OBRAZOVNA TEHNOLOGIJA

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DEVELOPMENT IN EDUCATION BY INTRODUCING HUMAN-ROBOT INTERACTION

Abstract

The main goal of this paper is to explore how robots and artificial intelligence (AI) can improve and reshape the educational environment. Specifically, it examines the interactions between humans and robots in educational settings, emphasizing the potential roles, benefits, and challenges of integrating robots into teaching and learning. As educational technology continues to advance rapidly, robots are increasingly being used as teaching assistants, peer learners, tutors, or facilitators to support student engagement, motivation, and personalized learning experiences. The paper mainly discusses the advantages and challenges of incorporating robots into educational contexts. On one hand, robots and AI systems can enhance learning outcomes by providing personalized feedback, aiding students with special educational needs, and reducing teachers' workload. On the other hand, their integration raises important concerns about ethics, data privacy, accessibility, teacher training, and the risk of overreliance on technology in classrooms. Additionally, the paper reviews existing research on the use of robots in education and highlights key findings from recent studies. Several examples of robots currently used in educational environments are discussed to illustrate practical applications. Overall,

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the paper underscores the importance of carefully addressing the challenges associated with AI and robotics in education to fully realize the benefits these technologies can offer.

Keywords: human-robot interaction, education technology, learning environments, robot-assisted learning, social robots.

Introduction

Rapid advances in educational technology over recent years have transformed how teaching and learning occur globally. With the rise of AI (artificial intelligence), the educational landscape has gained new opportunities to tailor instruction to better meet students' needs (Kamalov, Calonge, & Gurrib, 2023; Vieriu & Petrea, 2025). Information technologies, especially artificial intelligence (AI), are revolutionizing modern education. Today, learning management and training systems depend heavily on AI algorithms and educational robots to support various teaching and learning activities (Wang et al., 2024). AI mimics human cognitive processes and is defined as the capacity of machines to learn and make judgments using algorithms. In educational settings, AI is a subfield of computer science that can carry out tasks that are typically associated with human intellect, including learning, thinking, and decision-making (Garzón et al., 2025).

Students' understanding of AI and ML (machine learning) improves through hands-on robotics experience, which also fosters creativity, problem-solving, and teamwork (Karalekas, Vologiannidis, & Kalomiros,2025). To clarify the distinction between AI and ML, machine learning is a subset of artificial intelligence. Machine learning techniques enhance the optimization of AI systems, enabling real-time responses (Okagbue et al., 2023). Classroom robots have helped students engage meaningfully with technology, enhancing their social, emotional, and cognitive abilities. Robotics in education can be considered an underlying branch of robotics that focuses on teaching students to design and construct robots. To accomplish this, students must construct robots and use software to assess their capabilities (López-Belmonte et al., 2021).The use of robotics in education can be considered from two well-distinguished approaches. On the one hand, the perspective concerns the programming of devices or software; on the other, it concerns the assembly and operation of devices or hardware (López-Belmonte et al., 2021). One of the fastest-growing fields is AI integration, in which significant advances are transforming human-robot cooperation. Robots can provide more individualized experiences by adjusting to the behaviors of the people they interact with, thanks to machine learning algorithms (Han & Conti, 2025). Through human–robot interaction, jobs can be distributed between humans and robots based on their respective skills to leverage their respective advantages. For example, in human–robot collaborative assembly activities, robots can perform arduous, strength-based sub-tasks, whereas people can perform brainwork-based sub-tasks (Wang et al., 2019).

Still, the limits of human-robot interaction in educational contexts remain poorly researched. Many aspects remain unclear, underscoring the importance of further research in this area.

This paper offers insight into how robots can be used in educational settings, focusing not only on students' but also on teachers' perspectives. It explains human-robot interactions and distinguishes their main features. The paper aims to analyze the potential usage of robots in the classroom with a focus on the benefits and challenges that may arise from this type of change in the education setting.

It is essential to review the use of robots in education to better understand their role and determine the most effective ways to incorporate them as tools for an AI-enhanced learning experience. Examples from practice will be included in the research to provide a more straightforward overview of current experiences with human-robotic interactions as a path toward AI inclusion in education. The paper thus offers clear insight into the main aspects of human-robot interaction and provides a basis for future research in this field.

