Innovations in Digital Education: An Overview of Technological Trends in Technical Education

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ABSTRACT

Aim. The aim of the presented survey was to explore modern digital tools entering the educational process, including educational videos, AR and VR devices, and programming tools, and to examine ways of their use in schools together with the barriers to their broader effective use by teachers.

Methods. With regard to the stated aim the survey was carried out by means of an online questionnaire. Within the research sample were two target groups of the survey: primary school teachers teaching technical subjects and pupils from the second grade of (Slovak) primary school (grades 5-9).

Results. The survey found that commonly the most used digital tools include interactive learning systems, educational videos and programming tools. Commonly the most used didactic methods include project-based learning, group work and multimedia-enhanced lectures. However, lack of preparation time, outdated technical equipment and poor internet connectivity are the main obstacles to introducing digitalisation into learning.

Conclusions. Based on these findings, systematically incorporating digital elements into school curricula is recommended, modernising the technical infrastructure, establishing a position of digital coordinator, providing regular specialised training for teachers, and allocating flexible time blocks for project activities. These recommendations can significantly improve the quality of teaching and better prepare pupils for the digital challenges of the future.

Keywords: teaching, use of digital tools, forms of digital learning content, digital learning efficiency

Introduction

The trend influencing educational processes nowadays is the digitalisation of education. It affects all aspects of education and learning, from preparing for a teaching unit to implementing teaching, assessment, and feedback. This study aims to identify the key factors of the use of digital tools in practical teaching of technical subjects in primary schools in Slovakia. It analyses the used technologies and availability of their infrastructure. Subsequently, to identify the primary barriers to their implementation the required level of professional and methodological support related to their use is assessed. Based on the identified barriers some measures that could contribute to the use of these tools in educational process are proposed.

Literature Review

The digitalisation of education is a key element in the field of education, and in Slovakia it is currently supported by education reform. By this reform, the Ministerstvo Školstva, Výskumu, Vývoja a Mládeže Slovenskej Republiky intends to modify the content and forms of education in primary and secondary schools in Slovakia (Hašková & Lukáčová, 2022, 2023; Ministerstvo Školstva, Výskumu, Vývoja a Mládeže Slovenskej Republiky, 2024). The implementation of digital technologies in the educational process will provide new approaches to teaching and opportunities to expand traditional teaching methods with interactive and innovative elements that promote active learning and the development of pupils´ key competencies (Redecker & Punie, 2017). Pedagogical approaches focused on digital learning emphasise the active involvement

of pupils in the learning process. The outcomes of more studies confirm that the proper deployment of digital learning using constructivist approaches, including inquiry-based learning, experiential learning, the flipped classroom, and project-based learning, fosters pupils' independence, teamwork, critical thinking, and problem-solving skills. In this way, these approaches significantly contribute to the development of competencies needed for the 21st century (Liat & Havak, 2024; Sasson et al., 2018). The study by Irit Sasson, Itamar Yehuda and Noam Malkinson (2018) analyses project-based learning as a tool for developing critical thinking and questioning skills. The research showed that pupils engaged in project-based activities were able to frame relevant questions and seek deeper connections in their learning, which is at the core of the constructivist approach. The authors emphasise that active inquiry and teamwork promote the development of cognitive skills. At the same time, project-based learning provides an opportunity for the practical application of knowledge in real-world contexts. This method has been efficient in promoting autonomy and self-regulation of pupils. Eyal Liat and Merav Hayak (2024) focused their research on integrating digital games into teaching within a constructivist framework. The study demonstrates that digital games, when effectively integrated into the teaching process, can facilitate experiential learning. The authors present the integration of game elements with pedagogical goals. They demonstrate that this approach leads to increased pupil engagement and the development of cooperation and problem-solving skills in a dynamic environment. Games serve as means to simulate complex situations that promote learning based on the acquisition of new knowledge and experiences. Michal Mančík et al. (2025) focus on the use of augmented (AR) and virtual reality (VR) technologies in teaching technical subjects in primary schools. The authors note that AR and VR offer pupils opportunities to engage in practical and visually stimulating activities that foster contextual and experiential learning. Their research results show that the use of these technologies leads to higher levels of motivation and a better understanding of technical concepts. They also enhance spatial thinking and strengthen creativity, thus contributing significantly to technical literacy (Mančík et al., 2025). Florence Sullivan and John Heffernan (2016) analysed robotic building blocks as a teaching tool in STEM activities. In their research, they demonstrated that robotic building blocks can function as tools that connect abstract programming to the physical world. Learning through robotics enables pupils to experiment, test hypotheses, and build solutions in cooperation with others, thereby developing technical skills, teamwork, and logical problem-solving thinking (Sullivan & Heffernan, 2016). Despite the benefits that digital technologies bring to the educational process, their implementation and use in practice are often limited by several barriers. Kamaljit Kaur's study (2023) states that trust in digital technologies, as well as the competence and availability of digital technology, are critical elements for integrating digital technologies into institutions. It is essential to provide teachers with the necessary digital technology, including both hardware and software, to support their educational needs. Teachers need specialised

