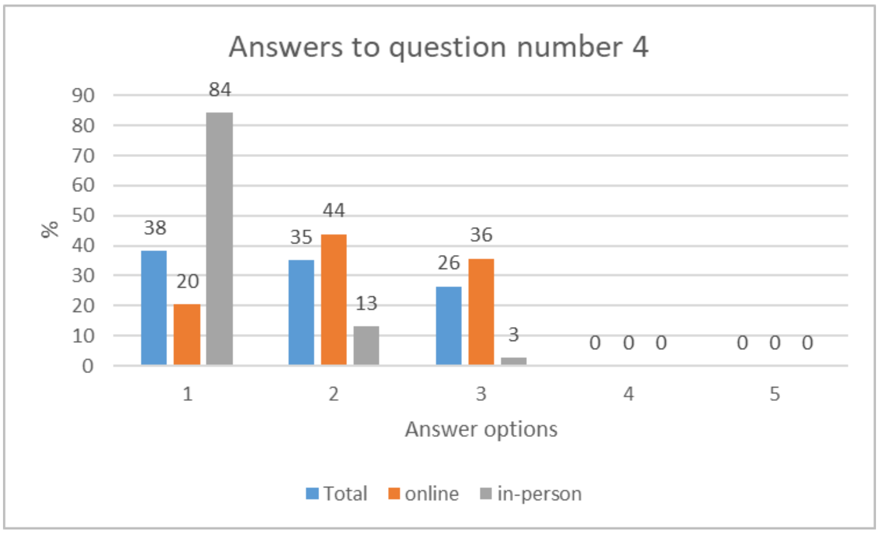

Figure 4: Adequacy of Time Allocated to Activities.

In Question Q5, respondents evaluated the benefit of the workshop in terms of acquiring new knowledge and skills (Figure 5). Most participants (65%) stated that the workshop was highly beneficial in this regard. The highest rating (1) was selected by 79% of in-person participants, while 59% of online participants chose the same rating. Option 2 was selected by 35% of online participants and 18% of in-person participants. Only 5% of respondents rated the workshop's contribution as average. These results suggest that face-to-face learning allows for more effective acquisition of practical skills, which require direct observation and hands-on manipulation of materials.

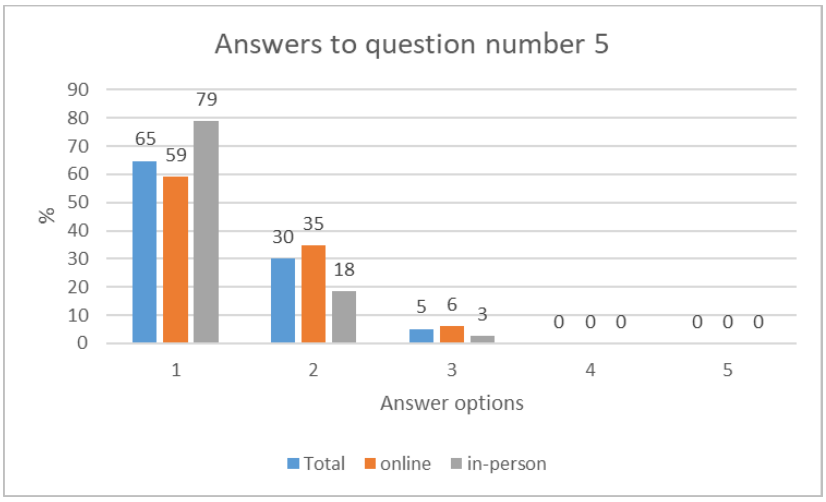

Figure 5: Acquiring New Knowledge and Skills.

In Question Q6, which focused on participants' willingness to attend a similar workshop in the future, 79% of respondents answered positively (Figure 6). Among them, 55% of in-person participants and 41% of online participants selected rating 1, while 26% of in-person and 37% of online participants chose rating 2. Option 3 was selected by 21% of respondents, mostly from the online group.

These results indicate a high level of teacher motivation to continue their professional development through similar workshop formats.

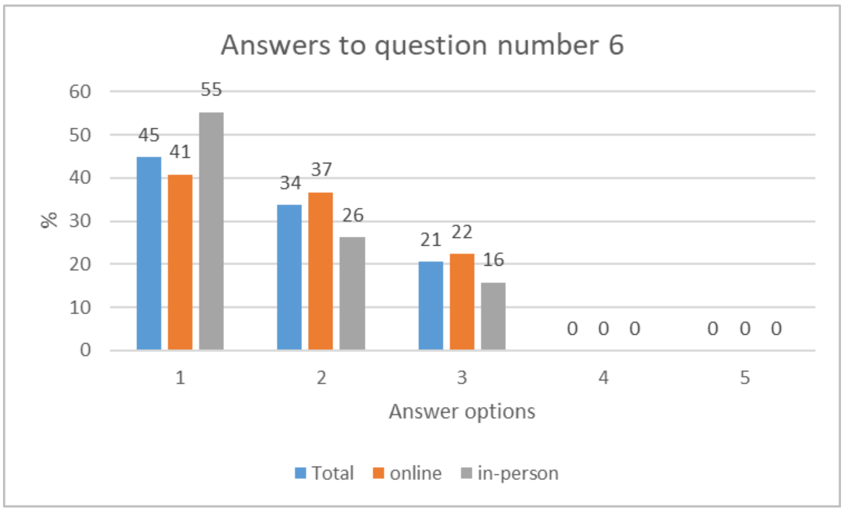

Figure 6: Willingness to Participate in a Similar Workshop.

The final, open-ended item of the questionnaire (Q7) provided additional qualitative data regarding participants' experiences. In-person participants particularly appreciated the connection between theory and practice, methodological guidance for creating didactic materials, the trainer's approach, and the opportunity to exchange experiences with colleagues. Reported disadvantages included time demands and the absence of activities involving recycled materials.

Online participants valued the opportunity to engage in professional development without the need for travel, the methodological insights, and the relevance of the workshop content to practice. However, they identified several technical limitations of the online format — in particular, poor visibility of details, lack of personal consultation, and communication noise. According to their feedback, these factors reduced work quality and affected overall satisfaction.

The comments suggest that, despite the technological accessibility of online education, face-to-face formats remain preferred for manually oriented activities. Participants emphasized the importance of personal interaction, immediate feedback, and shared experience, which are essential for the effective development of practical competencies among primary education teachers.

5 Discussion and Interpretation of Research Findings

The results of the conducted research demonstrated a high level of participant satisfaction with the content, organization, and overall benefits of the workshop. The collected data indicate that most respondents evaluated the workshop as fully meeting their expectations, confirming its effectiveness and relevance in relation to the stated objectives. As many as 89% of participants reported that the workshop met their expectations, while the differences between in-person participants (IP) and online participants (OP) suggest that the mode of delivery significantly influenced the perceived quality. The higher ratings given by IPs can be interpreted because of more intensive interaction, immediate feedback, and authentic engagement in practical activities, which are more difficult to achieve in an online environment.

In evaluating the content focus of the workshop (Q2), its high relevance for the personal and professional development of participants was confirmed. Respondents most frequently selected the highest possible rating, with a 21% difference in favor of in-person participants (IP), suggesting that personal contact and direct engagement in the creative process contribute to more effective acquisition of knowledge and skills. This finding aligns with the insights of several authors (e.g., Kolb, 2015; Turek, 2008), who emphasize the importance of experiential learning and active participation in the development of teachers' professional competencies.

From the perspective of applicability, most respondents (97%) considered the activities implemented during the workshop suitable for use in their teaching practice (Q3). The near absence of negative evaluations confirms that the workshop met the criteria for integrating new knowledge into the educational environment and provided participants with specific methodological approaches applicable to the development of pupils' manual skills. This result supports the effectiveness of practice-oriented forms of teacher professional development, which enable the immediate connection between theory and practice.

The most significant differences between IP and OP were observed in the evaluation of the adequacy of time allocation for individual activities (Q4). While 84% of IP considered the allotted time sufficient, only 20% of OP shared this opinion. This difference can be explained by the specific characteristics of the online environment, where the fluidity of interaction is reduced, visual perception of details is limited, and communication between participants and the instructor is hindered. These factors ultimately affect the work pace and participants' subjective perception of time adequacy. These factors ultimately influence the pace of work and subjective perception of time adequacy, which points to the limitations of distance learning in activities requiring spatial coordination and direct manipulation of materials.

When assessing the workshop's contribution to acquiring new knowledge and skills (Q5), positive evaluations prevailed and 65% of respondents reported a clear benefit. The recorded difference between IP and OP (20% in favor of IP) once again points to the greater effectiveness of in-person learning for practical and experience-based activities. The results support the theoretical foundations of the constructivist approach to learning, which emphasizes that active participation and social interaction are key prerequisites for the effective acquisition of new knowledge (Vygotsky, 1976; Petlák, 2004).

The responses to Question Q6 revealed that as many as 79% of participants would be willing to attend a similar type of educational activity in the future. This figure indicates a high level of participant satisfaction and confirms the need for continuous professional development focused on the enhancement of practical competencies.

The open-ended responses (Q7) provided a qualitative context for evaluating the workshop. IP particularly appreciated the connection between theoretical knowledge and practical demonstrations, the opportunity to exchange experiences, and the methodological support provided by the instructor. In contrast, OP pointed out technical limitations, the lack of visual access to details, and the absence of direct consultation. These findings underscore the need for careful design of online educational activities and suggest that for manually oriented topics, an in-person or hybrid format is more suitable.

From an overall evaluation perspective, it can be concluded that the workshop fulfilled its primary goal—to support the professional development of primary education teachers through the enhancement of their methodological and manual skills. At the same time, the results highlight the importance of differentiating educational formats based on the content and nature of activities. For practically oriented topics, the in-person format appears to be more effective, while the online environment can serve as a valuable supplement for theoretical preparation and experience sharing.

6 Conclusion

The research provided valuable insights into the effectiveness of a workshop focused on developing primary school pupils' manual skills and supporting teachers' professional growth. The data confirmed a high level of participant satisfaction with the content, organization, and practical applicability of the activities. Participants regarded the workshop as a meaningful form of professional learning that connects theoretical knowledge with direct experience and fosters creativity and reflection in pedagogical practice.

The comparison between in-person and online formats highlighted the importance of personal interaction and experiential learning for acquiring manual and methodological competencies. In-person participants consistently evaluated the workshop more positively across all indicators, indicating that physical presence is crucial for effective learning in activities involving material handling, detailed observation, and immediate feedback. However, the online format proved a suitable alternative for theoretical components and methodological inspiration, supporting the development of hybrid learning models.

From a pedagogical perspective, such educational formats significantly contribute to teachers' professional development by enabling them to enhance practical skills, reflect on their teaching practice, and share experiences with peers. Given the positive feedback from participants, it is recommended to continue organizing similar workshops, ideally enriched with elements of collaborative learning, work with recyclable materials, and reflective sharing of outcomes.

For the future, it would be beneficial to conduct research on the long-term impact of such workshops on teachers' pedagogical practice, as well as to compare the effectiveness of different forms of professional education. Such analyses could provide deeper insights into how to most effectively support teachers' competence development in the context of an evolving educational environment.

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Monitoring Indoor Environmental Quality in a University Classroom

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Abstract

Indoor environmental quality in educational facilities is a critical factor influencing student well-being and learning efficiency. This study aimed to assess classroom environmental quality by measuring key parameters, including temperature, relative humidity, and carbon dioxide (CO_2) concentration, at two different heights (1.2 m and 2.65 m). The results demonstrated that air quality is significantly affected by the number of students, insufficient air circulation, and inadequate ventilation. CO_2 measurements showed that the recommended threshold of 1000 ppm was often exceeded at the beginning of lessons, with a maximum recorded concentration of 3540 ppm. No statistically significant differences were observed between the two measurement heights. Relative humidity ranged from 34 to 51%, in line with recommended classroom values, whereas temperature occasionally exceeded recommended limits. Based on these findings, measures to improve indoor environmental quality are proposed, with the implementation of efficient ventilation systems identified as a key intervention.

Keywords: Indoor Environmental Quality, Carbon Dioxide, Well-being

1 Introduction

The design of buildings involves a wide range of requirements and factors that must be considered to ensure that the structure is efficient, safe, and functional, also in accordance

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with EU directives (Directive 2002/91/EC, Directive 2010/31/EU, Directive 2012/27/EU). This applies equally to school interiors (De Giuli, 2012). It is of great importance that schools provide an adequate level of indoor comfort that does not negatively affect students' health or intellectual performance (Mendell & Heath, 2005). In school buildings, it is essential to achieve an appropriate balance between energy costs and comfort levels in order to positively influence student outcomes through effective systems for air temperature control, humidity regulation, air velocity management, and air purification (Katić et al., 2021).

Indoor air quality (IAQ) is a key factor influencing health, comfort, and learning performance in educational environments. Among the most common indicators of IAQ, carbon dioxide (CO_2) concentration is widely used as a proxy for ventilation adequacy and occupant density (Daisey, Angell & Apte, 2003; WHO, 2011, Bluyssen, 2013; Zhang et al 2022). Elevated CO_2 levels are mainly the result of insufficient ventilation relative to the number of occupants, which can lead to drowsiness, headaches, reduced attention span, and lower cognitive performance among students (Satish et al., 2012; Bakó-Biró et al., 2012, Tureková et al., 2022a).
Many schools around the world (Piera, 2014; Issa et al., 2011; Schibuola & Tambani, 2020; Ferreira & Cardoso, 2014), as well as in Slovakia, use natural ventilation. The absence of mechanical ventilation systems results in unsatisfactory microclimatic conditions in classrooms. Measurements taken at 28 Slovak schools showed that students and teachers spend hours in classrooms with volatile chemical compounds, dust, and record-high levels of carbon dioxide. This is also associated with high noise levels and overheating of classrooms during the summer period (Vilčeková et al., 2017, Hašková at al., 2019, Tureková et al., 2022b, Tureková et al., 2021).
Carbon dioxide (CO_2) is a colorless and odorless gas naturally present in the atmosphere at about 400 ppm. It is a normal by-product of cellular respiration, the process by which the human body converts oxygen and nutrients into energy (Coley & Beisteiner, 2002). In enclosed environments such as school classrooms, CO_2 levels can rise quickly due to the exhalation of many students. When concentrations exceed approximately 1000 ppm, it can negatively affect children's comfort and performance – causing fatigue, drowsiness, headaches, and reduced concentration during lessons. (Bogdanovica et al, 2020, Küçükhüseyin 2021). Table 1 shows the effect of CO_2 concentration in ppm on the human body.

Concentration	**Effect**
350 to 450 ppm	Typical atmospheric concentration
600 to 800 ppm	Reliable indoor air quality
1 000 ppm	Upper range of reliable indoor air quality
5 000 ppm	Maximum workplace concentration over 8 hours
6 000 to 30 000 ppm	Critical, only short-term exposure
3 to 8%	Increased breathing frequency, headaches
> 10%	Nausea, vomiting, loss of consciousness
> 20%	Rapid loss of consciousness, death

Table 1: Effects of Carbon Dioxide Concentration on Human Health and Perform. (Satish et al., 2012)

In Europe, there are no comprehensive legally binding regulations for quality requirements regarding indoor air. Instead, several evaluation values exist, which are called guide values, orientation values or target values, for example. In Germany, a CO_2 value of 0.15 vol% (= 1 500 ppm) applies as a hygienic guide value according to DIN 1946 - 2.

In Finland, the maximum permitted CO_2 concentration in indoor air under usual weather conditions and when the room is in use is 1 200 ppm. The Norwegian and Swedish guidelines fix a maximum CO_2 concentration of 1 000 ppm for living rooms, schools and offices. In Denmark the carbon dioxide concentration in children's day care centres, schools and offices should not exceed 1 000 ppm. The air exchange is described as insufficient when the CO_2 concentration exceeds the value of 2 000 ppm several times a day for a short time (Health and Environment Alliance, 2019; Küçükhüseyin, 2021).