A scoping review is selected as the methodological approach for this paper, as the main aim is to assess the scope and key findings on the use of human-robot interaction in education. The primary focus was on studies published in the last five years, 2020-2025, with some exceptions for sources that significantly contributed to the topic in earlier years. All studies that addressed human-robot interactions but were unrelated to education were excluded. Due to the limited number of studies that address this topic, no further narrowing down of the topic was done (to a certain age group or level of education). The literature was searched using a combination of the following keywords: "AI robots", "schools", "education", "human-robot interactions", "benefits", "challenges". The primary database used for searching for sources was Google Scholar.

Usage of robotics in educational settings

Understanding how robots are used in education requires a clear look at how, where, and for whom robotic technologies are implemented. Instead of viewing educational robotics as a single, uniform phenomenon, current research shows significant differences across educational levels, pedagogical functions, and the roles assigned to robots in learning settings.

Types and Functions of Robots in Education

Recent advances in robotics have led to the development of interactive systems equipped with sensors, cameras, actuators, and expressive features such as head movements, gestures, singing, and animations (Fung et al., 2025; Almutoory & Jiang, 2025). These technological capabilities enhance human–robot interaction by making it more realistic and engaging. Although such innovations mainly originate in healthcare, customer service, and industry, their application in education reflects a growing interest in utilizing robots' strengths—such as consistency, physical stamina, and data processing—alongside human cognitive and emotional skills (Wang et al., 2019).

In educational environments, robots are primarily used as interactive learning tools, social participants, or assistive teaching agents, rather than as independent instructors. Their educational value, therefore, relies not only on their technical features but also on how effectively their functions align with learning goals.

Educational Levels and Age-Specific Applications

Research on educational robotics spans various educational levels, although the applications differ greatly across age groups. In early childhood and elementary education, robots are primarily used as social or learning companions to foster curiosity, creativity, and engagement. Social robots in these environments often encourage independence, imagination, and critical thinking while supporting social-emotional and cognitive development (Ekström & Pareto, 2022). For example, learning-by-teaching scenarios—where children teach a robot to perform tasks like playing a digital math game—have been shown to increase motivation and enhance understanding through social interaction.

In contrast, studies in higher education place greater emphasis on learning outcomes, engagement metrics, and system efficiency. Cui (2022) demonstrated that robotics-integrated learning models in higher education significantly improved student engagement, participation ratios, predictive accuracy, and learning rates. These findings suggest that, at advanced educational levels, robots are primarily valued for their capacity to support data-driven learning environments, rather than for social companionship alone.

Pedagogical Roles of Robots

Across educational levels, robots serve various pedagogical roles, including tutor, teaching assistant, peer, or learning partner. Social robots, in particular, act as embodied social beings that provide feedback, express emotions, and adapt to learners' needs (Rojas Vistorte et al., 2024). This adaptability supports personalized instruction and boosts student engagement, especially when robots are designed to respond to learners' preferences and behaviors (Fung et al., 2025).

Robots also play a key role in STEM and AI literacy education, where their physical form supports hands-on learning and visualization of abstract concepts. Their inclusion in STEM-focused curricula further emphasizes their suitability for fostering computational thinking and AI-related skills (Bellas et al., 2024).

It is important to interpret these roles of robots as an addition to the teaching process and to emphasize the role of teachers that cannot be replaced. The following group of sources addresses the academic findings on the impact of these changes on teachers and how this development can affect their roles and work.

Implications for Teachers and Instructional Practice

Despite demonstrated benefits for students, the role of teachers in robot-supported classrooms remains underexplored. Much of the existing research emphasizes child–robot interaction while marginalizing or ambiguously defining teachers' instructional roles (Hrastinski et al., 2019). However, the introduction of robots inevitably reshapes classroom dynamics and instructional responsibilities. Teachers often lack the confidence and technical expertise needed to effectively integrate robotic technologies into their teaching practices, particularly when curricular alignment is insufficiently addressed (Ekström & Pareto, 2022; Hrastinski et al., 2019). It is important to note that the role of the robots is not to replace teachers, but with strategic integration, they can lead to the best results. For example, automating routine tasks allows teachers to redirect their energy towards their core strengths, such as complex learning and building relationships with students (Mate, 2025).

