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Originalni naučni rad
UDK: 37:004.8
DOI: 10.5937/IstrPed2402361M

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EDUCATIONAL ROBOTS IN TEACHERS' EDUCATION

Summary: The contemporary educational paradigm, which brings learning outcomes and competencies to the foreground, puts special emphasis on digital competencies. The relevance of their development is visible in a series of strategies and initiatives at the global and national level. The application of AI and robotics poses a number of pedagogical challenges to teachers, with the use of robots in education being one of the latest trends. The paper discusses the perceptions of students of the University of Belgrade's Faculty of Education (Serbia) about robots. The aim of the research was to determine how future preschool and primary school teachers perceive robots, and their pedagogical implications, in order to create opportunities for improving teaching on the use of robots in an educational setting. Students perceive robots in two dominant functions: educational and assistive. A statistically significant difference in the attitudes of future preschool and primary school teachers were observed regarding the reasons for choosing the robot they drew. Preschool teachers gave primacy to the cognitive domain, while primary school teachers found it difficult to judge which domain was dominant. Misconceptions about robots were observed among some of the respondents, and these were further analyzed. The most dominant function of the robot was the educational one, and its predominant appearance was in the animal form. Most of the respondents did not draw elements that would indicate emotions of the depicted robots. However, the drawings of the robot in the animal form included clear positive emotions. The obtained results can be a significant predictor of the way in which future preschool and primary school teachers will use robots in their teaching and educational work with children and students. They can also give the professors of the faculties of education useful guidelines for modifying syllabuses used for building student digital competencies.

Keywords: robots, education, artificial intelligence, perceptions, teachers

Introduction

Artificial Intelligence (AI) literacy has become the most topical issue of digital literacy research in education (Su, Ng, & Chu, 2023). Artificial intelligence enables personalization of the educational experience. It enables the creation of customized materials that suit each child in accordance with its individual abilities, prior knowledge and interests. Giving feedback is also provided. These are good preconditions for increasing children's engagement and motivation to acquire new and improve their existing competencies. New challenges are made by using robotics and artificial

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intelligence in all phases of education (Mandic, 2023).

Despite the present dilemmas whether preschool children are too young to explore and acquire knowledge about artificial intelligence (Su, Zhong, & Ng, 2022), more and more people are beginning to realize that early AI literacy is an indispensable part of digital competencies, which affect many aspects of child development, such as theory of mind skills, creative research, research of emotions, as well as collaborative research (Su & Yang, 2022). It is considered that very young children are able to develop their AI literacy even in preschool age, and the use of robots in education is one of the latest trends, which is introduced at the earliest ages as a means of enriching the learning environment and improving children's competencies (Li, Fengchao, & Zhang, 2024; Papadakis, 2020). In papers on the developmental perspective of robotic coding, it was determined that it can positively affect many domains of child development at an early age, such as cognitive, linguistic, socio-affective, psychomotor and technological literacy (Kirksekiz, & Kol, 2023). The new theoretical framework of preschool education in Serbia, *Years of Ascent – Preschool Curriculum Framework* (*Godine uzleta*, 2018), foresees the development of digital competence in children of preschool age, which develops in a certain context, together with other competencies. Educational robots, leveraging artificial intelligence, play a pivotal role in shaping K-12 education and fostering computational thinking, a vital skill for today's youth and their educators. That is why introducing stimulating didactic-methodological integration of educational robots in everyday work in the kindergarten is a very challenging task.

There are educational robots based on artificial intelligence already being used in preschool education, such as: iRobiQ, NAO, Keepon, KASPAR, AIBO, Iromec, Paro, Probo, PaPeRO, EngKey, RUBI-6, iCAt, and some of them have various integrated accessories such as: cameras, speakers, microphones, light or tactile sensors, etc. (Yi, Liu, & Lan, 2024). The hardware components of these educational robots are designed in such a way that the child can easily familiarize with them since they perceive them as toys due to their appearance in the form of an animal, a doll, toy car, and the like. Regardless of the robot's appearance, thanks to the intelligent components integrated into the robot's software, it is possible for these educational robots to have multiple functions, such as strengthening inclusive education, prevention, detection or alleviation of certain defectological issues in emotional and social development. Also, due to the camera which can recognize facial expressions, they can be used in behavioral therapy with students experiencing problems with attention, anxiety or depression, but also in the development of pro-social skills, in the STE(A)M educational area and language learning (Yi, Liu, & Lan, 2024). In research with children aged 4-5 years, it was found that playing with an AI robot fostered inquiry literacies (Kewalramani, Kidman, & Palaiologou, 2021). According to some researchers, robots are a positive factor in improving the learning outcomes of children under the age of 12 and in the time ahead of us. Thus, there is a possibility that robots will become a common teaching tool in the classroom just like the traditional ones, such as the blackboard, projector, or computer (Huang, 2024).

