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Investigating perceptions of primary and preschool educators regarding incorporation of educational robotics into STEM education

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ABSTRACT

STEM education integrates an interdisciplinary pedagogical model that includes rigorous scientific principles across the fields of science, technology, engineering, and mathematics into realistic problem-solving exercises oriented toward real-world challenges, incorporating educational robotics. For the successful integration of quality STEM education, it is crucial to comprehend the perceptions of educators. This study aims to investigate the perception of primary and preschool educators regarding the incorporation of educational robotics into STEM education and the factors that influence their convictions. The research involved 307 (n=307) pre-service teachers. Data collection was carried out using a closed-ended questionnaire with a reliability coefficient of Cronbach's alpha=.885. It was observed that the respondents largely hold a highly positive attitude regarding the incorporation of educational robotics into STEM, recognizing its fundamental principles while simultaneously acknowledging the need for professional development in this domain. STEM-related courses attended by educators influence their perspectives to a certain degree, while no correlation was found with gender or specialization.

Keywords: STEM education, educational robotics, perceptions, pre-service teachers, preschool education

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INTRODUCTION

In the epoch following the 20th century, education has diverged from conventional methodologies, intertwining itself intricately with societal, economic, political, and cultural progressions at both domestic and international magnitudes. A salient progression within this paradigm is the emergence of STEM education. Widely acclaimed as a forward-looking pedagogical paradigm, STEM education assumes pivotal significance in nurturing fundamental facets of existence and the fiscal framework (Xie et al., 2015).

Definition of STEM

STEM, an acronym originating from the amalgamation of "SMET" during the 1990s, materialized as a consequence of the targeted directives outlined by the National Science Foundation in the realms of science, technology, engineering, and mathematics (STEM). The primary impetus was to acquire a rudimentary comprehension of these disciplines and their interdependencies among every student. This instructional endeavor was envisioned to equip learners with the proficiency requisite for gainful vocation. From the broader perspective, the enduring ambition encompassed the enactment of transformative modifications conducive to upholding the global competitive standing of the nation (Al-Balushi et al., 2023; Chesky & Wolfmeyer, 2015; National Governors Association, 2007).

In 2001, biologist Ramaley officially coined the term "STEM", encapsulating an approach that aspires to amalgamate the realms of technology and engineering with natural sciences and mathematics pedagogy. Rooted in educational policies and curriculum augmentations, the crux of STEM lies in cultivating competitiveness pertinent to scientific and technological progressions (Curtis, 2014; Forbes & Davis, 2010). Central to STEM education is the active engagement of students in experiential erudition, predicament elucidation, and interdisciplinary expedition, drawing upon assorted scientific domains encompassing science, technology, engineering, and mathematics. The domain of STEM education finds pertinence across the entire spectrum of educational tiers, spanning Pre-primary, primary, and secondary education, higher education, as well as post-doctoral education, spanning both formal and informal scholastic milieus (Gonzalez & Kuenzi, 2012; Li et al., 2020).

Object, Purpose, & Goals of STEM Education

STEM education, as a progressive pedagogical paradigm, seamlessly amalgamates the disciplines of science, technology, engineering, and mathematics, embodying an interdisciplinary approach that transcends traditional boundaries (McComas, 2014; Tan, 2022). This comprehensive educational framework not only imparts rigorous scientific principles but also instills a dynamic and continuous process of STEM literacy (Asunda, 2012). Transitioning from the educational realm to real-world applications, STEM education unfolds as a perpetual learning milieu, emphasizing practical exercises aimed at resolving tangible predicaments encountered both within and beyond educational institutions (Jackson et al., 2021; Zollman, 2012).

The essence of STEM education lies in its multidisciplinary nature, fostering a diverse exploration of subjects that establishes interconnectedness among disparate scientific fields. Through collaborative undertakings, students actively immerse themselves in exercises that enhance cooperative aptitudes, integrating pre-existing knowledge and experiential reservoirs purposefully (Norman, 2022; Singh, 2015). Starting the delving into the constituents of STEM education, science (S), encompassing biology, chemistry, geology, and physics. It advances scientific literacy but also cultivates early scientific proficiencies through immersive problem-solving and empirical inquiry (Harlen, 2010; National Research Council, 2009). Technology (T) within STEM education embraces the intricate amalgamation of people, knowledge, systems, and processes, aiming to foster technological adeptness and digital acumen. The educational focus extends to programming, robotics, and the utilization of virtual reality to incubate computational thought processes (García-Carrillo et al., 2021; Yasar et al., 2006). Engineering (E) in STEM education embodies a systematic methodology for conceiving and constructing objects, procedures, and systems. While less developed in lower-grade education, engineering education allows students to hone skills relevant to devising fabrication and problem-solving (McGowan & Bell, 2020; Mohd Shahali et al., 2016; Simarro & Couso, 2021). Mathematics (M) literacy within STEM education transcends conventional instruction, forging interdisciplinary bridges that interlink mathematics with other scientific disciplines, thereby engendering mutual reinforcement and interconnectedness (Just & Siller, 2022; Milaturrahmah et al., 2017). In summation, STEM education embraces an interdisciplinary modality, assimilating scientific principles to confer practical experiences in solving predicaments. Its overarching objective is to cultivate scientific, technological, engineering, and mathematical literacy by establishing contextual linkages to real-world scenarios, thereby nurturing critical thinking abilities (Dewanti et al., 2021; Parno et al., 2021).