This gap highlights the need for a more balanced analytical view that considers not only student outcomes but also teachers' pedagogical agency and professional preparedness. Understanding how robots can support, rather than complicate, instructional practice remains a key challenge for the successful adoption of educational robotics.

Barriers and motivators for human-robot interaction in education

Human–robot interaction in education is influenced by a complex interplay of learner characteristics, technological features, and contextual factors related to educational level and instructional design. Although the literature emphasizes the significant motivational and pedagogical potential, it also recognizes notable barriers that vary with learners ages, teachers' roles, and curricular requirements.

Individual Characteristics as Moderators of Human–Robot Interaction (HRI)

Predicting the educational impact of HRI remains difficult because students' reactions to robots vary. Personal traits, such as temperament and anxiety, significantly influence interaction quality. Children with higher levels of generalized anxiety tend to show less emotional engagement, while those with higher surgency are more likely to interact verbally with social robots (Barry, Neumann & Neumann, 2025). These findings indicate that robot-based learning environments are not universally motivating and require designs that consider learners' psychological profiles. As robotic technologies develop, it becomes increasingly important to explore how individual traits affect engagement and learning outcomes.

Technological and Ethical Barriers Across Educational Contexts

Technological limitations are among the most significant barriers to effective HRI, particularly in school settings. Chou et al. (2023) highlight poor audio quality, hardware failures, and software bugs as major obstacles to achieving natural and autonomous child–robot interactions. These problems are particularly disruptive in classrooms, where reliability is key to keeping instructional flow.

Beyond technical challenges, broader ethical and organizational issues complicate large-scale adoption. These include concerns regarding privacy, security, emotional attachment, accountability, and the potential reduction in human contact (Lampropoulos, 2025). While these issues span different educational levels, their implications vary: in primary and secondary education, ethical concerns are closely linked to child protection and emotional development, whereas in higher education, they focus more on autonomy, data governance, and institutional responsibility.

The fact that robots in education become more emotionally intelligent comes with certain repercussions related to ethical barriers. It is important to ensure that unbiased and accurate emotions are detected and that data is collected and protected accurately. Any type of manipulation represents another ethical risk (Mate, 2025).

Educational Level–Specific Benefits and Challenges

In higher education, robot-assisted instruction is valued primarily for its capacity to supplement traditional instruction and enhance engagement in structured learning environments. Evidence indicates that robot-assisted education can improve learning outcomes and participation by supporting lab work, programming lessons, and STEM activities (Chou et al., 2023; Phokoye et al., 2024). However, infrastructure barriers—such as power outages and limited access to robotic equipment—can impede sustained implementation, particularly in under-resourced institutions (Phokoye et al., 2024). These challenges emphasize the need to align robotic integration with institutional capacity and curriculum planning.

Primary and Secondary Education

In primary and secondary education, social robots are most often used to increase motivation, engagement, and skill development. Robots support language learning through conversations, pronunciation practice, and immersive scenarios, often lowering anxiety and encouraging students to communicate more (Ružić & Balaban, 2024; Newton & Newton, 2019). At the same time, some students face affective barriers, such as embarrassment or anxiety, in second-language learning, which robots may help mitigate by providing a nonjudgmental interaction partner (Newton & Newton, 2019).

However, effectively using them at these levels requires adapting the curriculum and ensuring that teachers are well prepared. Without proper instructional integration, the motivational effects of robots may only be temporary or superficial.

Special Education

Robots play an especially important role in special education, where they assist with communication, emotional regulation, and social skill development, particularly for children with autism spectrum disorder (Ružić & Balaban, 2024). As collaborative partners, robots promote social interaction, teamwork, and creativity, thereby supporting both cognitive and socioemotional development. However, extended interactions have revealed limitations in robots' social responsiveness, necessitating teacher mediation and "repair" when robots do not respond appropriately (LeTendre & Gray, 2023).

