Informatics in Education, 2025, Vol. 24, No. 3, 559–585

DOI: 10.15388/infedu.2025.18

Primary School Students' Awareness of the Ethical Aspects of Using Artificial Intelligence Tools

Predrag OREŠKI[1], Tanja OREŠKI[2], Ivana RUŽIĆ[3,4]
[1]*Department of Information and Communication Sciences, University of Zagreb Faculty of Teacher Education, Zagreb, Croatia*
[2]*Orehovica Primary School, Orehovica, Croatia*
[3]*University of Zagreb Faculty of Organization and Informatics, Varaždin, Croatia*
[4]*First Primary School Čakovec, Čakovec, Croatia*
e-mail: predrag.oreski@ufzg.unizg.hr, tanja.oreski@skole.hr, ivana.ruzic@skole.hr

Received: May 2025

Abstract. This paper presents research findings on primary school students' awareness of the ethical aspects of using artificial intelligence (AI) tools for homework. The study used a self-constructed online questionnaire administered to 301 primary school students from grades five to eight attending two primary schools in Northwestern Croatia. The results show that 57.8% of students already use AI tools to complete their homework. Students in higher grades use it more often than those in lower grades. A significant Spearman correlation exists between respondents' daily time spent on social media and the use of AI tools ($r = 0.34$, $p < .001$). Only 36.5% of students in the sample believe it is unacceptable to copy AI-generated answers when completing their homework. The results underscore the need to integrate AI education into the primary school informatics curriculum in the Republic of Croatia, including introducing content that addresses the ethical aspects of using AI tools.

Keywords: informatics, large language models, academic integrity, homework.

1. Introduction

Artificial intelligence

Artificial intelligence (AI) is the ability of a digital computer or computer-controlled robot to perform tasks commonly associated with intelligent beings (Copeland, 2025, July 15). AI can be described as the effort to automate intellectual tasks normally performed by humans (Chollet and Watson, 2025). AI consists of disciplines such as natural language processing, knowledge representation, automated reasoning, machine learning, computer vision, speech recognition, and robotics (Russell and Norvig, 2020).

Alan Turing played a most influential role in shaping the concept of AI. As early as 1947, he discussed the idea in lectures at the London Mathematical Society. In his landmark 1950 paper Computing Machinery and Intelligence, he laid out a compelling framework for the field. In this work, he proposed the Turing Test ("imitation game" (Turing, 1950)) and explored key ideas such as machine learning, genetic algorithms, reinforcement learning (Russell and Norvig, 2020), and discussed the production of a programme to simulate the human mind (Turing, 1950).

As a field, artificial intelligence (AI) was established in 1956 by John McCarthy, who organized a summer workshop at Dartmouth College aimed at exploring how machines could use language, develop abstractions and concepts, solve problems typically reserved for humans, and improve themselves (McCarthy *et al.*, 2006). Since then, AI research has experienced periods of both optimism and disappointment, commonly referred to as 'AI winters', such as those following the rise and fall of symbolic AI and expert systems in the 1980s and early 1990s (Chollet and Watson, 2025).

Some of the most important milestones in AI research throughout history include:

- 1997: For the first time, IBM's computer Deep Blue defeated the reigning world chess champion, Garry Kasparov (Campbell *et al.*, 2002).
- 2012: Significant progress was made in image classification using ImageNet classification with deep convolutional neural networks (Krizhevsky *et al.*, 2012).
- 2016: Google DeepMind's AlphaGo software defeated world champion Lee Sedol in the complex board game Go (Silver *et al.*, 2016).
- 2017: AI matched or exceeded expert performance in detecting diseases from medical images (Esteva *et al.*, 2017).
- 2019: Pretrained language models such as BERT and GPT achieved state-of-the-art results in natural language understanding (Devlin *et al.*, 2019).
- 2020: Google DeepMind's AlphaFold accurately predicted complex 3D protein structures, solving a decades-long challenge in biology (Jumper *et al.*, 2021). This breakthrough contributed to the awarding of the 2024 Nobel Prize in Chemistry to researchers John Jumper, Demis Hassabis, and David Baker.
- November 2022: OpenAI publicly released ChatGPT, a revolutionary large language model (LLM) capable of generating human-like responses to user prompts. It was made freely available to the public.
- 2023–2024: Multimodal large models, such as OpenAI's GPT-4 and Google Gemini, demonstrated the ability to process and reason across text, images, audio, and video (OpenAI, 2023).

Machine learning is a method that enables a computer to learn from its inputs, without requiring explicit programming for every circumstance (Copeland, 2025, July 15). Deep learning is a specialized area within machine learning that focuses on automatically learning multiple layers of increasingly meaningful data representations. The core concept involves building these hierarchical layers, with each layer capturing more meaningful features. Contemporary deep learning models typically consist of tens or even hundreds of such layers, all trained directly from data. These representations are formed using neural networks, which are composed of multiple stacked layers designed to process and transform input data step by step (Chollet and Watson, 2025).

Deep learning has led to significant breakthroughs, including software and widely used services that impact many people in their daily lives (Chollet and Watson, 2025):

- Fluent and highly versatile chatbots.
- Programming assistants.
- Photorealistic image generation.
- Human-level image classification.
- Human-level speech transcription.
- Human-level handwriting transcription.
- Dramatically improved machine translation.
- Dramatically improved text-to-speech conversion.
- Human-level autonomous driving.
- Improved recommender systems.
- Superhuman Go and Chess playing.

Generative AI is a type of artificial intelligence capable of producing digital content, such as text, images, video, and sound, in response to user input (a prompt). The generated content is based on patterns learned from large datasets containing numerous examples. Large language models (LLMs) are a subset of generative AI that can generate human-like responses to user prompts.

Examples of generative AI include ChatGPT, Gemini, Claude, and Mistral for text generation (LLMs); DALL·E, Midjourney, and Stable Diffusion for image generation; Sora and Runway ML for video generation; and ElevenLabs, Voicemod, and Respeecher for voice and audio generation.

Generative AI is reshaping how people work by enhancing their productivity. However, it also has the potential to disrupt certain professions, potentially substituting some of them (Deranty, 2024). Its use raises several concerns, including risks to user privacy, bias and discrimination, copyright infringement, societal and environmental well-being, accountability, and others (European Commission, 2022).

All AI systems developed so far are classified as weak or narrow AI. They are designed to perform a specific task or range of tasks. The next highly expected revolutionary achievement in the field of AI is human-level machine intelligence (HLMI), which is a term interchangeably used with terms artificial general intelligence (AGI) and strong AI. HLMI is a system capable of performing the majority of human jobs as effectively as an average person (Bostrom, 2014). The machine superintelligence is a property of a machine that surpasses human general intelligence. This may be the most significant and formidable challenge humanity has ever encountered (Bostrom, 2014).

AI in education

The number of weekly users of one of the first publicly available and well-known large language models, ChatGPT, has grown from 100 million in January 2023 to 400 million in February 2025 (Reuters, 2025). It was immediately clear that this tool would significantly impact students' learning and raise ethical concerns regarding academic honesty and plagiarism (Cotton *et al.*, 2023). The universities responded by introducing

policies and ethical guidelines for using AI tools in teaching, learning, and researching (University of Rijeka, January 23, 2024; University of Zagreb Faculty of Organization and Informatics, April 12, 2024), and immediately started developing and offering new courses regarding AI in education and responsible and ethical use of AI tools. However, primary education relies on curricula and textbooks, which a government ministry must approve. It appears that primary education struggles to respond quickly and adapt to the widespread availability of AI tools. There is a need to educate teachers about how to utilize AI tools, what AI opportunities are, the challenges they present, and the ethical questions that need to be addressed.

In the Republic of Croatia there are at least the following available documents for educators regarding using AI in education: Ethical guidelines on the use of artificial intelligence (AI) and data in teaching and learning for educators (European Commission, 2022), Artificial Intelligence in Education - Educational manual on the application of artificial intelligence in learning and teaching for teachers, educators and professional associates in schools (Kralj *et al.*, 2024), Artificial Intelligence: From Concept to Application - Extracurricular Activities Curriculum for Primary Schools (Croatian Academic and Research Network, 2024), Artificial Intelligence in the Classroom – Tools, Applications and Teaching Strategies (Jajić, 2024), and other available educational materials created and published primarily by teachers on `https://edutorij.carnet.hr` which is a central place for storing, publishing, sharing, evaluating and retrieving digital educational materials created by experts (Edutorij, n.d.). However, AI tools and their capabilities are growing, developing, and becoming available faster than teachers and students can keep up with.

Ethical issues

The available AI tools immediately caught the attention of primary education students because it was evident from the start that these tools could produce human-like answers and texts to a wide range of questions. Suddenly, the students can have a non-human expert helper to help them learn and complete their homework. The inclusion of AI topics in K–12 education is a recent yet vital issue for school systems around the globe, however, efforts to tackle this challenge are significantly limited by the shortage of curriculum resources and teaching tools available to support educators in delivering AI content (Kahila *et al.*, 2024). In situations where there are no official guidelines, no support, and no education for primary education teachers and students on how to deal with the influence of AI tools, it is possible that this can lead to situations where students use AI tools excessively and unethically to complete their homework. At the same time, teachers can struggle to recognize the influence of AI on their students' homework. They have to organize the students' assignments differently to minimize the impact of AI tools.

In such situations, where AI tools have yet to be incorporated into the curriculum and textbooks for the subject of informatics for education on responsible and ethical use of AI tools, it seems that the primary school students are left to their own devices to learn

how to use AI tools, especially to use them to complete their homework. To identify potential issues and provide guidance, it is essential to explore primary school students' awareness of the ethical implications of using AI tools for homework. There is a need to analyze the impact of AI tools on the educational process, particularly in terms of their ethical use aspects, such as academic integrity, fairness, and honesty.