training on how to use technology and software focused on achieving educational goals. It is crucial to ensure sufficient time to create preparations using digital technology and to provide expert technical assistance when problems arise with its use.

Research Methodology

Although nowadays trends in education focused on digitalisation of teaching do not differentiate among the subjects taught, in our opinion different teacher categories (understand teachers of different majors - general education subjects, social science subjects, natural science subjects, technical subjects, foreign languages teachers) face various challenges and demands to reflect requirements of these trends in their teaching practice (Kaur, 2023; Záhorec et al., 2019). Within the framework of the presented research attention was put on demands, experiences and opinions of primary school teachers whose majors are technical subjects. The main goal of the presented survey was to analyse technologies used by this category of teachers and availability of their infrastructure. Subsequently, a further task of the survey was to assess the level of professional and methodological support required to identify the primary barriers to their implementation. Based on the identified barriers some measures that could contribute to the use of these tools in educational process are proposed.

Research methodology was based on a combined research approach that consisted of analysing accessible specialised literature and implementing empirical research through a questionnaire survey. The theoretical background provided us with a basis for formulating the research questions RQ1 - RQ4 focused on current trends and problems in primary and secondary schools related to digital learning, which were as follows:

- RQ1: What digital technologies are most frequently used in the practical teaching of technical subjects in primary schools?
- RQ2: What is the perceived contribution of digital technologies to the development of technical literacy, creativity and critical thinking of pupils?
- RQ3: What barriers hinder the efficient use of digital technologies in practice in primary schools?
- RQ4: What measures and strategies can contribute to a more effective integration of digital technologies in the educational process?

The empirical research was carried out by means of an online questionnaire created in Google Forms and distributed via email to a research sample of primary schools in the Slovak Republic. At this point it is necessary to point out that in Slovakia primary schools represent integration of primary and lower secondary education (ISCED 1 and ISCED 2, grades 1 – 9, pupils aged from 6 to 15 years; which are in Slovakia called first, grades 1 – 5, and second grade, grades 6 – 9, of a primary school).

The questionnaire items were focused on following seven areas:

- kinds of the specific digital education tools used at schools;
- frequency of their use at lessons;
- quality of these tools;
- benefits related to their use at lessons;
- efficiency of different forms of their use at lessons;
- barriers related to their use at lessons;
- suggestions to improvement of their use at lessons.

Totally it consisted of 16 questionnaire items, from which some were close-ended questions and some were open-ended questions. At some of the close-ended questions, only one response of the respondent was possible, but in case of others, respondents could mark more choices.

