
THE ADOPTION FACTORS OF EDUCATIONAL HUMANOID ROBOTS: THE CASE OF CROATIAN SECONDARY SCHOOL TEACHERS

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Abstract

Humanoid robots are, to an increasing extent, being used in education. Due to the sensors, actuators, cameras, speakers, and special programs that are the leading equipment of most educational humanoid robots, teachers are enabled to create a more personalized learning environment, which can improve the quality of teaching and increase the involvement of pupils in the teaching process. Implementing educational humanoid robots in classes depends on teachers' acceptance of this innovative technology. This study investigated the perception of secondary school teachers on the benefits and challenges of using educational humanoid robots in their teaching processes as factors that can influence their adoption of this innovative technology. In this regard, a survey was conducted among 154 Croatian high school teachers, almost all of whom were not users of educational humanoid robots in the teaching process. The results of the study conducted in this paper can contribute to understanding the adoption factors of educational humanoid robots by secondary school teachers and develop strategies for implementing this innovative educational technology.

Keywords:

Educational humanoid robots, adoption, benefits, challenges, secondary teachers, Croatian

Introduction

In general, humanoid robots can perform certain pre-programmed activities, communicate with humans, and receive commands from their users. From a technical point of view, this type of robot is equipped with sensors, speakers, cameras, and actuators and very often has the shape of a human body. Several categories of these robots on the market today are designed for specific areas of activity, for example, humanoid healthcare robots, social humanoid robots, and educational humanoid robots. (Choudhury et al., 2018). Today, humanoid robots with social skills have been used in different fields of education, such as foreign language education, science education, and special education (Sisman et al., 2019). As an example, Pepper and NAO are humanoid robots designed to interact with humans used in education, healthcare, and research and can perform multiple actions. Compared to other educational technologies, the key advantage of humanoid robots in teaching is their social and physical presence and individual teaching capabilities, which can improve learning outcomes (Belpaeme and Tanaka, 2021). Ekström and Pareto (2022) emphasize that educational humanoid robots are didactic tools and social actors because they can "add social interaction" to the educational environment. Implementing robotics-based activities in the teaching process can enable teachers to apply constructivism, constructionism, and inquiry-based learning that include collaboration, creative thinking and problem solving, and active learning to improve teaching and learning (Chalmers et al., 2021). Considering the complexity of implementing educational humanoid robots in classes, Mishra et al. (2021) proposed a multidisciplinary framework for the use of humanoid robots in an educational environment that integrates the following four perspectives: (1) technological (human-robot interaction); (2) pedagogical/didactic, (3) effectiveness of humanoid robots (psycho-social); (4) ethical implications of using humanoid robots. Researchers in this field have identified numerous benefits and challenges of using humanoid robots as teaching and learning assistants. The results of qualitative research conducted by Ahmad et al. (2016) show that language teachers in primary and secondary schools, after using the NAO robot, perceived that the NAO robot could be helpful in language teaching due to its ability to answer frequently asked questions in class, the possibility of monitoring the child's memory, the ability to adapt to the child's personality and emotions in real-time, and the possibility of adapting to different cultures. The authors also concluded that a user interface design that is easy to update with new lessons would be a factor that would make it easier for teachers to use the NAO robot in the classroom. After testing the robot Pepper as a storyteller in a real context in two modalities, De Carolis et al. (2021) concluded that the synthesized voice of the robot, in combination with non-verbal behavior, had a more