The research

The research presented in this paper aims to examine how primary education students are coping with the increasing presence of AI tools and whether they are aware of the ethical implications of using them.

The authors conducted a survey using a self-constructed online questionnaire, which was administered to 301 primary school students in grades five through eight from two primary schools in Northwestern Croatia. The questionnaire included items on respondents' demographic data, use of social media and AI tools, perceptions of the accuracy and usefulness of AI tools, and ethical aspects of their use.

The main contributions of this paper are the analyses of:

- The number and ratio of primary school respondents who use AI tools, categorized by gender and grade.
- The primary school subjects in which respondents use AI tools.
- Respondents' perceptions of the usefulness of AI tools.
- How respondents use the answers provided by AI tools.
- Respondents' awareness and perception of the ethical aspects of using AI tools.
- The possible correlation between respondents' daily time spent on social media and their use of AI tools.

The authors emphasize the need to educate young students on the responsible and ethical use of AI tools in their learning and homework.

2. Literature Review

Ethical issues in using AI tools

The key requirements for any trustworthy AI system deployed and used in education are human agency and oversight, transparency, societal and environmental well-being, privacy and data governance, technical robustness and safety, and accountability. These considerations and requirements enable educators, school leaders, and technology providers to effectively evaluate the impact of AI systems in education, mitigate potential risks, and maximize their benefits (European Commission, 2022).

Numerous AI ethical issues exist, including transparency, data security and privacy, autonomy, intentionality and responsibility, accountability, ethical standards, human rights laws, automation and job replacement, accessibility, democracy and civil

rights, among others (Huang *et al.*, 2023). Despite the potential benefits of AI to support students' learning experiences and teachers' practices, these systems' ethical and societal drawbacks are rarely fully considered in K-12 educational contexts (Akgun and Greenhow, 2021). According to Kralj *et al.* (2023), excessive reliance on AI applications for schoolwork can lead to a lack of cognitive effort, diminished critical thinking, and hindered development of problem-solving skills. While AI tools provide support and convenience, they should enhance rather than substitute traditional learning and creative processes. Relying too heavily on AI for academic and daily tasks may hinder the development of essential skills, such as research, analysis, and communication (Kralj *et al.*, 2023).

The research results of Zhai *et al.* (2024) suggest that excessive dependence on AI, driven by ethical concerns, affects cognitive abilities because people increasingly prioritize quick and optimal solutions over slower ones constrained by practicality. This preference highlights why users favour efficient mental shortcuts, despite the ethical challenges associated with AI technologies.

The integration of artificial intelligence in education is a topic of widespread discussion. ChatGPT offers several advantages, including enhanced student engagement, collaboration, and accessibility. However, it also raises concerns about academic integrity and the potential for plagiarism (Cotton *et al.*, 2023). In their SWOT analysis of ChatGPT, Farrokhnia *et al.* (2023) identify several threats to education, including a lack of contextual understanding, risks to academic integrity, perpetuation of discrimination in education, democratization of plagiarism, and a decline in high-order cognitive skills. ChatGPT and similar AI tools come with various risks and limitations, including plagiarism, copyright violations, the spread of misinformation, hindrance of critical and creative thinking, and a decline in writing skills (Compilatio, November 7, 2023). Generative AI (GenAI) enables students to submit text they did not write as their own, introducing a new form of plagiarism. In the short term, institutions focus on maintaining academic integrity through human-led detection and accountability. In the long term, educators and institutions must rethink assignment design, shifting assessments away from tasks that AI excels at and instead emphasizing uniquely human abilities, such as creativity, critical thinking, and compassion in addressing complex real-world challenges (UNESCO, 2023).

Turnitin (April 9, 2024) reports that, on the first anniversary of its AI writing detection tool, over 200 million papers have been reviewed. Turnitin data show that approximately 22 million (11 percent of over 200 million) have at least 20 percent AI writing present, and over six million (roughly three percent of over 200 million) have at least 80 percent AI writing present.

AI in education

Only a few research papers have addressed the use of AI tools across different grade levels within primary schools. Most studies focus on high school or university students rather than primary school students specifically.

According to Matzinger (July 27, 2023), a survey conducted by Junior Achievement in collaboration with the research firm Big Village explored the increasing dependence of teenagers on AI for their school assignments. The study, which gathered responses from 1,006 adolescents aged 13 to 17, offers meaningful insights, along with its impact on students' learning and ethical concerns: 44% of them expressed their likelihood to use AI tools to tackle their schoolwork in then upcoming 2022-2023 academic year while significant majority of 60% perceive reliance on AI tools as cheating. The same study explored the reasons why students use AI tools: 62% see AI as just another tool, 24% are dissatisfied with school or schoolwork, 22% believe AI makes learning unnecessary, 22% are influenced by peer pressure, 17% fear doing poorly without AI, and 8% think subject knowledge is not important (Fig. 1).

Shaw *et al.* (October 23, 2023) report that, on the sample of 1,600 postsecondary students, half of the higher education students regularly use GenAI, and 75% of those already using it intend to continue, regardless of any bans imposed by their professors or institutions. Compilatio (November 7, 2023) performed research on a sample of 4,443 students from French universities and reports that 55% of the students use AI tools at least occasionally, 65% of students think that using AI tools for homework or exams is cheating, and ⅔ of them are against banning AI tools. According to the same report, 28% of students believe using AI to generate entire paragraphs for their assignments is acceptable.

Miljkovic Krecar *et al.* (2024) examined a group of 350 university students in Croatia and found that the majority had not formed a regular habit of using ChatGPT for homework. Specifically, 50.6% reported using it only occasionally, 24.3% used it a few times per month, 22.5% used it weekly, and just 2.6% used it daily (Fig. 2). Male

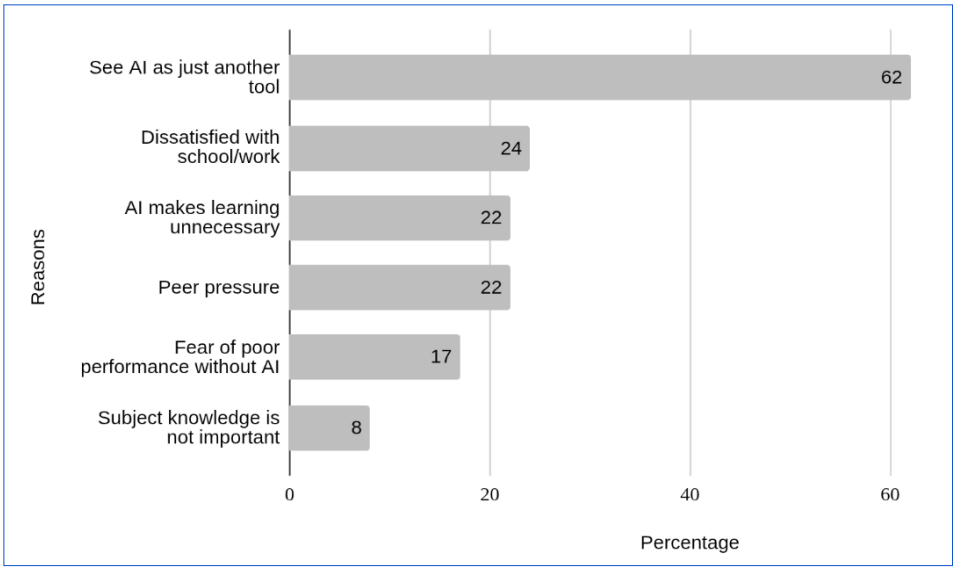

Fig. 1. Reasons why students use AI tools (Matzinger, July 27, 2023),

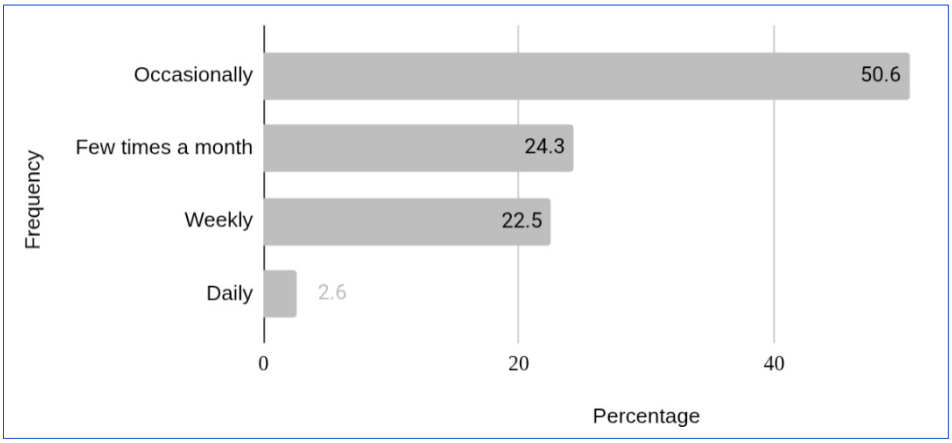

Fig. 2. Frequency of using ChatGPT for homework (Miljkovic Krecar *et al.*, 2024),

students and those studying science and technology disciplines tended to use ChatGPT more frequently than their female and social sciences counterparts. Additionally, 29.4% of participants viewed ChatGPT as a helpful tool for generating ideas or gathering preliminary information. However, a significant majority (74.8%) believed it was unacceptable to use AI to write more than half of an assignment and then complete the rest themselves. At the same time, the remaining students found this practice acceptable.