In essence, STEM education molds and enlightens students, equipping them with essential knowledge, skills, and competencies for the contemporary epoch. The ultimate goal is to prepare students to be critical thinkers capable of applying their learning across various contexts, contributing to the advancement of society as a whole (Gavrilas & Kotsis, 2023; Nur Basyir et al., 2018; Stohlmann et al., 2012).

Learning Theories & Teaching Methods in STEM Education

STEM education, with its interdisciplinary nature, is deeply rooted in constructivism, a pedagogical philosophy that places students at the center of the learning process. The constructivist framework, pioneered by Piaget (1972) and further developed by Papert and Harel (1990), positions learners as active participants who assimilate new concepts and adapt them to their existing cognitive frameworks. This methodology emphasizes the formative aspect of instruction, fostering a continuous feedback loop that promotes cooperation and collaborative engagement among students (Ackermann, 2001).

To effectively integrate STEM education into the pedagogical process, it is imperative to employ instructional methodologies that cultivate critical thinking, innovation, and problem-solving skills relevant to students' daily lives. The project method (Bertacchini et al., 2022), problem-based learning (PBL) (Coufal, 2022; Hmelo-Silver, 2004), and inquiry-based learning (IBL) methods (Abdurrahman et al., 2019; Yuliati et al., 2018), are identified as ideal modalities for advancing STEM education (Erdogan & Stuessy, 2016).

The project method, closely aligned with the discovery learning method (Purwaningsihet et al., 2020), emphasizes group dynamics and the exploration of authentic challenges within students' surroundings (Sahin, 2013). This approach not only fosters collaboration but also nurtures intrinsic motivation, encouraging students to identify and solve problems within their immediate environment (Brawner, 2015; Hakim et al., 2019).

Problem-solving, another student-centered approach, involves collaborative efforts, interactive exchanges, and query resolution grounded in students' ideas and experiential knowledge (Crippen & Antonenko, 2018; Phillips et al., 2016). Small group interactions replace traditional teacher-directed learning, stimulating an interdisciplinary approach to knowledge acquisition. Similarly, the discovery learning method revolves around students' exploration and generation of queries (Karan, 2023), drawing on Bruner's (1977) theoretical foundations. This approach encourages hypothesis formulation, mental leaps, and heuristic frameworks, with the instructor serving as a facilitator, guide, and instigator (Bruner, 1977). The effectiveness of the discovery learning paradigm hinges on intrinsic elements such as attitude, motivation, and readiness to acquire knowledge.

In conclusion, the fusion of constructivism with instructional methodologies such as the project method, PBL, and IBL provides a robust framework for STEM education (Blessinger & Carfora, 2015; Schmidt & Fulton, 2016; Smith et al., 2022). This amalgamation places learners at the forefront, fostering a dynamic and collaborative learning environment that prepares students with the essential skills needed for the challenges of the future (Attard et al., 2021; Gavrilas et al., 2022a; Jerrim et al., 2019; Ješková et al., 2022).

Fostering STEM Education Through Educational Robotics

The integration of robotics into education provides students with active engagement opportunities in STEM fields, fostering constructive thinking. Educational robotics facilitates the development of crucial technical skills and programming proficiency (Gavrilas et al., 2024a; Gura, 2012; Hallström & De Vries, 2024). Students can actively design and assemble diverse objects, gaining a solid understanding of programming concepts (Ibrahim et al., 2020; Papadakis et al., 2022; Paucar-Curasma et al., 2023). Research demonstrates that Lego educational robotics kits enable students to easily grasp science and mathematics concepts, empowering them to solve mathematical problems involving proportions, positive and negative numbers, square roots, and algebraic equations (Allen, 2013; Estivill-Castro, 2020; Kelana et al., 2020; Rahman, 2021; Whitman & Witherspoon, 2003).