positive effect on the emotional experience of children (from 8 to 9 years) and creating the impression of easier learning compared to the first modality, when a human voice narrated the story. Pepper played "only the role of a device", i.e. when the robot was a kind of audiobook. In the example of the use of the NAO robot as a teaching assistant in primary school, the results of Mubin et al. (2019) found that the children were more active in class, but there was no significant difference in test scores. Furthermore, Karakosta et al. (2019) found that the robot Kaspar positively impacted children diagnosed with autism spectrum disorder behaviors in specific domains such as communication and interaction, prompted speech, unprompted imitation, and focus/attention. According to Sisman et al. (2019), students' attitudes towards using humanoid robots in an educational environment are influenced by their perceptions of enjoyment, anxiety, and engagement. Alhashmi et al. (2021) found that teachers expressed concern and desire for ease of use of robots in class, while students expressed satisfaction with using humanoid robots as co-teachers in class. The results of the research conducted by Woo et al. (2021), in a sample of studies between 2000 and 2020 that examined social robots in classrooms, show that there is no solid evidence that social robots are more operative than human teachers. Until then, there has been very little research on ethical and safety issues. Furthermore, Fridin and Belokopytov (2014) determined that teachers' intention to use NAO robots in teaching is strongly influenced by their perceived usefulness. Therefore, as already mentioned in this paper, the results of numerous studies have shown that teachers perceive numerous benefits of using humanoid robots as assistants in learning and teaching; for example, it helps in the development of communication skills and the development of teamwork skills (Burbaite et al., 2013; Fridin and Belokopytov, 2014; Khanlari, 2015; Chevalier et al., 2016), students are more creative, it stimulates good emotions, the robot is easy to use (Fridin and Belokopytov, 2014; Reich-Stiebert and Eyssel, 2016), improves students' interpersonal skills (Khanlari, 2015), develops logical and creative thinking (Chevalier et al., 2016), robots bring added value in education, increase student activity in classes, increase student motivation (Burbaite et al., 2013; Reich-Stiebert and Eyssel, 2016), encourage innovative pedagogical practices and can facilitate the education of students who encounter difficulties during the regular curriculum (Kradolfer et al., 2014). Also, research has shown that teachers perceive significant technical, economic, and logistical challenges to introducing humanoid robots into teaching (Belpaeme and Tanaka, 2021). In this regard, as an example, teachers perceive a lack of time to start the robotic activity during the lesson, inadequate access to supporting materials, lack of technical and teaching support, and lack of technical and pedagogical knowledge (Burbaite et al., 2013; Almisis, 2013; Kradolfer et al., 2014). Based on the experience of implementing a NAO robot in an elementary school, Gaber (2021) concludes that the main challenge for implementing a NAO robot in the classroom is its cost (e.g. a NAO robot costs between 8000 and 16000 USD) and the additional cost for the professional training of the user of the educational humanoid robot. Also, the author points out that there is a need to research challenges related to the implementation of educational humanoid robots in classrooms, which relate to problems such as safety and the need for professional training of teachers. In general, the results of the research by Babić et al. (2020) showed that Croatian high school teachers' intentions to use information and communication technologies (ICT) in their teaching are influenced by their attitudes and perceptions of educational values, computer anxiety, self-efficacy, subject characteristics, previous experience with ICT, technical and pedagogical education, and use of ICT. Based on the theoretical research, it is evident that there was a justified need to conduct research in this context in different educational environments. In the continuation of the paper, the methodology of the conducted research and the key findings of the conducted research are described. In the end, the most important conclusions of this work are given. It is essential to emphasize that almost all respondents were non-users of a humanoid robot in the teaching process.

Methodology

This paper examines Croatian secondary teachers' opinions about the benefits and challenges of using humanoid robots in teaching and identifies the adoption factors. Based on a voluntary and anonymous approach, the research was conducted from May to June 2021 for the master thesis of the co-author of this paper (Lenić, 2021). The questionnaire was created using an online Google Forms questionnaire forwarded to the Croatian Facebook group "School Staff Room", WhatsApp and Viber. Some secondary school principals distributed the questionnaire by e-mail or posted it in virtual groups (e.g., Yammer). A new questionnaire containing 37 closed questions was created for this research. Answers to 13 questions related to adoption factors of humanoid robots are modulated on five points Likert scale (1 = completely false; 2 = mostly false; 3 = neither true nor false; 4 = mostly true; 5 = completely correct). Some items in this questionnaire have been adapted from unified theory of acceptance and use of technology - UTAUT (Venkatesh et al., 2003), then some items are defined according to the researched literature (Almisis, 2013; Burbaite et al., 2013; Fridin and Belokopytov, 2014; Kradolfer et al., 2014; Khanlari, 2015; Chevalier et al., 2016). In this research paper, only the selected results of the conducted study (Lenić, 2021) are presented.

Results and Discussion

Participants

A total of 154 respondents (Croatian secondary school teachers) participated in the research (75.97% women and 24.03% men). Most respondents were between 31 and 40 years old (29.9%), followed by those between 41 and 50 years old (26.6%), between 51 and 60 years old (24.7%), 5.8% of them were under 30 years old, while 4.5% of them were over 60 years old. Most respondents had completed higher education (75.3%), higher vocational education (14.3%), and slightly fewer respondents (10.4%) had secondary vocational education. As for the subject area, most respondents were teachers from scientific-mathematical and professional fields (56.5%), social-humanities (19.5%), language-communication (13.6%), IT-technical occupations (6.5%), art (1.9%) and other fields (1.9%). Most respondents had between 21 and 30 years of teaching experience (28%), between 4 and 10 years (27%), between 11 and 20 years (25%), less than three years (14%), and 6% of them had 30 years or more of teaching experience. Most respondents were teachers working in vocational schools (96.02%), while 27.90% worked in grammar schools and 4.5% in other schools. The results of processing the collected data show that the most significant number of respondents never used educational robots in class (92.2%), and 90.3% of them did not attend any form of education, nor did they educate themselves on the topic of using educational humanoid robots in the teaching process. Most respondents self-assess their knowledge about using humanoid robots in the teaching process as insufficient (44.2%) and sufficient (39.6%). In comparison, 16.2% state that they know more about educational humanoid robots.