Within the research sample there were two different target groups of the questionnaire survey. One were primary school teachers teaching technical subjects and the other were pupils from the second grade of primary school (grades 5-9). The decision to address beside the teachers ,also the pupils to take part in the questionnaire survey was evoked by our interest in obtaining also an opinion on the use of digital education tools at schools from the pupils perspective. Of course, one has to be aware that this decision is a two sided coin. On one hand we wanted to confront the teachers´ statements on the issue of which technologies and how they use in their teaching practice with the pupils´ experiences and perceptions which they obtain during the lessons. On the other hand, it is obvious, that the pupils´ responses to certain questionnaire items should be taken with considerable caution or certain limitations, as the pupils are not able to offer a professional evaluation to the stated issues. For example this is a case of "confrontation" the pupils responses with the teachers responses to the questionnaire item asking the respondents to mark from the given five choices the one which in their opinions is the most efficient form of the digital learning content (interactive games and quizzes, videos and animations, simulations and digital content creation, others).

To make the questionnaire as simple as possible, its structure was designed according to the type of its respondents. After selecting the category "teacher", the teacher participants were directed to the part containing questions for teachers, and after selecting the category "pupil", the pupil participants were directed to the part with questions for pupils. As to the content the questionnaire items were, more or less the same for both categories of the respondents. They differed only in their formulation and that, depending on the category of respondents they addressed, e. g. how often you assign tasks that require digital learning content outside the classroom – a question for teachers, versus how often you have assigned tasks that require digital learning content outside of the classroom – a question for pupils. This design of the used questionnaire allowed comparison of similarities and differences between the digital technologies perceptions between pupils and teachers.

The research sample consisted of a total number of N = 276 respondents, of which n= 203 (73.6 %) were pupils and n = 73 (26.4 %) were teachers. Detailed characteristics of the research samples of both target groups of the survey are presented in Table 1 and Table 2.

Table 1

Characteristics of the Group of Respondents – Pupils, Absolute and Relative Numbers

	14 - 15 year-old	**12 - 13 year-old**	**10 - 11 year-old**	**under 10 year-aged**
n	114	78	9	2
n [%]	56.2	38.4	4.4 %	1.0
	rural school pupils		urban school pupils	
n	116		87	
n [%]	57.1		42.9	

Source. Own research.

Table 2

Characteristics of the Group of Respondents – Teachers (Age, Length of Teaching Practice), Absolute and Relative Numbers

age	**25 - 34 year old**	**39 - 49 year old**	**50 - 60 year old**	**over 60 years**
n	6	37	24	6
n [%]	8.2	50.7	32.9	8.2
teach. exp.	less than 5 years	5 - 9 years	10 - 19 years	over 19 years
n	13	8	18	34
n [%]	17.8	11.0	24.7	46.6
	rural school teachers		urban school teachers	
n	43		30	
n [%]	58.9		41.1	

Source. Own research.

Interestingly, although 42.4 % of the teachers who teach technical subjects do not hold a formal specialisation in this field, they teach these subjects regularly. This fact reflects the reality of education in Slovakia, where, hypothetically, a shortage of qualified teachers forces schools to assign teachers without specialisation. The lack of qualified teachers confirms the need for systematic training and methodological support.

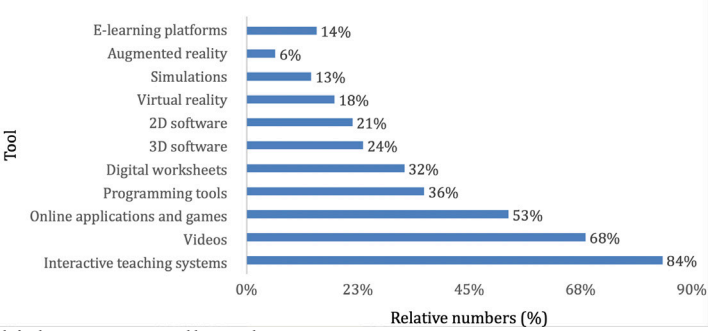
The data from Google Forms were exported to CSV format and processed in Microsoft Excel software. The closed-ended questions were processed by descriptive statistics. Responses to the open-ended questions were processed by means of the content analysis with systematic categorisation according to the thematic areas.

