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Exploration of the prospective utilization of educational robotics by preschool and primary education teachers

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ABSTRACT

Educational robotics integrates aspects from various scientific disciplines, encompassing the entire spectrum of science, technology, engineering, and mathematics (STEM) education. Its effective application is heavily reliant on educators tasked with implementing it within a school setting. This study aimed to investigate the potential adoption of educational robotics among preschool and primary education teachers. The study involved 191 preschool teachers (62.2%) and 115 primary school teachers (37.8%). Data was gathered using a structured questionnaire, AKAER, demonstrating strong internal consistency with a Cronbach's alpha reliability coefficient of α=.892. Educators, irrespective of their specialization, gender, or scientific background, acknowledge the significance of educational robotics and express eagerness to incorporate it. A substantial percentage of educators expressed discomfort in using educational robotics and related if they had trained or not. Nonetheless, more than 70.0% of the surveyed educators expressed interest in receiving training on educational robotics to proficiently integrate it into their teaching methodologies. To ensure that the new generation of students can reap the benefits of modern teaching tools like educational robotics, closely tied to STEM education and the cultivation of 21st century skills, we must not only supply schools with the required materials but prioritize the provision of adequately trained and informed educators.

Keywords: educational robotics, prospective utilization, teachers, preschool education, primary education

INTRODUCTION

Robotics

The robotics field integrates software development, artificial intelligence, mechanical engineering, control systems, and electronics. Initially, robotics found broad applications in the manufacturing, healthcare, and aviation industries. Robotics significantly transformed the production industry, supplanting human labor in tasks requiring rapidity and accuracy. More recently, students at various educational levels have demonstrated a growing awareness of emerging technologies, displaying a specific inclination toward robotics (Ajay Kumar & Srinivas, 2019; Cannon et al., 2007; Hemantkumar & M, 2023).

Robotic technology involves advancing robotic machines capable of replicating or supplementing human actions and capabilities. Robots find extensive applications across diverse fields and serve various purposes. Instances encompass the industrial and manufacturing domain, conditions that are not suitable for humans (e.g., bomb disposal, deep-sea exploration, hazardous environments, etc.), medical settings necessitating high precision or constrained spatial, and mobility demands, and service sectors, where robots mimic human-like appearance for enhanced aesthetic acceptance (McLeay et al., 2021). These robots can imitate human actions such as walking, speaking, and displaying artificial intelligence–essentially, performing tasks akin to those carried out by a human. Moreover, contemporary robots often draw inspiration from nature, emulating insects or animals. Over the past few years, robotics has seen widespread application in the realm of education, referred to as educational robotics, which constitutes the focus of this study (Dautenhahn, 2007; López-Belmonte et al., 2021)

Educational Robotics

Educational robotics aims to provide a structured series of activities and hands-on learning opportunities for students (Bano et al., 2023). These educational experiences aim to develop the knowledge, competencies, and mindsets necessary for robotic systems' design, analysis, application, and operation (Stokes et al., 2022). In this context, the term 'robot' encompasses many robotic systems, including articulated, mobile, autonomous, and vehicles of varying scales. The level of rigor in pursuing these objectives can be adjusted to align with the educational stage of implementation, spanning from early childhood, primary, middle, and high school levels to university education and the diverse range of postgraduate programs focusing on educational robotics (Ching & Hsu, 2023; Michaelis & Mutlu, 2019). Furthermore, educational robotics enables the instruction of essential subjects and scientific principles, including computer programming, artificial intelligence, and mechanics. The evolution of activities and applications in educational robotics has transformed robots into educational tools, extending their utility from the traditional laboratory context to seamless integration within classroom environments (Amo et al., 2020).

Teaching Using Educational Robotics

To ensure that students acquire particular skills and achieve the intended educational objectives, educators must design an educational framework for integrating and effectively using educational robotics. Utilizing the project-based learning approach, which emphasizes prolonged, interdisciplinary, and student-centered learning endeavors, differs from traditional teacher-led classroom methodologies. Students are prompted to structure their work and manage their time according to a well-defined plan. This approach relies on engaging students in real-time problem-solving, nurturing their continuous and collaborative critical thinking and involvement (Bertacchini et al., 2022; Coufal, 2022; Sahin, 2013).

