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Using Open Source Software and Artificial Intelligence in Teaching Technical Subjects at Secondary Schools

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Abstract: The current concept of education and training in the Slovak Republic reflects not only emerging educational trends grounded in contemporary learning theories and philosophies of education, but also societal changes driven by the rapid advancement and widespread adoption of artificial intelligence. Within this context, technical subjects occupy a prominent position, as their integration with information and communication technologies and artificial intelligence represents a synergistic convergence of both the content and methodology of teaching. This paper provides an analytical overview of the implementation of artificial intelligence and open-source applications in the teaching of technical subjects. Its objective is not only to describe the current state of affairs but also to present a range of meaningful opportunities for their effective use in the education of future secondary-level technical professionals. The paper seeks to answer how teachers of technical subjects approach this issue, how it is perceived by students, where their perspectives converge, and how these commonalities can be leveraged to enhance the effectiveness of teaching technical subjects.

Keywords: Artificial intelligence, Open-source software, Teacher of technical subjects, Teaching effectiveness

Introduction

Digital transformation has become one of the most influential factors shaping contemporary education. The rapid development of information and communication technologies has changed traditional approaches to teaching and learning and has created new possibilities for increasing educational accessibility, flexibility, and personalisation (García-Peñalvo, 2021; OECD, 2021). Educational institutions are increasingly adopting digital solutions that support communication, collaboration, knowledge sharing, and the development of learners' competencies required in the digital society (OECD, 2021).

Among the most significant technological trends affecting education are open-source technologies and artificial intelligence (AI). Open-source solutions provide access to software whose source code can be studied, modified, and redistributed, enabling educational institutions to adapt digital tools according to their specific needs. In education, open-source approaches are closely connected with the development of open educational resources (OER), which support equal access to knowledge, encourage collaboration, and contribute to more sustainable approaches to digital education (UNESCO, 2019).

Artificial intelligence represents another major technological advancement with considerable potential to transform educational processes. AI-based systems can analyse learning behaviour, provide personalised recommendations, generate educational content, support assessment, and assist teachers in administrative and pedagogical activities (Popenici & Kerr, 2022; Zawacki-Richter et al., 2020). The emergence of generative AI tools has further accelerated discussions about the future role of technology in education, particularly regarding personalised learning, content creation, and teacher support (Wang et al., 2024; Yusuf et al., 2024).

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Despite significant benefits, the implementation of open-source technologies and artificial intelligence also creates new challenges. These include ethical questions, protection of personal data, digital inequality, reliability of AI-generated information, academic integrity, and the need to develop digital competencies among teachers and students (European Commission, 2022; UNESCO, 2021). The aim of this paper is to analyse the role of open-source technologies and artificial intelligence in teaching, identify their main educational benefits, and discuss the conditions necessary for their effective and responsible implementation.

Open Source Technologies in Education

The concept of open source is based on the principle that software source code is publicly available and can be studied, modified, improved, and redistributed. Unlike proprietary software, open-source solutions provide users with greater control over technological tools, support adaptability, and reduce dependence on individual vendors (UNESCO, 2019). In education, open-source technologies have become an important component of digital learning environments because they enable institutions to create flexible and sustainable technological infrastructures while reducing financial barriers associated with software licensing.

One of the most significant applications of open-source technologies in education is the development of learning management systems (LMS). Platforms such as Moodle demonstrate how open-source principles can support large-scale educational environments by providing tools for online courses, communication, assessment, and learning analytics. Open-source learning platforms allow institutions to adapt digital environments according to their pedagogical objectives and organisational requirements (UNESCO, 2019).

Open-source solutions also contribute to the development of open educational resources (OER). These resources include digital textbooks, multimedia materials, simulations, and educational content that can be freely accessed, adapted, and shared. According to UNESCO (2019), open educational resources represent an important instrument for improving educational equity, expanding access to quality learning materials, and supporting lifelong learning. The main advantages of open-source technologies in education include:

- lower financial costs,
- adaptability to institutional requirements,
- transparency of software solutions,
- community-based development,
- support for innovation and collaboration.

These advantages make open-source technologies particularly relevant for educational institutions seeking sustainable approaches to digital transformation. However, successful implementation requires appropriate technical support, teacher training, institutional strategies, and continuous development of digital competencies among educators (OECD, 2021).