At workplaces which are subject to the stipulations of the Dangerous Substance Directive a workplace limit value of 5 000 ppm CO_2 applies (Government Regulation No 355/2006).
Pettenkofer's criterion (1858) defines the maximum comfortable indoor carbon dioxide (CO_2) concentration at 1000 ppm (0.1% vol.). This value represents the upper limit of good indoor air quality, ensuring suitable conditions for human comfort and concentration. Elevated concentrations indicate insufficient ventilation and may lead to reduced performance or fatigue. This criterion will serve as the reference value against which the measured CO_2 concentrations in classrooms will be compared.

Although numerous studies have focused on primary and secondary schools, similar issues are increasingly recognized in university classrooms, where occupancy patterns and ventilation systems differ significantly (Madureira et al., 2012; Plowman & Smith, 2013). University lecture rooms often rely on natural or manually controlled ventilation, which may not adequately respond to changing occupancy levels and can result in CO_2 concentrations exceeding the recommended limit of 1000 ppm (ASTM D6245, 2002; WHO, 2011).

Continuous monitoring of CO_2 concentrations in university classrooms provides valuable insights into ventilation efficiency, indoor environment dynamics, and the need for implementing automated demand-controlled ventilation systems (Laverge et al., 2011; Luther & Horan, 2014). The aim of this paper is to determine:

- how the concentration of CO_2, air temperature, and humidity change over time and depending on the classroom occupancy by students,
- the difference between the measured values of CO_2 concentration, humidity, and temperature in the classroom at heights of 1.2 m and 2.65 m above the floor,
- to propose measures for maintaining optimal conditions while ensuring energy-efficient ventilation control.

2 Materials and Methods

2.1 Classroom and its Characteristics

Indoor environmental measurements were conducted at the Faculty of Education, Constantine the Philosopher University in Nitra, at the Department of Technology and

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Information Technology. The two-floor building is oriented north-south and not insulated. The classroom under study is in a section constructed in 1936 and subsequently renovated in 2004 for educational use. (Figure 1).

Figure 1: Classroom for indoor environmental parameter measurements (Kravčenko, 2025).

The classroom has a rectangular floor plan measuring 6.4 × 5.2 m, a ceiling height of 3.15 m, and a total volume of approximately 104.7 m³. The room is equipped with six ceiling lights (1 × 0.5 m), two large windows (1.75 × 2 m) on one wall, 12 student desks, a teacher's desk, and conventional radiators under the windows. Doors measure 1.95 × 2 m. The windows provide natural lighting and ventilation; no mechanical ventilation systems were used.

2.2 Measured Parameters

The study focused on three indoor environmental parameters:

- Relative humidity (%),
- Temperature (°C),
- CO_2 concentration (ppm).

Measurements were conducted using a Testo 315-3 device (Testo SE & Co. KGaA, Germany) (Figure 2), positioned at the centre of the room. Key specifications of the device are listed in Table 2.

Parameter	Measuring Range	Accuracy	Resolution
Carbon dioxide (CO_2)	0 to 10 000 ppm	±300 ppm (0 to 4,000 ppm); 8% of measured value (4,000 to 6,000 ppm)	10 ppm
Temperature t_0(°C)	-10 to +60 °C	±0,5 °C (±1 Digit)	0,1 °C
Relative humidity φ (%)	+5 do +95%	±2,5% (5 do +95%)	0,1%

Table 2: Key technical specifications of the Testo 315-3 device (https://www.testo.com/sk-SK/testo-315-3/p/0632-3153).

Figure 2: Testo 315-3 used for measurements.

2.3 Measurement Procedure

Measurements were conducted in real time during teaching sessions between November and December 2024, on five selected Wednesdays (6, 13, 27 November, and 4 and 11 December 2024). Each session lasted 90 minutes, with five measurements taken at 20-minute intervals (7:40, 8:00, 8:20, 8:40, and 9:00 h).
During practical exercises, the number of students varied depending on their participation in activities outside the classroom. Prior to the first measurement, the room was ventilated for 10 minutes.

2.4 Measurement Heights

Measurements were performed at two heights:

- 1.5 m above the floor, representing the students' breathing zone,
- 2.65 m above the floor (0.5 m below the ceiling), chosen to test the hypothesis of lower CO_2 concentration near the ceiling due to its higher density relative to air.

3 Results and Discussion

Measurements were conducted on five selected days (6 November 2024, 13 November 2024, 27 November 2024, 4 December 2024, and 11 December 2024) at the same times and are labelled as follows: Measurement 1 at 7:40, Measurement 2 at 8:00, Measurement 3 at 8:20, Measurement 4 at 8:40, and Measurement 5 at 9:00. Measurements were performed at two heights above the floor: 1.5 m and 2.65 m.

Measurement date	Measurement no.	CO_2 (ppm)		Temperature t_0 (°C)		Relative humidity φ (%)		No. of students in the classroom
		Height 1.2 m	Height 2.65 m	Height 1.2 m	Height 2.65 m	Height 1.2 m	Height 2.65 m	
06/11/2024	1	1210	1200	20.4	21.1	40.0	43.0	15
	2	2160	2170	22.6	22.9	42.0	44.0	13
	3	3000	2860	23.0	23.1	44.5	50.6	10
	4	3020	3040	23.4	23.5	52.8	56.3	14
	5	3540	3540	23.6	23.6	54.4	61.2	14
13/11/2024	1	1640	1430	23.1	23.1	40.5	40.5	12
	2	2130	2070	23.4	23.4	43.2	43.2	13
	3	2320	2270	23.5	23.5	44.5	44.5	7
	4	2840	2320	23.6	23.6	44.8	44.8	10
	5	2910	2890	23.8	23.8	45.0	45.0	11
27/11/2024	1	1150	1100	23.1	23.5	35.4	35.5	15
	2	1710	1730	23.7	24.1	38.6	38.0	9
	3	2400	2360	24.4	24.6	39.3	40.1	7
	4	2420	2390	24.8	25.0	40.3	40.3	7
	5	2450	2440	25.1	25.3	41.5	41.1	15
04/12/2024	1	1400	1290	22.7	22.9	39.5	38.0	14
	2	1620	1640	23.9	24.4	42.0	39.6	9
	3	2180	2180	24.7	25.0	45.5	45.9	10
	4	2410	2430	25.2	25.4	45.0	48.5	11
	5	2690	2690	25.5	25.8	46.7	50.8	15
11/12/2024	1	640	640	18.8	19.2	32.5	30.9	10
	2	800	810	19.6	21.0	32.5	32.4	13
	3	1350	1370	22.1	22.5	32.6	32.3	8
	4	1660	1670	23.2	23.8	35.5	35.4	15
	5	2270	2270	23.8	24.1	40.0	39.5	15

Table 3: Results of CO_2 concentration, temperature, and relative humidity measurements at different heights, including classroom occupancy.

3.1 Evaluation of CO_2 Concentration Results in the Classroom

Based on the obtained results, it can be stated that during all measurements—except for the last one, which was preceded by a 10-minute ventilation period—the classroom was not sufficiently ventilated. The concentration of carbon dioxide exceeded the reference limit of 1000 ppm in all such cases. Figures 3–7 illustrate the progression of CO_2 concentration over time during the individual measurements.

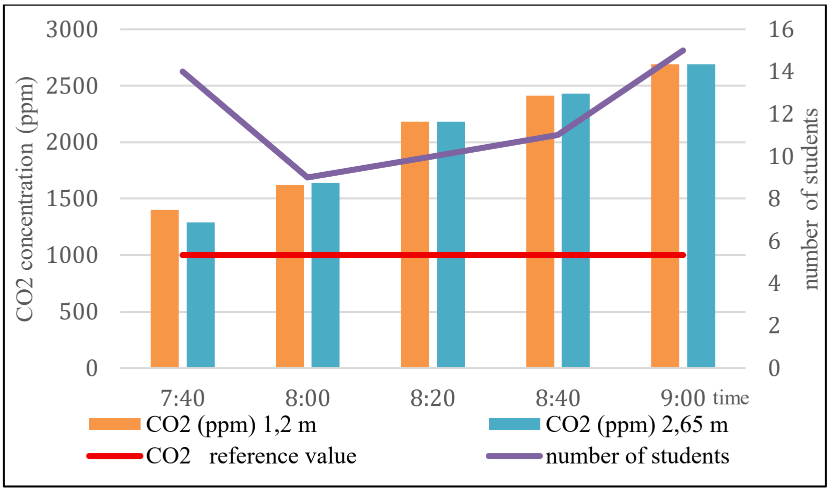

Figure 3: Increase in carbon dioxide concentration on 6 Nov 2024 at heights of 1.5 m and 2.65 m.

The difference between CO_2 concentrations measured at the two heights was not significant, and all deviations were within the margin of measurement tolerance. At the end of the lesson, the concentration reached 3540 ppm, representing a critical level that can substantially affect students' cognitive performance and health. This value was the highest among all measurements.

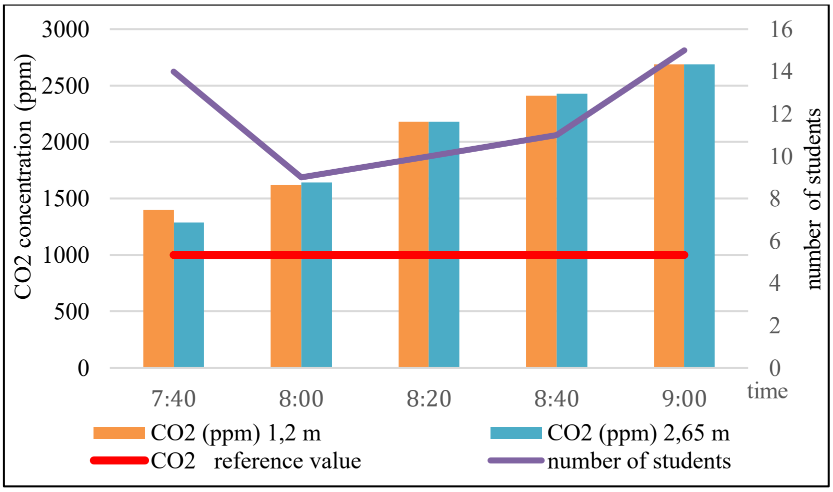

Figure 4: Increase in carbon dioxide concentration on 13 Nov 2024 at heights of 1.5 m and 2.65 m.

Similarly, during the second series of measurements, no significant difference in CO_2 concentration was observed between the two measurement heights. The concentration at the beginning of the lesson was 1640 ppm (1430 ppm) and did not exceed 3000 ppm at the end. However, even this level is associated with reduced concentration ability, increased fatigue, drowsiness, and lower productivity. The results are consistent with findings from other studies (e.g., Satish et al., 2012), which report that at 1000 ppm, performance may decrease by approximately 10%, and at 2500–3000 ppm, by 20–50%.

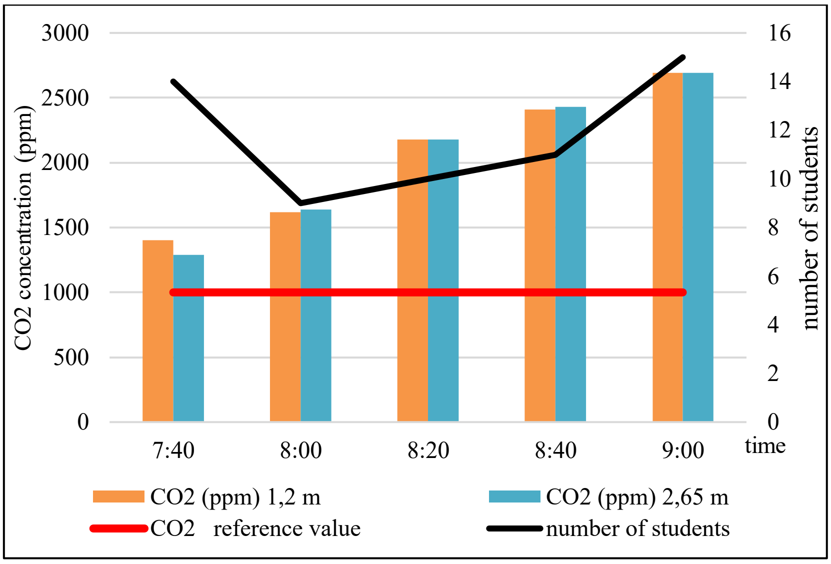

Figure 5: Increase in carbon dioxide concentration on 27 Nov 2024 at heights of 1.5 m and 2.65 m.

The third measurement series began with a concentration slightly above the reference limit (1150 ppm) and ended at 2450 ppm. Compared with the first measurement, this lower final concentration may have been influenced by a smaller number of students present in the classroom. Nevertheless, the measured value again exceeded the recommended limit. The concentrations recorded at both heights were almost identical.

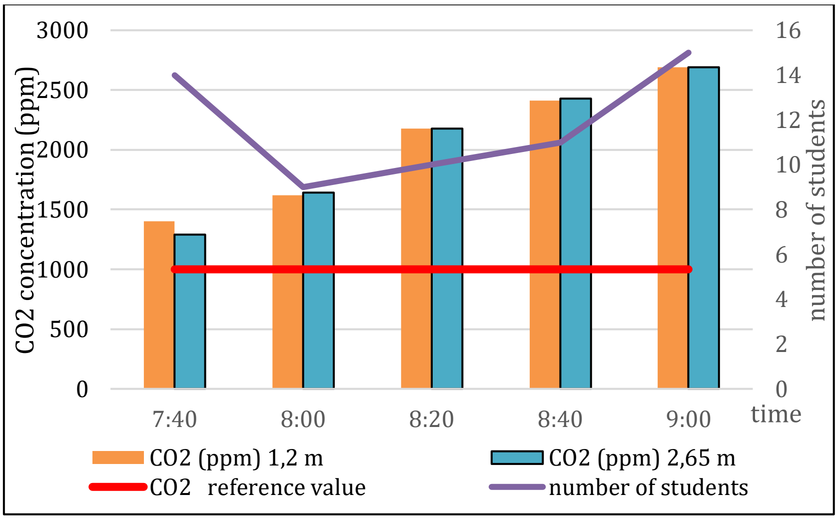

Figure 6: Increase in carbon dioxide concentration on 4 Dec 2024 at heights of 1.5 m and 2.65 m.

In this case as well, the classroom was not sufficiently ventilated, as the CO_2 concentration exceeded the reference limit at the start of the measurement. The concentration increased gradually with time and the number of students, reaching 2690 ppm at the end of the lesson. The difference between the two measured heights was not statistically significant.

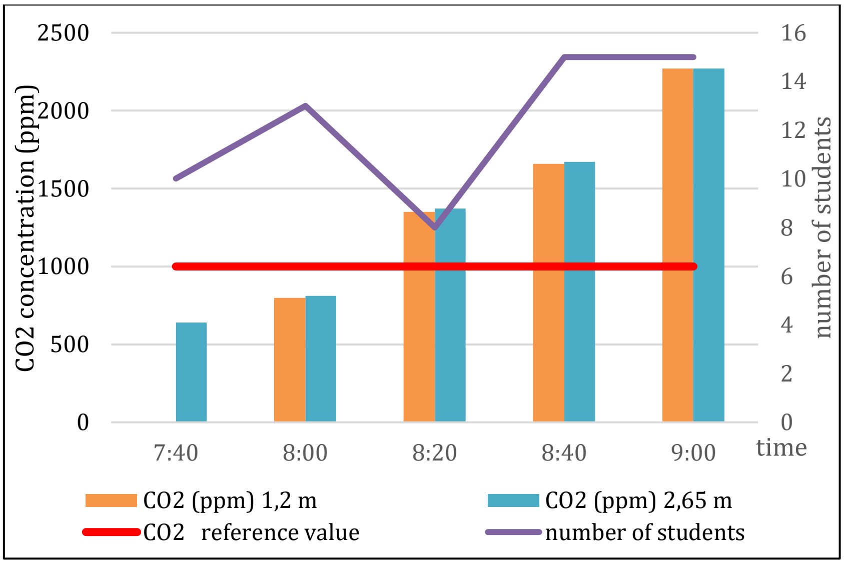

Figure 7: Increase in carbon dioxide concentration on 11 Dec 2024 at heights of 1.5 m and 2.65 m.