Pedagogical Roles and Teacher Implications

Across educational settings, robots serve as tutors, learning companions, telepresence tools, or instructional assistants. Humanoid robots, in particular, have been used to teach basic algorithms, support programming education, and enable remote participation for hospitalized or absent students (Tuna & Tuna, 2019). While these applications demonstrate versatility, they also modify instructional responsibilities. Teachers must manage technological limitations, integrate robots into curricula, and maintain pedagogical control, highlighting the need for professional training and curriculum alignment.

Synthesis of Benefits and Barriers

Overall, the literature emphasizes numerous benefits of educational robotics, including increased motivation, improved learning outcomes, personalized instruction, and greater inclusivity. However, these benefits are not universal and rely on learners' individual characteristics, their educational level, the reliability of the technology, and teachers' instructional roles. Therefore, understanding both the motivators and barriers is crucial for developing effective robot-supported learning environments.

Examples of Human-Robot Interaction

This section illustrates how various educational robots apply key principles of human–robot interaction to support specific learning objectives across different educational levels. Instead of isolated technological solutions, these examples demonstrate that robots function as teaching tools whose effectiveness depends on learners' ages, instructional goals, and the types of interactions they enable.

In early childhood and primary education, robots are mainly designed to support fundamental cognitive skills and early engagement through simple, intuitive interactions. For example, BeeBot, a visually appealing, bug-shaped robot, is widely used with young learners to introduce basic programming, math, and sequencing concepts. Its focus on directional language, repetition, and control aligns with teaching methods that emphasize experiential and play-based learning in early education. Similarly, LEGO Mindstorms kits are often used in primary and lower secondary education to promote problem-solving, computational thinking, and introductory programming skills across fields like robotics, computer science, and language learning. These robots demonstrate how structured interaction and hands-on manipulation support learning through active exploration.

At the secondary education level, robots increasingly facilitate more advanced interaction and abstract reasoning. Platforms like VEX IQ and the broader VEX Robotics systems are used to teach algorithmic thinking, engineering principles, and programming logic. Their integration into formal curricula and competitive robotics events encourages collaborative learning, continuous engagement, and the application of theoretical knowledge to real-world problems. These examples demonstrate how human–robot interaction can support higher-order cognitive skills when aligned with inquiry-based and project-oriented teaching approaches (Urwin, 2024).

Humanoid and social robots, such as Nao, Romibo, and Tega, are most often used in settings where social interaction and communication are key learning goals. Nao, which supports programming languages such as Python, C++, and Java, has been employed in therapeutic and educational interventions, particularly for learners who face challenges in traditional instructional environments. Its human-like design fosters social engagement, making it suitable for personalized and inclusive learning situations (Pai et al., 2024). Romibo also facilitates educational interaction through movement, gestures, and speech, with remote-control features that enable teachers to adjust the robot's behavior to meet instructional needs.

Tega, developed by the Personal Robots Group at MIT, illustrates the role of social robots in language learning and engagement-based instruction. Its expressive design encourages children to participate in educational activities, especially in second-language learning settings where emotional factors like anxiety and motivation are vital (Urwin, 2024). These social robots highlight the importance of emotional and communicative aspects of human–robot interactions, particularly in early and special education contexts.

Across all examples, the role of the teacher remains central. Teachers are responsible for selecting appropriate robotic tools, setting learning objectives, and guiding interactions to ensure that technology supports, rather than distracts from, educational goals. Collectively, these cases show that educational robots do not function as standalone solutions but rather as components of instructional systems shaped by curricular needs, student characteristics, and teacher expertise.