Artificial Intelligence in Education

Artificial intelligence has become one of the most influential technological innovations affecting contemporary education. AI refers to computer systems capable of performing tasks that traditionally require human intelligence, including learning from data, recognising patterns, generating information, solving problems, and supporting decision-making processes (OECD, 2021). In educational environments, artificial intelligence is increasingly used as a tool for supporting both teaching and learning activities.

Unlike traditional digital technologies, AI systems can adapt their responses according to individual learners' needs and provide personalised educational experiences. Research indicates that AI applications in education are expanding rapidly, particularly in areas such as intelligent tutoring systems, adaptive learning, automated assessment, and learning analytics (Almasri, 2024; Zawacki-Richter et al., 2020).

The integration of artificial intelligence into education is closely connected with the concept of personalised learning. Traditional teaching models often rely on standardised approaches in which all students receive similar learning materials and follow comparable learning paths. AI technologies enable the creation of adaptive learning environments that analyse students' performance, identify learning difficulties, and recommend appropriate educational activities (Wang et al., 2024).

Examples of AI applications in education include:

- intelligent tutoring systems,
- automated feedback systems,
- adaptive learning platforms,
- AI-assisted assessment,
- educational chatbots,
- automated content generation,
- learning analytics.

Intelligent tutoring systems represent one of the most developed applications of artificial intelligence in education. These systems simulate certain aspects of individual tutoring by providing explanations, guidance, feedback, and recommendations based on learners' progress. Previous research suggests that adaptive educational systems may contribute to improved learning outcomes when they are appropriately integrated into teaching strategies (Zawacki-Richter et al., 2020).

Generative artificial intelligence has introduced new possibilities for educational practice. Tools based on large language models can support teachers in preparing learning materials, creating examples, generating questions, designing learning activities, and explaining complex concepts. For students, these tools can function as learning assistants that support independent study, writing processes, language learning, and problem-solving (Popenici & Kerr, 2022; Wang et al., 2024). However, the use of generative AI in education requires careful consideration. AI generated outputs may contain inaccurate information, reflect biases present in training data, or create challenges related to authorship and academic integrity. Therefore, artificial intelligence should be understood as a supportive tool that complements human expertise rather than replacing teachers (European Commission, 2022; UNESCO, 2021).

Method

This paper is designed as a review study based on the analysis and synthesis of scientific literature related to digital transformation, open-source technologies, artificial intelligence, and technology-enhanced learning. The research methodology consists of three main steps:

1. Identification of relevant scientific sources

The analysis focuses on academic publications, international reports, and professional studies addressing the implementation of digital technologies in education.

2. Thematic analysis of findings

Selected sources were analyzed according to key themes:

- open-source technologies in education,
- artificial intelligence applications,
- benefits of educational technologies,
- ethical and organizational challenges.

3. Synthesis and interpretation

The identified findings were integrated into a broader discussion of opportunities and limitations associated with implementing open technologies and AI in teaching.

The objective of this methodological approach is not to measure the effectiveness of a specific technological solution but to provide a comprehensive overview of current approaches and identify important factors influencing successful implementation (Zawacki-Richter et al., 2020).

Applications for Open-Source Technologies in Teaching

Open-source technologies provide significant opportunities for improving educational processes by enabling institutions and teachers to create flexible and adaptable digital learning environments. One of the most common applications is the use of open-source learning management systems. These platforms support online course development, distribution of learning materials, communication between teachers and students, assessment

activities, and monitoring of learning progress. Open-source learning environments offer several educational advantages:

Accessibility and Equal Access to Education

Open-source solutions reduce financial barriers and enable educational institutions with limited resources to implement modern digital learning environments. This is particularly important for schools and universities that cannot afford expensive commercial software licenses. Open educational resources also support equal access to knowledge by allowing students and teachers to freely use and adapt educational materials. This approach contributes to the democratization of education and supports lifelong learning (UNESCO, 2019).

Adaptability and Innovation

A significant advantage of open-source technologies is their flexibility. Educational institutions can modify software solutions according to their pedagogical requirements and organizational needs. Teachers can adapt to digital environments, integrate additional functions, and create learning activities that correspond to specific groups of learners. This flexibility supports innovation and encourages experimentation with new teaching approaches (OECD, 2021).

