Implementing Educational Humanoid Robots in Croatian Secondary Schools: Potential Challenges and Benefits

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Abstract. *In this study, we have examined secondary school teachers' perceptions about the benefits and challenges of using educational humanoid robots in their teaching processes and their connection with the subject fields. In this regard, a survey was conducted among 154 Croatian secondary school teachers, almost none of whom were users of educational humanoid robots in the teaching process. The results of the research presented in this paper can contribute to understanding the factors of adopting educational humanoid robots by secondary school teachers and developing strategies for implementing this innovative educational technology.*

Keywords. educational humanoid robots, adoption, benefits, challenges, secondary school teachers, Croatian

1 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). Nowadays, 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). 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) have 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. Since the implementation of humanoid robots in the teaching process depends on teachers' acceptance of this innovative technology, there is a need for research in this area in different educational contexts. This paper examines the teachers' perception of the benefits and challenges of using educational humanoid robots in Croatian secondary schools.

2 Literature Review

The results of qualitative research conducted by Ahmad et al. (2016) show that language teachers in primary and secondary schools, after using a NAO robot, perceived that a 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 have 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) have concluded

that the synthesized voice of the robot, in combination with non-verbal behavior, has a more positive effect on the emotional experience of children (from 8 to 9 years of age) by creating the impression of a more accessible 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 a NAO robot as a teaching assistant in a primary school, the results of Mubin et al. (2019) have found that the children have shown more activity in class, but with no significant difference in test scores. Furthermore, Karakosta et al. (2019) have found that the robot Kaspar has had a positive impact on 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 toward using humanoid robots in an educational environment are influenced by their perceptions of enjoyment, anxiety, and engagement. Alhashmi et al. (2021) have found that teachers have expressed concern and desire for ease of use of robots in class, while students have 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, which examined social robots in classrooms, have shown that there is no solid evidence that social robots are more operative than human teachers. Prior to the aforementioned research, there had been very little research on the ethical and safety issues. Furthermore, Fridin and Belokopytov (2014) have found that teachers' intention to use NAO robots in teaching is strongly influenced by their perceived usefulness.

Therefore, as previously mentioned in this paper, the results of numerous studies have shown that teachers perceive multiple 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), it develops logical and creative thinking (Chevalier et al., 2016), robots bring added value to education, increase student activity in class, increase student motivation (Burbaite et al., 2013; Reich-Stiebert and Eyssel, 2016), encourage innovative pedagogical practices and can facilitate the education of students that 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) has concluded 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. Fox and Gambino (2021) emphasize that humanoid social robots in education are limited in the tasks for which they are programmed. They are thus limited in their ability to personalize; for example, most of the humanoid social robots have a small set of possible responses, cannot identify or differentiate between different users and have minimal conversational control. Based on the theoretical research, it is evident that there has been a justified need to conduct research in this context in different educational environments. In the continuation of this paper, the methodology of the conducted research and the key findings of the conducted study are described. Lastly, the most important conclusions of this work are given. It is essential to emphasize that almost all of the respondents were non-users of a humanoid robot in the teaching process.

3 Methodology

This paper focuses on the perceived benefits and challenges of using educational humanoid robots in the classroom by Croatian secondary school teachers to improve understanding of the adoption factors of this innovative technology. In this regard, the research questions are:

1. *What benefits and challenges of using educational humanoid robots in teaching do Croatian secondary school teachers see?*
2. *How do teachers see the benefits and challenges of using educational humanoid robots depending on the subject fields?*

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 via 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 the adoption factors of humanoid robots are modulated on

a five-point 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 the unified theory of acceptance and use of technology - UTAUT (Venkatesh et al., 2003), while some items are defined according to the researched literature (Alimisis, 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.