Unlike the previous cases, the classroom was sufficiently ventilated during this measurement. The initial CO_2 concentration was 640 ppm at both heights. After 20 minutes, it rose to 800–810 ppm, and after another 20 minutes, it exceeded the reference limit of 1000 ppm. The maximum recorded value during this measurement was 2270 ppm—the lowest among all sessions—yet, still considerably above the recommended level, indicating unsuitable indoor air.

Overall, all measurements confirmed an increase in CO_2 concentration above the recommended threshold of 1000 ppm during lessons. The recorded maximum values (3540 ppm, 2910 ppm, 2450 ppm, 2690 ppm, and 2270 ppm) substantially exceeded this limit. Comparing the measurements at two different heights (1.5 m and 2.65 m above the floor) revealed that the height of the measuring point had no significant influence on the CO_2 concentration, as the observed differences were within the allowable measurement error range.

3.2 Evaluation of Temperature and Relative Humidity Results in the Classroom

The Decree of the Ministry of Health of the Slovak Republic No. 259/2008 Coll. on detailed requirements for the indoor environment of buildings and on minimum requirements for low-standard apartments and accommodation facilities specifies the parameters of the thermal-humidity microclimate. These include the operative temperature t_o, relative humidity of air φ, and air exchange rate n.

For premises with special requirements, such as school and preschool facilities, the values of these parameters are presented in Table 4.

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Space	Temperature t_0 (°C)	Relative humidity φ (%)	Air exchange rate n (h^{-1})
Gymnasiums	15 – 17	30 – 70	5
Dormitories (DJ, kindergarten)	18 – 20	30 – 70	5
Classrooms, playrooms, day rooms	20 – 24	30 – 70	3 – 8
Isolation rooms	22 – 24	30 – 70	5
Gyms	15 – 17	30 – 70	5

Table 4: Parameters of thermal-humidity microclimate for spaces with special requirements (schools and pre-school facilities).

Another legal regulation (Decree of the Ministry of Health of the Slovak Republic No. 75/2023 Coll. on detailed requirements for facilities for children and youth) stipulates that in classrooms and other spaces where students perform activities for more than four hours a day, the temperature must be at least 20 °C. Although no specific limit value is defined for university classrooms, as continuous four-hour occupancy may not be typical, the reference parameters presented above can be used for comparison with the measured results.

The comparison of operative temperatures was carried out at a height of 1.5 m above the floor, as defined in the applicable regulation. The results show that the temperature increased progressively during all measurement sessions, depending on the duration of occupancy. The upper limit of 24 °C was exceeded during the third, fourth, and fifth measurements on 27 November 2024 (24.4–25.1 °C), and a similar trend was observed on 4 December 2024 (24.7–25.5 °C). In these cases, the temperature in the classroom did not meet the recommended microclimatic parameters.

When comparing temperatures measured at a height of 2.65 m, no statistically significant differences were detected. Minor deviations, when present, were likely due to measurement errors or local air movement.

Regarding the relative humidity of the indoor air, none of the measurements exceeded the recommended interval of 30–70%. The measurement height also did not have a significant influence on the recorded humidity values, indicating a relatively homogeneous humidity distribution within the classroom environment.

4 Conclusion

Buildings, particularly educational facilities, must be designed to fulfil their intended function — to provide a safe, functional, and healthy environment for their users. This includes not only spatial and technical design but also the assurance of adequate indoor environmental quality. Modern approaches to school building design increasingly emphasize minimizing environmental impact using sustainable materials, improved energy efficiency, and optimization of indoor microclimatic conditions (SIEA, 2023). The indoor environment —

especially air temperature, humidity, and air quality — has a demonstrable effect on the health, concentration, and performance of students (Bettinger, 2005).

The results of the measurements conducted in the university classroom showed a significant increase in CO_2 concentration during teaching hours, reaching values above 3000 ppm, i.e., more than three times the recommended limit of 1000 ppm. Such concentrations negatively affect students' alertness, comfort, and cognitive performance. The temperature in the classroom ranged between 20.4 °C and 25.5 °C, occasionally exceeding the recommended upper limit of 24 °C, which can cause thermal discomfort and decreased focus. The relative humidity was within the recommended range of 32.–52.8%.

Based on these findings, the main issue identified in the observed classroom is insufficient air exchange, related to both the number of students and the duration of teaching sessions. To optimize the indoor microclimate, it is recommended to implement regular ventilation before and during lessons, ideally every 30 minutes, or by using cross-ventilation to ensure rapid air exchange. Continuous air quality monitoring through CO_2, temperature, and humidity sensors is also advised to enable timely response to suboptimal conditions. Classroom design should consider the optimal number of students and ensure a minimum fresh air supply of 5 L/s per person.

Where natural ventilation is insufficient, automatic ventilation or heat recovery systems should be implemented to maintain adequate air exchange without excessive energy loss. Additionally, the placement of indoor plants can effectively improve air quality by reducing airborne pollutants and maintaining humidity balance.

Improving indoor environmental quality in classrooms can directly enhance students' health, concentration, and academic performance. As noted by Liptajová (2021), optimizing indoor air quality may improve student performance by up to 15%, with positive effects on attention, working speed, and task efficiency. Properly designed, well-ventilated, and environmentally sustainable classrooms therefore represent a key prerequisite for an effective and healthy educational process.

Acknowledgement

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The Influence of Digital Technologies on Students' Cognitive Function and Mental Health

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Abstract

Digital technologies have transformed education and student life by providing unprecedented access to information and flexible learning opportunities. However, their excessive use has also raised concerns regarding knowledge retention and mental health. This paper investigates the ways in which excessive reliance on digital tools contributes to declining critical thinking skills, superficial knowledge acquisition, and increasing psychological difficulties among students. Drawing on international research as well as a survey of Slovak university students, the study highlights the phenomenon of "digital amnesia," whereby dependence on search engines and digital devices undermines long-term memory retention. Furthermore, it explores links between intensive online activity and symptoms of anxiety, depression, sleep problems, and decreased concentration. The findings suggest that while digital technologies enhance access to information, they simultaneously undermine deep learning processes. The paper emphasizes the responsibility of educational institutions to foster digital literacy, critical thinking, and mental well-being, ensuring that students use technologies wisely while preserving knowledge and resilience.

Keywords: Digital Technologies, Knowledge Decline, Digital Dementia, Critical Thinking, Student Mental Health

1 Introduction

In recent decades, digital technologies have become an inseparable part of our everyday lives. They influence the way we communicate, work, learn, and even spend our leisure time. The

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Internet has enabled unprecedented access to information that, until recently, was difficult to obtain. This development has reshaped our understanding of education, knowledge, and the very meaning of learning in modern society. In a context where information is instantly accessible, a fundamental question arises: does an individual still need to systematically develop their own knowledge base, or is rapid access to data sufficient? Yet, it is increasingly evident that knowledge—rather than mere information—has a lasting impact on the quality of life of both individuals and society as a whole. An educated person is better able to understand the world, evaluate reality critically, solve problems calmly and rationally, and contribute to social progress. Digitalisation, therefore, should not be viewed as opposing education; instead, it represents a new challenge for educational systems. While it enables modern forms of learning, it also underscores the importance of fostering digital literacy, critical thinking, and the responsible handling of information. This is the essence of the contemporary educational process seeking balance between technology and wisdom, between access to knowledge and true understanding.

2 The Importance of Education for Society

The process of education may be regarded as a key mechanism of development and progress in every society. It constitutes a systematic, lifelong process of knowledge formation extending from birth to old age and exerts numerous positive effects on human personality. Long-term, systematic learning fosters individual development across multiple dimensions, including the cultivation of communication skills, the ability to manage crisis situations, and resilience to populism, among others. A direct correlation can therefore be observed: the higher the level of education, the greater the quality and efficiency of the state and society. This relationship is reflected, for example, in the quality of healthcare, the degree of corruption, and overall public safety. A modern and developed state that possesses a long-term vision of building a prosperous society invests significant financial resources into education. As a result, a confident and competitive community of individuals gradually emerges one capable of succeeding in the labour market while contributing to scientific discoveries and technological innovation, including patents. From an international perspective, such progress enhances the global standing of a nation. A good example can be found in the State of Israel, where numerous successful technological start-ups and scientific breakthroughs are generated every year.

From the perspective of education's current social significance, it is particularly important that educated and well-informed individuals are more capable of critically analysing and resisting misinformation, hoaxes, and conspiracy theories, which increasingly shape public attitudes and social dynamics today. In extreme cases, often intensified by the influence of social media, this leads to the dangerous phenomenon of societal division and polarization. The level of interpersonal aggression rises and becomes visible in public discourse, where citizens frequently demonstrate an inability to listen to or respect opposing viewpoints a fundamental component of a mature and democratic society. As a result, public debate, especially on social networks, has become markedly vulgarized, with a decline in respect toward ideological opponents. High-quality education and citizens' knowledge can therefore serve as essential tools for fostering mutual respect, civility, and constructive social dialogue (Kersting, 2023, p. 59). On an individual level, the quality of education also carries a notable psychological dimension. Attaining a higher level of education can positively shape an individual's personality by fostering greater rationality, emotional composure, and the ability to manage conflicts effectively and with perspective. Education also contributes to the development of healthy self-confidence, which is essential for everyday functioning, ambition, and resilience when coping with psychologically demanding situations. According to several empirical studies, educated individuals tend to maintain stable, well-paid employment, ensuring a decent standard of living throughout life. This demographic also exhibits lower divorce rates and reduced involvement in criminal behaviour, forming a socially balanced and rationally oriented population (Průcha, 2019, p. 15).

From a historical perspective, access to education has been a privilege for most of human history. Educational opportunities were typically reserved for a small percentage of the population usually the descendants of individuals with significant social status, wealth, or professional standing. In the past, only a small percentage of people were literate or intellectually cultivated, while the vast majority resided in rural areas, concentrating primarily on securing food and basic survival for their families. Over time, particularly under the influence of the Industrial Revolution and earlier educational reforms enacted during the reign of Maria Theresa, access to education gradually broadened to encompass wider segments of society. This transformation led to cultural and modernisation advances with several key benefits, including improved living conditions and quality of life. As scientific progress especially in healthcare accelerated, the global population grew significantly. While the world had approximately one billion inhabitants in the mid-nineteenth century, it now approaches nine billion, nearing the limits of sustainable capacity. Education thus continues to play a fundamental role in shaping not only the intellectual and moral dimensions of human civilization but also its capacity for sustainable development in the future.

2.1 The Importance of Education in the Digital Society

In the following section, we examine current trends and factors affecting the quality and level of education in society in the context of modern digital technologies. Education continues to be a central element of every developed society. Human life has undergone significant modernisation over the past two centuries, as discussed in the previous chapter. Until the mid-nineteenth century, humanity experienced relatively few systematic discoveries, such as the invention of the printing press and several other notable advancements. However, since the Industrial Revolution, numerous scientific and technological innovations have radically

transformed everyday life, which has, in turn, influenced both the status and the overall level of education within society.
The Industrial Revolution brought about unprecedented social change: individuals began to engage in structured education, receive wages for their labour, participate in cultural activities, and adopt healthier lifestyles. The inventions of the train and the automobile allowed people to travel greater distances, whereas previously, they spent their entire lives in one place. Following these transformations in the nineteenth century, the modern world experienced another major wave of innovation the information revolution associated with the emergence and expansion of the Internet. The rise of digital networks initiated a social and communicative revolution that reshaped the very nature of human interaction. Daily life began to adapt to the presence of digital technologies, and human activity increasingly shifted into the virtual sphere. The Internet fundamentally altered numerous dimensions of life, including communication, access to information, work processes, private life, leisure, and the formation of social relationships.

Given these developments, it is crucial to examine the specific impacts of the Internet on society both its contributions to development and its potential to erode knowledge and communication skills. From an analytical perspective, the Internet, as a product of the information revolution, introduced multiple dynamic innovations that have profoundly influenced not only social functioning but also educational processes. Human communication has become digitalised, shifting largely into virtual space. Globally, the Internet can be regarded as one of the defining symbols of globalisation the worldwide interconnection of information and economies. It enables instantaneous communication across the planet, remote work, and digital entrepreneurship (Haidt, 2025, p.132). Consequently, the concept of digital literacy has become increasingly important the ability to use digital technologies (the Internet and artificial intelligence) efficiently and responsibly, avoiding financial or psychological harm while leveraging them for personal and professional growth.

However, alongside its positive aspects, the digital transformation also brings several risks that can negatively affect various dimensions of human life, including privacy, communication, work, and the overall level of knowledge. Managing these influences is not a simple skill. Many individuals struggle to adapt, leading to disruptions in their personal and professional well-being. The ability to process and utilize the effects of the Internet and digital technologies constructively can be described as digital literacy. Therefore, the development of digital competencies should be considered a key element of modern education, ensuring that individuals can smoothly transition into the role of digital natives. This reality highlights the need for analytical research into the negative social and psychological impacts associated with the functioning of the Internet. One of the most influential factors in the lives of adolescents today is social media. The primary advantage of social networks lies in their ability to enable fast and inexpensive global communication. As their name suggests, their core purpose is networking connecting individuals for the purposes of communication, socialization, or the exchange of ideas and interests. Social media have also revolutionized the promotion of personal ideas and business products, which was previously financially demanding, relying on billboards and printed advertising. Today, through well-planned online strategies, ideas and products can be effectively promoted with minimal or no financial cost a practice commonly referred to as digital marketing.

In terms of educational quality, social media have had both positive and negative effects on the intellectual development of individuals. While they have expanded access to information and created new opportunities for learning, they have also facilitated the spread of false and manipulative content in the form of hoaxes and misinformation. A key question therefore arises: how can an ordinary individual resist half-truths and manipulation? The answer lies in the development of critical and analytical thinking, supported by a solid foundation of general knowledge and education. However, such individuals still represent a minority within society (Haidt, 2025, p.212). It is therefore crucial to instruct students from an early age in the skills of analysing, verifying, and interpreting the information they encounter. Failure to do so may result in the unintentional spread of falsehoods perceived as truth, thereby exacerbating misinformation and social polarization.