Collaboration and Knowledge Sharing

Open-source communities are based on cooperation and shared development. This principle is compatible with modern educational approaches that emphasize collaboration, knowledge exchange, and collective learning. Teachers using open technologies can share experiences, educational materials, and methodological approaches with colleagues from different institutions and countries. This contributes to professional development and the creation of collaborative educational networks.

Challenges of Open-Source Implementation

Despite significant advantages, open-source technologies also present several challenges. The most important include:

- requirement for technical expertise,
- need for system maintenance,
- insufficient institutional support,
- limited training opportunities for teachers,
- possible compatibility issues with existing systems.

Therefore, successful implementation depends not only on technological availability but also on strategic planning, technical infrastructure, and continuous professional development of educators (OECD, 2021).

Artificial Intelligence in Teaching Practice

The practical implementation of artificial intelligence in teaching creates new opportunities for improving educational effectiveness and supporting both teachers and students. AI should not be considered as a replacement for teachers but rather as a technological tool that enhances human expertise and enables more efficient learning processes.

One of the most important applications of AI in education is personalized learning. Traditional educational approaches often provide identical learning experiences for all students, regardless of their individual abilities, prior knowledge, and learning pace. AI-based systems can analyze student performance, identify learning difficulties, and recommend appropriate learning materials or activities.

Personalized learning supported by artificial intelligence may include:

- adaptive learning systems,
- individual learning recommendations,
- automated explanations,
- personalized exercises,
- continuous feedback.

Another important area is AI-supported assessment. Artificial intelligence can assist teachers by analyzing student responses, identifying common mistakes, generating assessment materials, and providing rapid feedback. Such tools may reduce administrative workload and allow teachers to focus more on educational interactions with students. Generative artificial intelligence has expanded the possibilities of educational applications. Large language models can support:

- preparation of teaching materials,
- creation of discussion questions,
- development of examples and case studies,
- language learning,
- writing assistance,
- explanation of complex concepts.

Recent systematic reviews indicate that generative AI in education is increasingly researched as a tool for pedagogical support, content creation, learning assistance, and professional development of educators. At the same time, researchers emphasize the importance of ethical frameworks and responsible implementation. For teachers, artificial intelligence can function as a professional assistant that supports lesson planning, differentiation of learning activities, and preparation of feedback. However, the final responsibility for educational decisions must remain with qualified educators who understand students' needs and educational objectives (European Commission, 2022; UNESCO, 2021).

Benefits and Challenges of Implementing Open Source and Artificial Intelligence in Education

The combination of open-source technologies and artificial intelligence creates significant potential for improving educational systems. Both approaches support innovation, accessibility, and flexibility; however, their implementation requires strategic planning and responsible management.

Main Benefits

Increased Accessibility

Open-source solutions and open educational resources contribute to reducing technological and financial barriers. Educational institutions can provide access to digital learning environments without dependence on expensive commercial licenses. Artificial intelligence can further improve accessibility by supporting students with different learning needs through adaptive interfaces, automated assistance, and personalized educational support.

Improved Learning Efficiency

AI-supported systems can provide immediate feedback and adapt learning materials according to individual student progress. This allows students to learn at an appropriate pace and receive additional support when needed.

Support for Teachers

Digital technologies can reduce routine administrative tasks and allow teachers to dedicate more time to creative teaching activities, mentoring, and student interaction.

Innovation and Collaboration

Open-source communities promote cooperation and knowledge sharing among developers, educators, and institutions. This collaborative approach encourages the creation of new educational solutions and the exchange of good practices.

Table 1. Comparison of open-source technologies and artificial intelligence applications in education

