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Attitudes of Engineering and Technology Teachers towards the Use of Humanoid Robots in Education

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Purpose: The aim of the study was to investigate the attitudes of teachers of technical and engineering subjects towards the use of humanoid robots in the learning process. The aim was to find out whether these teachers are more willing to integrate robots in the classroom than teachers of other subjects, and whether they perceive concrete possibilities to use robots in different learning situations (e.g. substituting in the absence of a student).

Study design/methodology/approach: The survey was quantitative and conducted through an online questionnaire, which was completed by 206 teachers of different subjects and levels of education in Slovenia. The questionnaire contained two sets of statements - one on the willingness to incorporate robots, the other on the concrete possibilities of their use. The analysis of differences between teachers of technical and non-technical subjects was carried out using the Mann-Whitney U-test, using IBM SPSS software. The questionnaire had high internal reliability (Cronbach $\alpha = .912$).

Findings: The results showed statistically significant differences in the expressed willingness to incorporate robots, with teachers of technical and engineering subjects showing higher willingness than other teachers. However, there were no statistically significant differences in the perception of concrete possibilities for the use of robots, such as helping to work with students remotely, assisting teachers with administrative tasks, etc. Teachers of technical subjects expressed more interest and openness to the use of robots in the classroom.

Originality/value: The research provides important insights into a specific segment of teachers (engineering and technology teachers) who, due to the nature of the subject, are more inclined to make practical use of new technologies such as humanoid robots. This is one of the few studies that comparatively analyses the attitudes of different groups of teachers towards this topic. The results have value for the further development of pedagogical approaches, teacher training and the design of strategies for introducing robots in schools, especially in STEM fields.

Introduction

A few years ago, the concept of Educational Robotics (ER) emerged in education, which covers and examines all areas in the learning process that are related to robots. ER is thus a new field that aims to enhance the learning experience of people through the development and implementation of robots in education (Angel-Fernandez & Vincze, 2018). Indeed, robots are becoming an increasingly common companion in education, which can be manifested in two ways: (1) the robot as a learning object (the robot is studied as an object in the educational process) and (2) the robot as a learning tool (the robot is a tool for learning and teaching) (Alimisis & Kynigos, 2009). Alongside this, robots take on different roles, involving robots as teaching assistants, as peers and co-teachers, as companions, or as platforms for learning (Alvez-Olivera et al, 2016; Belpaeme & Tanaka, 2021; Mubin et al., 2013). Humanoid robots could take on different roles in education. They could be assistants to teachers in teaching

content in their field, and they could also have an impact on improving students' attention. It is important to stress out that humanoid robots should not take on the role of a teacher but would merely be a companion or assistant to enhance the learning process. In particular, humanoid robots would be useful in situations where learning cannot be confined to a specific time and place. The implementation of humanoid robots in the educational process has been shown to have a positive impact on the development of skills at all levels of education (Conti et al., 2017; Rao & Ab Jalil, 2021). The use of robots in education has a positive impact, as students were more cooperative and had positive attitudes towards the humanoid robot that accompanied them in the classroom (Yousif, 2021). Despite the advantages, the potential disadvantages or concerns that arise when thinking about the integration of humanoid robots in teaching should not be neglected. Teachers also have concerns about the autonomy of using humanoid robots in the educational process (Reich-Stiebert & Eyssel, 2016). This is because teachers want to maintain control in teaching and limit the role of the humanoid robot. Potential barriers such as the cost and time to prepare activities with humanoid robots should not be neglected, which would take even more time for teachers to adequately prepare for the lesson (Istenič et al., 2021). This could be particularly difficult in engineering and technology lessons where teachers want more hands-on work. Integrating humanoid robots into education will certainly be a challenge, but there is optimism in the field. At the moment, we are not yet close to the point where humanoid robots are being integrated into the educational process at an accelerated pace, as they do not yet have the skills and versatility needed to be successful in the classroom (Reiner et al., 2023). Therefore, now is an excellent opportunity to explore how robots can act as learning tools and maximise their added value as stimulating and engaging educational tools.

Research Problem and Focus

Robots are evolving very fast and have already become a part of our lives in many forms. The same is happening with humanoid robots, which could soon become part of everyday life in schools. But the fact is that the subjects in the school curriculum are different, with some being more theory-oriented (teaching different theories) and others being much more practical (such as engineering and technology). Once humanoid robots become part of everyday school life, they will be required to perform a variety of tasks in different subjects. And whether they can be used in all subjects or just some will depend on what they are capable of. Engineering and technology is a quite specific subject, as it involves more practical work, so it is a perfectly reasonable question whether robots can be part of the teaching of engineering and technology.