Based on solid digital literacy foundations laid in preschool, later in school, students can use AI as a tool for personalized learning, getting feedback on their progress, identifying learning difficulties, helping with essay writing in terms of getting synthesized information, or generating concepts. Their teachers can also use it to perform administrative tasks more quickly, e.g. to automatically correct student assignments or provide feedback, create course syllabuses and personalized content for students, identify learning gaps that need to be addressed in a timely manner in order to guide the student, or anticipate the possibility of early school leaving (Galindo-Dominguez, Delgado, Losada, & Etxabe, 2024). Pedagogical robotics enables the creation of predictable and controlled environments, which are, for instance, especially suitable for children with special needs – autism spectrum disorder (ASD), whereby the application of one of them – Bee-Bot, together with a pedagogical syllabus, offered the potential for learning the skills of social-emotional reciprocity (Perez-Vazquez, Lorenzo, Lorenzo-Lledo, & Lledo, 2024).

The use of robots can enable an inclusive educational environment for all students, regardless of their abilities or disabilities. In particular, the application of socially assistive robotics can help children with ASD by enhancing their social and communication skills. (Gkiolnta, Zygopoulou, & Syriopoulou-Delli, 2023; Schiavo, Campitiello, Todino, & Di Tore, 2024). In the preschool period, the use of educational robots can lead to positive changes not only in acquiring AI-related knowledge, but also in attitudes towards engineering and science (Su & Yang, 2023). We are witnessing rapid technological advancement and the growing impact of artificial intelligence. The European Commission has established eight key competences for lifelong learning, and digital competence is one of them (Publications Office of the European Union). Aligned with this is the contemporary educational paradigm that emphasizes outcome- and competence-based learning, where digital competence is pointed out as crucial. Its importance is recognized through various global and national strategies and initiatives, including: 1) *UNESCO: Strategy on Technological Innovation in Education (2022–2025)*; 2) *Strategy for the Development of Education in the Republic of Serbia until 2030,* based on Article 38, paragraph 1 of the Law on the Planning System of the Republic of Serbia ("Official Gazette of RS", No. 30/18); 3) *Strategy for the Development of Artificial Intelligence in the Republic of Serbia for the Period 2020–2025,* based on Article 38 of the Law on the Planning System of the Republic of Serbia ("Official Gazette of RS", No. 30/18). Since 2018, Serbia has formally incorporated the concept of lifelong learning competencies into preschool education through the *Years of Ascent – Preschool Curriculum Framework* (*Godine uzleta*, 2018). Integrating technology into Early Childhood Education and Care (ECEC) has thus become a pivotal research topic. Preschool teachers are now introducing pedagogical approaches that utilize toys to foster children's ICT competencies. That is one of the reasons why it is essential to understand future preschool and primary school teachers' perceptions of the application and effectiveness of these educational toys (Pollarolo, Papavlasopoulou, Granone, & Reikeras, 2024).

Conceptions about robots

The word "robot" is attributed to Czech writer Karel Capek and his brother Josef Capek, who derived it from the Czech word "robota", which refers to the phrase "hard labour" (Guertler et al., 2023; *Merriam-Webster Online Dictionary*). To assess whether our respondents can distinguish robots from other devices, we referred to definitions of robots found in international dictionaries. One such definition describes a robot as a machine resembling a living being, capable of independent movement by walking or rolling on wheels, and performing complex actions (*Merriam-Webster Online Dictionary).* According to another dictionary definition, a robot is "a machine controlled by a computer that is used to perform jobs automatically" (*Cambridge Dictionary*). Related to robot classification and typology, one of the simplest distinctions is between human-oriented robots and product-oriented robots (Kwak, 2014).

The topic of *Anthropomorphism of Robots* has drawn significant attention among researchers. This concept refers to robots possessing characteristics that resemble humans, such as a face with a nose and mouth, or simulate motivation, intentions, and emotions. Research has shown that the degree of a robot's anthropomorphism can play a critical role in influencing perceptions, emotional processing, as well as judgments of robots (Wu, Du, Liu, Tang, & Xue, 2024).