Based on a sample of 262 high school students, the research results indicate that 86.3% of students utilize AI tools, 61.8% use them occasionally, 23.3% use them frequently, 4.6% daily, and 10.3% never (Hohnjec, 2024) (Fig. 3).

Pavlović-Šijanović *et al.* (2024) report that, among a sample of 215 high school students, 95.8% use AI tools: 43.3% rarely, 31.6% occasionally, 11.6% frequently, and 9.3% daily. Only 4.2% do not use them (Fig. 4).

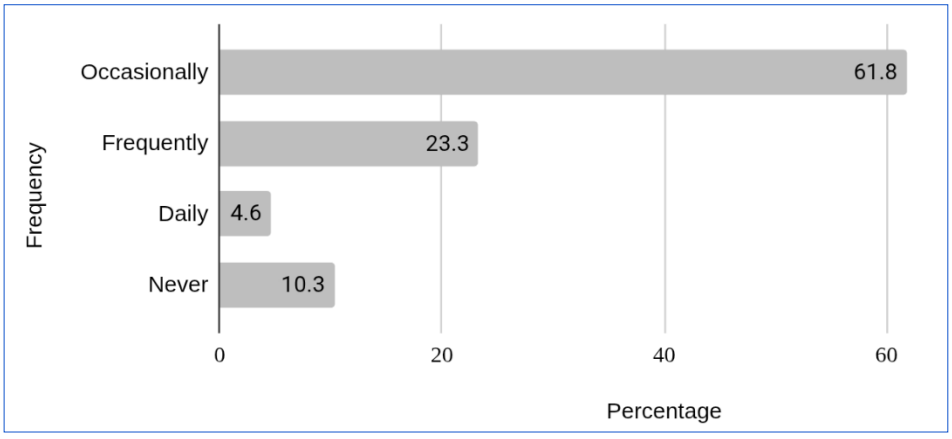

Fig. 3. Frequency of utilizing AI tools (Hohnjec, 2024).

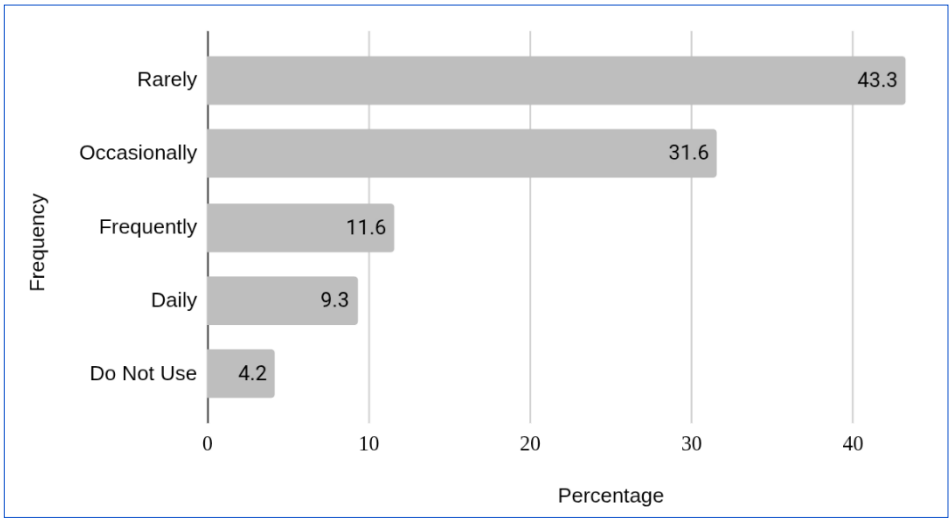

Fig. 4. Frequency of using AI tools (Pavlović-Šijanović *et al.*, 2024).

Key findings of Harvard's (2024) research on the US nationwide sample of 1,274 young people ages 14-22 are the following: 8% do not know what AI tools are, 41% never used AI tools, 17% used it only once or twice ever, 7% once or twice per year, 12% once or twice per month, 11% once or twice per week, and 4% almost daily or every day (Fig. 5).

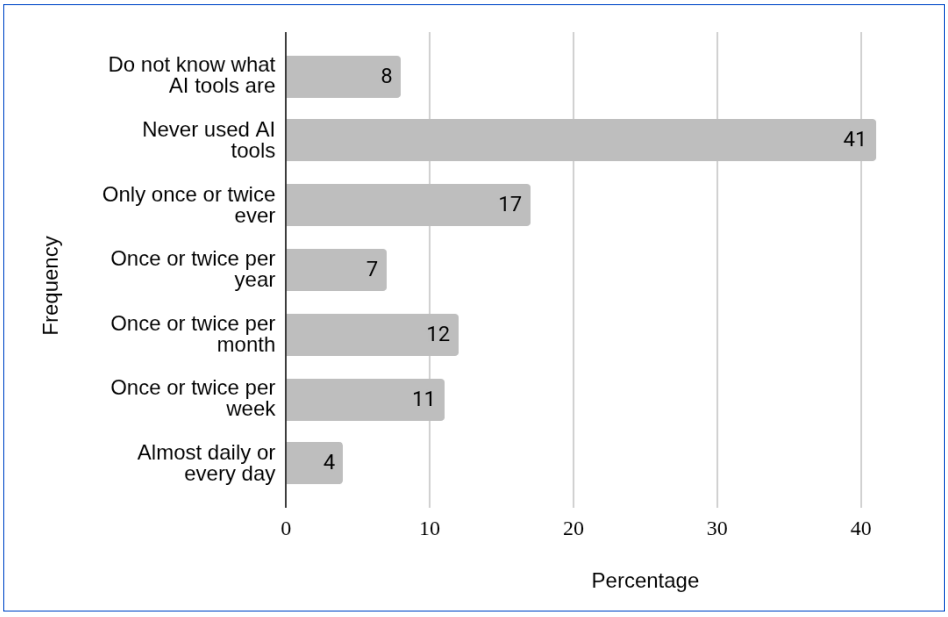

Fig. 5. Frequency of using AI tools (Harvard, 2024).

The reported uses of generative AI in Harvard's (2024) research are seeking information (53%), brainstorming ideas (51%), helping with schoolwork (46%), making pictures or images (31%), help in their job (17%), make sounds or music (16%), write code (15%), and something else (8%) (Fig. 6).

Wallan (2024) reports the research results on a sample of 60 primary education students aged 11 and 12 from Sweden. In the pre-test, 68% of students reported using some form of AI, 2% were unsure, and the remaining 30% stated they had not (Fig. 7). Some

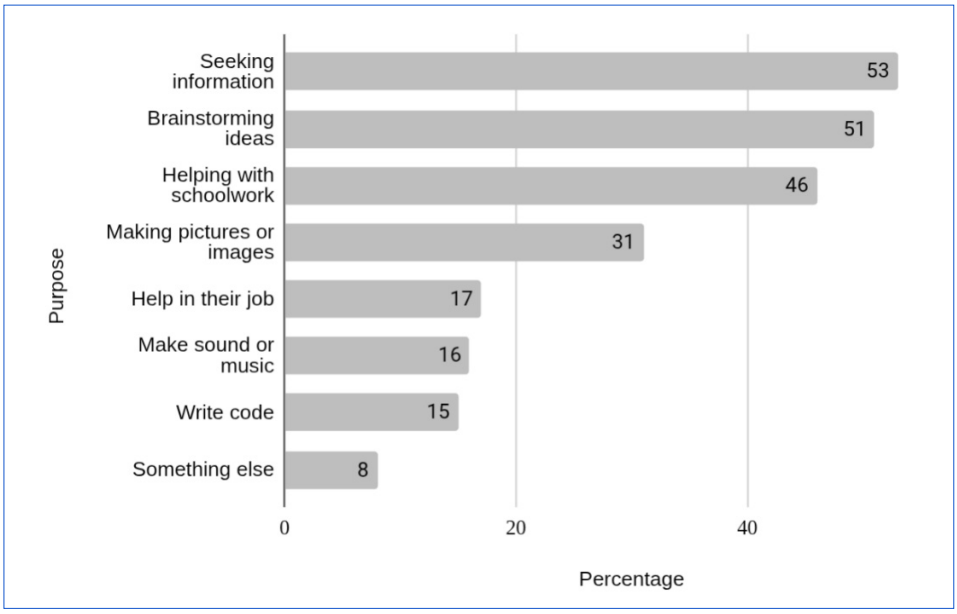

Fig. 6. The reported purposes of using generative AI (Harvard, 2024).

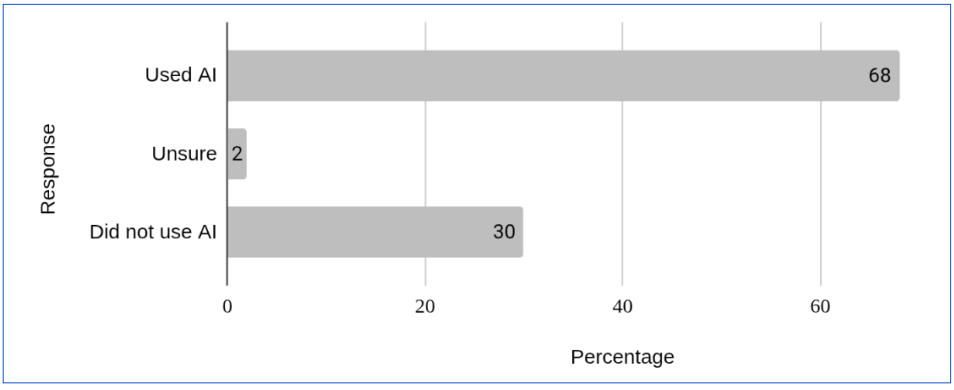

Fig. 7. Students' usage of some forms of AI (Wallan, 2024).

students raised concerns about the risk of cheating in schools using ChatGPT and have called for regulations.