The presented challenges revolve around creating a robot designed to fulfill a specific objective. Typically, students are responsible for planning and orchestrating their actions, making informed decisions, conducting research, and collecting essential information to accomplish the given task. These challenges are intricate and multi-dimensional, demanding students to strategically resolve and structure them toward achieving the project's ultimate objective. This methodology allows students to work autonomously or in collaboration over an extended duration, with minimal educator intervention unless needed (Markham et al., 2006).

This instructional approach is in harmony with modern learning theories that underscore integrating knowledge, critical thinking, application, and educational settings. Learning is acknowledged as a social endeavor taking place within cultural, communal, and individual real-life contexts. This signifies a departure from traditional teaching methods characterized by brief, stand-alone lessons centered on the teacher. Instead, the emphasis shifts towards prolonged, interdisciplinary, student-led learning engagements integrating authentic, real-world challenges and topics. Educators act as mentors, facilitators, and fellow learners in this context, fostering student interactions (Hees et al., 2009; Kucuk & Sisman, 2018; Papanikolaou et al., 2020).

STEM & Educational Robotics

Integrating robotics into education offers students active engagement opportunities in science, technology, engineering, and mathematics (STEM), promoting constructive thinking. Through educational robotics, students develop essential technical skills and proficiency in programming (Gura, 2012; Petre & Price, 2004). They can interactively design and assemble various objects, gaining a solid grasp of programming concepts. An additional study demonstrated that students can readily grasp Science and Mathematics concepts using Lego educational robotics kits, enabling them to tackle mathematical problems involving proportions, positive and negative numbers, square roots, and algebraic equations (Allen, 2013; Rogers & Portsmore, 2004). The utilization of educational robotics not only enhances students' understanding of Physics and Mathematics but also improves their academic performance (Wang et al., 2023). Ultimately, robotics stands as an engaging activity that captivates students, aiding their comprehension of STEM fields through practical exercises, problem-solving, and the integration of prior knowledge with new insights (Darmawansah et al., 2023; Hughes et al., 2022; Williams et al., 2007).

Research Questions

Considering the importance of educational robotics and the pivotal role educators play in its effective integration within the educational process to benefit students, we have formulated the following research inquiries. The primary objective of this study is to examine attitudes towards educational robotics, exploring its use potential, prospects, and the level of interest among educators. Additionally, will investigate various factors potentially linked to educators' responses, such as their specialization, gender, courses attended during their academic tenure, and training in the field of educational robotics.

METHODOLOGY

Participants

A survey encompassing 307 educators engaged in early childhood and elementary education was conducted. The demographic details of these participants, including gender, field of study, educational background in STEM-related disciplines, robotics education, and the area of study during their secondary education, were outlined in **Table 1**. The survey was administered, adhering rigorously to ethical standards, guaranteeing confidentiality, and elucidating the research's purpose to the participants. The teachers were assured that their responses would be treated with utmost confidentiality, and they were under no obligation to participate or provide specific responses, thereby encouraging honest completion of the survey.

Research Tool

A structured questionnaire with closed-ended questions was employed to gather quantitative data for this research. The design of the research instrument considered the specific characteristics of the respondents and was informed by a comprehensive literature review on the subject. This questionnaire had been previously utilized in a broader study centered on educational robotics and STEM education. The resulting tool from their study was referred to as the 'attitude, knowledge, and application of educational robotics' (AKAER) instrument (Gavrilas, 2019). This instrument is organized into five distinct domains:

Table 1. Demographic characteristics of participants

Variable	Category	Frequency	Percentage (%)
Gender	Male	26	8.5
	Female	281	91.5
Specialty	Primary education	116	37.8
	Preschool education	191	62.2
Background education track	Science track	37	12.1
	Technology track	23	7.5
	Art & letters track	247	80.5
Robotics courses	Yes	57	18.6
	No	250	81.4
STEM courses	Yes	20	6.5
	No	287	93.5
Computer science courses	Yes	292	95.1
	No	15	4.9
Robotics-related training	Yes	25	8.1
	No	282	91.9

the first domain evaluates participants' perceptions of their educational preparedness, the second delves into respondents' attitudes toward educational robotics, the third explores the impact of educational robotics on students, the fourth examines perceived obstacles to utilizing educational robotics, and the fifth evaluates participants' understanding of STEM education and the role of educational robotics in this field.