Many individual conceptions can be uncovered through tests where respondents are asked to depict something through drawings. For instance, the *Draw-A-Scientist Test (DAST)***,** initially developed by D. Chambers in the 1950s, has been frequently used to identify participants' conceptions (perceptions and stereotypes) about scientists as it is well-known that stereotypes and perceptions of scientists influence individuals' later career choices. By analogy with the *DAST* test, other researchers have created and analyzed a range of similar tests and studies on perceptions of scientists, including studies with preschool children (Blagdanic, Kadijevic, & Kovacevic, 2019). Tests have also been conducted to analyze drawings of engineers, such as the *Draw an Engineer Test*

(DAET) (Hammack, Utley, Ivey, & High, 2020; Kuvac & Koc, 2022), or the *Draw an Earth Scientist Test (DAEST)* (McNeal, Menon, Al Shorman, & Gajewska-Schaefer, 2024).

Earlier studies found that while teachers highly value the importance of ICT competencies, they rarely apply appropriate pedagogical approaches to facilitate their acquisition by children (Dong, 2018). To investigate this issue in greater depth, and by analogy with earlier studies of conceptions reflected in drawings, the *Draw-A-Robot Test (DART)* was developed and applied (Zhang, Chen, Bao, & Hu, 2023). The integration of AI and robotics presents numerous pedagogical challenges for teachers, including acquiring new skills, managing change, and implementing new technologies in the classroom. Thus making robots classroom-ready remains a demanding task (Cox, 2021; Williams, Ali, Alcantara, Burghleh, Alghowinem, & Breazeal, 2024). The use of artificial intelligence and robotics necessitates the acquisition of a range of new teaching competencies. It is therefore crucial to examine the conceptions of future preschool and primary school teachers during their studies – a period when institutional influence is still possible. Accordingly, curricula should be continuously innovated to align with these evolving demands.

Methodology

The *aim* of the research was to determine how future preschool and primary school teachers perceive robots and their pedagogical implications, in order to create opportunities for improving teaching on the use of robots in an educational setting. The *primary objective* of the research was to identify future preschool and primary school teachers' conceptions regarding robots. The *specific objectives* were to:

- determine whether respondents can distinguish robots from other devices, whether they have experience with them, and to identify any potential misconceptions about robots;
- identify the robots most commonly perceived and whether respondents visualize them with emotional expressions;
- explore the functions of the depicted robots;
- investigate the contexts in which experiences with robots have been acquired;
- uncover the reasons behind the choice of robot depictions.

In terms of the *methods* used, the study is based on a mixed-method approach (Creswell & Clark., 2011), combining qualitative and quantitative methods to analyze students' drawings and responses to open-ended questions. This approach aimed to provide insights into students' conceptions of robots, following the methodology used in other studies involving the Draw-A-Robot Test (Chen, Zhang, Bao, & Hu, 2022; Giang et al., 2023; Mallik, Sabouri, Ghosh, & Kapila, 2020; Zhang et al., 2023) The independent variable was the students' field of study – preschool teacher education or primary school teacher education – while the dependent variables were their conceptions of robots.

The initial sample consisted of 143 students. After identifying 22 misconceptions, the final sample included 121 students, of whom 75 were future preschool teachers and 46 were future primary school teachers from the Faculty of Education, University of Belgrade (Serbia). At the time of the study, conducted in 2024, all participants were in their fourth and final year of basic university education and consented to participate in the research.

The task required of the participants to create a detailed hand-drawn depiction of a robot, describe the environment in which they perceived it, explain its role, and elaborate on why they chose it as the subject of this analysis. A qualitative method was initially applied for coding purposes to identify the students' conceptions represented in the drawings. The students' papers were then reviewed, and a coding list was created based on similar earlier studies which used the DART test (Chen, Zhang, Bao, & Hu, 2022; Giang et al., 2023; Mallik, Sabouri, Ghosh, & Kapila, 2020; Zhang et al., 2023), as well as our participants' responses.

Based on this, a DAAT-Checklist (Draw-And-Answer-Test) was created for coding responses as a record of the information contained in the students' drawings. The checklist is provided in Appendix 1.

Two independent evaluators analyzed and categorized the drawings.