The study by Balalle and Pannilage (2025) concludes that academic integrity is a key factor in the quality of education, representing honesty, trust, and ethical conduct. In the rapidly evolving field of education, AI poses significant challenges to maintaining academic integrity within the educational system. While AI assists students in completing academic tasks, it often risks fundamental principles of academic integrity. The study emphasises the importance of creating a culture of academic integrity to ensure the ethical use of AI for educational purposes (Balalle and Pannilage, 2025).

3. Methodology

Aim of the research

In the situation where AI tools and the ethical aspects of using them have yet to be incorporated into the curriculum and textbooks for the subject of informatics in the Republic of Croatia, this research aims to explore:

- The respondents' daily time spent on social media.
- The number of users of AI tools by gender and grade.
- The primary school subjects in which AI tools are used.
- The respondents' perception of the usefulness of AI tools.
- How respondents use AI tools answers.
- Respondents' awareness and perception of the ethical aspects of using AI tools.
- Possible correlation between respondents' daily time spent on social media and the use of AI tools.

There are three research questions and three hypotheses in this paper based on the aims of this study:

RQ1. In what ways do the respondents use AI-generated answers when completing their homework?

RQ2. Do the respondents think copying AI-generated answers without modification when completing their homework is acceptable?

RQ3. Do the respondents consider using AI tools to complete homework a form of cheating?

H1. There is no statistically significant difference in the number of users of AI tools between genders.

H2. There is a statistically significant difference in the number of users of AI tools across grade levels.

H3. There is no correlation between respondents' daily time spent on social media and the use of AI tools.

Table 1
Respondents' demographic data

	Frequency	Percent	Valid Percent	Cumulative Percent
Male	154	51.2%	51.2%	51.2%
Female	147	48.8%	48.8%	100.0%
Total	**301**	**100.0%**		
Fifth grade	49	16.3%	16.3%	16.3%
Sixth grade	115	38.2%	38.2%	54.5%
Seventh grade	101	33.5%	33.6%	88.0%
Eighth grade	36	12.0%	12.0%	100.0%
Total	**301**	**100.0%**		
Urban School	167	55.5%	55.5%	55.5%
Rural School	134	44.5%	44.5%	100.0%
Total	**301**	**100.0%**		

The sample of respondents

The respondents are a convenience sample of 301 primary school students from grades five to eight (ages 11 to 14) attending two primary schools, one rural and one urban, in Northwestern Croatia.

The sample includes 154 (51.2%) male students and 147 (48.8%) female students. There are 49 (16.3%) students in the fifth grade, 115 (38.2%) in the sixth grade, 101 (33.5%) in the seventh grade, and 36 (12.0%) in the eighth grade. By school locality, there are 167 (55.5%) students from urban schools and 134 (44.5%) students from rural schools (Table 1).

The instruments

The authors used a self-constructed online questionnaire to collect data (Google Forms).

It consists of 31 items:

- Multiple-choice items dealing with respondents' demographic data (gender, grade, school locale), amount of daily time spent on social media, using AI tools (knowing AI tools, frequency of using AI tools, how AI tools' answers are used), and perception on the importance and ethical use of AI tools.
- Checkboxes for multiple answers (types of computer devices used, online sources for learning, reasons for using AI tools, the subjects in which AI tools are used).
- Five-point Likert scale items (interest in informatics, using AI tools, perception of correctness, and usefulness of AI tools).

The internal consistency of items regarding variables that measure respondents' perception of AI tools' correctness and usefulness is acceptable (Cronbach's Alpha = 0.79, McDonald's Omega = 0.8).

The research results presented in this paper do not include all the items mentioned in the questionnaire.

Procedure

The survey was conducted from February 10 to March 14, 2025, in accordance with the ethical guidelines outlined in the Code of Ethics for Research with Children (Ajduković and Keresteš, 2020). This means that the study adhered strictly to the document's ethical requirements, e.g., before completing the questionnaire, respondents were provided with a brief overview of the study's objectives and detailed instructions to ensure clarity and informed participation, and their teachers also informed them that their responses would remain anonymous and that their participation was voluntary.

The respondents were invited to complete the online questionnaire during their informatics classes, which took approximately ten minutes to complete. Their teachers were present during the process to provide assistance if needed.

The methods

The following statistical methods are used in the data processing:

- Descriptive statistics (frequencies, percentages, median, standard deviation, tables, charts).
- Cronbach's Alpha and McDonald's Omega for reliability/internal consistency of survey items.
- Chi-squared test for testing the hypotheses H1 and H2.
- Dunn-Bonferroni post-hoc test for testing the difference between groups (grades) in testing the hypothesis H2.
- Spearman's correlation for testing the hypothesis H3.

Statistical data processing was performed using the statistical software GNU PSPP 2.0.0 (`https://www.gnu.org/software/pspp/`), R 4.4.3 (`https://www.r-project.org/`, and Statisty (`https://statisty.app/`).

4. Results

There are 238 respondents (79.1%) who have heard of the term artificial intelligence and 63 (20.9%) who have not (Fig. 8). There are 174 (57.8%) respondents who explicitly state that they use AI tools to complete their homework, and 127 (42.2%) who do not (Fig. 9).

Respondents who indicated that they use AI tools had the opportunity to answer how frequently they employ them to complete their homework. A total of 125 respondents (41.5%) reported using AI tools rarely, for one or two assignments per month. Fifty-

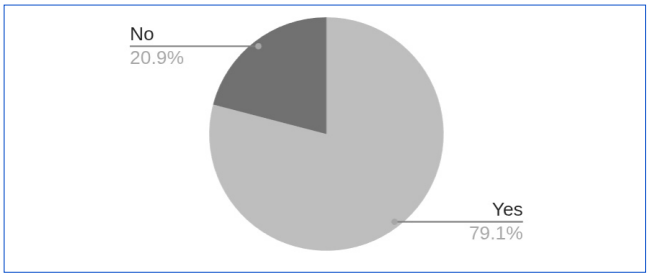

Fig. 8. The respondents who have heard of the term artificial intelligence and who have not.

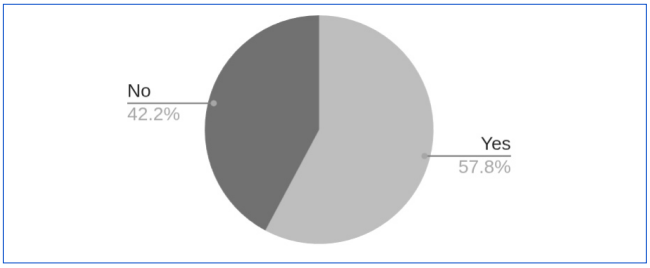

Fig. 9. The respondents who use AI tools to complete homework and who do not.

three respondents (17.6%) stated they use them for one assignment per week, while 52 (17.3%) reported using them for more than one assignment per week. Additionally, 43 respondents (14.3%) indicated that they complete almost all of their assignments with the assistance of AI tools. Conversely, 28 respondents (9.3%) reported not using AI tools (Fig. 10).

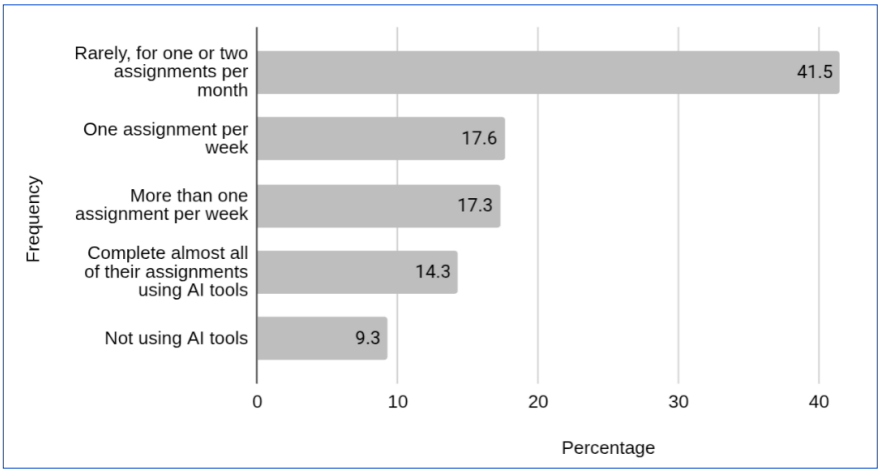

Fig. 10. The frequency of employing AI tools to complete the homework.

The answers to research questions

RQ1. In what ways do the respondents use AI-generated answers when completing their homework?

If the respondents indicated that they used AI tools, they had the opportunity to answer how they utilized the AI-generated answers. Most of them, 109 (36.2%), responded that they read the answer, think about it, and then use it as a guide to write their answer, 77 (25.5%) read the answer and adapt it to the task, 45 (15.0%) read the answer, copy parts of the text, and adjust the rest, 37 (12.3%) copy the answer, and 33 (11%) say that they do not use AI tools (Fig. 11).