To evaluate the internal consistency reliability of question subsets (subscale) and the entire set of questions (full scale), the researchers utilized Cronbach's alpha coefficient. This coefficient measures the uniformity of a scale and is widely employed to assess the reliability of measurement instruments. It can be applied to a single sentence, a group of questions, or the complete instrument that measures the same concept (variable). Internal consistency reliability refers to the extent to which different items accurately measure the same concept or variable (Cronbach, 1971). The coefficient value for the entire questionnaire was .929, and it stood at .892 for the scale. Typically, a coefficient value falling between .600 and .700 is considered acceptable, while a value of .800 or higher is regarded as highly reliable (Ursachi et al., 2015). It's important to note that only the results of the research questions of this study are presented.

Data Collection & Analysis

The researchers administered paper-based questionnaires to gather research data. Before distribution, the researchers furnished the participants with introductory information concerning the research's objectives, data utilization, questionnaire anonymity, and guidelines for completing the questionnaire. After the designated time passed, the completed questionnaires were collected and digitized for subsequent data analysis.

Data analysis was carried out using the statistical software called statistical package for social sciences version 21. Descriptive statistics were utilized to summarize the data, and the findings were displayed through suitable tables and graphs generated using Microsoft Excel. Pearson Chi-square (χ^2) statistical test was applied to investigate relationship between respondents' responses and their respective fields of expertise, courses, training, educational track, and gender, with a significance level set at α=.050.

RESULTS OF ANALYSIS

According to **Figure 1**, the overall conclusion is that educators, in the majority of cases, either agree or give a neutral response to the questions they were asked. Specifically, 58.0% of the respondents agree with the proposition that the use of new technological means in the educational process is of interest to them. Additionally, 42.7% feel that educational robotics can improve the way they teach, while 44.0% stated that the idea of using educational robotics in teaching excites them. Only 29.3% of the respondents stated that they feel comfortable with the idea of using educational robotics as a teaching tool. Most of them, with 47.6%, gave a neutral response. A very high percentage, reaching 34.5%, stated they would love to participate in an educational robotics competition with their students. A similar percentage of educators, reaching 39.4%, feel fascinated by the prospect of using educational robotics in their teaching. 57.7% of the educators who participated in the survey agreed, and 22.5% strongly agreed with the proposition that educational robotics are a modern and original educational tool. Finally, the highest agreement percentage from respondents, with 47.2%, was recorded for their interest in attending educational robotics classes.

Continuing with the data analysis, according to **Table 2**, in the first question, 'The use of new technological means in the educational process is of interest to me.' we did not observe any correlation with any characteristics of the responders. Moving on to the second question 'educational robotics can improve the way I teach.' we find a correlation with attending a robotics course (χ^2[4, n=307]=14.910, p=.005<.050). Similarly, in the third question The idea of using educational robotics in teaching excites me.' a correlation was observed with robotics seminars (χ^2[4, n=307]=9.881, p=.042<.050). In the fourth question, an additional correlation was found with robotics courses (χ^2[4, n=307]=20.036, p=.000<.050), and robotics seminars (χ^2[4, n=307]=34.128, p=.000<.050). Moving on to the fifth question 'I would love the idea of participating in an educational robotics competition with my students.' the only correlation was found with robotics training (χ^2[4, n=307]=21.437, p=.000<.050). In the next question 'I am fascinated by the prospect of using educational robotics in my teaching.' correlation was found with robotics courses (χ^2[4,

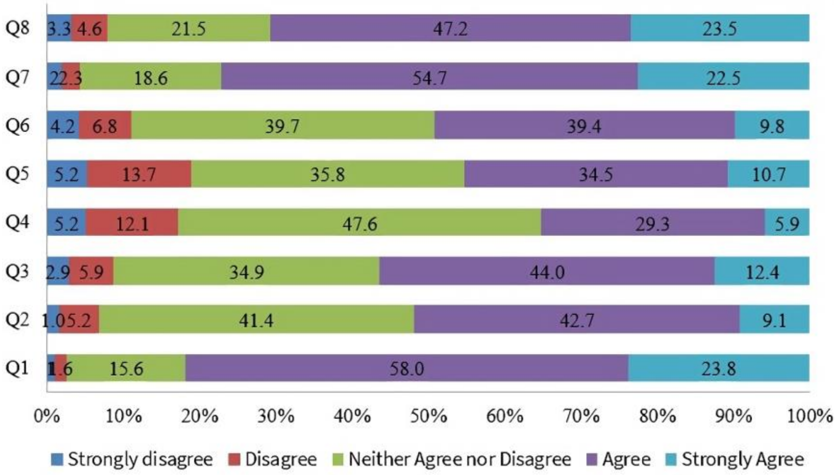

Figure 1. Distribution of participant responses (Source: Authors' own elaboration)