Results

The graphs in Figure 1 present on overview of the different kinds of digital tools which are in school practice commonly most frequently used by technical subject teachers (related to RQ1). Given that the questionnaire item allowed more choices (multiple selections), the dataset contains more answers (n) than the number N of respondents. That is why the sum of the percentages stated at the graphs in Figure 1 exceeds the amount of 100 percent.

Figure 1

Digital Educational Tools Used in Technical Subjects Teaching



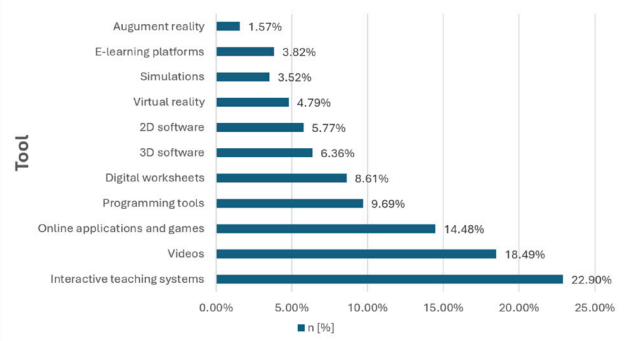
Note. Multiple responses allowed.

Source. Own research.

To avoid misleading percentage totals and to provide a clearer representation of the distribution of tools use, the percentages were normalised, i. e. n denotes the total count of all selected options while N is the number of respondents (Figure2).

Figure 2

Digital Educational Tools Used in Technical Subjects Teaching



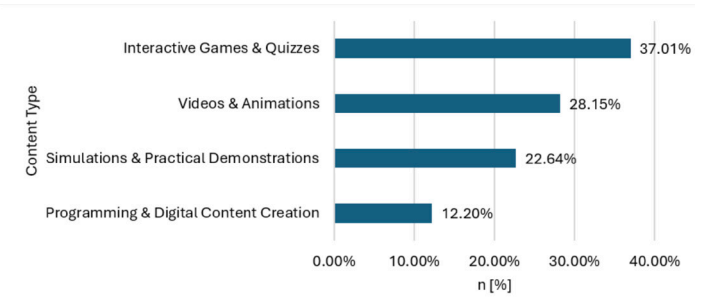
Note. Multiple responses allowed.

Source. Own research.

According to the teachers and pupils' responses, up to 22.90 % of all recorded answers referred to interactive teaching systems (Figure 2). This result can be related to the national project *Modern Education - Digital Education for General Education Subjects*. To support implementation of the digital educational tools in schools, the Ministry of Education distributed in frame of this project more than 2,600 interactive boards to schools (Ministerstvo Školstva, Výskumu, Vývoja a Mládeže Slovenskej Republiky., 2013, 2014). Interactive whiteboards help in the development of creative thinking and cooperation among pupils (Bajúzová & Hrmo, 2024). A further 18.49 % of responses referred to the use of videos, which are commonly used to support the explanation of complex technical concepts. Online applications and games accounted for 14.48 % of responses, suggesting that interactive formats are used to enhance learner motivation and introduce elements of interactivity into technical subjects. In contrast, 9.69 % of all responses were related to the use of programming tools. As the results of the questionnaire survey have shown, teachers often focus more on teaching theoretical knowledge of informatic science than on the practical application of programming within their teaching practice. The study of José-Manuel Sáez-López et al. (2019) confirms the need to extend programming in primary schools. The authors discuss the usefulness of programming in robotics, IoT devices, and app development in primary education. They highlight significant contribution of these means to development of computational thinking, creativity, problem-solving skills, and pupils' better understanding of mathematics and natural sciences. Integrating these technologies into primary school education prepares pupils for future careers in technical fields and active participation in the digital society a part of which they will be in their future life (Sáez-López et al., 2019). Less frequently represented forms of technology included virtual reality (4.79 %), simulations (3.52 %), and augmented reality (1.57 %), reflecting the limited penetration of advanced digital technologies into everyday school practice. Figure 3 offers a list of the digital content forms (kinds) which are in technical subject teacher´s opinions the most efficient ones (together with the next Figure 3 and their discussions related to RQ2).