Table 1

Summary of the sources

Authors	**Robot**	**Educational level (age group)**	**Context**	**Key Findings**
Barry, Neumann & Neumann (2025)	Social robots	Primary education	Engagement, emotional interaction	Learner temperament moderates human-robot interaction outcomes, higher anxiety linked to lower emotional engagement, and high surgency linked to increase verbal interaction
Chou et al. (2023)	Educational robots	High education	General instructions, human-robot interactions implementation	Robot-assisted education enhanced learning support, but technical issues limited natural interaction
Lampropoulos (2025)	AI- enabled educational robots	Cross-level	Ethical and organizational dimensions	Identified ethical challenges, including privacy, attachment, accountability, and reduced human contact, emphasized contextual dependency

Ružić & Balaban (2024).	Social robots	Primary and secondary education	Language learning, individualized instruction	Robots supported vocabulary development, pronunciation, motivation, and individualized feedback, and increased inclusivity
Phokoye et al. (2024).	Robot-based learning platform	Higher-education, undergraduate students	Programming, STEM, laboratory work	Improved programming comprehension and lab attendance, infrastructural barriers
Newton & Newton (2019).	Social robots	Primary and secondary education	Second-language learning	Robots reduced anxiety and affective barriers, supported balanced communication, and learner initiative
LaTendre & Gray (2023).	Social robots	Lower secondary educations	Social and cognitive development	Limited robot social capacity observing during prolonged interaction, teachers are required to mediate and repair interactions

Pai et al. (2024).	LEGO Mindstorms, BeeBot	Primary and lower secondary education	Robotics, computer science, basic programming, and mathematics.	Significance for problem-solving skills and interdisciplinary learning, improved sequencing, and early coding skills through play-based learning
Urwin (2024).	VEX, Tega	Early and primary to secondary education	Basic programming and mathematics, STEM, and engineering	Improved sequencing, directional language, and early coding skills through play-based learning. Increased engagement, teamwork, and application of STEM knowledge in competitive and curricular settings
Tuna & Tuna (2019).	Humanoid robots	Primary to secondary education, hospitalized students	Algorithms, online presence	Supported algorithm learning and enabled remote participation, maintaining instructional continuity

Cui (2022).	Robotics-enhanced learning systems	Higher education	Student engagement, learning outcomes	Robotics-enhanced models improved engagement, interaction, prediction accuracy, and learning rates
Bellas et al. (2024).	Educational robots for AI literacy	Secondary education	STEM, AI literacy	Robots effectively supported AI and computational thinking instruction through embodied learning
Fung et al. (2025).	Interactive social robots	Primary and secondary education	Engagement and adaptive learning	Expressive robot features increased engagement and supports adaptive individualized instruction
Hrastinski et al. (2019).	Educational robots	Primary education	Teacher-robot interaction	Teacher roles are often not defined sufficiently, lack of pedagogical integration limits effectiveness
Ekström & Pareto (2022).	Social robots	Primary education	Learning by teaching, social interaction	Robots acting as tutees enhanced motivation and learning through social interaction
Wang et al. (2019).	Collaborative robots	Cross-domain (applied to education)	Human- robot interaction	Human comfort and task allocation are critical for effective collaboration

Mate (2025).	Educational robots	Primary and secondary education	Overview of the significant topics related to integration of robots	The major benefits and limitations included in the publication

Emerging trends

Recent research from 2025–2026 reveals significant shifts in how social robots are developed and utilized in education. A major trend is the growing integration of large language models (LLMs) and advanced generative AI into social robotics platforms. Studies are beginning to explore how robots powered by LLMs can enable more natural, smooth, and interactive conversations, which is vital for advancing human–robot interaction beyond basic pre-programmed scripts. For example, research on combining LLMs with robotic systems offers technical frameworks for creating more context-aware and personalized dialogue, illustrating how LLMs can support richer interaction styles suitable for educational environments (Rodríguez Lera et al., 2025; Garello et al., 2025).

Table 2 highlights key emerging trends in educational robotics research published between 2025 and 2026, focusing on the integration of generative AI and large language models, the expansion of longitudinal research designs, and increased inclusion of adolescent and secondary-school students. The studies summarized in the table show a shift from short-term, task-specific robot applications toward more adaptive, conversational, and context-aware social robots.

Across the reviewed literature, recent work increasingly investigates the use of LLM-enhanced robots, such as NAO and other social robotic platforms, to facilitate interactive dialogue, knowledge retrieval, and adaptive tutoring. Importantly, the table highlights a methodological shift toward longitudinal designs, particularly in higher education, to capture sustained engagement and interaction patterns over time.