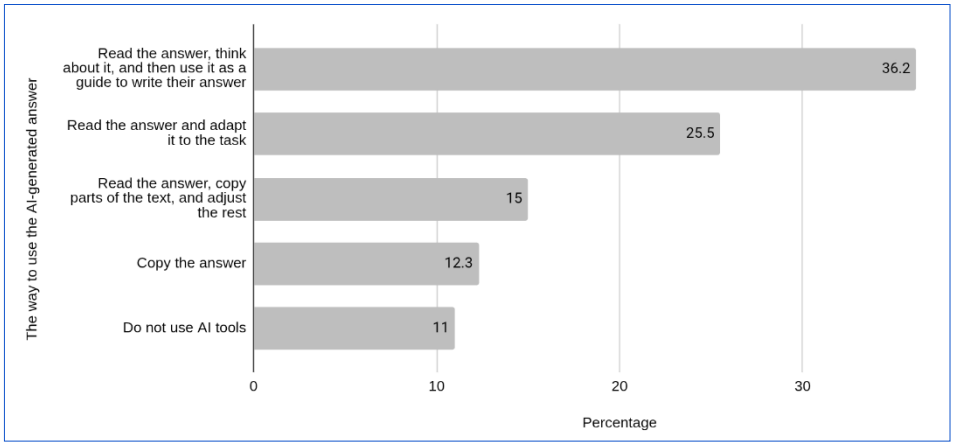

Fig. 11. The ways of using AI-generated answers when completing homework.

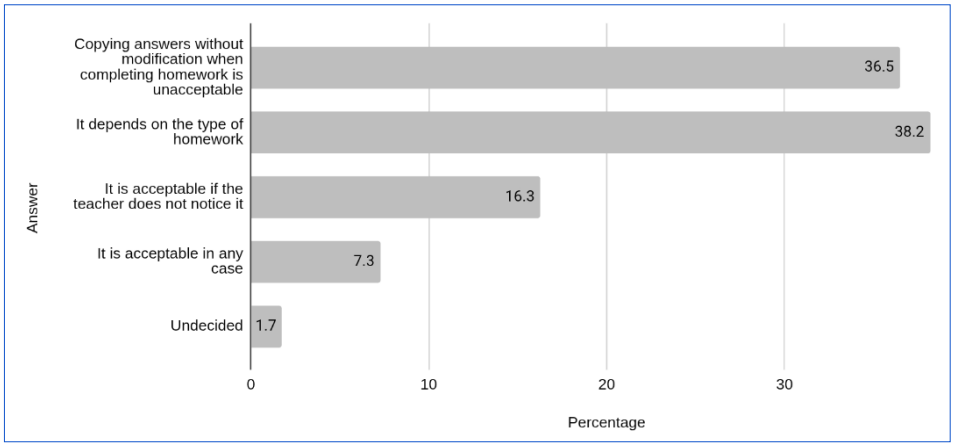

Fig. 12. Respondents' opinions on whether copying an AI-generated answer without modification when completing homework is acceptable.

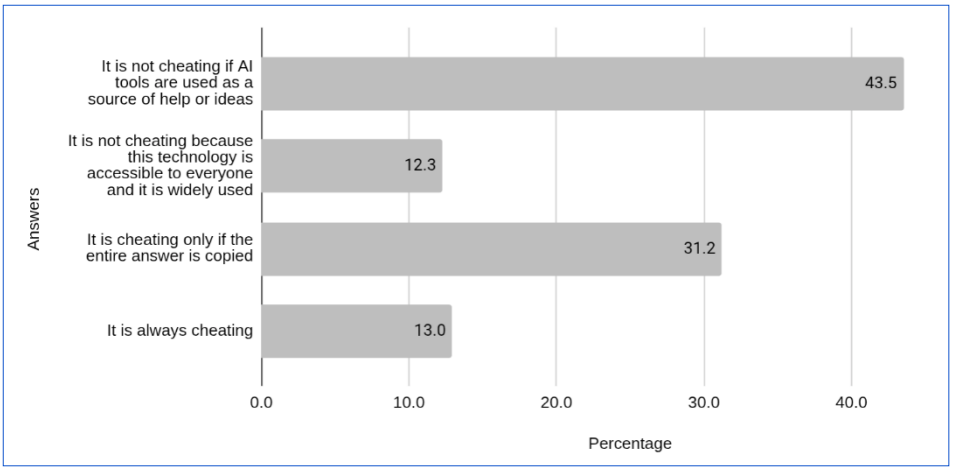

Fig. 13. Respondents' opinions on the statement that using AI tools is a form of cheating.

RQ2. Do the respondents think copying AI-generated answers without modification when completing their homework is acceptable?

Only 110 (36.5%) respondents think copying AI-generated answers without modification when completing their homework is unacceptable. Others say that it depends on the type of homework (115 respondents, 38.2%), that it is acceptable if the teacher does not notice it (49 respondents, 16.3%), and that it is acceptable in any case (22 respondents, 7.3%). Five respondents (1.7%) are undecided (Fig. 12).

RQ3. Do the respondents consider using AI tools for completing homework to be a form of cheating?

Respondents believe that using AI tools to complete homework is not cheating if they are used as a source of help or ideas (131 respondents, 43.5%) and because this technology is accessible to everyone and is widely used (37 respondents, 12.3%). Other respondents think it is always cheating (39 respondents, 13.0%) and only if the entire answer is copied (94 respondents, 31.2%) (Fig. 13).

The usefulness of AI tools

Most respondents (174, 57.8%) believe that AI tools can help complete their homework (agree and totally agree). There are 84 (27.9%) undecided respondents and 43 (14.3%) respondents who do not agree (disagree and totally disagree) (Fig. 14).

Using the AI tools in the primary school subjects

A total of 278 out of 301 respondents answered that they use the AI tools for the following primary school subjects (multiple answers): History 62.6%, Croatian lan-

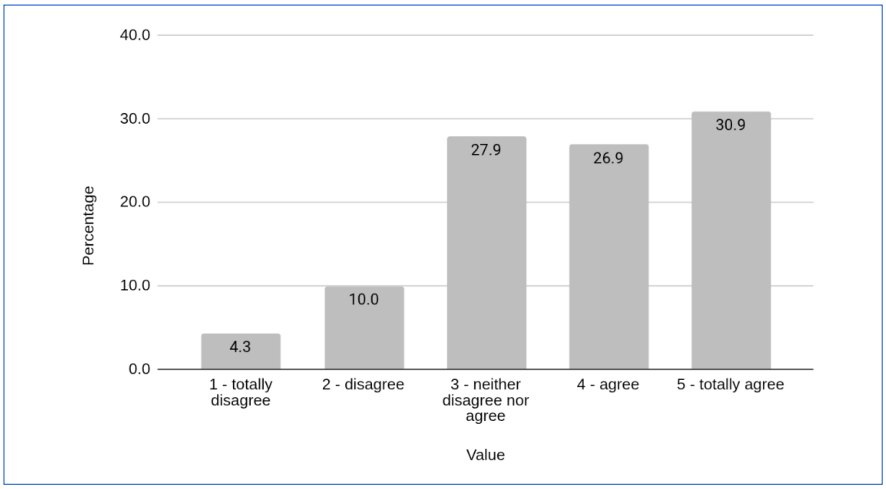

Fig. 14. Respondents' opinions on the statement that AI tools can help complete homework.

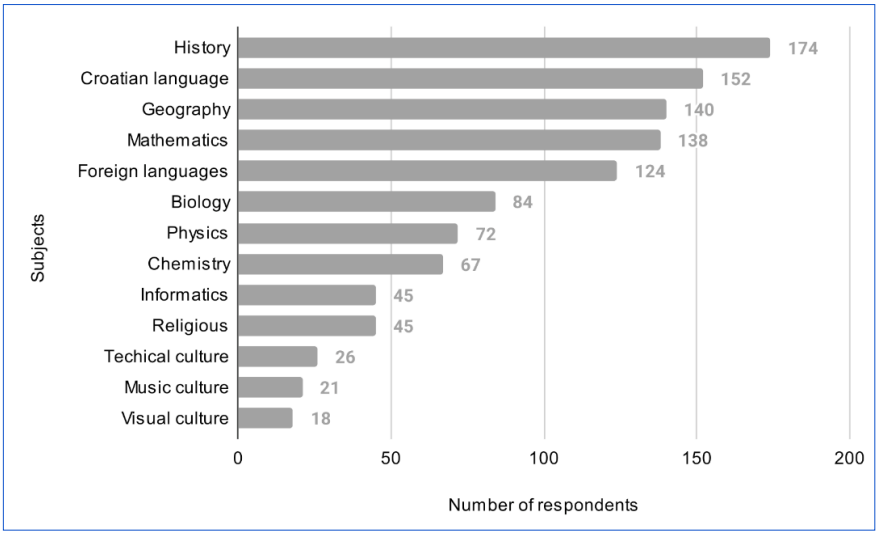

Fig. 15. The number of respondents using AI tools by primary school subject.

guage 54.7%, Geography 50.4%, Mathematics 49.6%, Foreign languages (English, German) 44.6%, and others (Fig. 15). In the Republic of Croatia, the subjects Biology, Chemistry, and Physics are taught only in the primary school's seventh and eighth grades.

Respondents are divided on whether AI tools encourage laziness: 127 (42.2%) believe they do not, 131 (43.5%) think they do, and 43 (14.3%) are unsure.

Table 2.
The number of respondents who do not use and use AI tools by gender

			Use AI tools		Total
			No	Yes	
Gender	Male	Count	61	93	154
		Row %	39.6%	60.4%	100.0%
	Female	Count	66	81	147
		Row %	44.9%	55.1%	100.0%
Total		Count	127	174	301
		Row %	42.2%	57,8%	100.0%

The difference in the number of users of AI tools between genders (Hypothesis 1)

The data in Table 2 show the number of male and female respondents who use and do not use the AI tools. There is no statistically significant difference in the number of users of AI tools among respondents by gender, $\chi^2 = 0.66$, df = 1, $p = .417$.