Figure 3

Most Effective Forms of Digital Content



Note. Multiple responses allowed.

Source. Own research.

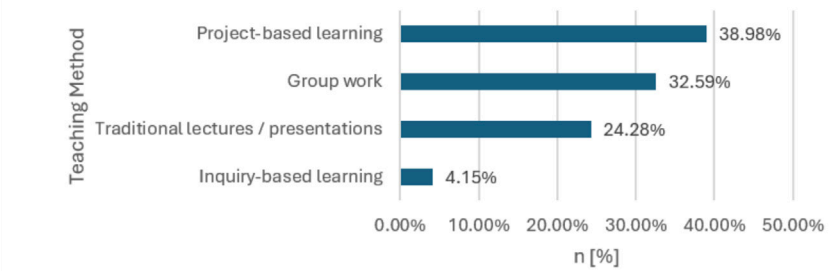
According to 37.01 % of the recorded responses, interactive games and quizzes are considered the most effective forms of digital content for teaching technical subjects. This finding agrees with conclusions of Zi-Yu Liu et al.'s research (2020) research examining influence of gamification on pupils´ learning achievements. According to them gamification increases primary school pupils´ engagement in assigned activities and promotes their motivation to learn. 28.15 % of responses indicated that videos and animations are regarded as preferred digital content. This result is related to the above-mentioned finding, which highlights that pupils and teachers often encounter videos and animations in the educational process. The study by Angganingrum Shinta Hapsari et al. (2019) evaluated the effectiveness of the use of videos in a research sample. Their research has proved that incorporating videos into the educational process is effective and enhances learning outcomes. Simulations and practical demonstrations were identified as effective by 22.64 % of all responses. Simulations and practical demonstrations enable active experimentation with technical concepts, promoting inquiry-based learning and the transfer of knowledge to real-world situations. Qualitative insights revealed responses in which respondents reported that interactive games provide them with immediate feedback: "Quizzes make me think faster, and I can see my mistakes immediately".

Others appreciated videos for their ability to show processes comprehensively: "Seeing the animation of the machine in motion helps me to understand better how it works."

Analysis of the respondents´ responses to the questionnaire item asking on the teaching methods combining digital learning content which the respondent encounter most identified four dominant approaches (Figure 4). The percentages shown in the Figure 4 represent the distribution of the most frequently selected responses (n), where n denotes the number of recorded responses within these four frequently occurring categories.

Figure 4

Most Often Occurring Teaching Methods Combining Digital Learning Content



Source. Own research.

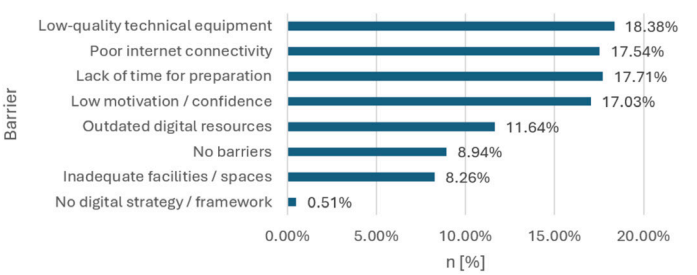
The most frequently reported method was project-based learning, selected in 38.98% of the responses within the four most frequently occurring categories (n). Michael Prince and Richaed Felder (2006) define project-based learning as an inductive method in which pupils work on a large-scale task leading to the creation of a spe-

cific artefact using digital simulations, 3D models, or interactive platforms. The emphasis is on the application and integration of existing knowledge, pupil autonomy and reflection on the learning process. The second most frequently mentioned method was group work, accounting for 32.59 % of the responses within these four categories. In the context of cooperative learning, Prince and Felder emphasise that efficient group work requires structured mutual dependence and individual responsibility, where each team member contributes to the given common goal and develops own team skills.