2.2 The Impact of Populism, Disinformation, and Digital Literacy on Educational Systems

The dissemination of mass psychosis and alarmist messages may lead to criminal offences. Moreover, false information represents a serious threat not only to social stability but also to the political domain. Politicians with a distorted moral and ethical compass can exploit social networks through sophisticated yet deceptive and emotionally charged campaigns. Although such campaigns are often effective in mobilizing voters, their promises are frequently unfeasible in practice yet remain attractive to target audiences. Consequently, educational systems should prioritize the development of analytical thinking and critical reasoning across society, fostering the ability to evaluate information objectively and resist manipulation. A growing body of research indicates that manipulative populist communication can elevate individuals to positions of power whose ineffective and poor governance lead to the economic decline of the state and a deterioration in citizens' living standards (Muller, 2016, p. 85). Populists typically seek social popularity and are therefore highly dependent on public opinion polls. Their objective is not national economic progress but rather the maintenance of personal popularity and power an inherently detrimental societal phenomenon.
In terms of educational quality, populists often target segments of the population with lower levels of education. Such individuals may lack the capacity to assess whether semi-truths and misleading information are valid, tending instead to accept them as factual. Exploiting this

cognitive vulnerability, populists substitute realistic policy solutions and strategic visions with fabricated hoaxes and conspiracy theories that, due to their simplicity and emotional appeal, attract public attention. These narratives engage the emotional rather than the rational dimension of individuals, diverting public discourse away from addressing genuine social and economic challenges. From an economic perspective, this trend represents a serious risk (Muller, 2016, p. 54). Populists frequently adjust their strategies according to public mood and survey data, deploying fiscal mechanisms such as increasing pensions and public-sector salaries to secure popularity. While such measures are well received by citizens, they impose a heavy burden on the state budget, contributing to long-term indebtedness. Therefore, a key educational priority must be the cultivation of information literacy the ability to identify, analyse, and resist hoaxes and conspiracies, and to critically evaluate mainstream information. Strengthening these competencies would enhance societal resilience against populist communication strategies.

This constitutes one of the most critical contemporary challenges for educational institutions. Their strategic objective should be to nurture a confident, well-educated society capable of working effectively with information and resisting manipulative narratives. Populists often rely on the simplicity of their communication, which appeals to broad segments of the population, especially in a digitally mediated society where much of the information exchange occurs in largely unregulated online spaces. In contrast, traditional political parties, which communicate with technical precision and intellectual depth, tend to appear less accessible or less engaging to average voters, despite offering more sustainable visions of state development. (Hansen, 2020, p. 135) When populists eventually assume governmental power, their need to fulfill certain promises frequently results in extreme fiscal burdens, further destabilizing the national economy.

The media and political pressure generated by hoaxes and conspiracy theories has become pervasive. These narratives function without self-reflection or concern for economic decline and the erosion of citizens' quality of life. Their primary focus remains the pursuit of power rather than societal well-being. Consequently, addressing disinformation and populism represents one of the most profound historical and contemporary challenges for education systems. Despite often being undervalued or underfunded compared to sectors such as infrastructure or healthcare, education holds transformative potential. Countries that have invested systematically and generously in education demonstrate long-term outcomes in the form of low unemployment, reduced crime rates, and greater resistance to disinformation.

If individuals are digitally competent, the use of social media can serve as an advantage. However, a significant proportion of adolescents are becoming dependent on digital platforms, raising the critical question: At what age should young people first engage with digital technologies? Scholars and researchers continue to debate this issue. In his influential study The Anxious Generation (2015), Jonathan Haidt suggests that the initial meaningful

contact with digital technology should occur around the age of fifteen coinciding with the start of secondary education. Parents often counter this recommendation, citing safety concerns and the necessity of children carrying mobile phones for communication. Similarly, Manfred Spitzer (2015) advocates for the same age threshold but proposes stricter supervision of online profiles and the use of basic mobile phones without access to social networks. On the other hand, it is important to acknowledge that social media can provide rapid and useful information that people once obtained primarily from television or newspapers. This access to information is faster and more cost-effective. (Haidt, 2025, p.132)
However, under the influence of social networks, social solidarity and mutual understanding among individuals are gradually declining. Material values are increasingly prioritized over traditional moral and cultural ones, while the importance of science and education is being relativized and questioned.

A notable consequence of this social shift is the rise of cyberbullying among students, which illustrates a broader erosion of interpersonal respect. From a political science perspective, the internet represents a symbol of democracy and freedom of expression. Nevertheless, unlike books and newspapers, it is not regulated in terms of truthfulness or verifiability. The internet contains a vast amount of valuable academic and professional information that was once difficult to access. However, because it is an open and largely unregulated space, it also contains a significant number of falsehoods, conspiracy theories, and manipulative content. A large segment of society in many countries tends to perceive such information as truthful, thereby losing objectivity and critical reasoning. Consequently, ordinary individuals often struggle to verify or assess the credibility of online information (Hari, 2023, p. 182). This can result in a phenomenon in which people begin to lose trust in their everyday reality, perceiving deception or hidden motives behind ordinary social events. Such attitudes can give rise to mass psychosis and a growing level of social aggression among members of society.

One possible solution lies in systematically improving information literacy across the population. This should be implemented not only within formal education systems but also through lifelong learning initiatives, equipping both students and adults with the ability to filter and verify the accuracy of information. Another key approach is to strengthen the general knowledge base of society, since research consistently shows that well-educated individuals are less vulnerable to misinformation and deliberate fabrications. A professional analysis of the impact of internet use reveals that, when used effectively and responsibly, the internet can significantly facilitate many aspects of everyday life (Carr, 2020, p. 57). It can, for example, support the systematic preparation of scholarly texts and the retrieval of diverse academic sources. However, for adolescents, the effects can be profoundly negative. Many young people use the internet not to seek quality information but rather to play games or engage in unproductive online activities.
Such behaviour can have detrimental long-term consequences on the emotional and social development of adolescents, particularly in terms of their capacity for empathy toward

others. Although these young individuals may not immediately perceive such habits as problematic, the transition to adulthood may bring psychological difficulties such as depression or anxiety, often stemming from a lack of genuine social contact (Hansen, 2020, p. 135). From a developmental perspective, it is a well-established fact that human beings are inherently social creatures. Even though some adolescents may temporarily convince themselves that they can live in isolation, the reality grounded in evolutionary biology is that humans are fundamentally social beings. Consequently, after a certain period, individuals naturally seek out interaction and connection with others.

From a professional perspective, it is also possible to examine the global impact of digital technologies on reducing economic inequalities. Overall, it appears that digital technologies have not delivered the anticipated improvements in human intelligence or educational outcomes, especially among economically disadvantaged populations. Several scholars have identified the emergence of non-substance addictions, such as online gaming and social media dependency, as negative consequences of the digital era. These factors can deepen existing socioeconomic disparities between wealthier and poorer social classes. As a result of these trends, societies around the world are increasingly facing a condition known as the digital divide a state characterized by unequal access to technology, disparities in digital skills, and differences in the capacity to benefit from technological advancements.

2.3 The Current State of Digitalisation and Education

Contemporary society is undergoing a permanent digital revolution. Unlike past revolutions, such as the Industrial Revolution, which unfolded gradually over hundreds of years, the current digital revolution brings transformative discoveries almost every year. This rapid pace creates significant pressure on the average individual to adapt to the constant influx of changes. Younger generations, namely Generation Z and Generation Alpha often referred to as digital natives can absorb these changes relatively quickly, as they grow up surrounded by digital technologies and use them naturally in nearly all aspects of their daily lives. From the perspective of adaptation to technological development, they possess an undeniable advantage. However, an important question arises: are these generations truly more educated and psychologically resilient? Research findings suggest otherwise. Studies, such as those by Jonathan Haidt (2025), indicate that these generations face a greater prevalence of psychological problems. Therefore, it is crucial to ask what the underlying causes of this negative trend are and how it might be addressed. The issue is complex and multifaceted, involving several interrelated factors. Numerous scientists and experts are currently engaged in analysing and attempting to resolve these challenges through their academic studies.

In assessing the state of research on the impact of digital technologies on education, it is evident that, in Slovakia, this topic has not yet been systematically explored by any specific scholar or institution. However, internationally, several prominent theories and scholarly works stand out in this field. Among the most influential are Manfred Spitzer's Digital Dementia, Thomas Kersting's Disengage: Reclaim Your Life in the Digital Age, Anders Hansen's

The Instabrain, Jonathan Haidt's The Anxious Generation, and Nicholas Carr's The Shallows: What the Internet Is Doing to Our Brains. Within the Czech Republic, the topic has been addressed by authors such as Jan Martin Stránský in The Rise and Fall of the Human Mind and Jozef Vlčej in Digitalisation of the Mind. Further discussions are offered by Domborovská and Šidlichovská in their publication: Information Detox, which critically examines the psychological and social consequences of excessive digital engagement.

3 Digitalisation of Education

Education represents one of the most important processes within society, with the completion of its fundamental stage being compulsory. It accompanies human life from early childhood through primary, secondary, and possibly higher education. It is undeniably a key component in shaping an individual's personality and intellectual development. Educational processes are currently experiencing a range of modernisation initiatives that are dynamically reshaping their character and significance. Among the most influential factors are digital tools and artificial intelligence, which highlight the challenges of modernisation and digitalisation in education, particularly regarding the integration and effective use of digital technologies within teaching and learning processes (Haidt, 2025, p.132). From a technical perspective, the use of digital technologies as a supplementary tool in teaching is generally viewed positively, as it has accelerated access to essential information. Their application fosters modernisation and contributes to improving the qualitative level of knowledge, aligning it with the practical competencies required in today's labour market.

The main goal of a digitalisation strategy in education should be to enhance the general level of students' knowledge and literacy. This goal reflects a contemporary necessity arising from broader developmental trends in society. However, it is equally important to analyse both the positive and negative aspects of introducing digital technologies into education. The general educational strategy increasingly emphasizes the implementation of digital tools as a symbol of modernisation and progress. Yet, it is necessary to note that such processes are not inherently positive (Carr, 2020, p. 122). The integration of digital aids into teaching should be gradual, emphasizing their effective and meaningful implementation in the educational process. Simultaneously, it is essential to carefully evaluate the advantages and disadvantages of this implementation to ensure that the digitalisation of education does not become counterproductive leading to the demotivation of teachers or students. Such an outcome could result in the devaluation of educational quality.

A crucial premise must not be overlooked: while the introduction of digital technologies into education may be extensive, the teacher must remain at the centre of the educational and formative process. When effectively utilized, digital technologies can greatly enhance the quality of instruction by supporting lesson preparation and classroom delivery. However, a potential risk emerges when teachers begin to feel that more investment is directed toward digital technologies than toward their professional development, training, or financial recognition. This perception may lead teachers to believe that their role within the educational system has become secondary. Practical testimonies from educators suggest that some teachers feel that, for governmental authorities, digital technologies in education are considered more important than the teachers themselves.

Consequently, they may begin to feel undervalued or even discriminated against. Certain groups of teachers perceive that more funds are invested in technology than in improving the material infrastructure of schools or in securing adequate compensation for teachers (Stránský, 2024, p.174). This situation sometimes results in a narrow and disillusioned outlook, where teachers perceive that while the state is willing to invest heavily in modern technologies, financial resources for even modest salary increases are scarce. Such perceptions can lead to demoralization and a general decline in the competitiveness of national education systems.

It can therefore be concluded that the implementation of digital technologies into educational processes is undeniably important and represents a hallmark of modernisation trends. Nonetheless, in practical application, it is essential to uphold the teacher's dignified and motivating role as the primary and indispensable element of the student's educational and formative experience. This leads us to a specific question: do digital technologies in teaching genuinely contribute to improving students' knowledge? The answer to this question is neither straightforward nor simple. Based on Manfred Spitzer's Digital Dementia theory, it may rather be argued that digital tools have a negative impact on society's overall level of knowledge. Particularly, among today's adolescents, there is frequent mention of a declining capacity for critical thinking and general information literacy often linked to digital dependency. Students spend excessive time on social media and similar platforms, dedicating minimal time to study and class preparation.

Consequently, this leads to academic underperformance and, in some cases, a deterioration of school results (Spitzer, 2018, p. 89). A concrete example can be found in mathematics test outcomes among primary school pupils, where many students increasingly fall below the European average. When digital technologies are misused, they can become a negative factor rather than a supportive one. Over the long term, this trend may contribute to a qualitative decline in overall educational attainment and intellectual competence.

4 Education and Artificial Intelligence

In analysing the effects of current social and technological influences on education, academic discourse increasingly focuses on the potential decline in the quality and scope of students' knowledge and competencies. Regarding the causes and specific agents behind this phenomenon, the professional community is divided into two main camps. Some scholars advocate for the use and broad integration of digital technologies in teaching, whereas others attribute the decline in educational quality directly to their influence. Consequently, it is essential to examine these factors in greater depth. Artificial intelligence (AI) is gaining an ever-increasing role not only in everyday human life but also within educational processes (Harari, 2024, p.122). AI represents a manifestation of technological modernisation and social progress. It is a digital tool capable of accelerating numerous educational processes, particularly those involving teachers and lecturers. In the past, for instance, the preparation of educational materials could take several weeks. Today, with the aid of AI, the same task can be accomplished within days, thereby contributing to qualitative improvements in instructional content and delivery.

When comparing the preparation and acquisition of teaching materials using traditional internet searches versus AI systems, we can observe several qualitative differences. In the past, searching for information online required manually reviewing numerous articles and summarizing the findings. This was already a major improvement compared to the pre-digital era, when research demanded extensive time spent in libraries extracting information from printed books. Today, however, a teacher can simply prompt AI with a detailed request such as “Provide a comprehensive overview of India’s political and economic system.” AI will generate a systematically organized, multi-page text, which the user can then verify for accuracy and supplement with specific details (Stránský, 2024, p.174). The result is a complete educational resource produced in a single day—a process that would previously have taken weeks. Hence, AI can serve as an effective tool for enhancing the professional quality of teaching.

On the other hand, it is crucial to consider the influence of AI on students’ learning processes. From a positive perspective, if students know how to use AI efficiently, they can, like teachers, access high-quality academic information, thereby broadening their general knowledge base and advancing their intellectual capacity. Competence in AI usage may become an essential digital skill, enhancing students’ employability in the labour market. However, a significant risk emerges when students use AI primarily to simplify their studies for instance, by generating required texts for coursework or final theses without engaging in genuine cognitive effort. Many students thus take AI-generated material, present it as their own, and bypass deeper analysis and reflection. This behaviour represents a dangerous phenomenon that can be described as digital complacency. This tendency is rooted in the biological nature of humans, who generally prefer fewer demanding options when given a choice, even at the expense of long-term intellectual or professional growth. Consequently, many students fail to revise, supplement, or critically engage with AI-generated texts, thus neglecting the activation of critical thinking processes that are vital for cognitive and professional development (Harari, 2024, p.184).

However, when AI is used as a supportive tool or advisor in academic work assisting with research, structuring arguments, or identifying relevant literature it can significantly enhance both efficiency and quality. The resulting output may be an innovative, authentic, and well-supported academic work enriched with relevant and up-to-date data.
When working with digital technologies and artificial intelligence, ethical and moral considerations should also play a fundamental role. It should be seen as ethically inappropriate to use AI to produce academic or professional work without personal revision, correction, or intellectual contribution, while presenting the result as one's own. In practice, a portion of individuals indeed use AI as an supplementary tool to improve their work and would not claim its output as their own intellectual product. However, the majority tend to replace moral responsibility with convenience and a form of ethical dishonesty, justifying it through time efficiency. This tendency stems from the innate human inclination to seek ease rather than exert effort toward a high-quality outcome. The ultimate consequence may be an extreme decline in critical thinking and in the complexity of neural networks within the brain.
Among researchers and academic experts, there is ongoing debate about the reliability and informational quality of data produced by AI. At the outset, it must be acknowledged that AI systems are still in an early and dynamically evolving stage of development. Some experts point out that the data and outputs generated by AI are not always accurate or verifiable.

From a systematic information-processing perspective, this represents a certain imperfection. Yet, from a pedagogical viewpoint, this imperfection may paradoxically have positive effects. AI's occasional production of inaccurate or distorted information something even noted by industry leaders such as Sam Altman, CEO of OpenAI can serve as a catalyst for users to engage in critical verification and analysis of the information provided. In this way, users are encouraged to cross-check data across multiple sources, expanding their general knowledge and improving the qualitative depth of their intellectual output. Conversely, if users accept AI-generated information uncritically and use it as the result of their work a natural shortcut for many individuals the outcome is likely to be poor-quality, derivative output subject to academic disapproval and possible sanctions.