Table 1. *Pearson correlation coefficient.*

		Researcher A	Researcher B
Researcher A	Pearson Correlation Sig. (2-tailed) N	1 121	.99 .00 121
Researcher B	Pearson Correlation Sig. (2-tailed) N	.99 .00 121	1 121

The degree of agreement between the evaluators' assessments was calculated using Pearson's correlation coefficient, which amounted to 0.99. This indicates an extremely high level of agreement, confirming that the scoring was not influenced by the person conducting the evaluation, thus ensuring objectivity (Table 1).

Results and discussion

1. Distinguishing robots from other devices

It was first important to establish terminological distinctions among the concepts of *preconception, conception,* and *misconception*. In this context, the literature defines *preconception* as a conception that arises from daily experiences prior to formal learning (Zhang et al., 2023). *Conception* is a mental structure that includes a person's beliefs and basic presuppositions, a dynamic entity that can undergo changes based on practice and/or exposure to other sources of knowledge (Gorodetsky, Keiny, & Hoz, 1997). *Misconceptions* are preconceptions containing errors and misunderstandings (Zhang et al. 2023: 2). as well as wrong assimilations contrary to scientifically accepted conceptions (Miscevic, Blagdanic, & Bosnjak Stepanovic, 2021: 36).

In line with the ways robots are defined in other studies, for the purposes of this research, we have adopted the definition of a robot as a machine that is more of an electronic device that mimics a living being in that it can carry out intricate tasks and have multiple functions. Conceptions and beliefs about robots, shaped through various personal experiences and formal education, can influence the formation of students' attitudes, which may, in turn, affect their future use of robots in work with children.

After analyzing the robot drawings and descriptive accounts provided by the respondents, it was concluded that 121 participants depicted and described an accurate representation of a robot, while 22 presented drawings indicated misconceptions about robots. Almost all respondents with accurate conceptions of robots had acquired their experience either in person (98 participants) or through media exposure (21 participants). Only two participants, despite having correct conceptions, reported no prior experience with robots. There was a statistically significant difference ($t(121)=31.15$, $MD=1.38$, $p=0.000$, $p<0.05$) between the respondents enrolled in the preschool education department and those in the future primary school education department, as shown in Table 2.

Table 2. *Students' experience associated with the drawn robot according to their study department.*

		EXPERIENCE			
		No	Yes from real life	Yes from the media	**total**
Department	Future preschool teachers	1	72	2	**75**
	Future primary school teachers	1	26	19	**46**
	total	**2**	**98**	**21**	**121**

Three times as many future preschool teachers had in-person experience with using robots compared to their counterparts. It is presumed that one reason for such an outcome is the focus of the faculty curriculum for preschool education, which requires students to design project-based activities during methodological practice aimed at developing algorithmic thinking in preschool-aged children.

Some respondents exhibited misconceptions about robots. These misconceptions pertain to mental models that conflict with the generally accepted scientific consensus (Bewersdorff, Zhai, Roberts, & Nerdel, 2023). The misconceptions were identified in two ways: first, through the drawings, and then confirmed via descriptive analysis of students' responses to questions about the robot's function. There were 22 respondents with identified misconceptions (Appendix 2), which were classified into the following four categories: 1) incorrect humanoid appearance; 2) electrical appliances; 3) virtual reality; 4) avatar.

Table 3. *Distribution of future teachers' misconceptions of robot appearance based on DAAT.*

CATEGORIES	N	PERCENT (%)
humanoid appearance	3	13.46 (%)
electrical appliances	15	68.18 (%)
virtual reality	3	13.64 (%)
avatar	1	4.55 (%)
total	**22**	**100 (%)**

The most common misconception (68.18%), as shown in Table 3, involved depicting robots as electronic devices (e.g., a mixer, washing machine, microwave, coffee machine, curling iron, hair dryer, or an old-fashioned vacuum cleaner). Misconceptions were also expressed by drawing robots as stick figures (13.46%), hardware components of virtual reality technology such as VR glasses and controllers (13.64%), and digital avatars seen in video games (4.55%). Although some studies have shown that future preschool teachers hold positive and constructive attitudes toward the use of coding toys (Pollarolo, Papavlasopoulou, Granone, & Reikeras, 2024), it is crucial to identify both conceptions and misconceptions about robots. These findings are invaluable for adapting faculty syllabuses even better in order to enhance the digital competencies of future preschool and primary school teachers.

2. The most common robot depictions

During the analysis of the collected robot drawings, the following classification was made, as presented in Table 4.