Research Aim and Research Hypotheses

The aim of the research was to find out what the opinions or attitudes of engineering and technology teachers are towards the inclusion of humanoid robots in engineering and technology lessons. We were interested in whether they would be willing to teach a subject with the presence of a humanoid robot and if they would be willing to use robots in concrete situations that would overcome potential problems, such as those that arise during a student's prolonged absence or in other similar situations. For the purpose of the study, we formulated the following hypotheses:

- Hypothesis 1: There are statistically significant differences in the willingness to integrate humanoid robots into the learning process between teachers of engineering and technology and teachers of other subjects. Teachers of engineering and technology will show a higher willingness than teachers of other subjects.
- Hypothesis 2: There are statistically significant differences between teachers of engineering and technology and teachers of other subjects when it comes to concrete examples of the possibilities of integrating humanoid robots into the learning process.

Teachers of engineering and technology will show more positive attitudes towards concrete examples of integrating robots into teaching than teachers of other subjects.

Research Methodology

For the purpose of the survey, several research studies were reviewed and analysed as the basis for the development of this questionnaire (Serholt & Barendregt, 2014; Xia & LeTendre, 2020; Saari, et. al. Al. 2022; Negrini, 2020; Rao & Ab Jalil, 2021). Based on these studies, some discretionary statements were included in the questionnaire. This strategy was used to fill research gaps and to design the questionnaire in line with the objectives and hypotheses of this study. Modifying the statements of existing surveys allowed for the use of previously established information and experience, ensuring the inclusion of validated measures.

Sample

The survey was conducted in autumn of the 2022/2023 school year. The online questionnaire was created in the 1ka.si online survey application and the link to the questionnaire was sent to randomly selected teachers by email. The link was also posted on the Innovative Teachers Association of Slovenia forum. The questionnaire was designed in accordance with all guidelines, allowing it to be completely anonymous. Participants were informed before the survey started and had to agree to answer the questions. 255 teachers started the questionnaire and 49 did not complete it. 206 responses were taken into account for the analysis. The questionnaire covered different groups of teachers according to years of teaching experience (all teachers were included, those with less experience, up to 5 years of experience, as well as very experienced teachers with more than 35 years of experience.), teachers of different genders (female and male) and teachers from different backgrounds (social studies teachers, science teachers, vocational teachers, primary teachers and secondary teachers). It is also important to point out that the teachers had no previous experience of teaching with educational robots but had to put themselves in this (hypothetical) role for the purpose of the study.

Instrument and Procedures

The questionnaire consisted of a first set of 5 statements related to the willingness to integrate robots in teaching. The statements were as follows: “I want to use robots in teaching as soon as possible”, “I am interested in the use and integration of robots in the classroom”, “I see great potential in the use of robots in teaching in general”, “I see great potential in the use of robots in teaching in my subject area” and “I am following progress in this area”. The second part of the questionnaire consisted of 7 general statements, which basically referred to concrete examples of the use of humanoid robots in teaching. The statements were as follows: “I have experience in using technology in teaching”, “I am aware of the potential of robots in teaching”, “I think that, in the classroom, robots could be used for a variety of purposes”, “Robots could be used in teaching for students with special needs”, “Robots could help interact with students who are participating remotely (for example, due to illness)”, “Robots in education could be used only to assist the teacher” and “Robots could also be used in education for teachers' administrative work”. Finally, the teachers were asked to specify whether they were teachers of engineering and technology or not, which allowed us to compare the results of the analysis between teachers of engineering and technology and teachers of other subjects.

Teachers were asked to indicate their agreement with the statements on a five-point scale, which was formatted as follows: '1 – Do not agree at all', '2 – Disagree', '3 – Undefined', '4 – Agree' and '5 – Strongly agree'. The main purpose of the study was to explore teachers' attitudes towards the introduction and use of humanoid robots in the educational process, where teachers' possible experience of working with humanoid robots was not relevant. It was important (and

teachers were warned about this) to try to put themselves in a situation during teaching where they would be accompanied by a humanoid robot in the classroom. The teachers were asked to express their views on the claims made, based on the situation they were put in.

Data Analysis

For this questionnaire, a reliability test of the questionnaire was carried out. The internal consistency of the scale is acceptable for this sample, with a Cronbach's Alpha (α) of .912 (Nunnally, 1978). The data were analysed using the IBM SPSS statistical software. To test for statistically significant differences between the statements, an non-parametric Mann-Whitney U-test was performed on the sample to compare the results between two independent groups at the 95% confidence level.

Research Results

First, the results on teachers' willingness to integrate robots into their teaching are presented. Table 1 summarises the results of the Mann-Whitney U test for a set of statements relating to the willingness to include robots in teaching among teachers teaching engineering and technology and teachers teaching other subjects. The results of the analysis showed statistically significant differences between the two groups of teachers for all statements.