4 Results and Discussion

4.1 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%), and those 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 higher education (75.3%), followed by 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%), followed by 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%), followed by those between 4 and 10 years (27%), and between 11 and 20 years (25%), while 14% had less than three years of teaching experience, 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 have never used educational robots in class (92.2%), and 90.3% of them have not attended any form of education, nor have they educated themselves on the topic of using educational humanoid robots in the teaching process.

Most respondents have self-assessed their knowledge about using humanoid robots in the teaching process as insufficient (44.2%) and sufficient (39.6%). In comparison, 16.2% have stated that they know more about educational humanoid robots.

4.2 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.

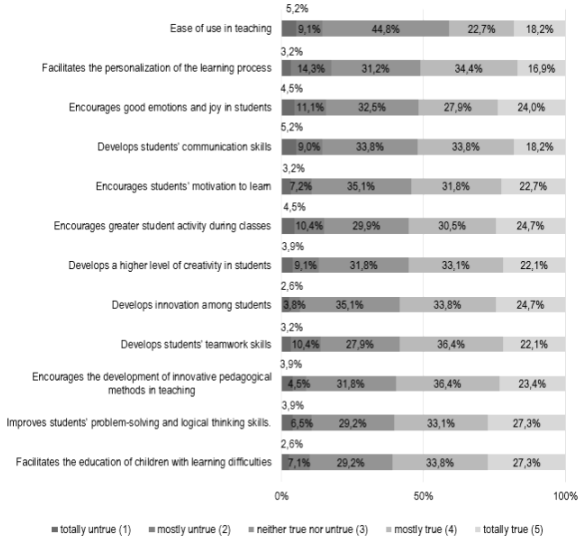

Figure 1: Croatian secondary school teachers' (N = 154) response percentage concerning their perceived benefits of educational humanoid robots (according to Lenić, 2021)

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 believe that this innovation in teaching can improve students' problem-solving and logical thinking skills, developing students' innovation (58.5%), and improve students' teamwork skills (58.5%). Furthermore, the results show (Figure 1) that 59.8% of the participants agree with the statement that the use of humanoid robots as teaching and learning assistants encourages the development of innovative pedagogical methods in the teaching process by secondary school teachers. Arithmetic mean (shown in Figure 1) indicates that 55.2% participants are of the opinion that robots can encourage greater student activity during classes and develop a higher level of creativity in students, and 54.5% of them believe that humanoid robots as teaching and learning assistants encourage students' motivation to learn. The results of the collected data (Figure 1) show that only half of the participants generally agrees that the use of a humanoid robot in class could develop students' communication skills (52%), that it facilitates the personalization of the learning process (51.3%), encourages good emotions and joy in students (51.09%). Most of them, 44.8%, are undecided in response to the statement about the ease of using an educational humanoid robot. This is confirmed by the result of the arithmetic mean (M=3.40, SD=1.08), which indicates that the participants, on average, are undecided. In addition, from the results shown in Figure 1, it is evident that a 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 also do not agree that the humanoid robots encourage good emotions and joy in students (15 .5%), nor that they promote more significant student activity during class (14.9%).

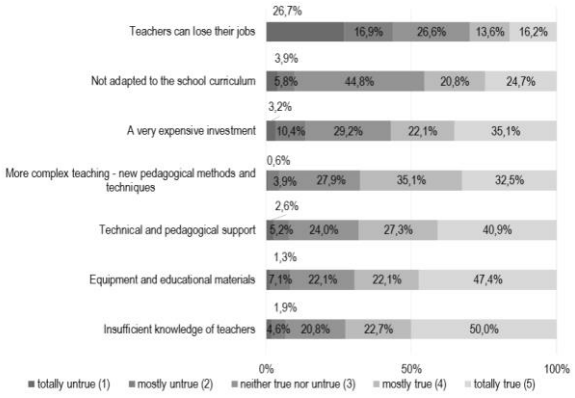

Figure 2. Croatian secondary school teachers' (N = 154) response percentage concerning their perceived challenges of educational humanoid robots (according to Lenić, 2021)

The results presented in Figure 2 show that the majority of the respondents (72.7%) believe that secondary 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 school 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%) agree with the statement that the use of humanoid robots in classes "is not adapted to the school curriculum". In comparison, 44.8% of them remain undecided, and only 9.7% of the participants believe this item to be "mostly untrue" and/or "totally untrue". Furthermore, 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 the respondents (29.8%) believe that implementing humanoid robots in education may result in losing a teaching job, and 26.6% of them are undecided (see Figure 2).