Traditional lectures and presentations represented 24.28 % of the responses within the frequently occurring categories, indicating that deduction-based instruction remains a relevant part of teaching practice. In this approach, instruction begins with an introduction of theoretical principles and then their applications are demonstrated. Prince and Felder expand it with multimodal components, such as videos, interactive simulations, and quizzes, which serve as immediate illustrative examples and provide feedback. In this way, they increase pupils' engagement and retention. The least frequently selected method was inquiry-based learning, chosen by 4.15 % of the responses within these categories. Prince and Felder (2006) define this approach as an inductive method in which pupils analyse data or experimental scenarios, ask questions, and systematically discover underlying principles through active exploration. Rarer mentions of other approaches and methods point to the need for further methodological expansion and innovation in technical education.Graphs in Figure 5 presents an overview of the identified barriers to effective use of the digital technologies together with the frequencies of their occurrences in schools (related to RQ3). Since the questionnaire item allowed multiple responses, the percentages shown in the figure represent the distribution of all recorded responses (n) within the classified barrier categories, where n denotes the number of responses assigned to these categories (while the number of respondents was still N). Responses that could not be meaningfully categorised (e.g., irrelevant, ambiguous or idiosyncratic answers) were excluded from the analysis and are therefore not displayed in the figure. As a result, the values shown form a complete distribution of 100% of the categorised responses.

Figure 5

Barriers to Effective Use of Digital Technologies



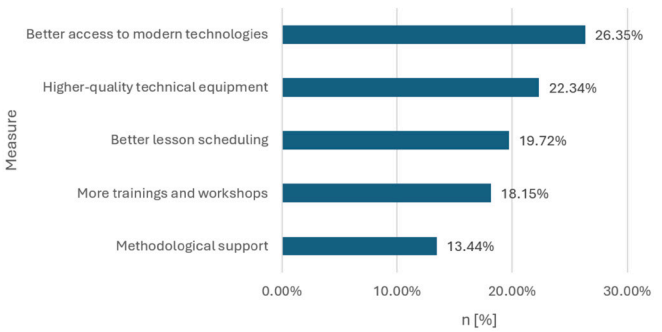
Note. Multiple responses allowed .
Source. Own research.

The analysis revealed three barriers reported with nearly the same highest frequency: low-quality technical equipment (18.38 %), poor internet connectivity (17.54 %), and a lack of time for preparing digital content (17.71 %). The first barrier reflects the challenge teachers face when balancing administrative duties with the preparation of high-quality digital materials, which may reduce their willingness to adopt new tools. The low quality of technical equipment - including outdated hardware and limited software licenses hindering the smooth flow of lessons and reducing teachers' willingness to experiment with technology. Similarly, poor internet connectivity impedes the efficient use of digital resources. Studies by Miłosz Wawrzyniec Romaniuk and Joanna Łukasiewicz-Wieleba (2024) and Wei Wang (2022) highlight that stable internet access is essential for real-time feedback, interactive teaching, and effective communication, all of which form the basis of contemporary digital learning environments. A further 17.03 % of the recorded responses indicated low motivation or confidence as another significant barrier to the effective use of digital technologies. This finding aligns with the review by Khalid Abdullah Bingimlas (2009), who identifies lack of time, limited technical resources, and low teacher motivation and confidence as key factors hindering the successful integration of digital tools into teaching.

Figure 6 offers an overview of the measures proposed by the respondents to improve the use of digital content in teaching practice of schools (related to RQ4). Since this questionnaire item allowed multiple responses, the percentages shown in the figure represent the distribution of all recorded responses n, i.e. n denotes the total number of selected measures while the number of respondents was still N.

Figure 6

Measures to Improve the Use of Digital Content in Teaching



Note. Multiple responses allowed.
Source. Own research.