The difference in the number of users of AI tools across grade levels (Hypothesis 2)

The data in Table 3 show the number of respondents who do not use and use AI tools by grade. There is a statistically significant difference in the use of AI tools among respondents' grades, $\chi^2 = 9.53$, df = 3, $p = .023$.

The results of the Dunn-Bonferroni post-hoc tests on respondents using AI tools by grade (Table 4) indicate significant differences between the Eighth and Fifth groups ($p = 0.017$) and the Fifth and Seventh groups ($p = 0.004$). However, the Dunn-Bonferroni post-hoc test reveals that only a statistically significant difference in using AI tools is

Table 3
The number of respondents who do not use and use AI tools by grade

			Use AI tools		Total
			No	Yes	
Grade	Fifth	Count	29	20	49
		Row %	59.2%	40.8%	100.0%
	Sixth	Count	51	64	115
		Row %	44.3%	55.7%	100.0%
	Seventh	Count	35	66	101
		Row %	34.7%	65.3%	100.0%
	Eighth	Count	12	24	36
		Row %	33.3%	66.7%	100.0%
Total		Count	127	174	301
		Row %	42.2%	57.8%	100.0%

Table 4
The results of Dunn-Bonferroni post-hoc tests of respondents using AI tools by grade

	Test Statistics	Std. Error	Std. Test Statistics	p	Adj. p
Eighth - Sixth	16.58	14.22	1.17	.244	1.000
Eighth - Fifth	38.90	16.34	2.38	.017	.104
Eighth - Seventh	1.99	14.45	0.14	.891	1.000
Sixth - Fifth	22.33	12.70	1.76	.079	.473
Sixth - Seventh	-14.59	10.15	-1.44	.151	.904
Fifth - Seventh	-36.92	12.96	-2.85	.004	.026

Adj. p: Values adjusted with Bonferroni correction.

observable between the Fifth and Seventh grade groups (adjusted value with Bonferroni correction, $p = 0.026$).

Possible correlation between respondents' daily time spent on social media and the use of AI tools (Hypothesis 3)

To analyze the possible correlation between respondents' daily time spent on social media and the use of AI tools, the respondents reported their social media accounts, as presented in Fig. 16, and their daily time spent on social media, as shown in Table 5. The respondents utilize the social media platforms Snapchat (260 respondents, 86.4%), TikTok (224 respondents, 74.4%), YouTube (217 respondents, 72.1%), Instagram (174 respondents, 57.8%), Facebook (112 respondents, 37.2%), and X (40 respondents, 13.3%). Some respondents do not use these platforms (10 respondents, 3.3%) (Fig. 16).

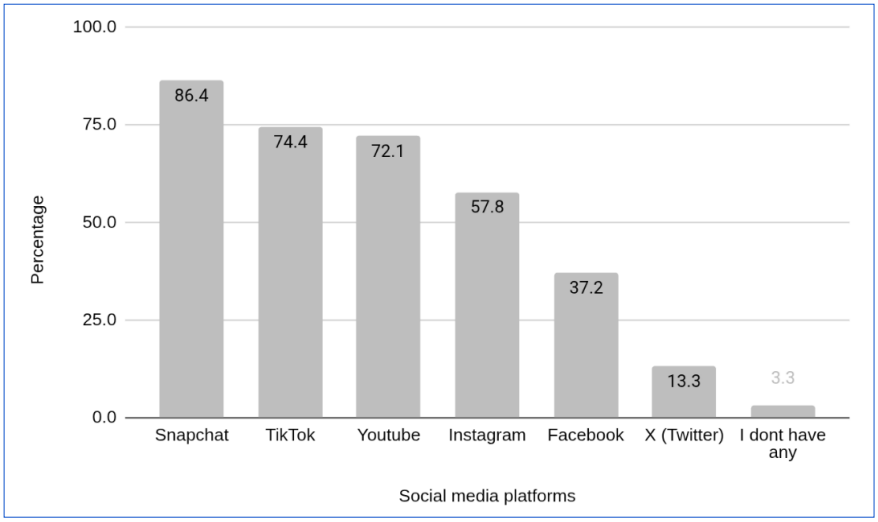

Fig. 16. Percentage of respondents using specific social media platforms.

Table 5
Respondents' daily time spent on social media by gender

		Male	Female	Total	Percent	Valid Percent	Cumulative Percent
Valid	Not using social media	5	5	10	3.3%	3.3%	3.3%
	Less than one hour	21	14	35	11.6%	11.6%	15.0%
	One to two hours	31	37	68	22.6%	22.6%	37.5%
	Two to three hours	40	43	83	27.6%	27.6%	65.1%
	More than three hours	57	48	105	34.9%	34.9%	100.0%
Total				301	100.0%		

The data in Table 5 show the respondents' daily time spent on social media by gender. There are 34.9% of respondents who use social media platforms for more than three hours a day.

Figures 17 and 18 display the number of respondents and the percentage of respondents who do not use and use AI tools, categorized by the amount of time spent on social media daily. The data show that the more time spent on social media daily, the more users there are of AI tools.

A Spearman correlation was performed to determine if there is a correlation between the variables "*Daily time spent on social media"* and *"Using AI tools"*. There is a medium, positive, and significant Spearman correlation between the variables *"Daily time spent on social media"* and *"Using AI tools*", with r = 0.34, $p < .001$.

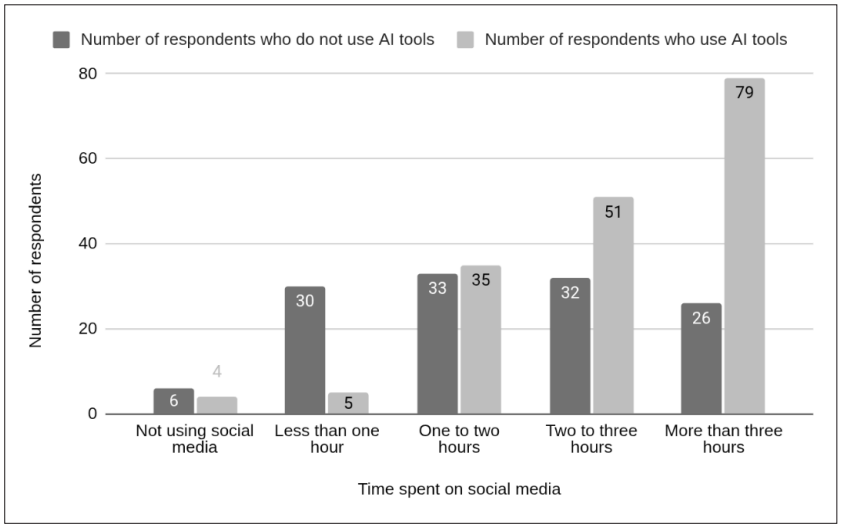

Fig. 17. Number of respondents who do not use and use AI tools by the amount of daily time spent on social media.

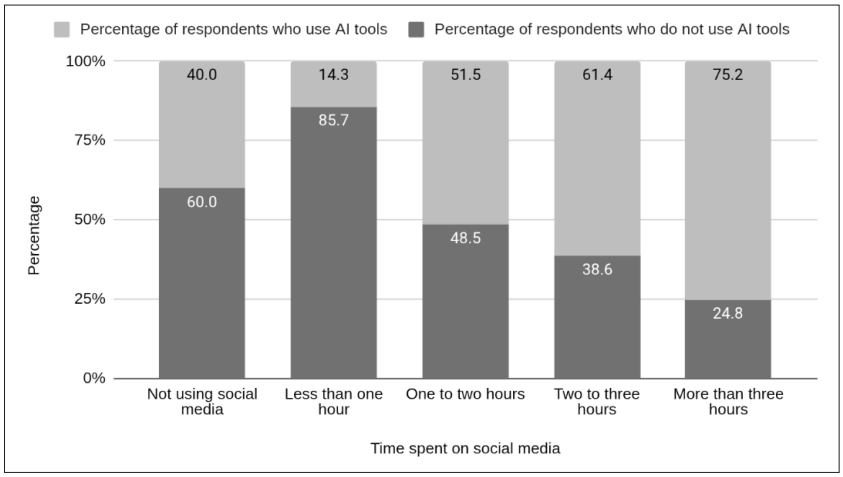

Fig. 18. Percentage of respondents who do not use and use AI tools by the amount of daily time spent on social media.

5. Discussion

The percentage of respondents using AI tools

There are 57.8% of respondents who currently use AI tools to complete their homework. This is lower than the 68% of primary school students reported by Wallan (2024). As previously stated, most studies on students' use of AI tools focus on high school or university students rather than specifically primary school students. The other currently available research results pertain only to older students. For instance, 44% of adolescents aged 13 to 17 reported being likely to use AI tools for schoolwork (Matzinger, July 27, 2023). Additionally, studies found that 95.8% (Pavlović-Šijanović *et al.*, 2024), 86.3% (Hohnjec, 2024), 50% (Shaw *et al.*, October 23, 2023), and 55% (Compilatio, November 7, 2023) of respondents reported using AI tools. Furthermore, 51% of young people aged 14–22 said they had used generative AI at least once (Harvard, 2024) (Fig. 19).

The research results indicate that many respondents utilize AI tools because they find them helpful for completing their homework (57.8%). The Snapchat app even has an integrated chatbot called My AI, which is powered by LLMs like GPT from OpenAI and Gemini from Google (Snapchat Support, n.d.).

The results on the usage frequency of AI tools (Fig. 10) indicate that 34.9% of respondents use them for one or more assignments per week. There are 14.3% of respondents who answered that they complete almost all their homework using AI tools. The total number of respondents who use it more often than rarely is 148 (49.2%). There are 9.3% of respondents who did not answer this question because they do not use AI tools for learning and completing homework.