On average, those Croatian secondary school teachers that have participated in this research (M=3.54; SD=1.28) have stated that they intend to use educational humanoid robots in the near future if given the opportunity to do so. In this regard, 53.3% of them have agreed that in the near future, they intend to use a humanoid robot as an assistant in teaching and learning. In comparison, 27.9% are undecided, and only 18.8% have not declared their intention to use a humanoid robot in their teaching.

4.2.1 Differences in the perception of educational humanoid robots between secondary school teachers with no knowledge and those with partial knowledge of this technology

An independent samples t-test was conducted on a sample of 129 respondents, of whom 47.3% have reported partial knowledge and 52.7% reported no knowledge of educational humanoid robots to determine the differences in their perception of the benefits and challenges of the implementation of educational humanoid robots in their teaching.

According to the results obtained in Table 1, the results of the t-test for independent samples show that there is a statistically significant difference between the respondents in this study who have expressed partial knowledge and those who have expressed no knowledge at all about educational humanoid robots with regard to the perception of ease of use (t=2,69, p=,008), as well as facilitation of the personalization of the learning process (t=2.01, p=,047), stimulation of good emotions and joy in students (t=2,75, p=,007), development of students' communication skills (t=3,27, p=,001), stimulation of students' motivation for learning (t=3,04, p=,003), stimulation of greater student activity during classes (t=2,82, p=,006), development of a higher level of creativity in students (t=2,44, p=,016), development of innovation in students (t=3,02, p=,003), development of students' teamwork skills (t=3,53, p=,001), encouragement of the development of innovative pedagogical methods in teaching (t=2,79, p=,006), improvement the problem-solving skills and logical thinking of students (t=2,60, p=,010); with the group of teachers that have expressed partial knowledge about educational humanoid robots at a higher level perceiving the mentioned advantages compared to one teacher who has expressed that they had no knowledge at all about this innovative technology. Furthermore, the results of the t-test (t=1,97, p=,051) have shown that there are no statistically significant differences between the observed groups of subjects with regard to the perception of facilitating the education of children with learning difficulties (see Table 1).

However, the T-test for independent samples has confirmed a statistically significant ($p<0,05$) difference between the observed groups of respondents in this research regarding the opinion about insufficient knowledge about educational humanoid robots by teachers, where the respondents who have stated that they have insufficient knowledge about educational humanoid robots (t=-2.14, p=.034) believe more that teachers do not have enough knowledge about educational humanoid robots compared to the respondents who have stated that they have partial knowledge about this innovative technology (see Table 2).

Table 1. The results of the t-test analysis among respondents (N=129) about the perceived benefits of educational humanoid robots in teaching and teachers' knowledge about them

Variables/ benefits	Teachers' knowledge		T-test (p-value)
	sufficient (4)	insufficient (5)	
	M (SD)	M (SD)	
Ease of use in teaching	3,46 (0,91)	3,00 (1,02)	**2,69 (,008)**
Facilitates the personalization of the learning process	3,62 (1,10)	3,25 (1,01)	**2,01 (,047)**
Encourages good emotions and joy in students	3,79 (1,08)	3,26 (1,07)	**2,75 (,007)**
Develops students' communication skills	3,75 (1,01)	3,18 (0,99)	**3,27 (,001)**
Encourages students' motivation to learn	3,85 (0,95)	3,31 (1,07)	**3,04 (,003)**
Encourages greater student activity during classes	3,84 (1,04)	3,29 (1,13)	**2,82 (,006)**
Develops a higher level of creativity in students	3,75 (1,04)	3,31 (1,03)	**2,44 (,016)**
Develops innovation among students	3,92 (0,90)	3,41 (1,00)	**3,02 (,003)**
Develops students' teamwork skills	3,90 (1,01)	3,28 (0,99)	**3,53 (,001)**
Encourages the development of innovative pedagogical methods in teaching	3,85 (0,93)	3,37 (1,04)	**2,79 (,006)**
Improves students' problem-solving and logical thinking skills.	3,90 (1,01)	3,43 (1,06)	**2,60 (,010)**
Facilitates the education of children with learning difficulties	3,90 (0,93)	3,54 (1,11)	1,97 (,051)