Findings

The results of the analysis of the data collected in this research on the factors of acceptance of educational humanoid robots by Croatian secondary school teachers are divided into benefits and challenges, which are shown in Figure 1 and Figure 2. A 5-point Likert scale was used to measure the items shown in the mentioned figures.

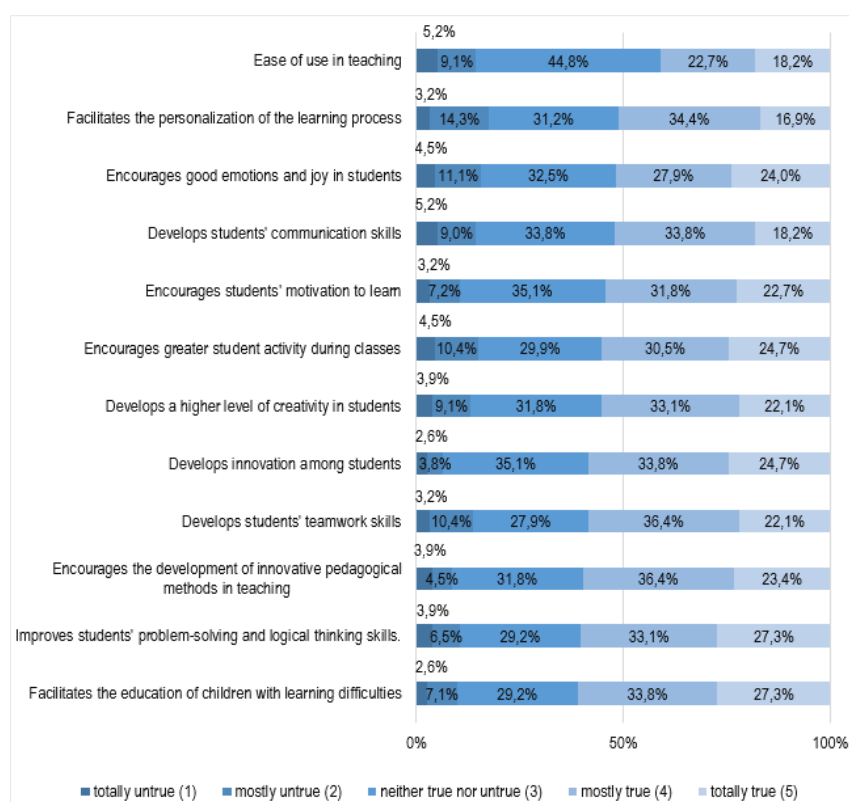


Figure 1. Respondent response percentage for the samples of Croatian secondary school teachers (N = 154) concerning their perceived benefits of educational humanoid robots (according to Lenić, 2021)

As can be seen in Figure 1, most participants (61.1%) in this study believe that the use of educational humanoid robots helps facilitate the education of children with learning disabilities, and 60.4% of them think that this innovation in teaching can improve students' problem-solving and logical thinking skills (60.4%), developing students'

innovation (58.5%), and that improve pupils' teamwork skills (58.5%). Furthermore, the results show (Figure 1) that 59.8% of the participants agreed with the statement that the use of humanoid robots as teaching and learning assistants encourages the development of innovative pedagogical methods in the teaching of high school teachers. Arithmetic means (shown in Figure 1) indicate that 55.2% of participants consider that robots can encourage more excellent student activity during classes and develops a higher level of creativity in students, and 54.5% of them think that humanoid robot as teaching and learning assistants encourage students' motivation to learn. The results of the collected data (Figure 1) showed that only half of the participants generally agreed that the use of a humanoid robot in class could develop students' communication skills (52%), facilitates the personalization of the learning process (51.3%), encourage good emotions and joy in students (51.09%). Interestingly, almost one-third of respondents could not decide in response to all the statements presented in Figure 1. Most of them, 44.8%, were undecided in response to the statement about the ease of using an educational humanoid robot. This is confirmed by the result of the arithmetic means ($M=3.40$, $SD=1.08$), which indicates that the participants were, on average undecided. In addition, from the results given in Figure 1, it is evident that the most significant number of respondents do not agree that the use of humanoid robots as assistants in teaching and learning in the classroom facilitates the personalization of the learning process (17.5%), they encourage good emotions and joy by students (15.5%), promote more significant student activity during class (14.9%).