Table 1: Mann-Whitney Test Results for Willingness to Integrate Robots into Teaching Based on Teacher Type

Willingness to integrate robots into teaching	Teacher Type	Mean Rank	Mann-Whitney U Test
I want to use robots in teaching as soon as possible.	E&T	141.18	U = 1106.5 z = -3.089 p = .002
	other	99.45	
I am interested in the use and integration of robots in the classroom.	E&T	136.57	U = 1198.5 z = -2.702 p = .007
	other	99.94	
I see great potential in the use of robots in teaching in general.	E&T	132.40	U = 1282 z = -2.360 p = .018
	other	100.39	
I see great potential in the use of robots in teaching in my subject area.	E&T	136.53	U = 1199.5 z = -2.694 p = .007
	other	99.95	
I am following progress in this area.	E&T	130.20	U = 1326 z = -2.177 p = .029
	other	100.63	

Note: E&T: teacher of engineering and technology; other: teachers of other school subjects

For all statements, teachers of engineering and technology expressed higher agreement with the statements, indicating that teachers show more positive attitudes towards the integration of robots in teaching than teachers of other subjects. Thus, teachers who teach engineering and technology show more agreement with the statement that they want to use robots in the classroom as soon as possible, that they are interested in integrating robots in the classroom, that they see a high potential for integrating robots in the classroom in general, that they see a high potential for integrating robots in the classroom, and also for monitoring the progress in this area. The results of the survey show that teachers are more likely to agree with the statement that they want to use robots in the classroom as soon as possible.

Table 2 summarises the results of the statistical analysis of the possibilities to integrate robots into teaching.

Table 2: Mann-Whitney Test Results for the Analysis of the Possibility of Using Robots in Teaching Based on Teacher Type

Possibility of using robots in teaching	Teacher Type	Mean Rank	Mann-Whitney U Test
I have experience in using technology in teaching.	E&T	96.75	U = 1725 z = -.591 p = .555
	other	104.23	
I am aware of the potential of robots in teaching.	E&T	118.23	U = 1565.5 z = -1.229 p = .219
	other	101.92	
I think that, in the classroom, robots could be used for a variety of purposes.	E&T	121.45	U = 1501 z = -1.521 p = .128
	other	101.57	
Robots could be used in teaching for students with special needs.	E&T	126.73	U = 1395.5 z = -1.902 p = .057
	other	101.00	
Robots could help interact with students who are participating remotely (for example, due to illness).	E&T	117.95	U = 1571 z = -1.208 p = .227
	other	101.95	
Robots in education could be used only to assist the teacher.	E&T	118.58	U = 1558.5 z = -1.253 p = .210
	other	101.88	
Robots could also be used in education for teachers' administrative work.	E&T	119.15	U = 1547 z = -1.304 p = .192
	other	101.82	

Note: E&T: teacher of engineering and technology; other: teachers of other school subjects

In none of the statements was there a statistically significant difference between teachers teaching technology and other teachers. However, a closer examination shows that teachers of other subjects have more experience of integrating technology into their teaching. For the other statements, the rank is higher for teachers of technology and engineering. This suggests that engineering and technology teachers might be aware of the potential of integrating robots into teaching, that robots could be used for a variety of purposes in the classroom, that robots could be helpful for teaching students with special needs, and that robots could also be helpful for distance learning. Teachers of engineering and technology also show a stronger preference for the statements that robots could help assist the teacher and that they could help the teacher with administrative work. But it is important to point out that for this set of statements, the analysis did not show statistically significant differences between the teachers of engineering and technology and the teachers of other subjects, so it cannot be said with certainty that either group shows a more positive attitude towards the statements than the other group.

Discussion

The analysis of the data shows that there are statistically significant differences between the opinions expressed by teachers of engineering and technology and those of teachers of other subjects in the statements related to the willingness to integrate robots in the teaching of engineering and technology. All five statements showed a statistically significant difference and in all of them the mean rank was higher for the teachers of engineering and technology. This suggests that teachers of engineering and technology show a higher level of agreement with the statements related to the willingness to include humanoid robots in the teaching of engineering and technology. The largest statistically significant difference is in the first statement “I want to use robots in teaching as soon as possible”, where teachers of engineering