Table 4. *Distribution of different future students' conceptions of robot appearance based on DAAT.*

		Frequency	percentage (%)
APPEARANCE	animal	57	47,1(%)
	humanoid	5	4,1(%)
	typical	30	24,8(%)
	mechanical object	29	24,0(%)
	total	**121**	**100,0(%)**

The largest number of respondents (57), accounting for 47.1% of the sample, perceived robots as a digital toy in the form of an animal (e.g., Bee Bot – a bee-shaped robot, or Mouse Bot – a mouse-shaped robot), as shown in Appendix 3. Among these, the Bee Bot robot was the most frequently represented. The Bee Bot – a bee-shaped robot designed to foster children's algorithmic thinking – is used during classes in Educational Technology and Informatics Teaching Methodology at the Faculty of Education of the University of Belgrade, and in the Center for Robotics and Artificial Intelligence in Education[5], which is part of the faculty. The Bee-Bot allows children to input programming commands (forward, backward, pause, 90° left and right turns, clear, and GO) and intuitively engage with a block-based programming language (Salinas, Seckel, Breda, & Espinoza, 2024). For teachers, it is crucial to have knowledge about robots that can be used for educational purposes – what types are available, where to find additional information, when and how to use them in practice, and for what objectives.

The analysis of the drawings also revealed representations of robots with a robust appearance, which were present in 30 drawings, accounting for 24.8% of respondents. This type of robot appearance is often referred to as *robotness*, but we have chosen to label it differently as a *typical robot*. In these drawings, the robot is depicted with a robust body consisting of a square head with antennas, a rectangular or oval torso with elements resembling sensors or buttons, and arms and legs made of straight lines, often with additional features (Appendix 3). The third most common depiction (24%) appeared in 29 drawings, portraying robots as mechanical objects such as smart vacuum cleaners, drones, robots in hotels, restaurants, or shopping centers that greet people and clean spaces, as well as factory machines mimicking human movements (Appendix 3). Humanoid robots, with characteristics most typical of humans, were perceived by only 5 respondents (4.1%). Besides the four typical representations, respondents independently depicted robots with certain emotions, which were categorized in Table 5 as: 1) positive; 2) negative; 3) neutral (no expressed emotion). An interesting observation from the cross-analysis of the robots' appearance and the expressed emotion revealed that most of the respondents (N=76) perceived robots without any expressed emotion. This finding suggests, to some extent, that future preschool and primary school teachers do not view robots as entities likely to replace humans.

[5] https://craie.edu.rs/inovacije-u-obrazovanju

Table 5. *Students' conceptions of the emotions associated with the drawn robot according to the robot's appearance.*

		EMOTIONS				
		positive	negative	Neutral	**Total**	**percentage** (%)
APPEARANCE	animal	33	0	24	**57**	**47.11(%)**
	humanoid	3	0	2	**5**	**4.13(%)**
	typical	8	1	21	**30**	**24.79(%)**
	mechanical object	0	0	29	**29**	**23.97(%)**
	total	**44**	**1**	**76**	**121**	**100.0(%)**

Additionally, 33 drawings depicting animal-like robots with a joyful (positive) emotion suggest that respondents hold a favorable attitude towards this type of robot (e.g. the Bee Bot and the Mouse Bot). Conversely, only one respondent depicted a robot with a negative facial expression. These observations are significant as they may indicate a positive or negative orientation in the attitudes of future preschool and primary school teachers towards robots, which could, in turn, influence their use of robots in their future professional work with children.

3. The functions of the depicted robots

In general, robots serve numerous functions, including automating tasks that require precision and speed, collecting and analyzing data from various sources, navigation, etc. According to the descriptive explanations provided by our respondents, the robots they drew were categorized based on the following functions: game; educational; communicative; assistive; other.