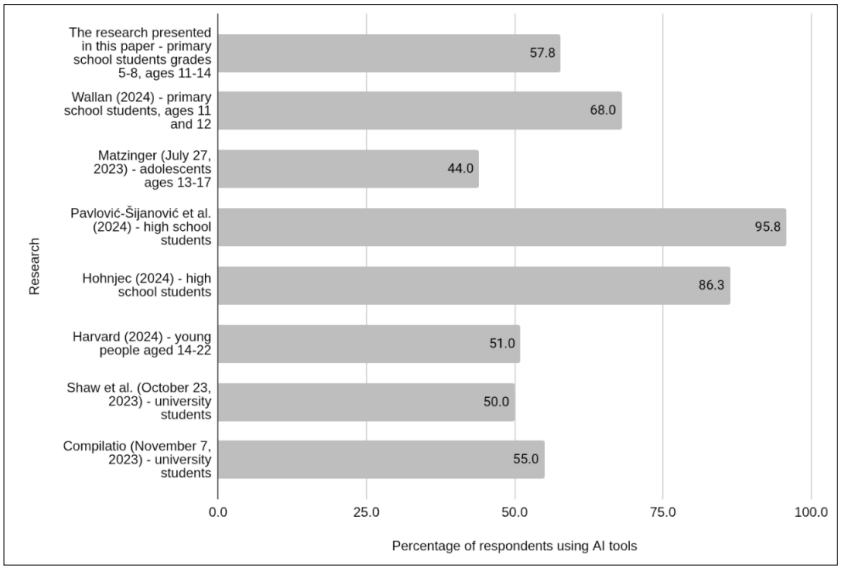

Fig. 19. The percentages of respondents using AI across similar research.

Suppose students use AI tools for all their homework. In that case, this could lead to excessive dependence on AI applications for schoolwork, resulting in a lack of cognitive effort, diminished critical thinking, and hindered problem-solving development (Kralj *et al.*, 2023).

Ethical issues in using AI tools

In RQ1, the results show that 15% of respondents read the AI-generated answer, copy parts of the text, and adapt the rest, while 12.3% copy the answer verbatim. These uses of AI tools are unethical and underscore the need to educate students on the ethical use of AI and the prevention of plagiarism.

RQ2 stated: Do the respondents think copying AI-generated answers without modification when completing their homework is acceptable? The answer is that only 110 (36.5%) respondents believe that it is unacceptable to copy AI-generated answers without modification when completing their homework. Others answered that it is acceptable under specific conditions (depending on the type of homework or if the teacher does not notice) and is acceptable unconditionally. Once again, this highlights the need to educate students about the ethical use of AI tools and prevent plagiarism.

In RQ3, most respondents, 43.5%, believe that using AI tools to complete homework is not cheating if it is used as a source of help or ideas. However, when AI tools are used this way, students have fewer opportunities to express their original ideas and creativity. By comparison, the significant majority of respondents, at 60%, in Matzinger's research (July 27, 2023), perceive reliance on AI tools as cheating.

In this regard, respondents are divided on whether using AI tools encourages laziness: 42.2% believe it does not, 43.5% believe it does, and 14.3% do not know.

Most respondents (174, 57.8%) believe that AI tools can help complete their homework (agree and totally agree). It appears that AI tools are more commonly used for primary school subjects that students find less interesting, such as History, Croatian Language, Geography, and Mathematics (Fig. 15).

Confirming hypotheses

There is no statistically significant difference in the use of AI tools by respondents' gender, $\chi^2 = 0.66$, df = 1, $p = .417$, confirming hypothesis H1. Both male and female respondents use AI tools to complete their homework.

There is a statistically significant difference in the use of AI tools among respondents' grades, $\chi^2 = 9.53$, df = 3, $p = .023$. The Dunn-Bonferroni post-hoc test reveals a statistically significant difference in the use of AI tools, observable only between the fifth and seventh grades (adjusted value with Bonferroni correction, $p = 0.026$). There are 40.8% of respondents using AI tools in the fifth grade and 65.3% in the seventh grade. The hypothesis H2 is confirmed. One possible reason for the difference in the use of AI tools between the fifth and seventh grades is their varying levels of digital literacy and experience. Seventh graders, being older and likely having more experience with technology, may have a better grasp of how to use AI tools effectively compared to fifth graders, who may still be developing those skills.

There is a medium, positive, and significant Spearman correlation between the variables *"Daily time spent on social media"* and *"Using AI tools*", with $r = 0.34$, $p < .001$. The hypothesis H3, which states that there is no correlation between respondents' daily time spent on social media and the use of AI tools among respondents, is not confirmed. It is possible that students increasingly encounter content or discussions about using AI tools as they spend more time on social media platforms. This exposure could come from posts, advertisements, influencers, or even discussions among their peers about artificial intelligence. Essentially, the more time they spend on social media, the more likely they are to encounter information or experiences related to AI tools. At the same time, another possible supplemental explanation is that when students spend a lot of time on social media, they may lack the time, energy, or motivation to complete their homework on their own, so they turn to AI tools for help.

Limitations

The respondents are a convenience sample of 301 primary school students from two primary schools. There are fewer students in grades five and eight compared to grades six and seven.

Implications

The research results indicate a pressing need to educate primary school students on the ethical use of AI tools. This process requires an updated curriculum of the primary school subject of informatics and updated textbooks. Teachers need continuous education about the opportunities and risks associated with applying AI tools in education.

Future research should investigate the impact of introducing education on the ethical use of AI tools and the influence of these tools on teachers' work in primary, secondary, and tertiary education settings.

One of the key challenges in informatics today lies in finding effective ways to teach programming, databases, and other core areas, as well as in rethinking the organisation of students' projects and assignments in the age of AI which is capable of generating code and producing detailed descriptions of database tables, including attributes, primary keys, and relationships.

6. Conclusion

The research results show that 79.1% of the respondents have heard of the term artificial intelligence, and that 57.8% already use AI tools to complete their homework. The number of respondents who use it more often than rarely is 148 (49.2%). They read the AI answer, think about it, and then use it as a guide to write their answer (109 respondents, 36.2%), but 37 (12.3%) copy the AI answer as their homework. Only 110 (36.5%) respondents think copying AI-generated answers without modification when completing their homework is unacceptable. Respondents believe that using AI tools to complete homework is not cheating if they are used as a source of help or ideas (131 respondents, 43.5%). Other respondents believe it is always cheating (39 respondents, 13.0%) and only occurs when the entire answer is copied (94 respondents, 31.2%).

The two of three research hypotheses are confirmed: there is no statistically significant difference in using AI tools by the respondents' gender, $\chi^2 = 0.66$, df = 1, $p = .417$, and there is a statistically significant difference in using AI tools by the respondents' grade, $\chi^2 = 9.53$, df = 3, $p = .023$. The Dunn-Bonferroni post-hoc test reveals a statistically significant difference in the use of AI tools only between the fifth and seventh grades. The third hypothesis is not confirmed: there is a medium, positive, and significant Spearman correlation between the variables' *Daily time spent on social media'* and *'Using AI tools',* with $r = 0.34$, $p < .001$.

The research results indicate that it is essential to educate primary school students about the ethical aspects of using AI tools in learning, beginning from the early stages of their education, to promote academic integrity, honesty, and the rejection of plagiarism. It is necessary to update the primary school informatics curriculum and textbooks by incorporating content addressing the ethical use. There is an urgent need to educate teachers about the benefits and risks of using AI in education. This will enable them to integrate AI tools into their teaching effectively, recognize AI-generated content, and adapt student assignments in ways that encourage critical thinking and creativity.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Funding Sources

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Research Data

Research data are available upon reasonable request. Please note that the data cannot be publicly deposited at this time, as follow-up analyses are still ongoing.

References

Ajduković, M., Keresteš, G. (2020). *Etički kodeks istraživanja s djecom* [*Code of Ethics for Research with Children*]. https://mrosp.gov.hr/UserDocsImages/dokumenti/Socijalna%20politika/Obitelj%20i%20djeca/Eti%C4%8Dki%20kodeks%20istra%C5%BEivanja%20s%20djecom%20-%20integrirani%20tekst%20s%20prilozima.pdf

Akgun, S., Greenhow, C. (2021). Artificial intelligence in education: Addressing ethical challenges in K-12 settings. *AI and Ethics, 2*(3), 431–440. https://doi.org/10.1007/s43681-021-00096-7

Balalle, H., Pannilage, S. (2025). Reassessing academic integrity in the age of AI: A systematic literature review on AI and academic integrity. *Social Sciences & Humanities Open, 11*, 101299. https://doi.org/10.1016/j.ssaho.2025.101299

Bostrom, N. (2014). *Superintelligence: Paths, Dangers, Strategies*. Oxford University Press.

Campbell, M., Hoane, A. J., Hsu, F. H. (2002). Deep Blue. *Artificial Intelligence*, *134*(1–2), 57–83. https://doi.org/10.1016/S0004-3702(01)00129-1

Chollet, F., Watson, M. (2025). *Deep Learning with Python, Third Edition*. Manning.