Table 2. Participant's answers & Chi-square tests results

Questions	G	S	ET	RC	RLT	CSC	SC
1. The use of new technological means in the educational process interests me.	.452	.234	.699	.332	.095	.524	.930
2. Educational robotics can improve the way I teach.	.129	.437	.335	.005*	.075	.301	.331
3. The idea of using educational robotics in teaching excites me.	.090	.793	.205	.157	.042*	.875	.160
4. I am comfortable with the idea of using educational robotics as a teaching tool.	.095	.558	.366	.000*	.000*	.097	.121
5. I would love to participate in an educational robotics competition with my students.	.781	.509	.480	.232	.000*	.983	.198
6. I am fascinated by the prospect of using educational robotics in my teaching.	.205	.574	.372	.004*	.010*	.031*	.020*
7. Educational robotics is a modern and original educational tool.	.629	.816	.598	.376	.236	.026*	.094
8. I would be interested in attending educational robotics classes.	.749	.793	.352	.428	.026*	.162	.203

Note. G: Gender; S: Specialty; ET: Education track; RC: Robotics courses; RLT: Robotics related training; CSC: Computer science courses; SC: STEM courses; *χ^2 test (Pearson Chi-square) & p<.050

n=307]=15.189, p=.004<.050), as well as with robotics training (χ^2[4, n=307]=13.357, p=.010<.050), computer science courses (χ^2[4, n=307]=10.639, p=.031<.050) and STEM courses (χ^2[4, n=307]=11.617, p=.020<.050). In the seventh question 'educational robotics is a modern and original educational tool.' the only correlation was found with computer science courses (χ^2[4, n=307]=11.089, p=.026<.050). Finally, in the eighth question 'I would be interested in attending educational robotics classes.' no significant differentiation was observed, as once again the responses of the surveyed educators were related to whether they had attended any training or seminar related to robotics (χ^2[4, n=307]=11.034, p=.026<.050).

DISCUSSION

The undeniable advantages of integrating educational robotics into students' learning experiences have been extensively corroborated through a plethora of research conducted across various educational levels (Arocena et al., 2022; Gerecke & Wagner, 2007; Kandlhofer & Steinbauer, 2016; Kerimbayev et al., 2023; López-Belmonte et al., 2021; Screpanti et al., 2021). Nevertheless, an examination of the demographic data in this study reveals a relatively small proportion of educators in preschool and primary education have undergone formal training in educational robotics during their academic studies or through subsequent professional development offered by relevant institutions or organizations (Chalmers, 2017; Schina et al., 2021). This observation holds for STEM-focused education as well. The lack of education among educators in the field of educational robotics may lead to the same challenges faced by education in the past, involving difficulties in integrating and accepting new technologies by teachers (Hew & Brush, 2007; Lawson & Comber, 1999). It is essential to emphasize that a computer is a fundamental and indispensable tool for most educational robotic kits accessible in the market (El-Hamamsy et al., 2021; Gavrilas et al., 2020b). Training has proven to be an essential component of incorporating new technologies into education, ensuring their efficient assimilation into the educational framework and ultimately enhancing the educational experience for students (Bers et al., 2013; Wang et al., 2011).

Another observation, evident from the demographic data of the research, is that female educators significantly outnumber their male counterparts, a trend also documented in other studies (OECD, 2018; Ohide & Mbogo, 2017). The societal environment and prevailing expectations regarding women's involvement in STEM fields remain notably restrained, subtly nudging them toward alternative scientific domains like Theoretical Sciences and lower-tiered education (Gavrilas & Kotsis, 2023). It appears that girls tend to demonstrate more interest, engagement, and accumulation of experience and knowledge in areas such as cooking, caregiving, and arts, aligning with longstanding societal stereotypes (Gavrilas et al., 2020a, 2022; Gontas et al., 2020; Tindall & Hamil, 2004). However, with the advent of educational robotics in the educational landscape, they will inevitably engage with STEM fields, domains they had essentially overlooked or deliberately avoided during their career choices.