Area of application	Examples of technologies/tools	Main educational benefits	Main challenges and risks
Learning management systems (LMS)	Moodle, Open edX, Canvas LMS (open components)	Support for online courses, communication, assessment, learning management, and blended learning models	Need for technical administration, maintenance, and teacher training, system integration
Open educational resources (OER)	Open textbooks, Creative Commons materials, digital repositories	Increased accessibility to educational knowledge, reduced costs, possibility of adaptation and sharing of learning materials	Quality control, copyright issues, need for systematic evaluation of resources
Collaborative learning environments	Wikis, open knowledge platforms, collaborative digital tools	Development of teamwork, knowledge sharing, peer learning, active student participation	Management of content quality, moderation requirements, unequal digital competencies
Digital assessment and feedback	Online quizzes, automated assessment tools, AI-supported evaluation systems	Faster feedback, reduced teacher workload, continuous monitoring of learning progress	Reliability of automated evaluation, fairness, possible reduction of qualitative assessment
Personalised learning systems	Adaptive learning platforms, AI-based recommendation systems	Individual learning paths, adaptation to student needs, identification of learning difficulties	Data privacy, transparency of algorithms, dependence on technology
Intelligent tutoring systems	AI tutors, educational chatbots, virtual assistants	Individual support, explanations, learning guidance, availability beyond classroom hours	Limited understanding of context, inaccurate responses, need for human supervision
Generative artificial intelligence	Large language models, AI writing assistants, AI content generators	Support for lesson preparation, creation of learning materials, brainstorming, language learning, personalised explanations	Academic integrity issues, misinformation, authorship concerns, ethical challenges
Learning analytics	Data analysis platforms, AI-based prediction systems	Identification of learning patterns, early detection of student difficulties, evidence-based decision-making	Protection of personal data, ethical use of student information
Teacher professional support	AI assistants for lesson planning, content creation, and resource organisation	Saving preparation time, supporting creativity, improving differentiation of instruction	Risk of overreliance on AI-generated materials, need for critical evaluation

Source: Author's own synthesis based on UNESCO (2019, 2021), OECD (2021), Zawacki-Richter et al. (2020), and recent research on artificial intelligence in education (Almasri, 2024; Wang et al., 2024).

Challenges and Risks

Despite their advantages, open-source technologies and artificial intelligence also create several challenges.

Digital Competencies

Successful implementation depends on teachers' ability to effectively use digital technologies. Lack of training and insufficient digital skills may limit the educational benefits of these tools.

Ethical Issues and Data Protection

AI systems process large amounts of information, including potentially sensitive student data. Educational institutions must ensure transparency, privacy protection, and responsible data management.

Academic Integrity

Generative AI creates new challenges related to plagiarism, authorship, and assessment validity. Universities and schools need to develop clear guidelines defining acceptable and responsible AI use.

Dependence on Technology

Excessive reliance on digital tools may negatively affect independent thinking, creativity, and interpersonal communication. Technology should therefore complement, not replace, human interaction in education.

Accuracy and Reliability of AI Outputs

AI-generated content may contain incorrect or incomplete information. Students and teachers must develop critical evaluation skills and verify information obtained from AI systems.

Discussion

The analysis shows that open-source technologies and artificial intelligence represent important components of contemporary educational transformation. Their effective use can contribute to improving accessibility, personalization, and efficiency of teaching processes. Open-source technologies provide educational institutions with flexibility, independence, and opportunities for collaborative innovation. They support the development of sustainable digital learning environments and contribute to equal access to educational resources.

Artificial intelligence introduces new possibilities for adapting education to individual learner needs. Current research demonstrates growing interest in AI applications in teaching, assessment, and learning support. However, successful implementation depends on balancing technological opportunities with pedagogical principles, ethical considerations, and human responsibility. The future role of artificial intelligence in education will likely depend not only on technological development but also on the ability of educational institutions to establish appropriate strategies, regulations, and professional development programs for teachers. The key challenge is therefore not whether artificial intelligence should be used in education, but how it can be integrated in a way that strengthens learning quality, supports teachers, and develops students' competencies for the digital society.

Conclusion

Open-source technologies and artificial intelligence represent significant opportunities for modernizing educational processes. Open-source approaches contribute to accessibility, adaptability, and collaboration, while artificial intelligence enables personalized learning, automated support, and innovative approaches to teaching and assessment.

The implementation of these technologies can improve the quality and effectiveness of education; however, technological adoption alone cannot guarantee better learning outcomes. Successful integration requires qualified teachers, appropriate institutional strategies, ethical principles, and continuous development of digital competencies. The future of education will not be determined by technology itself but by the ability of educational communities to use technology responsibly and creatively. The combination of human expertise, open approaches, and artificial intelligence can create more inclusive, flexible, and effective learning environments.

Scientific Ethics Declaration

* The authors declare that the scientific ethical and legal responsibility of this article published in EPES journal belongs to the authors. Artificial intelligence was used for formal revision and verification of the translation.

Conflict of Interest

* The authors Vašková and Rusková declare that they have no conflicts of interest.

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