Table 6. *Students' conceptions of the function associated with the drawn robot according to the robot's appearance.*

		APPEARANCE					
		animal	humanoid	typical	mechanical object	**Total**	**percentage** (%)
FUNCTION	game	0	0	6	0	**6**	**5(%)**
	educational	56	4	4	0	**64**	**52.9(%)**
	communicative	0	0	1	1	**2**	**1.7(%)**
	assistive	0	1	10	27	**38**	**31.4(%)**
	other	1	0	9	1	**11**	**9.1(%)**
	total	**57**	**5**	**30**	**29**	**121**	**100(%)**

The analysis of the numerical indicators in Table 6 reveals that the educational function (N=64) is the most dominant, as slightly more than half of the respondents (N=56) drew animal-shaped robots used for educational purposes. Following this, the second most recognized function was assistive (N=38), primarily associated with mechanical robots (N=27). Respondents identified the game (N=6) and communicative (N=2) robot functions to a lesser extent. Besides these four categories, a number of respondents (N=11) depicted robots without a specific function or with functions that could not be classified under the four main categories. Similar studies have observed that teachers also drew humanoid robots, mobile robots on wheels, stationary robots, or insect-like robots, as did our respondents. Their identified functions included cleaning, delivery, construction, etc. (Mallik, Sabouri, Ghosh, & Kapila, 2020). By using a Chi-square test, we identified differences in the frequency of these functions between students from the preschool department and the primary school department, $\chi^2(N=121)=0.01$, $p<0.05$.

Table 7. *Students' conceptions of the function associated with the drawn robot according to their study department*

		FUNCTION					total	percentage (%)
		game	educational	Communicative	assistive	other		
DEPARTMENT	future preschool teacher	3	47	1	22	2	**75**	**61.98(%)**
	future primary school teacher	3	17	1	16	9	**46**	**38.02(%)**
	total	**6**	**64**	**2**	**38**	**11**	**121**	**100.0(%)**

Students from both departments recognize the educational and assistive functions of robots as more dominant compared to other functions; however, the following differences were observed: 1) in the preschool department, the educational function is the most dominant; 2) students in the primary school department attribute equal importance to both the educational and assistive functions (Table 7).

4. The place where experiences with robots were gained

Data on the places where the respondents gained experience with or observed robots are presented in Table 8. Referring to the findings in Table 2, it is encouraging that a large number of respondents (N=98) had real-life experience with various robots. An examination of Table 8, with details on the specific places where these experiences were gained, shows that the majority of respondents encountered robots at the Faculty of Education (N=61). For most of them, the robot was in the form of an animal (N=54).

Table 8. *Students' conceptions of appearance associated with the place where they saw the robot.*

		APPEARANCE				total
		animal	humanoid	typical	mechanical object	
LOCATION	without answer	0	0	2	0	**2**
	Home	0	0	2	15	**17**
	faculty	54	3	2	2	**61**
	kindergarten/school	2	0	3	0	**5**
	Outdoor	0	0	0	1	**1**
	social places	1	0	4	9	**14**
	Media	0	2	17	2	**21**
	Total	**57**	**5**	**30**	**29**	**121**

The robots that most of our respondents noticed in the media are the typical form robots, while in homes or social environments, mechanical robots were the ones most commonly observed. The finding that most respondents saw their first robot at the Faculty of Education is particularly significant. As a center for training future teachers, this institution provides a structured environment for acquiring theoretical and practical knowledge about various educational robots, their functions, and the most effective ways to use them in education, for fostering critical thinking, problem-solving, and creativity. Such an approach not only enhances the quality and durability of acquired knowledge (Miscevic-Kadijevic, 2011) but also offers a deeper understanding of the significance of educational robots in stimulating critical thinking, solving problems, and fostering creativity in the educational process. The quality of teacher education programs significantly influences the overall quality of education (Radulovic, Dzinovic, & Miscevic, 2024). The development of digital literacy is crucial in modern classrooms and in the preparation of students for future challenges, while the use of robots adds dynamism and engagement to the teaching process. Just as teachers possess the skills to select the most suitable textbook from various publishers to meet the specific needs of their classroom and their personal preferences, they should also be capable of identifying, selecting, and effectively utilizing various educational robots in their work with students. This can only be achieved if teachers are both personally competent and motivated.

5. Revealing the reasons for specific robot depictions

Engaging a child in the learning process is a complex task that requires the integration of various domains of personality development. In research, *engagement* is defined as a learning task or value referring to the cognitive process, active participation, and emotional involvement of learners in specific learning procedures (Wang, Mirzaei, Xu, & Lin 2022). With reference to that, three significant domains are emphasized: 1) cognitive domain as a psychological component encompasses learners' willingness to invest extra effort in learning; 2) affective domain as learners' affective reactions to learning and learning environments; 3) behavioral domain as learner participation, such as time spent on learning activities (Fredericks, Blumenfeld, & Paris, 2004; Wang et al., 2022).