Table 2

Recent studies overview

Authors	Robot	Educational level	Focus	Empirical evidence
Fragakis et al. (2025).	NAO and LLM	Primary education	Knowledge retrieval, engagement	Pilot study

Donnermann et al. (2025),	Social robot	Higher education	Longitudinal human-robot interactions	Long-term deployment
Rodríguez Lera et al. (2025).	LLM	Adolescents	Dialog and personalization	Conceptual study
Garello et al. (2025).	Social robot and LLM	Secondary education	Adaptive tutoring and contextual reasoning	System design and simulation
Latif, Liu, & Zhai (2026).	Intelligent & robot tutoring systems	Secondary & higher education	Personalized learning and AI-driven tutoring	Systematic review

Overall, the studies included in this table show how modern research is shifting toward AI-driven personalization and wider educational relevance. However, they also reveal that much of the 2025–2026 literature remains exploratory, with limited reporting of effect sizes or comparable outcome measures. This justifies presenting these studies separately as emerging trends rather than including them in the main comparative table.

Conclusion

This paper explored human–robot interaction in educational settings by synthesizing evidence of its potential to motivate students and its practical, ethical, and technological limits. Drawing on recent empirical studies from various educational contexts, the review shows that robots can effectively support learning by boosting student motivation and engagement, personalizing instruction, and, in some cases, enhancing learning outcomes. However, the analysis also highlights that these benefits vary and depend on learners' age, personal traits, educational level, and the specific roles assigned to robots.

A key contribution of this paper is its integrated approach to benefits and barriers. Instead of viewing educational robotics as inherently transformative, the findings show that technical limitations, ethical issues, infrastructure challenges, and teacher preparedness all influence the success of human–robot interaction. Examples from higher education, primary and secondary schools, and special education illustrate that the educational value of robots depends on how well they align with curriculum goals and their ability to support, rather than replace, human teaching.

Notably, the reviewed research provides solid evidence on how robots are used in education today—especially for enhancing engagement, language learning, personalized teaching, and inclusive education. Conversely, claims about the broader transformative impact of robots and AI on educational systems are largely speculative and lack substantial long-term evidence. Existing studies often have limitations, including short intervention periods, small sample sizes, and a primary focus on student outcomes, with less emphasis on teachers' roles or institutional challenges.

These limitations point to several possibilities for future research. Future studies should employ longitudinal designs to assess the long-term effects of human–robot interaction on learning and development, explicitly compare outcomes across educational levels, and examine how teachers integrate robotic technology into daily teaching routines. Moreover, greater attention should be paid to ethical considerations, accessibility, and infrastructure challenges to ensure that educational robotics promotes equitable and sustainable innovation.

Based on the reviewed literature and recent advances in educational robotics, several practical recommendations can be made to support the effective and responsible integration of social robots and AI in classroom settings. First, educators should view educational robots as teaching tools rather than replacements for human teachers. Evidence from studies across various educational levels shows that robots are most effective when they supplement existing teaching methods, such as supporting individualized instruction, facilitating small-group activities, or providing extra practice opportunities, while teachers remain responsible for learning objectives, classroom management, and assessment. Second, the selection of robots and the design of instruction should be customized to learners' age and developmental stage. Research indicates that younger students benefit from simple, embodied interactions that promote engagement and basic cognitive skills, whereas adolescents and older students need more advanced, dialogue-based, and goal-oriented interactions. Therefore, educators are encouraged to match robotic features with students' social, emotional, and cognitive development, especially in secondary education, where independence and motivation are particularly crucial.

Third, educators must be prepared to address the social and emotional aspects of human-robot interaction. While social robots can reduce fear, encourage engagement, and create a nonjudgmental learning environment, extended interactions might lead to issues such as overreliance, limited peer interaction, and false expectations about robot capabilities. To ensure robots support meaningful human interaction in the classroom rather than replace it, active teacher mediation is essential.