Note: p<0.05

Table 2. The results of the t-test analysis among respondents (N=129) about the perceived challenges of educational humanoid robots in teaching and teachers' knowledge about them

Variables/ challenges	Teachers' knowledge		T-test (p-value)
	sufficient (4)	Insufficient (5)	
	M (SD)	M (SD)	
Teachers can lose their jobs	2,67 (1,33)	3,10 (1,42)	-1,78 (,078)
Not adapted to the school curriculum	3,61 (1,13)	3,65 (1,02)	-0,21 (,831)
A very expensive investment	3,80 (1,03)	3,87 (1,14)	-0,33 (,739)
More complex teaching - new pedagogical methods and techniques	4,02 (0,79)	3,96 (1,01)	0,38 (,708)
Technical and pedagogical support	4,11 (0,97)	3,99 (1,14)	0,69 (,491)
Equipment and educational materials	4,08 (1,02)	4,19 (1,04)	-0,60 (,549)
Insufficient knowledge of teachers	**3,69 (0,96)**	**4,07 (1,07)**	**-2,14 (,034)**

Note: p<0.05

4.2.2 The connection between perceived benefits and challenges of using humanoid robots in teaching and subject fields

One-way analysis of variance (ANOVA) and Tukey post hoc tests were used to determine the relationship between perceived benefits and challenges of using humanoid robots in teaching and the subject areas.

As previously stated, in this research, subject areas are divided into scientific-mathematical (28.6%) and professional fields (27,9%), social-humanities (19.5%), language-communication (13.6%), IT-technical occupations (6.5%), art (1.9%) and other fields (1.9%). Table 3 shows the results of the ANOVA analysis among respondents/Croatian secondary school teachers on the perceived benefits of educational humanoid robots in teaching and subject areas. According to the obtained results in Table 3, it is evident that regarding the subject field, there is a statistically significant difference in the perception of the following benefits of an educational humanoid robot in teaching by secondary school teachers: (it) facilitates the personalization of the learning process, encourages students' motivation to learn, encourages better student activity during classes, develops a higher

level of creativity in students, develops innovation among students, develops students' teamwork skills, improves students' problem-solving and logical thinking skills, facilitates the education of children with learning difficulties. By carrying out the Tukey post hoc test, it has been determined that secondary school teachers in the professional fields believe that using humanoid robots can facilitate the personalization of the learning process and develop innovation among students, develop students' teamwork skills, and improve students' problem-solving skills and logical thinking, in comparison to teachers from the social-humanities field. Furthermore, it has been determined that secondary school teachers of other fields believe that using humanoid robots can facilitate the education of children with learning disabilities and encourage better student activity during classes than teachers of scientific-mathematical and professional fields.