Various factors influence attitudes towards robots and artificial intelligence in general, which can affect daily interactions with robots (Koverola, Kunnari, Sundvall, & Laakasuo, 2022). The emotional complexity and multifaceted nature of affective perceptions of AI have also been observed in studies involving students aged 11-12 years. These perceptions include positive emotions, associated with the perceived support provided by AI in learning and completing tasks, as well as negative emotions, stemming from concerns about AI's potential negative impacts – such as fears related to its rapid development, job loss, and privacy issues (Walan, 2024). For this reason, it is essential that teachers themselves are well-informed and pedagogically equipped to address their own dilemmas and concerns regarding this all-pervasive topic. Additionally, they should serve as leaders of change and creators of future directions in educational policy.

The final question in the DAAT test was open-ended, requiring respondents to explain why they chose to depict a particular robot in their drawing. Through qualitative analysis of the collected responses (Table 9), it was determined that the largest proportion of respondents (N=41, 33.9%) based their choice on the belief that robots are highly practical and easy to use, particularly for educational purposes. This finding suggests that the cognitive domain plays the most significant role in shaping the attitudes of future preschool and primary school teachers toward robots.

***Table 9**. Students' key domain in forming their conceptions.*

REASON	FREQUENCY	PERCENTAGE (%)
cognitive domain	41	33.9 (%)
affective domain	28	23.1 (%)
behavioral domain	20	16.5 (%)
It is not possible to estimate	32	26.4 (%)
total	**121**	**100.0** (%)

An equally significant aspect in attitude formation is the affective relationship towards the subject of study. Analysis revealed that respondents often chose a specific robot due to their strong personal interest in using it (N=28, 23.1%). Personal experience gained through interactions with robots resulted in (N=20, 16.5%) respondents demonstrating a stronger behavioral domain in forming an attitude towards the robot they chose to depict in their drawings.

However, for a significant number of respondents (N=32, 26.4%), it was hard to determine the internal intentions behind their choice of the robot to draw. The most common responses included: *"It was the first thing that came to mind", "It was my first association regarding a robot", "This is the robot I see most often", "This is the robot I remember best", "I don't have much prior knowledge about robots",* and *"I think it's a good idea to use this robot."*

Conclusion

This study revealed a minimal number of misconceptions in the analyzed student papers, indicating that most future preschool and primary school teachers possess accurate and well-founded understandings of educational robots. The results obtained can serve as an important predictor of how future teachers will be using robots in teaching and their educational work with children and students. The majority of respondents had real-life experience with robots based on correct conceptions, while the small number of identified misconceptions primarily involved depicting robots as conventional electronic devices. Students perceive robots through two dominant functions: educational (e.g., Bee Bot and Mouse Bot) and assistive. Regarding the most frequent perception of robots' appearance, the most prevalent were animal robots or robots as mechanical objects. A divergence in attitudes between future preschool and primary school teachers was observed in their reasons for choosing the robot depicted. Future preschool teachers prioritized the cognitive domain, while for future primary school teachers, it was hard to determine a key domain due to the frequent overlap of the three primary domains (cognitive, affective, and behavioral). Future preschool teachers exhibited more vivid conceptions characterized by consistency, whereas such consistency was not registered among future primary school teachers. While the number of misconceptions was small, some of them still need to be addressed. It is recommended to introduce educational robots into teaching more frequently and purposefully, as activities involving robots can significantly enhance the development of algorithmic thinking at an early age (Matovic, 2024). This recommendation paves the way for the transformation and improvement of syllabuses of the subjects where future preschool and primary school teachers develop and refine digital competencies. To support this, it is necessary to form teams dedicated to developing curricula for the application of robots, based on a holistic approach.

The digital transformation of education demands changes in the way we learn, teach, assess, and evaluate students' knowledge and achievement. Thanks to the development of telecomcommunication systems (primarily 3G and 4G data transfer), hardware (computers, transfer devices and accessories) and software (intelligent tutor systems, web tools, mobile applications, social networks and technology and augmented reality) (Ristic, 2019), as well as artificial intelligence, opportunities are created for transforming the teaching model into a mixed learning environment. Mixed learning environment is flexible and stimulating, and it supports both different learning styles and teaching models, with opportunity to use different applications and web tools (Ristic, 2019). Therefore, it is crucial for children and students to continuously develop competencies for lifelong learning.