Teachers and pupils highlight the need to improve access to modern technologies, which was proposed in 26.35 % of the recorded responses, and to enhance the quality of technical equipment, reported in 22.34 % of responses. A further 18.15 %

of responses emphasised the importance of introducing regular professional training and workshops led by practitioners, focusing not only on the technical mastery of digital tools but also on their didactic integration into activities such as project-based learning and the creation of interactive tasks. Relatedly, 13.44 % of responses called for stronger methodological support for teachers. Respondents also considered better organisation and scheduling of lessons to be an important prerequisite for improving the quality of teaching, as indicated by 19.72 % of responses. The study by Alena Hašková and Danka Lukáčová (2022) similarly emphasises the importance of practical activities, teacher collaboration, and connecting educational content with real-world contexts relevant to pupils' future practice. Such an approach encourages a more flexible framework for lesson organisation, enabling teachers to adapt the pace and forms of instruction to pupils' individual needs while ensuring coherence of content across subjects.

Recommendations

Based on the presented results and the literature review, we recommend that primary schools take a targeted and conceptual approach to digitalisation. Each school should have a plan for developing and integrating digital learning into its curriculum and budget. To effectively plan, coordinate, and implement new digital technologies into the teaching process, the position of digital coordinator has been created in Slovak schools. This position is intended for a teacher with specialised ICT competencies who provides methodological and technical support to colleagues, manages the digital infrastructure and oversees the fulfilment of the strategic goals of digitalisation (Ministerstvo Školstva, Výskumu, Vývoja a Mládeže Slovenskej Republiky, 2023). Key to meeting the ambitious goals is the modernisation of the technical infrastructure, including the regular renewal of computers, tablets, and interactive devices, as well as the introduction of reliable high-speed internet connectivity and centrally licensed cloud tools. Digitalisation also requires functional methodological and technical support mechanisms. Regional digital learning centres provide specialists who can provide consultations, demonstration sessions, and rapid technical assistance. They are a proven way to relieve the burden on teachers and increase their confidence in working with technology. A typical example is the National Institute of Education and Youth (NIVAM), which has been running the DiTEdu project (Digital Transformation of Education and School) since 2023. It is a nationwide initiative aimed at systematically increasing the digital competencies of teachers. The project provides free training and methodological support to teachers. The results also highlight the need for a more flexible organisation of teaching. For example, by creating several-hour blocks instead of the traditional 45-minute lessons, we can gain space for complex projects or research activities with cross-curricular relations and reduce

the time constraints on preparing digital content for teachers. By systematically introducing programming, robotics, and IoT, pupils in the second grade at primary schools (grades 5-9) can access physical devices that connect abstract code with real-world objects. A comprehensive approach to digitalisation in schools will create a modern, inclusive, and stimulating environment in which pupils can acquire the practical competencies needed for the 21st-century labour market, and schools can prepare for dynamically changing technological trends.

Conclusions

The results of the research show that the digitalisation of technical education in Slovak primary schools is progressing. Interactive systems and videos have become a standard part of lessons, while more advanced technologies, such as augmented reality or programming are used only sporadically. The main barriers to effective use of digital technologies identified by means of the presented questionnaire survey include a lack of time to prepare digital content, outdated equipment, unstable internet connections, and low teacher motivation or confidence. Despite these barriers, digital technologies have a significant positive impact on the development of pupils' technical literacy, creativity and critical thinking. Interactive games, videos and project-based learning foster engagement and allow pupils to apply theoretical knowledge in practical situations. These findings align with international studies of Liu et al. (2020), Mančík et al. (2025), and Sasson et al. (2018) demonstrate that a well-designed digital environment can significantly enhance learning outcomes. To ensure systematicity and sustainability in the digital age for primary schools, digitalisation must become a natural part of schools' strategic plans. At the same time, it requires the support and investment of founders, the state, or other institutions supporting education. A key success factor is to enhance the professional development of teachers and foster a cooperative culture in which teachers share their materials and experiences and mentor one another. The implementation of the proposed recommendations will contribute to building a modern, inclusive and stimulating environment. Future studies should focus on integrating new digital technologies into the educational process in schools. They should monitor how these technologies impact both pupils' learning outcomes and the creation of assessment frameworks that more accurately capture pupils' progress in digital competencies.

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