Finally, professional development and training are essential. Many studies highlight that teachers often lack confidence and technical skills in using robotic devices. Therefore, in addition to technical procedures, ongoing training should encompass pedagogical integration, ethical considerations, and classroom management techniques to support effective human-robot collaboration.

In conclusion, human–robot interaction has great potential to improve educational practices, but its effects should be viewed as context-dependent rather than universally transformative. By clarifying both the opportunities and limitations of educational robotics, this paper helps build a more detailed understanding of how robots and AI can be responsibly and meaningfully integrated into future learning environments.

RAZVOJ U OBRAZOVANJU UVOĐENJEM INTERAKCIJE ČOVEK-ROBOT

Rezime

Usled razvoja digitalnih alatki brojne sfere doživljavaju svoju transformaciju. Ujedno sve češće se identifikuje potreba da se nastava unapredi da bolje odgovara potrebama učenika koje takođe doživljavaju ubrzane promene. U skladu sa tim se na polju digitalizacije traga za rešenjima sa polja digitalizacije koja mogu da doprinesu da se nastava poboljša i ostvare željeni rezultati.

Posledično, sa utvrđivanjem značaja teme, rad se bavi upotrebom robota u nastavi kao načinom za poboljšanje procesa učenja i boljeg odgovora na potrebe učenika. Fokus je stavljen na upotrebu robota u obrazovanju. Navodi se da se generalna dostignuća robota mogu primeniti na polje obrazovanja. Posebno se ističe da roboti imaju široku primenu u obrazovanju i da se koriste na širokoj populaciji što uključuje različite demografske profile i potencijalne smetnje u razvoju koje se mogu javiti kod dece. Polazeći od razvoja veštačke inteligencije i uticaja koji to ima na samu nastavu rad daje uvid u upotrebu robota, koji se sada uz razvoj veštačke inteligencije mogu značajno više upotrebljavati u nastavi. Da bi se roboti uključili na pravi način u nastavu, potrebno je da se sagledaju prepreke i prednosti uključivanja robota u nastavu. Rad daje uvid u ova pitanja. Zasnovan na pregledu postojeće literature, rad ukazuje na najznačajnije aspekte ove teme, dajući osnovu za dalje istraživanje uloge koju uključivanje robota podržanih mogućnostima koje nudi veštačka inteligencija ima za dalji razvoj obrazovanja.

Ovaj rad nudi uvid u to kako se roboti mogu koristiti u obrazovnom okruženju, fokusirajući se ne samo na perspektive učenika već i na perspektive nastavnika. Objašnjava interakcije između učenika i robota i razlikuje njihove glavne karakteristike. Cilj rada je da istakne potencijalne koristi i izazove koji se mogu pojaviti prilikom uvođenja robota u nastavu. Od velike je važnosti preispitati upotrebu robota u obrazovanju kako bi se bolje razumela njihova uloga i odredio najbolji način da se uključe kao alati za iskustvo učenja poboljšano veštačkom inteligencijom. Primeri iz prakse su uključeni u istraživanje kako bi se pružio jednostavniji pregled trenutnih iskustava sa interakcijama između čoveka

i robota kao putem ka uključivanju veštačke inteligencije u obrazovanje. Rad stoga nudi jasan uvid u glavne aspekte interakcije između čoveka i robota i pruža osnovu za buduća istraživanja u ovoj oblasti.

U radu se ukazuje na povećano angažovanje i aktivno učešće učenika u nastavi onda kada su u nastavu uključeni roboti, kao i široki spektar načina njihove upotrebe. Uloga robota u nastavi povezuje se i sa razvojem praktičnih veština. Među prednostima do kojih dovodi korišćenje robota navodi se i fleksibilnije okruženje za učenje, sticanje veština 21.veka, poboljšane komunikacione sposobnosti, veći stepen jednakosti i razumevanje kompleksnih programa. Ističe se da je od značaja i podrška na polju specijalnog obrazovanja. Postojeća literatura ističe niz prednosti. Ove prednosti poboljšavaju motivaciju učenika, ishode učenja i celokupno iskustvo učenja. Ono što treba uzeti u obzir su potencijalne prepreke i individualne karakteristike učenika koje mogu značajno uticati na ishode uvođenja ovih inovativnih pristupa učenju.