5 Digital Comfort

Contemporary global society is evolving at an extremely dynamic pace. In the past, revolutionary societal transformations unfolded over centuries. The first such major transformation was the Neolithic Revolution, which occurred approximately three thousand years ago, marking the transition of humans from hunters to gatherers. The next turning point came with the Industrial Revolution at the beginning of the 19th century, which fundamentally reshaped human life. Between these two revolutions lay a span of more than two thousand years. The subsequent Information Revolution, associated with the advent of the Internet at the end of the 20th century, occurred roughly 150 years after the Industrial Revolution, significantly accelerating social modernisation. The most recent transformation the Digital Revolution emerged only about a decade ago, closely tied to the rapid rise of artificial intelligence (Carr, 2020, p. 85). The temporal gap between the third and fourth revolutions has thus narrowed dramatically from roughly a thousand years in the past to merely ten years today. This evidence an unprecedented acceleration of social and technological development. We now live in a state of permanent technological revolution, which places immense pressure on individuals to continuously monitor and adapt to new digital and technological trends. These trends are profoundly reshaping not only the quality and nature of everyday life but also the meaning and structure of education in digital society.

A failure to keep pace with technological progress, even briefly, may lead to the emergence of digital lag, and in extreme cases, to the digital divide, which already exists today between the youngest and oldest members of society. The contemporary young generation often referred to as digital natives grows up immersed in digital environments and can naturally adopt and utilize new technologies for personal and educational advancement. However, researchers have also warned about the negative psychological consequences of digital technologies on adolescents' mental health (Hari, 2023, p. 152). According to several scientific studies, notably those of the American psychologist Jonathan Haidt and his theory presented in The Anxious Generation (2024), the introduction of social media to smartphones around 2010 coincided with a sharp increase in depression and anxiety among adolescents. The result is a marked deterioration in the mental well-being of the younger generation.

From a historical perspective on the influence of digital technologies, earlier generations—namely the Baby Boomers (1946–1964) and Generation X (1965–1979) are often described metaphorically as "digital Neanderthals." These individuals first encountered digital technologies in middle or later adulthood. Although they have gradually adapted to the digital transformation of society, they are generally unable to keep pace with its ongoing acceleration. Their use of digital tools tends to be limited to basic, practical functions necessary for daily life. Consequently, these generations often become targets of digital fraud due to their limited technological proficiency.

This raises an important pedagogical question: How should students use digital technologies effectively so that these tools enrich rather than diminish their intellectual development? In education, digital technologies should be employed to access otherwise unavailable information resources that are not easily searchable yet are valuable for expanding and deepening knowledge within a specific learning context.
Conversely, when digital technologies are used purely for purposeless entertainment or excessive leisure what psychologists describe as procrastination the effects can be harmful. Passive scrolling through social media, for example, leads to the depletion of dopamine, the neurotransmitter responsible for feelings of pleasure and satisfaction. When dopamine levels

are exhausted through overstimulation, individuals may experience emotional numbness and even depressive moods. This phenomenon contributes to what can be described as a state of digital comfort, in which cognitive effort, intellectual curiosity, and neural activity decline as the brain is no longer challenged. A striking example of this phenomenon is provided by Manfred Spitzer in his research on the intellectual abilities of London taxi drivers (Spitzer, 2018, p. 144). The study compared two groups: one that relied on traditional maps and memory to navigate, and another that depended solely on GPS technology. The findings revealed that the drivers who did not use GPS exhibited significantly greater intellectual and logical brain capacity than those who relied exclusively on navigation systems.

6 Cyberbullying

Digital technologies have brought numerous positive benefits, significantly improving and modernising both the quality of human life and the educational process. However, it is equally important to examine their negative aspects, one of the most pressing being cyberbullying, which increasingly disrupts the educational environment and demands targeted strategies for effective intervention. This phenomenon has become deeply rooted in school settings over the past two decades. Traditionally, schools have had to deal primarily with physical bullying, which is characterized by one individual asserting dominance over another where a stronger person targets someone weaker to compensate for personal insecurities or frustrations (Stránský, 2024, p.174). This form of bullying is visible, tangible, and therefore easier to detect and address. Today, however, the rapid expansion of the Internet has given rise to a new, more complex challenge cyberbullying, which is largely invisible, concealed, and difficult to trace. This very hidden nature makes it appealing to many perpetrators. Cyberbullying arises from several motivations and psychological mechanisms.

For some individuals, the Internet represents a powerful tool of control, offering the illusion of impunity through anonymity. Offenders hide behind false usernames, fake profiles, and fabricated identities. In this virtual environment, they often exhibit uncharacteristically bold or aggressive behaviour, driven by the belief that they will not face any real-world consequences for their actions. From a psychological perspective, this behaviour reflects an alibistic and compensatory pattern a way for individuals who feel unfulfilled, undervalued, or unsuccessful in real life to gain a sense of control and superiority online. These individuals often use the digital space to attack others emotionally, focusing on their weaknesses and intentionally undermining their mental well-being. As Kersting (2023, p. 78) notes, this leads to a paradoxical situation: individuals who appear confident and hostile online often display cowardice and insecurity in real-world interactions, remaining silent when faced with direct, face-to-face confrontation.

Empirical research supports this analysis. Studies show that individuals tend to lie, exaggerate, or act dishonestly much more frequently in online environments than in real life. The perceived anonymity of digital spaces weakens moral restraints and social accountability, often leading to increased aggression, particularly among adolescents. In earlier times, social control and fear of reputational damage prevented many potential bullies from acting out. Today, the online realm provides an illusion of safety and invisibility that encourages psychological manipulation and harassment (Harari, 2024, p.184). Cyberbullying therefore constitutes a form of psychological violence, designed to exert emotional pressure and distress upon a targeted individual. Its aim is often to provoke anger, fear, and helplessness in the victim. According to Manfred Spitzer (2018, p. 144), sustained exposure to such harassment can lead to serious psychosomatic and psychological symptoms, including insomnia, headaches, stomach pain, loss of appetite, self-harm, and in severe cases, clinical depression or suicidal ideation.

Conclusion

Digital technologies today permeate nearly all aspects of human existence, shaping the way we live, communicate, and learn. Their influence is inherently ambivalent: on one hand, they provide powerful tools that can significantly enhance the efficiency and quality of the educational process; on the other hand, excessive or inappropriate use may lead to reduced attention, loss of critical thinking, or even digital dependency. Education thus enters a new phase in which it is essential to find a balance between technological progress and the preservation of pedagogical authenticity and human integrity. Education remains a fundamental pillar of societal development and modernisation. Although the Internet and the digital environment have introduced numerous alternative perspectives on the meaning and purpose of learning, both research and practice consistently confirm that education continues to have a profound impact on individual and collective well-being. Systematically educated individuals tend to display higher social stability, lower levels of criminal behaviour, greater self-reflection, and an enhanced ability to solve problems with composure and perspective.

In this context, digital technologies should not be perceived as an end in themselves but rather as a means for the advancement of knowledge and the cultivation of thought. Their effective and sensitive integration into educational practice can significantly contribute to building a knowledge-based, ethical, and innovative society. Finally, it is worth recalling the timeless words of the Greek philosopher Socrates: “I know that I know nothing.” This statement continues to serve as a lasting reminder of intellectual humility and an enduring call for continuous self-improvement, critical inquiry, and openness to new knowledge. Such an attitude represents a crucial foundation for sustainable development and societal progress in the digital era.

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Synthesising Perspectives on Formative Assessment in ELT

Definitions, Benefits, and Future Directions

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Abstract

This review synthesises historical and contemporary perspectives on formative assessment in English Language Teaching (ELT), examines common practices and benefits, and identifies gaps in existing research. Peer-reviewed studies were retrieved primarily from Web of Science and Scopus using the keywords 'formative assessment' AND ("TEFL" OR "EFL"), supplemented by the snowball method. Findings indicate that common practices include feedback, peer and self-assessment, portfolios, questioning, and low-stakes testing, with technology-based tools increasingly supporting personalised learning. Reported benefits encompass enhanced motivation, autonomy, and achievement; however, implementation is frequently constrained by limited teacher expertise, insufficient training, time pressures, and institutional cultures that prioritise summative testing. Professional development and supportive school environments are critical for overcoming these barriers. A notable gap is the absence of empirical research on formative assessment practices in Slovakia, underscoring the need for localised studies. Despite methodological limitations and the lack of new empirical data, this review provides a conceptual framework for educators and researchers and offers directions for future research.

Keywords: ELT, Formative Assessment, Literature Review

1 Introduction

Research in language teaching has often been marked by claims that a particular approach, method, or technique is superior, only for subsequent studies to challenge those assertions. Over time, this debate has shifted towards the recognition that no single method works universally; rather, effectiveness depends on contextual factors and learner needs (Williams

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et al., 2016). Among the practices considered beneficial across diverse contexts is the teacher's use of feedback to guide and improve learning, a process commonly referred to as formative assessment.

Formative assessment has gained global attention as a cornerstone of modern curricula. Many countries have introduced reforms to embed formative practices within competency-based learning frameworks (Bøhn & Tsagari, 2022; Li & Gu, 2023). Slovakia is following this trend through its Education for the 21st century reform, scheduled for implementation in 2026 (ŠPÚ, 2022). This approach seeks to move beyond summative testing towards assessment integrated with instruction, emphasising feedback for growth, transparency in learning goals, and learner involvement through self- and peer-assessment (Jančová et al., 2024). Similarly, the updated CEFR (Council of Europe, 2020) which serves as a foundation for the Slovak national EFL curricula promotes criterion-referenced formative assessment by providing 'can do' descriptors that support reflection, autonomy, and alignment between assessment and learning.

Despite its prominence, research on formative assessment remains extensive yet fragmented, making it difficult for educators to navigate. This review aims to synthesise historical and contemporary perspectives on formative assessment in ELT, outline common practices and benefits, and identify gaps in existing research. By doing so, it provides a conceptual framework for educators and curriculum designers and highlights directions for future localized studies in Slovakia.

The studies reviewed in this paper were identified through two methods. First, a search was conducted in the Web of Science and Scopus databases, chosen for their inclusion of high-quality, peer-reviewed research. Keywords used included 'formative assessment' AND ("TEFL" OR "EFL"). Additionally, the snowball method was applied by examining reference lists of relevant studies and reviewing accessible literature. To guide the review, three research questions were formulated.

Research Questions

1. How has formative assessment been defined and conceptualised in English Language Teaching over time?
2. What types of formative assessment practices are reported in English Language Teaching, and what potential benefits are associated with these strategies?
3. What factors influence the implementation of formative assessment in EFL classrooms?

2 Historical And Conceptual Foundations

The concept of formative assessment originates from early discussions of evaluation. Andrade et al. (2019) trace its roots to Cronbach (1963), who argued that evaluation conducted during the learning process, while instruction is still adaptable, contributes more to educational improvement than evaluation applied after instruction is complete. Building on this idea, Scriven (1967) introduced the term formative evaluation as ‘assessment for learning’ and contrasted it with summative evaluation as ‘assessment for learning’.

Scriven’s ideas were later expanded and popularised by Bloom and colleagues (1971) in their Handbook for Formative and Summative Evaluation. Bloom’s framework emphasised formative assessment as a process aimed at helping learners understand rules and principles, master terminology and facts, apply procedures, and transfer knowledge to new contexts. This perspective reflects an effort to align formative assessment objectives with Bloom’s earlier taxonomy of educational objectives (Bloom et al., 1956), which organises learning outcomes from basic knowledge acquisition to higher order cognitive skills.

Sadler (1989) highlighted that closing the gap between a learner’s current state and the desired goal requires active engagement by the student. Simply following a teacher’s diagnostic prescription without understanding its purpose does not lead to learning, and therefore formative assessment cannot occur. Building on this principle, Black & Wiliam (1998) conceptualised formative activity as a sequence of two actions: first, the learner perceives a gap between the desired goal and their present state; second, the learner takes action to close that gap. The initial perception may arise from teacher feedback or student self-assessment, but the subsequent action must involve the learner.

Despite numerous attempts to define formative assessment, there is still no consensus on a single, unifying definition. Andrade et al. (2019) illustrate this by presenting eight different definitions, while Bennett (2011, p. 19) observes that formative assessment “does not yet represent a well-defined set of artefacts or practices.” Additionally, the term is often used interchangeably with related concepts such as benchmark, interim, or progress assessment (Andrade et al., 2019, p. 11), which adds to the ambiguity. This lack of clarity has significant implications: instructional techniques labelled as formative vary widely in form and effectiveness, classroom implementation can be inconsistent, and designing rigorous research becomes challenging.

Interest in formative assessment research grew substantially after Black and Wiliam’s (1998) influential review, which synthesised more than 250 studies and demonstrated the strong potential of formative assessment to enhance student achievement. They also identified several recurring elements that illustrate how formative assessment can be implemented in classroom settings. These practices include using classroom dialogue to elicit evidence of learning, providing feedback that helps students understand how to improve, and incorporating self-assessment and peer assessment into the learning process.

Building on these practical considerations, systematic reviews conducted in different educational settings have indicated various strategies for applying formative feedback. For example, Morris et al. (2021) reviewed 28 empirical studies and found that in higher education, formative assessment is commonly applied through feedback, low-stakes testing, peer assessment, and technology-based tools. They noted that frequent quizzes and tests support learning through retrieval practice, while detailed feedback without grades helps guide revision. Similarly, Halim et al. (2024) reviewed practices in secondary schools and identified four common strategies: remedial interventions, meaningful learning activities, exit tickets, and assessments that are clear and understandable to students. These findings demonstrate a shift in the use of formative assessment strategies across educational contexts. However, the strategies remain broad and conceptually ambiguous, as many hands-on activities could fall under these labels.

3 Practices and Benefits in ELT

Formative assessment has been widely explored in English Language Teaching (ELT), with research highlighting its diverse practices and positive influence on learning outcomes. Studies conducted across different educational settings demonstrate how strategies such as feedback, peer and self-assessment, and technology-enhanced tools contribute to learner motivation, autonomy, and achievement. This section reviews key findings on the practices commonly employed in ELT and the benefits they offer to both teachers and learners.

Zhang et al. (2024) synthesised findings from forty studies on formative assessment in K–12 EFL education and categorized intervention practices into six main types: peer assessment, self-assessment, feedback, portfolios, questioning, and specific formative assessment tasks. Their review indicated that applying formative assessment through these practices significantly improved students' motivation, self-regulation, and achievement. These results align with Burner 's (2014) literature review, which highlighted the positive impact of portfolio assessment on learner motivation, autonomy, reflection, responsibility, and writing performance.

In higher education, Song and Mukundan (2025) reported that self-assessment, peer feedback, and growth-oriented feedback in EFL writing foster learner autonomy, emotional well-being, and writing proficiency, although challenges such as limited teacher training and reliance on summative frameworks persist. Within the ELT context, there is a clear overlap in the formative strategies employed by EFL teachers, particularly peer assessment, self-assessment, and formative feedback.

Given the increasing role of technology in education, numerous studies have examined how digital tools support formative assessment practices. Wannas and Abdel-Mohsen (2025), in their synthesis of 19 articles, reported that online tools such as Automated Essay Scoring systems, Moodle, and game-based platforms offer flexibility and personalised feedback. Additionally, Chien et al. (2020) found that Spherical Video-Based Virtual Reality, used as a formative tool, significantly improved students' English-speaking performance and critical thinking while reducing language learning anxiety and enhancing motivation. These findings highlight the potential of integrating innovative technologies into formative assessment processes in ELT.

4 Challenges and Barriers

The implementation of formative assessment in EFL classrooms is widely acknowledged as beneficial, yet it faces numerous obstacles that limit its effectiveness. These challenges often arise from teacher-related factors, institutional constraints, and cultural attitudes towards assessment. Understanding these barriers is essential for developing strategies that support teachers and promote the successful integration of formative practices into language instruction.