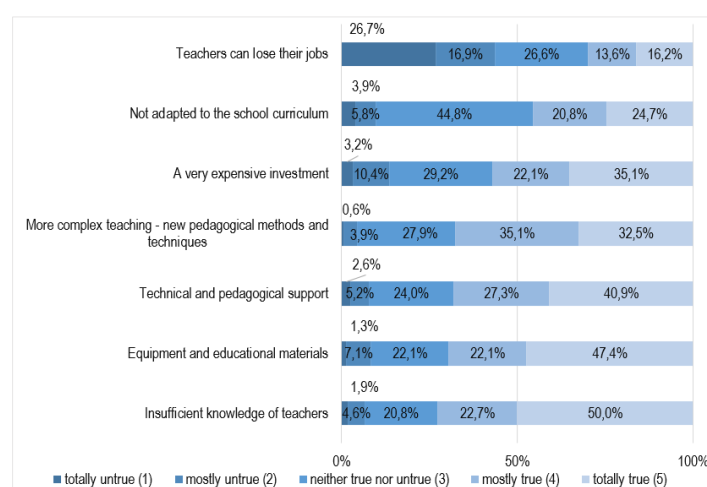


Figure 2. Respondent response percentage for the samples of Croatian secondary school teachers ($N = 154$) concerning their perceived challenges of educational humanoid robots (according to Lenić, 2021)

The results presented in Figure 2 show that the majority of respondents (72.7%) believe that high school teachers do not have enough knowledge to use humanoid robots in class, 69.5% of them believe that they do not have adequate equipment and educational materials and that they do not have technical and pedagogical support for the use of humanoid robots in teaching (68.2%). Also, most Croatian secondary teachers (67.6%) believe that teaching with educational robots would be more complex, considering the use of new pedagogical methods and techniques. The arithmetic mean ($M=3.75$, $SD=1.18$) shows that, on average, the respondents agree that using humanoid robots in teaching is a costly investment (57.1%). Only slightly less than half of the respondents (45.5%) agreed with the statement that the use of humanoid robots in classes "is not adapted to the school curriculum". In comparison, 44.8% of them remained undecided, and only 9.7% of the participants believed that this item was "mostly untrue" and/or "totally untrue". Then, 43.5% of respondents believe they cannot lose their jobs if humanoid robots are used as assistants in teaching and learning. In comparison, almost a third of respondents (29.8%) believe that implementing humanoid robots in education may result in losing a teaching job, and 26.6% of them were undecided (see Figure 2). On average, the Croatian high school teachers who participated in this research ($M=3.54$; $SD=1.28$) stated that they intend to use educational humanoid robots in the near future if they can do so. In this regard, 53.3% of them agreed that in the near future, they intend to use a humanoid robot as an assistant in teaching and learning. In comparison, 27.9% were undecided, and only 18.8% did not declare their intention to use a humanoid robot in their teaching.

Limitations of the Study

The limitations of this study are reflected in the number of research participants and the number of adoption factors. For the sake of generalization, research based on our findings should be carried out in the whole country (national

pilot study), as well as in an international context, to determine the difference in the perception of secondary school teachers about the advantages and disadvantages of this innovative educational technology in different educational settings, especially, considering different educational areas. The number of adoption factors should be expanded, with other factors related to its cost of implementation in the educational context and secondary school teachers' competencies for using humanoid robots in teaching. Despite the limitations, the findings offer an understanding of specific benefits, challenges, and recommendations for better understanding the determinants of acceptance of humanoid robots in secondary education.

Recommendations

Our findings can help researchers as a foundation for future research and all practitioners who want to develop strategies for implementing humanoid robots in educational environments. Based on the results of this study, below are the requirements when deciding on the wider implementation of humanoid robots in Croatian secondary education:

- Pedagogical and technical training of secondary teachers
- Technical and pedagogical support
- Defining the role of the humanoid robot in the teaching process so that teachers can be sure that their jobs are not threatened
- Defining the educational values of humanoid robots so that secondary school teachers develop a positive attitude towards their use
- Extra funding would be required - educational humanoid robots, educational materials, professional training for all stakeholders
- Development of innovative pedagogical methods and techniques for implementing humanoid robots in teaching.

Conclusion

Humanoid robots as assistants in teaching and learning are innovative educational technologies in education. It takes time for them to be accepted by all stakeholders of the educational process; among them is the key role of the teacher. In this paper, the factors of adoption of educational humanoid robots in classes by Croatian high school teachers were specifically investigated, and 92.2% of them stated that they were not users of this innovation. Furthermore, 83.8% of respondents said that they do not know how to use educational humanoid robots in class. Moreover, the collected data results show that Croatian secondary school teachers perceive the advantages and challenges of using humanoid robots in teaching. For example, 61.1% of participants believe that a humanoid robot can facilitate the education of children with learning difficulties. This is consistent with the results of other studies mentioned in this paper. Also, it should be emphasized that almost a third of Croatian high school teachers hesitated in their answers to statements related to the perception of the educational value of humanoid robots in class, which can be connected to their lack of knowledge of this innovative educational technology. The intention to use humanoid robots in courses in the near future was expressed by slightly more than half of the respondents (53.3%), while 27.9% could not decide. And finally, the research results showed a need to develop strategies for training secondary school teachers to use educational humanoid robots.

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