Takođe, u literaturi se ističu i različiti načini upotrebe robota u nastavi što predstavlja jednu od značajnih prednosti uvođenja ove novine u nastavu. Kao značajnu prednost robota do sada sprovedena istraživanja navode mogućnost prilagođavanja potrebama učenika koje nertko mogu biti raznolike. Roboti preuzimaju i različite uloge što povećava broj benefita. Roboti se mogu koristiti u nastavi kaopartneri za učenje ili kao nastavnici kada je to potrebno, predavači ili ispitivači.Upotreba robota, dodatno se ističe dovodi do potrebe usklađivanja nastavnog plana i programa. Izazovi se u tom pogledu javljaju usled nedostatka iskustva nastavnika.

Još jedno od pitanja koje je detaljno analizirano u radu su i barijere podsticaji za uključivanje robota u nastavu. Tehnološki aspekti su prepoznati kao potencijalne barijere za primenu robota u nastavi. Finansijski i logistički aspekti su takođe od značaja. Prepreke su vezane za lične karakteristike učenika, tehničke nedostatke koji sprečavaju da se roboti uključe u nastavu i izazove za nastavnike koji mogu otežati njihovu primenu. Potrebno je uskladiti postojeći plan i program sa uvođenjem napredne tehnologije poput robota i veštačke inteligencije.

Isitče se posebno kao prednost od posebnog značaja da roboti doprinose timskom radu, razvoju socijalnih veština, kritičkom razmišljanju i kreativnosti. Zbog toga se barijere prihvataju, ali se teži njihovom prevazilaženju umesto odbacivanju ovog koncepta.

Kroz sagledavanje praktične strane zaključuje se da primeri robota pokazuju da svaki nudi slično, ali jedinstveno iskustvo za svoje korisnike. Nastavnici imaju aktivnu ulogu u izboru i korišćenju robota kako bi obezbedili najbolji mogući oblik interakcije između čoveka i robota koji odgovara potrebama učenika.

Rad obuhvata neke zanimljive aspekte interakcije čoveka i robota u obrazovnom kontekstu. Prvi zaključak je da interakcija čoveka i robota može imati, i počinje da ima, vitalnu ulogu u obrazovnom kontekstu. Sa razvojem veštačke inteligencije, roboti će dobiti više prostora u organizaciji učionice, što *će na kraju preoblikovati obrazovno okruženje, uz druge promene koje se dešavaju istovremeno. Prednosti se odnose na kritične aspekte procesa učenja, uključujući motivaciju, angažovanje, personalizovano učenje i ishode učenja. Analiza postojećih primera i prepreka pruža jasan uvid u to kako roboti interaguju u kontekstu učionice i u kom pravcu treba razvijati ove interakcije. Utvrđene prepreke treba posmatrati kao oblasti koje zahtevaju dalja poboljšanja i prilagođavanja kako bi se omogućila šira upotreba robota koje podržava veštačka inteligencija u obrazovanju, sa manje problema koje treba rešiti tokom tog procesa. Uprkos nekim nedostacima povezanim sa uključivanjem interakcije čoveka i robota u obrazovno okruženje, ova interakcija nudi brojne prednosti. Istraživanja pokazuju kako društveni roboti značajno utiču na različite obrazovne kontekste i kako mogu pomoći nastavnicima i učenicima. Njihova fleksibilnost im omogućava da prilagode interakcije potrebama svakog učenika, procene veštine i pruže individualizovani sadržaj, povratne informacije i podršku u nastavi.*

Zaključuje se da je potrebno prevazići prepreke koje se javljaju u primeni robota u nastavi kako bi se ostvarili brojni benefiti koji su sve značajniji kako se tehnologija i mogućnosti veštačke inteligencije razvijaju. Buduća istraživanja trebalo bi da budu usmerena na praktičnu primenu i iskustva učenika.

Ključne reči: interakcija čoveka i robota, obrazovna tehnologija, okruženje za učenje, učenje uz podršku robota, socijalni roboti-

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