Table 3. The results of the ANOVA analysis among respondents (N=154) about the perceived benefits of educational humanoid robots in teaching and subject fields

Variables/Benefits	**Area of subject** ANOVA	
	F	p-value
Ease of use in teaching	1,14	,340
Facilitates the personalization of the learning process	**2,61**	**,019***
Encourages good emotions and joy in students	2,06	,062
Develops students' communication skills	1,90	,085
Encourages students' motivation to learn	**2,19**	**,047***
Encourages greater student activity during classes	**2,84**	**,012***
Develops a higher level of creativity in students	**2,28**	**,039***
Develops innovation among students	**3,03**	**,008***
Develops students' teamwork skills	**3,25**	**,005***
Encourages the development of innovative pedagogical methods in teaching	2,14	,052
Improves students' problem-solving and logical thinking skills.	**3,12**	**,007***

Note: p<0.05

Furthermore, as can be seen from the results of the ANOVA analysis in Table 4, regarding the subject area, there is a statistically significant difference in the perception of the following challenges of educational humanoid robots in the classroom: a costly investment, the need of technical and pedagogical support and insufficient knowledge of teachers.

Table 4. The results of the ANOVA analysis among respondents (N=154) about the perceived challenges of educational humanoid robots in teaching and subject fields

Variables/challenges	**Area of subject** ANOVA	
	F	p-value
Teachers can lose their jobs	2,12	,054
Not adapted to the school curriculum	1,92	,082
A very expensive investment	**2,57**	**,021***
More complex teaching - new pedagogical methods and techniques	0,67	,677
Technical and pedagogical support	**2,40**	**,031***
Equipment and educational materials	1,07	,384
Insufficient knowledge of teachers	**2,44**	**,028***

Note: p<0.05

The Tukey post hoc test has determined that secondary school teachers in other fields exhibit a significantly lower belief that implementing humanoid robots in their classes is a costly investment than secondary school teachers in the scientific-mathematical, social-humanities, and language-communication fields.

5 Limitations of the Study

The limitations of this study are reflected in the number of research participants, the number of adoption factors, and the participants' knowledge about the topic. According to the results of this research, 44.2% of the respondents have stated that they have insufficient knowledge, 39.6% of respondents have stated that they have sufficient knowledge, while only 16.2% of them have stated that they know more about educational humanoid robots. Regarding the abovementioned results, it should be noted that teachers do not have enough knowledge to be able to draw conclusions about the real benefits and challenges of this innovative technology. Accordingly, the interpretation of the results should be approached cautiously. But on the other hand, these results are considered to be of great importance because they confirm the difference in the perception of those secondary school teachers who have no knowledge and those who have partial knowledge about educational

humanoid robots. Consequently, selected factors can influence further acceptance of this technology by Croatian secondary school teachers, and therefore, they need to be additionally taken into account in further research in this context. 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 benefits and challenges 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 the 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 a better understanding of the determinants of acceptance of humanoid robots in secondary education.

6 Recommendations

Our findings can help researchers as a foundation for future research as well as all practitioners who wish 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 broader implementation of humanoid robots in Croatian secondary education:

- Pedagogical and technical training of secondary school 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 can develop a positive attitude toward 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.

7 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 adoption factors of educational humanoid robots in classes by Croatian secondary school teachers were specifically investigated, and 92.2% of them have stated that they are not users of this innovation. Furthermore, 83.8% of the respondents have said they do not know how to use educational humanoid robots in class.

Moreover, the collected data shows that Croatian secondary school teachers perceive the benefits 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 research has confirmed a statistically significant connection between Croatian secondary school teachers' perception of certain benefits and challenges of educational humanoid robots in classes and subject fields. This is consistent with the results of other studies mentioned in this paper.

A special contribution of this paper is in confirming the difference between those Croatian secondary school teachers who have stated that they do not have enough knowledge and those who do not have any knowledge about educational humanoid robots, with regard to the selected factors in this research. The aforementioned shows that the education of teachers about educational humanoid robots is very important for the implementation of humanoid robots in their teaching. Moreover, it confirms that the obtained factors can be used for further research in this context, as well as for defining the implementation strategy of this innovative technology in Croatian secondary schools.

The intention to use humanoid robots in courses in the near future has been expressed by slightly more than half of the respondents (53.3%), while 27.9% could not decide.

And finally, the research results have shown there is a need to develop strategies for training secondary school teachers to use educational humanoid robots.

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