show higher agreement. This means that, compared to teachers of other subjects, these teachers are significantly more likely to want to use humanoid robots in teaching than teachers of other subjects. The reasons for this could be found in a number of different areas, but we can certainly point to similar ones, such as the following study. In fact, the findings of the study showed that teachers want humanoid robots in their teaching because they believe that this would increase student engagement and motivation, which in turn could have an impact on learning outcomes (Ramírez-Montoya et. al., 2023). One study also found that a robot that was more integrated into the educational process provided opportunities for student development in all areas of learning (Crompton et. al., 2018). It is believed that the subject of engineering and technology would not be an exception, and that development would take place in areas such as those covered by engineering and technology. However, at the same time, we need to point out potential caveats that could affect the results of our research. The research conducted by Crompton et. al (2018) suggests that teachers who are confronted with the use of humanoid robots typically lack experience and knowledge in the integration and operation of the robot. This may pose a greater difficulty in decision-making if the teacher feels prepared to integrate a humanoid robot into their work. Yet, this same research confirms that teachers were nevertheless able to perceive the robot as a classroom tool that they could use to teach successfully (Crompton et. al., 2018). The same could be true for teachers of engineering and technology. For the other statements, the differences are not as pronounced, but nonetheless, engineering and technology teachers show a greater preference than other teachers. Engineering and technology teachers are more interested in integrating humanoid robots into teaching, seeing more potential in this, both in general and in the subject area.

It is also interesting to note that teachers of engineering and technology tend to follow progress in the integration of humanoid robots into teaching more closely and probably with more interest than teachers of other subjects. Based on the results of the analysis, we confirm the first hypothesis, which states that there will be statistically significant differences in the willingness to integrate humanoid robots into teaching and that teachers of engineering and technology will show a higher willingness than teachers of other subjects. It is true that engineering and technology teachers show a greater willingness to integrate humanoid robots into their teaching. Analysis of the data showed no statistically significant differences for the specific options of integrating humanoid robots into teaching. So no group of teachers stands out. Looking at the results in a little more detail, the only difference is that for the statement »I have experience in using technology in teaching«, the mean rank is higher for the group of teachers who teach subjects other than engineering and technology, and for all the other statements the mean rank is higher for teachers who teach engineering and technology. Since no statistically significant differences were found for this set of claims, we reject the second hypothesis, which states that statistically significant differences will be found between teachers of engineering and technology and teachers of other subjects for specific examples of opportunities to integrate humanoid robots into teaching and that teachers of engineering and technology will show more positive attitudes towards specific examples of the integration of robots into teaching than teachers of other subjects.

As the results show, teachers of engineering and technology are eager to include and use humanoid robots in their teaching, they also show more interest in the field and are more open to new approaches in teaching engineering and technology. It would therefore make sense to reflect on how to approach this field and help teachers, not only of engineering and technology, but of all, to implement humanoid robots in their teaching. It is believed that this should be approached in a holistic way. Here is the proposal of 4 actions that could help to implement robots in teaching faster and more effectively: (1) teacher training: to provide comprehensive training, with a focus on gaining experience and skills in the operation and use of humanoid

robots, (2) development of pedagogical approaches: to develop pedagogical approaches that integrate humanoid robots into the strategies of engineering and technology courses, (3) monitoring and evaluation: establish a permanent system for improving and adapting pedagogical approaches by introducing an appropriate Monitoring and Evaluation System on the effectiveness of the use of humanoid robots in teaching, in particular in engineering and technology, and (4) promote collaboration: foster collaboration between teachers and industry, research institutions and experts in the field, allowing for the exchange of knowledge and experience and contributing to a more successful integration of humanoid robots in education. We believe that the implementation of humanoid robots in education, in particular in the subject of engineering and technology, is an area that will require a great deal of research that will examine teachers' motivations and attitudes towards the use of humanoid robots, as well as actual use and the impact on motivation, student engagement, final learning outcomes, etc., and that will also be important for the future of humanoid robots.

Conclusions and Implications

The research provided insights into the attitudes of engineering and technology teachers towards the inclusion and use of humanoid robots in engineering and technology lessons. The survey explored the views of engineering and technology teachers on the inclusion of humanoid robots in the teaching of engineering and technology. The findings show that teachers of engineering and technology are eager to integrate and use humanoid robots in their teaching, as they show a greater interest in this area and are more open to new approaches in teaching engineering and technology.

A survey of teachers was conducted to assess their willingness to use humanoid robots in teaching. The results showed that teachers of engineering and technology showed higher agreement with statements related to the use of humanoid robots in teaching compared to teachers of other subjects. Four actions were proposed to accelerate and make more effective the implementation of robots in education.

The findings of this research have important implications for the future integration of humanoid robots in education, in particular in the teaching of engineering and technology. The recommended actions can help to better prepare teachers and develop pedagogical approaches involving robots. It is also important to further explore teachers' motivations and attitudes towards the use of humanoid robots and their impact on students' motivation, engagement and learning outcomes. These findings are important for both the scientific and educational communities, as they offer insights into effective strategies for integrating new technologies into the educational process.

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