The utilization of educational robotics not only enhances students' comprehension of physics and mathematics but also positively impacts academic performance (Ouyang & Xu, 2024; Wang et al., 2023). In essence, robotics emerges as an engaging activity that captures students' interest, aiding their understanding 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).

Educator's Crucial Role in STEM Education

As previously elucidated, STEM education entails an interdisciplinary framework demanding a departure from conventional pedagogical techniques toward the dynamic facilitation of students' acquisition of novel erudition. Educators ought to fervently endeavor to engender in students an impetus for exploration and innovation (Zhan & Niu, 2023). Furthermore, it becomes incumbent upon educators to seamlessly infuse interdisciplinary and multicultural perspectives into the educational tapestry, thereby enabling students to engage in collaborative endeavors and procure profound insights by emulating concepts and real-world scenarios that transcend the precincts of the educational institution or the immediate local milieu, within the expanse of the broader STEM education sphere (Dare et al., 2021; Gavrilas et al., 2020; Gulen, 2019; Jurdak, 2016).

The challenges encountered within the realm of STEM education are primarily rooted in the insufficiency of information and the resultant propagation of misconceptions. One prevailing fallacy is the perception that engineering, and technology are merely supplementary components within the educational curriculum. Technology often finds itself narrowly construed as activities confined to computing, such as word processing (Bybee, 2013; Texas Education Agency, 2021). Furthermore, a misapprehension exists positing that STEM education exclusively pertains to subject matters synchronized with workforce requisites. An additional erroneous perception stipulates that educators specialized in one particular domain, such as mathematics, are inept at efficaciously imparting instruction across various other STEM subjects, thereby contravening the inherently interdisciplinary nature of STEM education (Ansberry & Morgan, 2019; Lachapelle et al., 2011; Morrison, 2006).

In a study conducted by Ejiwale (2013), barriers impeding the implementation of STEM education are identified. These obstacles encompass inadequately prepared and insufficiently qualified STEM instructors, lack of substantial investment in the training of STEM educators, inadequate readiness of students, limited collaboration amongst educators, absence of support from the educational system, scant research collaboration within STEM domains, insufficient formulation of pedagogical content, ineffectual methodologies for assessment, inadequacy in terms of facilities and logistical infrastructure, and limited opportunities for hands-on practical training for students (Ejiwale, 2013; Sukarman & Retnawati, 2022; Susilo & Sudrajat, 2020).

Importance of Recording Educators' Perceptions

One of the key reasons for recording teachers' perceptions in STEM education is the dynamic and rapidly evolving nature of these fields. STEM subjects often involve complex concepts, cutting-edge technologies, and interdisciplinary approaches (UNESCO International Bureau of Education, 2019). Teachers, as facilitators of STEM learning, play a crucial role in translating these concepts into engaging and accessible lessons (Slavit et al., 2016). By recording their perceptions, educational institutions can gain valuable insights into the challenges and successes of integrating STEM disciplines, allowing for refinement of curriculum and teaching methods (Margot & Kettler, 2019).

Educational robotics, a key component of STEM education, brings an experiential and hands-on dimension to learning (Darmawansah et al., 2023; Rakhmanina et al., 2022). Teachers' perspectives on the integration of robotics into their classrooms provide a nuanced understanding of the impact on student engagement and comprehension (Kennedy & Odell, 2014). Recording these perceptions helps identify effective strategies for incorporating robotics into existing curricula, ensuring that it aligns with educational goals and enhances students' critical thinking and problem-solving skills.

Moreover, teachers' perceptions serve as a rich source of information for the development of targeted professional development programs in STEM and robotics education (Affouneh et al., 2020). As these fields continually evolve, teachers need ongoing support to stay abreast of advancements, pedagogical techniques, and the integration of emerging technologies.

By documenting their experiences, institutions can tailor professional development initiatives to address specific challenges faced by educators, fostering a community of practice that enhances teaching proficiency in STEM disciplines and robotics (Margot & Kettler, 2019).

Recording teachers' perceptions is also instrumental in addressing the gender gap in STEM fields. Teachers may provide insights into effective strategies for encouraging diversity and inclusion in STEM classrooms, thereby creating an environment, where all students, regardless of gender, feel empowered and capable of pursuing STEM-related careers. Understanding teachers' perspectives on fostering an inclusive atmosphere can guide educational institutions in implementing initiatives that promote diversity and equal opportunities in STEM education (Park et al., 2017; Smith et al., 2015).