Teacher-related factors play a critical role in the success of formative assessment. Zhang et al. (2024) report that low assessment literacy, insufficient training, and time constraints frequently hinder effective implementation in school settings. These challenges are compounded by cultural norms that prioritise summative testing, making formative approaches appear secondary. Furthermore, Mäkipää (2021) identified a disconnect between teacher perceptions and student experiences: while teachers believed their feedback was motivating, students did not share this view. Similarly, Razali et al. (2021) observed that teachers often fail to provide feedback on student writing, or when feedback is provided, it lacks formative value because it does not guide students on how to improve.

The ability of teachers to integrate formative practices into instruction depends on multiple factors. Amirian (2025) found that teaching experience is a stronger predictor of formative assessment literacy than age. Additionally, Muhammadpour and Sabet (2025) reported that teachers in private institutions in Iran demonstrated more positive perceptions of formative assessment compared to those in public schools, highlighting potential disparities in training and resources. These findings underscore the importance of preparing teachers and providing opportunities for targeted professional development.

Teacher preparedness remains a critical challenge for the effective implementation of formative assessment. Research indicates that many teachers lack practical experience and sufficient assessment knowledge, limiting their ability to integrate formative methods into instruction (Vattøy and Gamlem, 2020; Widiastuti et al., 2020).

Targeted professional development has proven essential for addressing this gap. For example, Li and Gu (2023) designed a 12-week programme for five secondary school EFL teachers in China, where formative assessment has been promoted for over two decades. Initially, these teachers struggled to articulate clear learning targets and communicate them to students, but the intervention significantly improved their ability to set and share objectives, demonstrating the value of structured training.

Similarly, Phuong et al. (2025) found that Vietnamese EFL teachers, after participating in a British Council professional development programme, were able to reframe their methods to include more dialogic, responsive, and student-centred practices.

5 Conclusions

This study set out to synthesize historical and contemporary perspectives on formative assessment in English Language Teaching (ELT), outline common practices and benefits, and identify gaps in existing research. Three research questions guided this review.

RQ1: Formative assessment has evolved from a general idea of improving instruction during learning to a structured process aimed at identifying gaps and helping learners close them through feedback and active engagement. Over time, it has become associated with broader educational objectives and the promotion of learner autonomy. However, the absence of a single, clear definition has resulted in inconsistent interpretations and practices. This ambiguity complicates classroom implementation and makes it challenging for researchers to design comparable studies.

RQ2: Common formative assessment practices in ELT include feedback, peer and self-assessment, portfolios, questioning, and low-stakes testing. These strategies provide learners with clear goals and actionable steps for improvement. When implemented effectively, they enhance motivation, foster autonomy, and support achievement. Technology-based tools and innovative approaches, such as virtual reality and automated feedback systems, further expand opportunities for personalised learning and engagement. Overall, formative assessment is most effective when feedback is timely, specific, and integrated into the learning process.

RQ3: Despite its benefits, successful implementation is often hindered by limited teacher expertise, lack of training, time constraints, and institutional cultures that prioritise summative testing. Teachers may struggle to provide feedback that guides improvement, and disparities in resources can affect quality. Professional development is essential for overcoming these barriers, as it equips teachers with practical strategies, builds confidence, and promotes responsive teaching practices. Supportive school environments and clear curricular frameworks also play a critical role in embedding formative assessment into language instruction.

A notable finding of this review is the absence of empirical data on formative assessment practices in the Slovak context. This gap highlights the need for future localised research to inform policy and practice.

The limitations of this study relate primarily to its methodology and scope. Although the review focused on peer-reviewed studies from reputable databases, the lack of a standardized reporting system (such as PRISMA guidelines) limits generalizability. Furthermore, this review's scope remains broad and does not provide specific applications. As a secondary study, it also does not contribute new empirical data.

Despite these limitations, this review offers a conceptual framework that can help researchers and practitioners navigate the topic of formative assessment in ELT. It also provides a foundation for future studies, particularly those addressing gaps in localised Slovak research.

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AI-Enhanced Distance English Teaching: Pre-Service EFL Teachers' Attitudes and Experiences

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Abstract

This study explores pre-service English as a foreign language (EFL) teachers' attitude towards artificial intelligence (AI) in English language teaching, as well as their experience with AI-enhanced online teaching. A questionnaire survey was conducted with 22 master's students enrolled the Didactics of Distance English Teaching course at Constantine the Philosopher University in Nitra, Slovakia in 2024. As part of the course, all participants designed and delivered a micro-teaching activity, which provided a context for integrating AI tools. The survey addressed the following issues: previous training in AI-supported pedagogy, use of AI tools during micro-teaching, perceived effectiveness of such tools, concerns related to AI in education, and perceived balance between benefits and drawbacks of AI in distance English teaching. By addressing these questions, the study contributes to ongoing discussions of AI in teacher education and aims to inform the design of training programs that prepare pre-service EFL teachers for effective AI integration into teaching English language.

Keywords: Teacher Education, Pre-service English as Foreign Language Teachers, Distance English Teaching, Artificial Intelligence, Attitudes, Experiences

1 Introduction

Artificial Intelligence (AI) has become an increasingly integral feature of educational practice, reshaping conventional classrooms and the landscape of distance and online learning. For pre-

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service teachers (PSTs) of English as a Foreign Language (EFL), this shift is particularly salient, as distance teaching is gradually emerging as a permanent and legitimate component of language education curricula - a trend accelerated by the global COVID-19 pandemic. Beyond crisis-driven adoption, AI technologies are now positioned as pedagogical partners that can alleviate teachers‘ workload while enhancing instructional quality. These systems support differentiated instruction through learner monitoring, automated yet personalised feedback, and self-paced learning opportunities that promote autonomy and engagement.

Recent international surveys further clarify how AI is already being used across EFL tasks and where gaps remain. A global mixed-method report with 1,348-teachers across 118 countries documents widespread classroom use of AI for language practice, and lesson support (Zhang & Li, 2024). Additional syntheses map perceived benefits and call for pedagogically aligned ethical integration (Holmes et al., 2022; Luckin et al., 2023). These findings place AI's potential within real practices and emphasise the importance of meaningful use.

The potential of AI for pedagogical personalisation was demonstrated by Kerr and Kim (2025), who reported that PSTs frequently employed AI-generated materials that catered to learners‘ specific linguistic and cognitive needs. Their findings underscore the need to align technological innovation with sound pedagogical principles (Kerr & Kim, 2025). Yet, despite the potential, AI in education continues to be accompanied by public scepticism and conceptual ambiguity as evidenced in a large-scale study by Cave, Coughlan, and Dihal (2019). They found that most of the British public associated AI with dystopian imagery and existential threat. Similar findings were reported by Cukurova, Luckin, and Kent (2020), who also observed that AI was often perceived as less credible, less scientific, and less valuable than human-led approaches, domains central to the educational profession. Public discourses appear to influence the educational sphere, as PSTs frequently mirror these ambivalent perceptions and tend to act on a similar note. Analogous results were detected by Derinalp and Halife (2025), who found that although PSTs maintained generally positive attitudes toward the use of AI in EFL contexts, they expressed persistent concerns related to overreliance, reduced emotional interaction, and the ethical implications of AI-mediated pedagogy.

Parallel developments in distance education reveal a similar duality of promise and challenge. Distance learning is widely recognised for its accessibility, affordability and as Katane, Kristovska, and Katans (2015) highlighted, temporal flexibility noting that students often emphasised the opportunity to engage with coursework at any time of the day. Current EFL evidence also documents concrete properties of AI across the four skills in digital environment, such as speech recognition tools for pronunciation practice, grammar and usage checkers for writing feedback, chatbots for speaking and listening interaction, and adaptive platforms for personalisation (Wang & Mokhart, 2025; Zawacki-Richter et al., 2019). At the same time, recent findings in practice call for clear pedagogical models and attention to ethics and equity, reinforcing that AI should complement, not replace teacher-led instruction (Holmes et al., 2022; UNESCO, 2023). More recent studies reaffirm these findings, identifying distance education as a sustainable and cost-effective modality that supports diverse learner needs (Masalimova et al., 2022). Nevertheless, several enduring limitations persist, including the lack of direct interpersonal contact, insufficient support, and ongoing technical difficulties (Karataş & Tuncer, 2020).

When integrated, AI and distance education represent a pedagogical powerhouse with the potential to redefine English language teaching and teacher education. However, their combined implementation also amplifies already existing issues, particularly teacher preparedness and ethical concerns. This apprehensive attitude is seen in PSTs' tendency to utilise AI tools only episodically, suggesting limited conceptualisation of AI as a transformative instructional resource (Guan, Zhang, & Gu 2025). Collectively, these studies reveal a paradoxical trend, while PSTs exhibit openness to integrating AI, they do not perceive it as a central or enduring component of teaching practice which correlates directly with their preceding experiences.

Educators themselves report needing support to address generative AI's curricular and assessment implications. Interview and survey studies in teacher and education settings (Laupichler & Spannagel, 2024; Ng, 2021) describe disruption along uneven confidence and competence, arguing for explicit training and ethical frameworks in initial teacher education. This study justifies implementing AI-based competence development into the repertoire of already existing courses.

Given these complexities, further empirical research in PSTs' attitudes and lived experiences with AI in distance education is imperative. As future educators, PSTs 'beliefs and confidence in AI integration will shape how effectively these technologies are embedded into pedagogical practice. Addressing their misconceptions and training needs is therefore critical to the development of informed and technologically literate language teachers.

Empirical studies with pre-service teachers (PSTs) repeatedly highlight the risks of overreliance and integrity issues related to classroom AI use. Multi-country investigations (Holmes et al., 2022; Zhang & Li, 2024) report persistent concerns about plagiarism, as well as the growing need for critical AI literacy in teacher education. These insights directly inform the present study's focus on the balanced, supervised, and ethical integration of AI in distance EFL teaching. Specifically, the research aimed to explore how PSTs at Constantine the Philosopher University in Nitra, Slovakia, respond to this agenda through their attitudes and lived experiences with AI during microteaching. To address this aim, the study was guided by the following research questions (RQ):

1. To what extent are pre-service EFL teachers prepared and trained to effectively integrate AI tools into distance English teaching?
2. How do pre-service teachers perceive the pedagogical value and effectiveness of AI tools in supporting language learning and teaching processes?

3. What concerns and ethical considerations do pre-service teachers associate with AI use in distance English teaching, and how do these influence their attitudes toward its adoption?
4. What recommendations do pre-service teachers propose for the balanced and ethical incorporation of AI in distance EFL teaching?

2 Methodology

This study employed a mixed-method design to explore pre-service EFL teachers' attitudes toward and experiences with AI in distance English teaching. The design enabled the triangulation of quantitative attitudinal data with qualitative reflections from microteaching observations and questionnaire responses.

Participants were 22 master's students (aged 22-24) enrolled in the *Didactics of Distance English Teaching* course at Constantine the Philosopher University in Nitra, Slovakia, in 2024. A full cohort sampling approach was used, with voluntary participation by all students. Ethical approval was granted by the Department of English Language and Culture, and all participants provided written informed consent.

Each participant conducted a 15-minute microteaching session that integrated at least one AI tool (e.g., chatbot, grammar checker, adaptive platform), following instructor guidance. Sessions were recorded for observational analysis. A researcher-developed questionnaire was administered via Google Forms within 24 hours of teaching to minimize recall bias. The instrument included both open-ended and closed-ended items, using a five-point Likert scale for attitudinal measures.

Quantitative data were analysed descriptively, whereas qualitative responses underwent thematic analysis. Findings from both strands were integrated through triangulation to enhance validity and interpretive depth.

3 PSTs Attitudes and Experiences with AI

The following section provides a detailed analysis of PSTs' responses to selected questions of the questionnaire.

3.1 Q1: Did you receive any training in how to effectively use AI tools in your teaching?

Two participants (9%) reported receiving training in the effective use of AI- tools for teaching, while remaining twenty (91%) had no such preparation. This indicates that most PSTs lacked structured guidance in AI integration and relied on informal, self-directed exploration.

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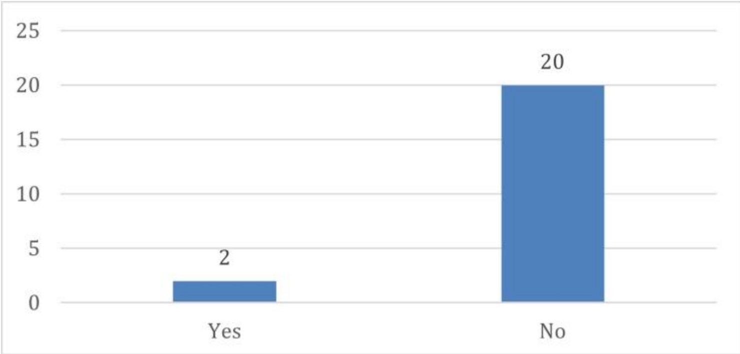

Figure 1: Prior training in effective AI use.

3.2 Q2: Did you incorporate any AI tools during your microteaching activity?

Fourteen participants (64%) reported incorporating AI-tools during their microteaching sessions, while eight participants (36%) did not.

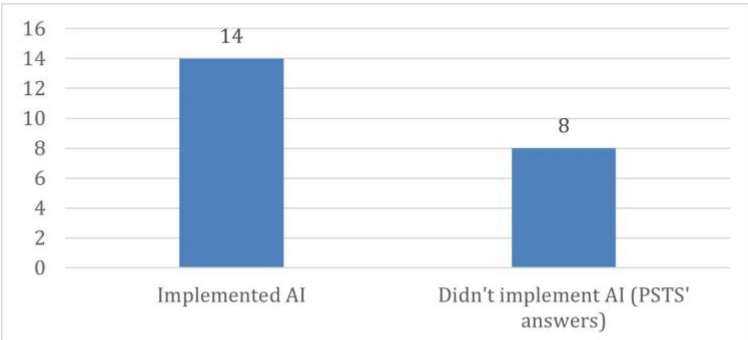

Figure 2: PSTs self-reported use of AI-tools during microteaching.

Although, observational data indicated that only six students (27%) refrained from using AI-tools, revealing a discrepancy between self-reported and observed use.

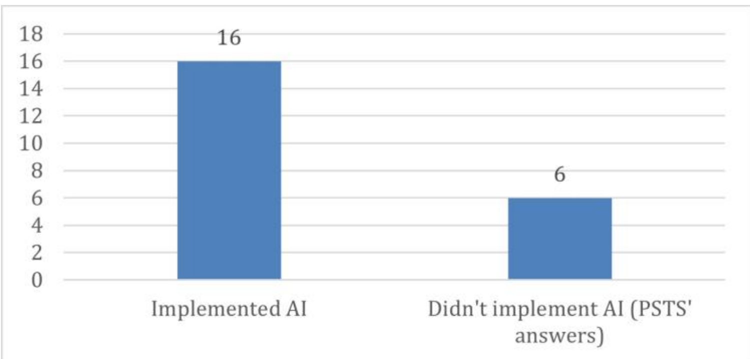

Figure 3: Observed AI-tool integration in microteaching.

This inconsistency may reflect divergent interpretations of what constitutes AI integration, revealing the need for clearer conceptual understanding among PSTs.
PSTs' most frequently mentioned tools included ChatGPT; AI-based image generators (e.g., *Pixlr, Microsoft AI Image Creator, Jweel*); AI-enhanced presentation platforms (e.g., *Canva, Prezi, Gamma AI*); and quiz or interactive applications with AI features. Several participants used AI for lesson planning, activity design, or creating visual teaching materials, as exemplified by responses such as *"I used AI (Gemini) to create an activity for my lesson"* and *"I let students to use AI to generate a picture of phrasal verbs."* Other PSTs utilised AI for presentation support or creative student engagement tasks.