Compilatio. (2023, November 7). *Survey results: Teachers and students confront their views on AI*. https://www.compilatio.net/en/blog/press-release-ai-survey-2023

Copeland, B. (2025, July 15). *Artificial Intelligence*. *Encyclopedia Britannica*. https://www.britannica.com/technology/artificial-intelligence

Cotton, D. R. E., Cotton, P. A., Shipway, J. R. (2023). Chatting and cheating: Ensuring academic integrity in the era of ChatGPT. *Innovations in Education and Teaching International, 61*(2), 228–239. https://doi.org/10.1080/14703297.2023.2190148

Croatian Academic and Research Network (CARNET). (2024). *Umjetna inteligencija: Od koncepta do primjene. Kurikulum izvannastavne aktivnosti za osnovne kole* [*Artificial Intelligence: From Concept to Application. Extracurricular Activities Curriculum for Primary Schools*]. https://edutorij.carnet.hr

Deranty, J.P., Corbin, T. (2024). Artificial intelligence and work: a critical review of recent research from the social sciences. *AI & Soc*, 39, 675–691. https://doi.org/10.1007/s00146-022-01496-x

Devlin, J., Chang, M. W., Lee, K., Toutanova, K. (2019). BERT: Pre-training of deep bidirectional transformers for language understanding. *Proceedings of NAACL-HLT 2019*, 4171–4186.

Directorate-General for Education, Youth, Sport and Culture (European Commission). (2022). *Ethical guidelines on the use of artificial intelligence (AI) and data in teaching and learning for educators*. https://op.europa.eu/en/publication-detail/-/publication/d81a0d54-5348-11ed-92ed-01aa75ed71a1/language-en

Edutorij. (n.d.). *Edutorij*. https://edutorij.carnet.hr/

Esteva, A., Kuprel, B., Novoa, R. A., *et al.* (2017). Dermatologist-level classification of skin cancer with deep neural networks. *Nature*, *542*(7639), 115–118. https://doi.org/10.1038/nature21056

Farrokhnia, M., Banihashem, S.K., Noroozi, O., Wals, A. (2023). A SWOT analysis of ChatGPT: Implications for educational practice and research. *Innovations in Education and Teaching International, 61*(3), 460–474. https://doi.org/10.1080/14703297.2023.2195846

Goodfellow, I., Pouget-Abadie, J., Mirza, M., *et al.* (2014). Generative adversarial nets. *Advances in Neural Information Processing Systems*, *27*, 2672–2680.

Harvard. (2024). *Teen and young adult perspectives on generative AI: Patterns of use, excitements, and concerns*. https://digitalthriving.gse.harvard.edu/wp-content/uploads/2024/06/Teen-and-Young-Adult-Perspectives-on-Generative-AI.pdf

Hohnjec, A. (2024). *Istraživanje: Percepcija i korištenje umjetne inteligencije među srednjoškolcima* [*Research: Perception and Use of Artificial Intelligence among High School Students*]. https://www.skole.hr/istrazivanje-percepcija-i-koristenje-umjetne-inteligencije-medu-srednjoskolcima/

Huang, C., Zhang, Z., Mao, B., Yao, X. (2023). An overview of artificial intelligence ethics. *IEEE Transactions on Artificial Intelligence, 4*(4), 799–819. https://doi.org/10.1109/TAI.2022.3194503

Jajić, V. (2024). *Umjetna inteligencija u učionici – alati, primjena i strategije poučavanja: Prvo izdanje CARNET-ovog priručnika* [*Artificial Intelligence in the Classroom – Tools, Applications and Teaching Strategies: First Edition of the CARNET Handbook*]. https://edutorij.carnet.hr

Jumper, J., Evans, R., Pritzel, A., Green, T., Figurnov, M., Ronneberger, O., Tunyasuvunakool, K., Bates, R., Žídek, A., Potapenko, A., Bridgland, A., Meyer, C., Kohl, S. A. A., Ballard, A. J., Cowie, A., Romera-Paredes, B., Nikolov, S., Jain, R., Adler, J., … Hassabis, D. (2021). Highly accurate protein structure prediction with AlphaFold. *Nature*, *596*(7873), 583–589. https://doi.org/10.1038/s41586-021-03819-2

Kahila, J., Vartiainen, H., Tedre, M., Arkko, E., Lin, A., Pope, N., Jormanainen, I., Valtonen, T. (2024). Pedagogical framework for cultivating children's data agency and creative abilities in the age of AI. *Informatics in Education, 23*(2), 323-360. https://doi.org/10.15388/infedu.2024.15

Kralj, L., Blažić, A., Valečić, H., Janeš, S., Blašković, V., Marinić, N., Slišurić, K., Dasović, D., Majdandžić, V., Rakić, D. (2024). *Umjetna inteligencija u obrazovanju* [*Artificial intelligence in education*]. Agencija za elektroničke medije and UNICEF. https://www.medijskapismenost.hr/wp-content/uploads/2024/04/Umjetna-inteligencija-u-obrazovanju.pdf

Krizhevsky, A., Sutskever, I., Hinton, G. E. (2012). ImageNet classification with deep convolutional neural networks. *Advances in Neural Information Processing Systems*, *25*, 1097–1105.

Matzinger, K. (2023, July 27). *The rising trend of teens using AI for schoolwork*. https://jausa.ja.org/news/blog/the-rising-trend-of-teens-using-ai-for-schoolwork

McCarthy, J., Minsky, M. L., Rochester, N., Shannon, C. E. (2006). A Proposal for the Dartmouth Summer Research Project on Artificial Intelligence, August 31, 1955. *AI Magazine*, *27*(4), 12. https://doi.org/10.1609/aimag.v27i4.1904

Miljkovic Krecar, I., Kolega, M., Jurcec, L. (2024). Perception of ChatGPT usage for homework assignments: Students' and professors' perspectives. *IAFOR Journal of Education, 12*(2). https://doi.org/10.22492/ije.12.2.02

OpenAI. (2023). GPT-4 Technical Report. *arXiv preprint* arXiv:2303.08774.

Pavlović-Šijanović, S., Šijanović, D., Milić, A. (2024). *Umjetna inteligencija u životu srednjoškolaca* [*Artificial Intelligence in the Lives of High School Students*]. https://edutorij.carnet.hr/materijali/4447491

Reuters. (2025, February 20). *OpenAI's weekly active users surpass 400 million*. https://www.reuters.com/technology/artificial-intelligence/openais-weekly-active-users-surpass-400-million-2025-02-20

Russell, S. J., Norvig, P. (2020). *Artificial Intelligence: A Modern Approach* (4th ed.). Pearson.

Shaw, C., Yuan, L., Brennan, D., Martin, S., Janson, N., Fox, K., Bryant, G. (2023, October 23). *GenAI in Higher Education: Fall 2023 Update – Time for Class Study*. Tyton Partners. https://tytonpartners.com/time-for-class-2023/GenAI-Update

Silver, D., Huang, A., Maddison, C. J., *et al.* (2016). Mastering the game of Go with deep neural networks and tree search. *Nature*, *529*(7587), 484–489. https://doi.org/10.1038/nature16961

Snapchat Support. (n.d.). *What is My AI on Snapchat and how do I use it?* https://help.snapchat.com/hc/en-us/articles/13266788358932-What-is-My-AI-on-Snapchat-and-how-do-I-use-it

Turing, A. M. (1950). Computing machinery and intelligence. *Mind 59*, *236*, 433–460

Turnitin. (2025, April 9). *Turnitin marks one year anniversary of its AI writing detector with millions of papers reviewed globally*. https://www.turnitin.com/press/press-detail_17793

UNESCO. (2023). *Guidance for generative AI in education and research*. https://unesdoc.unesco.org/ark:/48223/pf0000386693

University of Rijeka. (2024, January 23). *Politika korištenja umjetne inteligencije na Sveučilištu u Rijeci* [*Policy on the use of artificial intelligence at the University of Rijeka*]. https://medri.uniri.hr/wp-content/uploads/2024/01/13.-Donosenje-Politike-koristenja-alata-umjetne-inteligencije-na-Sveucilistu-u-Rijeci.pdf

University of Zagreb Faculty of Organization and Informatics. (2024, April 12*). Okvir korištenja alata umjetne inteligencije u nastavi, studentskim radovima i istraživanju na Sveučilištu u Zagrebu Fakultetu organizacije i informatike* [*Framework for using artificial intelligence tools in teaching, student papers, and research*]. https://www.foi.unizg.hr/sites/default/files/foi_okvir_koristenja_alata_umjetne_inteligencije-1.pdf

Walan, S. (2024). Primary school students' perceptions of artificial intelligence – For good or bad. *International Journal of Technology and Design Education, 35*, 25–40. https://doi.org/10.1007/s10798-024-09898-2

Zhai, C., Wibowo, S., Li, L. D. (2024). The effects of over-reliance on AI dialogue systems on students' cognitive abilities: A systematic review. *Smart Learning Environments, 11*, 28. https://doi.org/10.1186/s40561-024-00316-7

P. Oreški, PhD**,** is a professor at the Department of Information and Communication Sciences of the University of Zagreb Faculty of Teacher Education. His fields of interest include free and open-source software, programming, databases, web technologies, AI in education (including educational robotics), e-learning, and digital literacy. ORCID: https://orcid.org/0000-0002-5221-9990

T. Oreški holds a Master's degree in Information Sciences, having completed her Master's in Information and Software Engineering at the University of Zagreb Faculty of Organization and Informatics in 2004. She is currently working as a Computer Science teacher at Orehovica Primary School in Croatia. She is a co-author of several computer science textbooks and holds the professional title of Distinguished Teacher Advisor. Her areas of interest include ICT in education, programming education, the use of AI in education, and in particular the ethical use of AI in education.

I. Ružić graduated from the Faculty of Organization and Informatics in Varaždin, where she is currently pursuing a PhD in Information Sciences. She works as a computer science teacher at the First Primary School Čakovec and holds the professional title of Distinguished Teacher Advisor. She is Head of the County Expert Council of Computer Science Teachers, mentors students in national and international programming and robotics competitions, and leads international projects. She is a co-author of computer science textbooks and author of professional and scientific papers, while also regularly engaging in professional development.