Continuing the discussion of the results, we observe that young educators exhibit a highly positive attitude towards new technologies, expressing significant interest. This contrasts with older active educators who showed reluctance regarding integrating new technology in education, as previously mentioned (Hew & Brush, 2007; Lawson & Comber, 1999). Furthermore, this attitude is not influenced by their gender, specialization, or academic background. The only correlation found was with their education or training related to educational robotics.

Although the majority of educators have not been trained in educational robotics, most of them recognize the new possibilities it can offer, enhancing their teaching methods (Durbin, 2022; Gerecke & Wagner, 2007; Sanchez et al., 2019; Sisman & Kucuk, 2019). They express enthusiasm and outward orientation, eager to participate in educational robotics competitions (Aroca et al., 2016; Balogh, 2005), effectively utilizing it beyond the narrow confines of the school environment or restrictive curricula (Bascou & Menekse, 2016; Graffin et al., 2022; Nugent et al., 2016).

The inadequate training of educators impacts their comfort in using educational robotics, as they had stated. Despite expressing excitement and fascination with the use of robotics, only a relatively small percentage of educators feel comfortable using it. The sense of comfort is influenced, as one would expect, by educators' training. The integration of new technologies into education, training has been a necessary element for their effective integration into the educational process (Bers et al., 2013; Rao & Jalil, 2021; Stubbs & Yanco, 2009; Wang et al., 2011).

Concluding the discussion of the results, perhaps the most significant conclusion is that educators are increasingly interested in being trained in educational robotics. Merely providing robotic kits to schools without educating the educators who will use them does not yield the desired results. The role of educators in this process is distinct from traditional teaching methods (Hees et al., 2009; Kucuk & Sisman, 2018). It encompasses not only the teaching approach but also the additional knowledge they should possess, such as selecting appropriate robotics kits, assembling them, programming, and maintaining them, given that they consist of multiple components prone to damage during use by students (Cuban et al., 2001; Gavrilas et al., 2020b). The positive aspect is that educators express a willingness to undergo training. Thus, educational institutions responsible for training new educators, such as universities, should accordingly adjust their curricula, while educational bodies should offer high-quality training to in-service educators.

CONCLUSIONS

Due to the potential benefits it offers for the education of students across all levels, educational robotics has established itself as an effective pedagogical tool. However, successful implementation largely depends on educators who will utilize it. Prior training of educators is essential before its application. Simply providing the necessary materials is insufficient; it necessitates comprehensive training for educators across various specialties, whether within educational institutions such as universities for prospective educators or through training programs for active educators. Educators in primary and preschool education hold a favorable attitude towards educational robotics and are interested in incorporating it into the educational process. They also indicate a willingness to undergo further training. To ensure that the new generation of students can reap the benefits of modern teaching tools like educational robotics, closely tied to STEM education and the cultivation of 21st century skills, we must not only supply schools with the required materials but prioritize the provision of adequately trained and informed educators.

Limitations

The applicability of research outcomes may be constrained if the sample does not adequately represent the target population. Subsequent research endeavors should strive to encompass a broader, more diverse sample comprising participants from various regions and educational disciplines and backgrounds, thereby enhancing the applicability of the research findings.

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Ethical statement: The authors stated that obtaining ethical approvals or written consent was not required for the research. The study design incorporated multiple robust measures to safeguard participant rights and maintain ethical standards. The authors further stated that (a) the survey was anonymous, ensuring that participants' responses could not be traced back to individuals, (b) the participants were adults, capable of providing informed consent, (c) anyone who did not want to participate verbally informed the researchers before receiving the questionnaire, adding an extra layer of transparency and responsiveness to individual needs, and (d) participation was entirely voluntary, and participants could discontinue their involvement at any point without consequences.

Declaration of interest: No conflict of interest is declared by the authors.

Data sharing statement: Data supporting the findings and conclusions are available upon request from the corresponding author.

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