The following table summarises types of tools used and provides examples along with the number who employed each. The total number of tools exceeds the number of participants (n=22) due several students integrating multiple AI application within their microteaching sessions.

Type of AI Tool	**Examples Mentioned by Participants**	**Number of Presenters (n)**
Text-generating tools	ChatGPT, Gemini	3
AI-based image generators	MagicStudio, Pixlr (AI version), Microsoft AI Image Creator, Jweel	8
AI-enhanced presentation tools	Canva (Magic Design), Prezi (AI layout), Gamma AI	5
AI quiz or gamification tools	Grammarly (AI edition)	1
AI-based writing assistants	Mentimeter, Padlet (AI image)	2
No AI tools used (observed)	-	6

Table 1: Types of AI-related and digital tools used in microteaching.

3.3 Q3: How effective did you find the AI-tools in enhancing teaching?

Participants rated the perceived effectiveness of AI-tools in enhancing teaching on a five-point Likert scale (1= not effective; 5= very effective). Two participants selected 1, none selected 2, five chose 3, six selected 4, and nine rated them as 5. The distribution indicates a tendency toward higher effectiveness ratings, with a mean score of 4.0, suggesting generally favourable evaluations of AI use in microteaching.

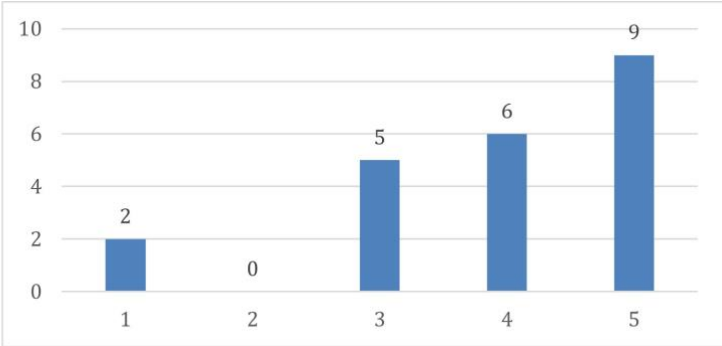

Figure 4: Perceived effectiveness of AI-tools during microteaching.

3.4 Q4: In your opinion, how does AI improve language skills?

PSTs articulated varied perspectives on how AI supports language skill development in EFL distance teaching. Most participants (17) expressed a positive view of AI's potential, frequently emphasising the value of personalised and adaptive learning opportunities it provides. Participant 2 stated that "*Learners can tailor the practice to themselves and their needs, which may be different from their peers,*" emphasising the flexibility attributed to AI. Likewise, P8 pointed to AI's versatility, explaining that "*Due to the versatility of AI tools, I think that they can certainly enhance writing skill of students who wish to learn how to write anything. The AI is there to assist, correct, and even improve their writing skills.*"

In contrast, a smaller group of participants (5) expressed scepticism about AI's pedagogical contribution. P11 argued that "*No, it is not a practising tool. I think it saves a lot of time for students or teachers, but I cannot say it improves anything it just helps students who are lacking some abilities to catch up with better students,*" indicating doubts about AI's ability to foster genuine skill development. Similarly, P12 warned that "*It makes students lazier,*" reflecting concerns that excessive dependence on AI may encourage passivity rather than active learning. Considered as whole, these perspectives suggest that PSTs acknowledge AI's potential to enrich language-learning processes, particularly through personalisation, feedback, writing support. They also accentuate the enduring importance of authentic communication and teacher mediation in ensuring meaningful language development.

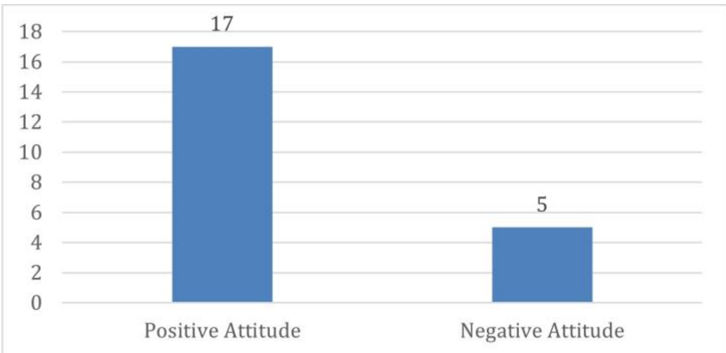

Figure 5: PSTs' views on AI and language-skill development.

3.5 Q5: Do you believe the benefits of using AI in Distance English Teaching outweigh the drawbacks?

Most PSTs expressed a generally positive outlook on AI in Distance English Teaching, while emphasising the need for modernisation alongside responsible use. Among the participants, 13 reported positive beliefs, 4 mixed views, and 5 expressed negative beliefs. The majority affirmed that benefits outweigh the drawbacks, citing AI's potential to enhance personalised learning, accessibility, efficiency, engagement, timesaving for teachers, and instant feedback for learners. For instance, P4 stated that "*Yes, the benefits of AI in distance English teaching outweigh the drawbacks, as it offers personalised learning, instant feedback, and accessibility, with manageable risks,"* while P21 similarly observed that "*I think yes, because teachers and students can seek help from AI. Then they wouldn't be so overloaded with the work, but it must be used as a supportive tool."*

However, several PSTs raised concerns regarding overreliance, reduced human interaction, and the risk of diminished creativity. Positive evaluations were tempered by opposing concerns. As P6 remarked, "*At this point, the drawbacks are enough of a reason to ban it in education outright. Until someone can properly check if the data accessible by AI is factually correct, I would not use it in my teaching at all."*

Overall, optimism was moderated by a balanced awareness of pedagogical and ethical considerations.

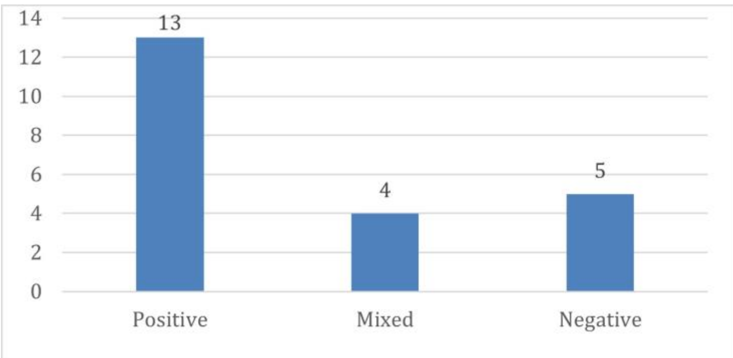

Figure 6: PSTs' belief in AI's benefits in Distance English Teaching.

3.6 Q6: Do you have any concerns about the use of AI in education?

Responses revealed a diversity of views. Six participants reported no concerns, describing AI as a "*useful*" or "*normative*" tool that can enhance teaching and learning processes. The remaining sixteen expressed varying degrees of apprehensive attitude, identifying several recurring themes.

The most prevalent concern related to student overreliance on AI. Many participants (P) indicated that learners might become "*lazy*" or overly dependent, using AI to complete assignments rather than engaging in independent thinking. This dependency was viewed as detrimental to the development of creativity and critical thinking. As P10 explained: "*Yes, I do have concerns about the overuse of AI in education. While AI can be a valuable tool, excessive reliance on it can hinder students' critical thinking and creativity by providing them with instant answers and limiting their opportunities for independent exploration and problem-solving.*" A similar concern was articulated by P11, who argued that "*Yes, education overall is focused on results, rather than the passion to learn. Students are railroaded into precise answers, said no when they try to do something else, and any creativity is guided, mostly. And AI can serve you all the answers, conveniently in seconds, and sometimes the information is wrong, because some users have convinced it as a prank. AI is a tool, a hammer is a tool, if you use it wrong, you can end up harming yourself.*"

Several participants noted that overreliance could shift students' perception of AI from a supportive aid to a replacement for genuine cognitive effort. As P15 observed, "*AI is amazing, but there are two approaches - 1. ai is great tool, which can help me be more effective 2. ai is amazing tool which can do it instead of me there is nothing wrong with first approach, but the second approach is my concern as possible future teacher.*" Likewise, P17 expressed apprehension about academic integrity, stating, "*Yes - As I stated before, I fear that the use of AI could make students lazier, as it can write and complete assignments for them, and therefore it will be hard for teachers to evaluate them.*"
Collectively, these views suggest that while many PSTs see AI's usefulness, a substantial number remain concerned that excessive reliance on such tools may undermine students' autonomy, creativity, critical thinking, and engagement with the learning process.

The table provides a summary of concerns (themes coded inductively; multiple concerns possible; n = 22):

Theme of Concern	Number of Participants (n)
No concerns expressed	6
Overreliance and laziness	9
Academic integrity and authenticity	4
Reduced critical thinking and creativity	3
Ethical accuracy concerns	2
Data privacy	1
Societal dependence on AI	1

Table 2: Summary of concerns regarding AI in education

3.7 Q7: What overall recommendations would you make for incorporating AI into distance English teaching based on your experience?

Recommendations emphasised balanced, meaningful, ethical, and supervised integration of AI into distance English teaching. Most agreed that AI should serve as supportive pedagogical tool rather than a replacement for teachers, with primary aim to enhance rather than dominate the learning process. PSTs specified that AI is most effective when applied to specific, minor task such as lesson planning, brainstorming, generating feedback, or creating lesson materials, while human interaction and critical thinking remain central. This view was reflected in P6's observation that" *It's a good tool for brainstorming, getting an outline or start is one of the more difficult and sometimes frustrating things a teacher can face, so having something, that can throw out a bunch of ideas is good."*

Participants cautioned against excessive or unreflective use of AI. As P8 noted, "*Don't focus too much on AI. It can take the attention away from students as fast as it can make them fixate on it. Use it sparingly to make the lessons more interesting*." Similarly, P21 recommended targeted, purposeful integration, stating, "*Use it as a supportive tool, maybe use it for creating special programs or activities for students with special needs, and also for creating activities when you don't have any ideas."*

Several PSTs advocated for teacher training to ensure informed and responsible use of AI, including awareness of data privacy and accuracy. A gradual, reflective approach was recommended, focusing on student engagement and the continuous evaluation of AI's educational impact.

4 Discussion

The findings indicate that pre-service EFL teachers generally view AI as a useful addition to distance teaching, despite limited formal preparation. Only a small fraction reported prior training, yet most incorporated AI tools in the mandated microteaching activity and rated their effectiveness favourably (mean = 4.0). This pattern suggests pragmatic engagement driven by instructional requirements rather than autonomous competence development, directly addressing RQ1 on preparedness and training. The discrepancy between self-reported and observed use points to definitional ambiguity around "AI integration," indicating the need for clearer conceptual frameworks and guidance on what constitutes meaningful pedagogical application. Participants' tool choices gathered around text generation, image creation, and AI-enhanced presentation platforms, i.e., functions that primarily support planning, material development, and learner engagement. Consistent with this profile, recommendations favoured AI for bounded tasks and as a supportive aid rather than as a substitute for teacher-led instruction, aligning with RQ2 and RQ4 on perceived pedagogical value and practical recommendations.

While most respondents judged the benefits to outweigh the drawbacks, concerns united around student overreliance, academic integrity, diminished creativity and critical thinking, and issues of accuracy and privacy. These reservations correspond with RQ3, highlighting persistent tensions between efficiency gains and the preservation of communicative competence, authenticity, and critical thinking, i.e., core aims in language education.

The implications of these results extended to the design of teacher-education curricula. Embedding structured AI-competence modules can transform the observed ad-hoc experimentation into deliberate instructional design (Kerr & Kim, 2025). Aligning such modules with existing competency frameworks (e.g., TPACK, DigCompEdu) would facilitate professional development and promote the transformation of AI-enhanced practices to authentic classroom settings (Wang & Mokhart, 2025). Moreover, policy makers should consider establishing institutional guidelines that describe ethical standards, data-privacy safeguards, and verification protocols; therefore, addressing the accuracy and privacy concerns voiced by participants (UNESCO, 2023).

Future research should examine longitudinal outcomes of AI-integrated teaching, assessing not only teacher perceptions but also learner achievement and communicative competence across instructional contexts. Finally, interdisciplinary collaboration among AI developers, language educators, and curriculum designers could be essential in creating tools that support the human dimensions of language teaching.

5 Limitations and Implications for Further Research

The study was limited by its small sample size of 22 pre-service teachers, which constrains the generalizability of the findings. Moreover, the data were collected through a self-reported questionnaire and 15-minute microteaching tasks involving AI integration, providing only a snapshot of participants’ practices and perceptions and restricting insight into longer-term pedagogical impacts. Future research should therefore draw on larger and more diverse cohorts to strengthen the applicability of results across contexts. In addition, longitudinal or mixed-method designs, including extended teaching practice, classroom observations, and follow-up interviews, are recommended to more comprehensively examine how AI-integrated pedagogical practices develop over time and whether competencies demonstrated in microteaching translate into sustained and authentic classroom use.

6 Conclusion

This paper indicates that pre-service EFL teachers adopt AI-tools primarily as an engagement feature or supplement to distance English teaching. Ambiguities in meaningful AI integration and concerns about ethical, accuracy, and privacy issues suggest the urgent need for structured competency courses and clear institutional guidelines. Policymakers and teacher-education programs should prioritise comprehensive AI literacy and ethical standards to ensure responsible and beneficial implementation in language instruction.

Acknowledgement

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Comparison of the Applicability of Graduates of Pedagogical Faculties to Practice at SOŠD

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Abstract

The article focuses on comparing the readiness of two groups of early-career teachers to enter the teaching profession at the Secondary Vocational School of Transport in Bratislava (SOŠD). In practice, disproportions are observed in the induction process between full-time graduates of faculties of education and employees who complete their teaching qualifications alongside their employment. We assume that the extent of teaching practice during university studies significantly affects the success of the adaptation process and the ability of an early-career teacher to work effectively with students.

Keywords: Quality of Graduates of the Faculty of Education of the University, Teaching Practice, Adaptive Education, Career System of Pedagogical Employees

1 Introduction

The most serious problems in the implementation of vocational education and training (VET) include not only the shortage of a new generation of teachers but also the quality of higher education (HE) graduates prepared to enter the teaching profession. This study focuses on a systematic comparison of two groups of HE graduates and their readiness to work as pedagogical staff. The first group includes recent graduates hired as teachers, while the second group consists of employees who completed their studies while already employed at a school. We consider the limited extent of teaching practice during HE studies to be a potential cause of insufficient competencies.
Analysis of the adaptation process of beginning teachers shows differences in their level of readiness and ability to integrate into the school environment. Graduates of part-time studies usually adapt more effectively and demonstrate greater stability in pedagogical practice.

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Conversely, graduates of full-time university studies require more intensive support and mentoring. The main challenges identified include work discipline, communication, and pedagogical competencies, as well as adaptation to specific work tasks and readiness for practical situations in school.

The SWOT analysis points to systemic factors influencing the quality of the adaptation process; specifically, the insufficient practical training of Faculty of Education (PF) graduates increases the demands on schools and the necessity for intensive mentoring. On the contrary, the dual education model at SOŠD, with its high share of practical training, significantly improves the readiness of graduates for direct entry into the profession and can serve as inspiration for the reform of teacher training.

The Secondary Vocational School of Transport in Bratislava prepares students within the dual education system for direct entry into the labour market. The significantly higher time allocation, comprising at least 50 percent of practical training for SOŠD students, allows them to enter the profession with a high level of expertise and preparedness, thus minimising the need for additional education after starting work. A significant positive factor is also the higher level of socialisation into the work environment, as evidenced by statistics on the employability of graduates in the given field.