One such competency is the development of algorithmic thinking at an early age and digital literacy for the safe, meaningful, and purposeful use of artificial intelligence, including robotics. It has an increasing impact on how we learn, organize teaching, and evaluate teaching outcomes, which implies that educational experts need to permanently follow innovations and provide adequate training of teachers for their application (Mandic, 2023; Mandic, 2024; Mandic, Miscevic, & Bujisic, 2024). The mere use of robots in teaching does not automatically lead to the innovation of the educational process. Robots can be employed in various fields, such as STEM, but also as tools to enhance the inclusion of children. When designing an educational environment, it is essential to consider students' specific needs, their diverse learning styles, abilities, and interests. Success depends on various factors, including the competencies of the teacher, the quality of the robots used, and the strategies applied by the teacher during their integration into the learning process. When working with robots, it is crucial to ensure the physical safety of children, such as preventing potential injuries and establishing behavioral rules for using robots. Additionally, safety must also encompass protecting the privacy of both children and teachers involved in using these technologies. The use of robots should be equally accessible to all children – not only in terms of physical access to the robot itself but also in terms of providing opportunities for learning and development facilitated by its use.

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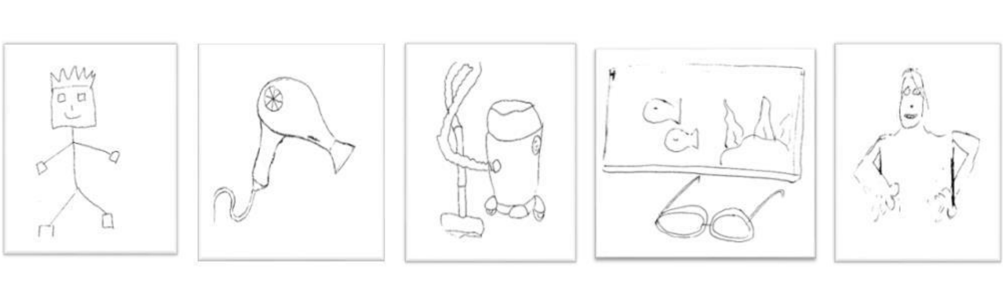
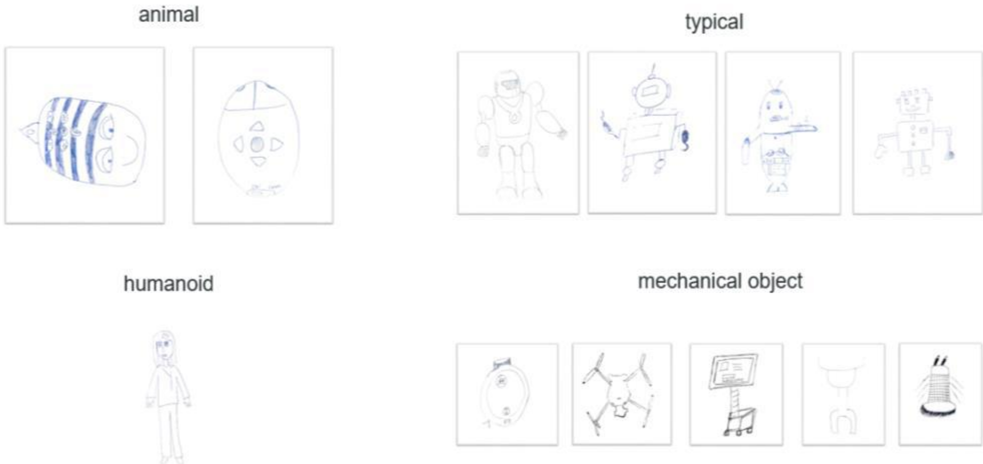
APPENDIX

Categories	Indicators
Department	1 future preschool teacher 2 future primary school teacher
Misconception	1 yes 2 no
Appearance	1 animal 2 humanoid 3 typical 4 mechanical object
Emotion	1 positive 2 negative 3 without
Location	0 Without answer 1 Home 2 Faculty 3 Kindergarten/School 4 Outdoor 5 Social places 6 Media
Experience	0 No 1 Yes from real life 2 Yes from the media
Function	1 Game 2 Educational 3 Communicative 4 Assistive 5 Other
Reason	1 Cognitive domain 2 Affective domain 3 Behavioral domain 4 It is not possible to estimate

Appendix 1. DAAT-Checklist – checklist for coding students' answers



Appendix 2. Different future students' misconceptions of robot appearance based on DAAT.



Appendix 3. Different types of robot appearances collected through DAAT.

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