On the contrary, graduates of faculties of education encounter a relatively low level of compulsory practice during their studies, which requires the implementation of an adaptation process during employment. Experience from SOŠD also indicates that not all graduates meet the requirements of the teaching profession, not only from a professional perspective but also from a personal perspective. This includes punctuality, communication skills and administrative competencies necessary to manage the school agenda. The main objective of this analysis is to identify existing shortcomings and propose recommendations that could contribute to increasing the quality of pedagogical training and the employability of graduates in the labour market.

The article is structured into three parts:

1. An analysis of the adaptation process in secondary vocational education within the career system of the Slovak Republic with the aim of identifying strengths and weaknesses (SWOT).
2. A comparison of the turnover of admitted university graduates with workers who study externally in addition to their employment at school, in the context of their applicability in the work environment.
3. The iIdentification of key aspects of graduate readiness.

The result is an opening of the given issue and a proposal of possible solutions and recommendations for practice.

2 Analysis of the Adaptation Process to SOŠD and the Career System

2.1 Introduction to the Career System

We have an established pedagogical development system at SOŠD:

Type	Goal	Content / characteristics
Adaptation process	Facilitate the integration of a new teacher into the school environment and work tasks	Mentoring, familiarisation with the school and work tasks, development of an adaptation plan, monitoring of progress and evaluation of adaptation
Updating education	Maintaining the up-to-date professional and pedagogical knowledge of teaching staff classified as independent or with 1st and 2nd certifications	Developments in subject areas, new methods and technologies, and legislative and curricular changes
Innovative education	Introducing new approaches and modernising teaching, successful completion is this stage provides the basis for a salary increase	Experimenting with teaching methods, digital and interactive tools, developing creativity and innovative thinking, sharing best practice
Specialised education	Deepening professional knowledge and acquiring specialised competencies	Professional expertise in a specific field, specific pedagogical skills, preparation for professional positions or certifications, support for career growth
Further education	Deepening professional and pedagogical competences	Updating professional competence, modern teaching methods, development of personal and managerial skills, legislative and methodological updates
Functional education	Improving practical and pedagogical skills – for leading pedagogical staff	The aim is to strengthen teachers' abilities to lead teaching effectively, solve specific problems in the classroom and apply proven pedagogical practices in practice

Table 1: Career development system at SOŠD.

2.2 Course of the Adaptation Process

The adaptation process for teachers at the Secondary Vocational School of Transport focuses on the calm and gradual integration of the new teacher into the school environment and their professional tasks. Essentially, this constitutes a process of onboarding or orientation, which enables the teacher to participate effectively in teaching and the broader functioning of the school.
The main components of the adaptation educational process are:

1. Appointment of a mentor – An experienced teacher or senior educator supports the new teacher, advises them, and supervises their initial progress (Hašková et al., 2023).
2. Development of an adaptation plan – The schedule and content of the adaptation process are structured, with specific goals and expectations established.
3. Familiarisation with the school and work environment – This includes school organisation, rules, internal regulations, and the systems utilised.
4. Adaptation to specific work tasks – The gradual acquisition of teaching procedures, classroom management, and student assessment.
5. Monitoring and evaluating the process – Continuous monitoring of how the teacher is adapting, identifying strengths and areas for improvement through the Common Assessment Framework (CAF) or internal evaluation mechanisms.

The aim is for the new teacher to quickly gain self-confidence, understand school processes and start working effectively with students. Between 2017 and 2025, 53 new teachers began the adaptation process at the Secondary Vocational School of Transport, of whom 28 were graduates of university faculties of education and 23 were employees who supplemented their qualifications through external studies.
To determine the level of readiness, we established a criterion that the graduate should remain in the post for at least two years after graduation. The monitored criterion was the termination of employment due to the low quality of the educational activities implemented by the teaching staff.
The survey was conducted by collecting data for the period 2017 to 2025 with the following results:

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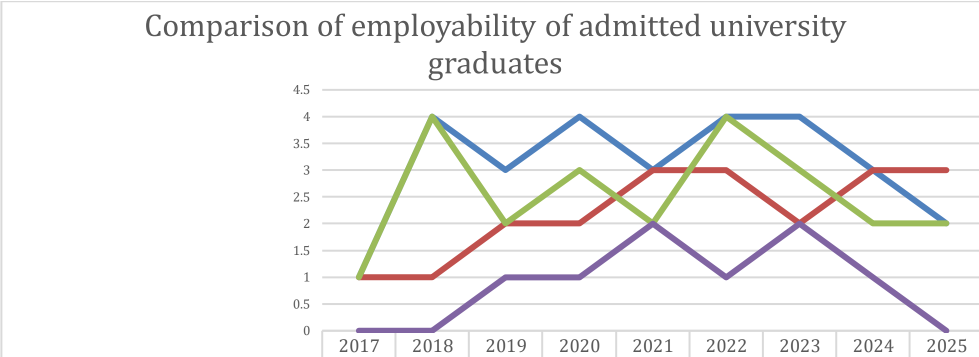
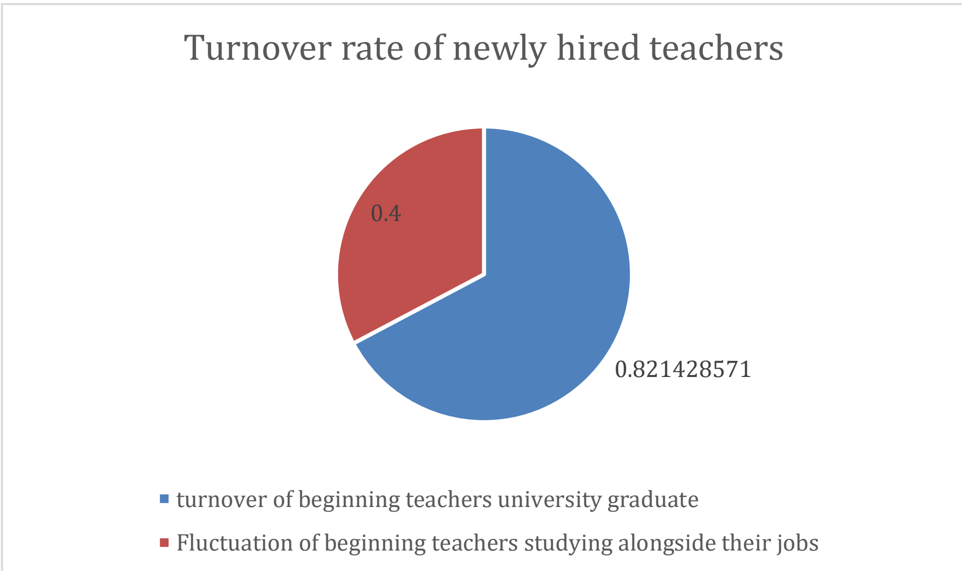


	2017	2018	2019	2020	2021	2022	2023	2024	2025
beginner teacher graduate	1	4	3	4	3	4	4	3	2
beginning teacher studying alongside his job	1	1	2	2	3	3	2	3	3
beginner teacher graduate fluctuation up to 2 years	1	4	2	3	2	4	3	2	2
beginner teacher working alongside employment, fluctuation up to 2 years	0	0	1	1	2	1	2	1	0

Graph 1: Comparison of the employability of full-time and part-time university graduates within secondary vocational education and training institutions between 2017 and 2025.



Graph 2: Staff turnover rate of newly hired employees at SOŠD from 2017 to 2025

The survey indicates that during the monitored period, 53 teachers started the adaptation training process; however, only 38 teachers completed it. Seventeen graduates successfully integrated and remained in the profession, of whom 12 were part-time graduates and five were full-time graduates.

The failure to complete induction was due to the termination of employment for the following reasons:

- *Failure to comply with work discipline and working hours*

Repeated tardiness, unexcused absences, or failure to meet work attendance requirements according to the agreed schedule.

- *Insufficient work habits and professionalism*

Failure to master basic duties related to work organization, work procedures, or fundamental hygiene standards.

- *Insufficient pedagogical and communication skills*

Inability to communicate effectively with students or colleagues, inappropriate behaviour in a pedagogical environment, and poor leadership or motivation skills.

- *Failure to complete the adaptation process*

Inability to adopt required procedures and standards during adaptive education, lack of flexibility in adopting school processes.

- *Inappropriate professional conduct*

Violation of internal school regulations, lack of initiative, low level of responsibility or an unwillingness to cooperate within a team.

- *Insufficient preparation for practical work*

Inability to perform fundamental work activities and tasks learned through practice in accordance with the employer's expectations.

2.3 Factors Influencing the Quality of the Educational Process

The fact that not every early-career teacher at the school successfully completes the adaptation process suggests a link between the professional development of teaching staff and the school’s personnel policy, specifically regarding the employment of university graduates.

This phenomenon can be examined through a SWOT analysis, in which the strengths and weaknesses sections identify factors affecting the stability and quality of the teaching staff.

Factor	**Description**
Strengths	Teachers who have successfully completed their induction and remained at the school bring high levels of expertise, knowledge of institutional processes, and motivation, all of which enhance the quality of teaching.
Weaknesses	A lack of practice leads to difficulties in mastering core professional duties among teaching graduates and results in a low level of socialisation into the school environment.
Opportunities	Motivating and developing those graduates who successfully complete the induction process allows for the building of a strong, loyal and forward-looking team of teachers. The school can establish a system of mentoring and support to increase the success rate of the induction process.

Threats	Teacher shortages and the failure to complete induction can lead to staffing deficits, increased pressure on current staff, reduced teaching quality, and a negative impact on the school's reputation. A shortage of education graduates and low success rates in initial teacher training reduce the availability of qualified teachers and can strain the existing workforce.

Table 2: SWOT analysis.

On the one hand, the school's openness to accepting promising early-career teachers, who bring fresh approaches, current knowledge, and modern pedagogical methods to the educational process, can be considered a strength. In this way, the school supports generational change and increases its innovative potential. At the same time, it maintains an induction system that helps new teachers integrate into the pedagogical team and master the school's internal processes.

On the other hand, the fact that not all novice teachers successfully complete the induction process is a weakness. This issue may be related to the demands of teaching in vocational education, but specifically to a lack of practical experience among graduates and limited opportunities for mentoring from experienced colleagues (Radulović et al., 2024).

This can result in high teacher turnover, which negatively affects the continuity of the educational process and increases the personnel burden on school management. The Secondary Vocational School of Transport, Kvačalova 20, Bratislava, employs a dual education model with a high proportion of practical training (at least 50%). Consequently, the student spends a significant part of their studies in a real working environment with an employer. Theoretical education, pedagogical and special educational support, as well as the professional training of instructors at the employers' premises, are provided directly by the school. This system allows graduates to enter the labour market professionally competent and prepared, without the need for extensive additional induction.

3 Vocational Training of Graduates of Teaching and Study Fields for Direct Entry into the Labour Market vs. Graduates of University Teaching

3.1 Secondary Vocational School in Transport and Employability of Graduates

Before its introduction, students repeatedly encountered shortcomings such as a lack of practical skills, a lower level of professional training, and insufficient discipline regarding commuting and the personal prerequisites necessary for the profession. In the context of technical and vocational schools, it is evident that a high proportion of practical training and a close connection with industry significantly increase the employability of graduates in the labour market. Such a model contributes to the better preparation of students for real working conditions and reduces the need for further training by employers.

3.2 Universities and Faculties of Education: the Readiness of Graduates

Studies at the Faculty of Education of the University for future teachers focus primarily on general pedagogical and psychological training, didactics, and teaching methodology. The aim of these subjects is to enable students to master the theoretical foundations required to implement the educational process. Although teaching practice is a component of the degree, its scope remains relatively limited. Slovak legislation transfers the responsibility for the induction process to the school, where teacher training occurs directly during the period of employment. Consequently, graduates enter the teaching profession with comprehensive theoretical training but with little or no experience in a real school environment. As an employer, the school must provide significant induction support, mentoring, and supervision to ensure the process is successful.

3.3 Comparison – Key Aspects of Graduate Readiness

Aspect	**Graduate – studying alongside employment, or employment during university studies**	**Graduate of the Faculty of Education / University of Teacher Education**
Amount of practice during studies	At least 50% practice in a real environment	Relatively low level of teaching experience
Professional preparation for the profession	Higher education in the field directly enters practice	Theoretical preparation for teaching
Turnover rate	Lower turnover rate	Higher turnover rate
Personal readiness (attendance, motivation, communication)	Better communication skills and work ethic	Risky – teacher graduates experience a lack of practical training.
Candidate selection and psychological testing	Vocational schools, in collaboration with universities, have the opportunity to select students based more closely on their genuine interest and ability to practise their chosen profession.	It reveals the low level of initial psychological screening and a lack of genuine interest in pursuing a teaching career after graduation.
Level of socialisation	Adapted to the work environment	A more challenging problem with work habits

Table 3: Key aspects of graduate readiness in addition to employment and full-time study.

3.4 Importance for Practice

The internship model with a time allocation of more than 50% at the Secondary Vocational School of Transport is highly suitable for increasing the readiness of graduates and their direct entry into the labour market without the need for extensive induction. The induction of a teacher graduate without an internship is more complex as university studies are more theoretically oriented and the internship period is relatively short, meaning that schools must invest in adaptive education. Disadvantages include increased costs (time, mentoring, and training) and the potential risk regarding the graduate's level of preparation; where personal prerequisites are lacking, a negative impact on the quality of teaching may arise.

The study model with an internship share of more than 50% for a university student brings several advantages: a more significant portion of the course involves school-based work, there is the opportunity to apply theoretical knowledge in practice, and the student receives financial and material security. Furthermore, mentor assistance and the completion of the internship improve the readiness of graduates and significantly increase work performance.

Current shifts (digital generations and changing motivations) and technological changes (digital tools and hybrid forms of teaching) are significantly altering the teacher's profile. Graduates of faculties of education must be prepared not only for traditional teaching but also for modern learning methods, digital competences, and adaptation to change. Consequently, practice and induction processes must also incorporate these dimensions (Hašková et al., 2024).

4 Research Results and Recommendations for Practice

By comparing the preparedness of graduates from part-time and full-time teaching programmes, we found that a model with a high proportion of teaching practice can significantly improve graduates' readiness for the profession. The study of education at universities in the Slovak Republic still faces challenges, such as the quality of practical training and the personal prerequisites necessary for high-quality teaching. It is essential to introduce measures such as increasing the proportion of teaching practice, selecting suitable candidates, and providing mentoring and induction during studies. The starting point remains the integration of vocational education and teacher training.

This paper serves as an incentive for discussion and systemic transformation, ensuring that graduates enter the teaching profession fully prepared and that schools acquire excellent new teachers without the need for extensive additional induction.

Based on the analysis and results, we recommend the following steps:

1. **Increase the proportion of teaching practice in teacher training** - We recommend that faculties of education introduce a system where teaching practice constitutes more than 50% of the curriculum. If graduates completed a significant portion of their practice during their studies, they could enter the profession as prepared teachers without the need for an extensive adaptation process.
2. **Improve the selection of applicants for teacher training** - Introduce personality screening, motivational interviews, psychological testing, and aptitude tests (e.g. the ability to engage students, independent learning, and attendance). This can reduce the risk of recruiting teachers with inappropriate attributes.
3. **Intensify the connection between theoty and practice** - Faculties of education should establish partnerships with primary and secondary schools to create a network of training schools where student teachers can complete extended periods of placement. Vocational schools can also serve as partners, as technical disciplines involve a significant proportion of practical training.
4. **Take digital and generational changes into account** - teachers' adaptive practice must include competencies in the areas of digital technologies, hybrid teaching, motivating digital learners, and creating interactive activities.
5. **Monitor and evaluate the effectiveness of adaptation programmes** - Schools should regularly evaluate the success of adaptation processes (e.g. how quickly a new teacher adapts, the resulting outcomes, satisfaction levels, and staff turnover) and adjust programmes according to specific needs.

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