Furthermore, the insights derived from teachers' perceptions of STEM education can inform the development of educational policies and partnerships with industry stakeholders (John et al., 2018). Teachers are well-positioned to observe the real-world applications of STEM knowledge and the skills required in the workforce (Stohlmannet al., 2012; Wang et al., 2011). Their input can contribute to the alignment of educational goals with industry needs, ensuring that STEM education remains relevant and responsive to the demands of a rapidly changing global landscape (Lee & Lee, 2022).

In conclusion, recording teachers' perceptions in the context of STEM education and educational robotics integration is essential for the continued growth and effectiveness of these transformative educational approaches (Lesseig et al., 2016; Nadelson & Seifert, 2013).

By valuing and documenting the experiences of educators, institutions can refine teaching strategies, enhance professional development, promote diversity, and ensure that STEM education remains a powerful catalyst for equipping students with the skills needed for success in the modern world (Hue et al., 2020; Mohd Najib et al., 2020).

Research Questions

Recognizing the significance of STEM education and the pivotal role educators play in its successful implementation within the educational context for the betterment of students, particularly in the incorporation of educational robotics, we have formulated the following research inquiries. The present investigative study aims to address the following two questions:

1. How do primary and preschool educators perceive the integration of educational robotics in STEM education?
2. What factors influence their perceptions regarding the implementation of robotics in teaching STEM fields?

Table 1. Demographic characteristics of participants

Variable	Category	n	P (%)
Specialty	Primary education	116	37.8
	Preschool education	191	62.2
Gender	Male	26	8.5
	Female	281	91.5
Robotics-related training	Yes	25	8.1
	No	282	91.9
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
Background education track	Science track	37	12.1
	Technology track	23	7.5
	Art & letters track	247	80.5

Note. n: Frequency & P: Percentage

METHODOLOGY

Participants

A survey was carried out on 307 teachers involved in preschool and primary education. The demographics of these participants, such as their gender, major, educational background in STEM-related subjects, robotics-related education, and their field of study during secondary education, were presented in **Table 1**. The survey was carried out in different locations, and ethical standards were strictly followed, ensuring confidentiality and explaining the purpose of the research to the participants. The teachers were assured that their answers would remain confidential and were not obliged to take part or give specific answers, which allowed them to complete the survey honestly.

Research Tool

For the collection of quantitative data in this study, a closed-ended questionnaire was utilized. The research instrument was developed taking into consideration the unique characteristics of the respondents, and a literature review on the subject was conducted. This questionnaire had previously been employed in a broader study on educational robotics and STEM education. The outcome of their study was termed 'attitude, knowledge, and application of educational robotics' (AKAER) instrument (Gavrilas, 2019). This instrument is structured into five distinct domains: the first domain focuses on participants' perceptions of their educational preparedness, the second explores respondents' attitudes towards educational robotics, the third investigates the impact of educational robotics on students, the fourth scrutinizes perceived barriers to using educational robotics, and the fifth assesses participants' perceptions of STEM education and the role of educational robotics within this discipline. The fifth domain is presented in this particular research. It is important to emphasize that educational robotics constitutes a significant auxiliary tool for the successful implementation of STEM education (Darmawansah et al., 2023). Therefore, this specific research tool simultaneously examines both the knowledge and attitudes related to STEM.

To ascertain the internal consistency reliability of both subsets of questions (subscale) and the entire set of questions (full scale), the researchers employed Cronbach's alpha coefficient. This coefficient quantifies the homogeneity of a scale and is widely utilized to evaluate the reliability of measurement instruments. It can be applied to a single sentence, a subset of questions, or the entire instrument that measures the same concept (variable). Internal consistency reliability pertains to the degree to which different items accurately measure the same concept or variable (Cronbach, 1971; Tavakol & Dennick, 2011). The coefficient value for the entire questionnaire was .929 and for the entire scale was .885. Cronbach's alpha coefficient values range from zero to one, where zero indicates no reliability and one indicates perfect reliability of the research instrument. Generally, a coefficient value between .60 and .70 is deemed acceptable, while a value of .80 or higher is considered very good. This is a commonly accepted criterion (Cronbach, 1951; Nunnally & Bernstein, 1994; Ursachi et al., 2015). It should be noted that only the results of the questions of the research inquiries of this study are presented.

Data Collection

The researchers distributed the questionnaires in paper form to collect research data. They had consulted with the professor beforehand to ensure they had the required time. The researchers provided introductory information to the participants about the research purpose, data usage, questionnaire anonymity, and instructions for completing the questionnaire before distributing it. Once the allotted time had elapsed, the questionnaires were collected and digitized for data analysis.

Data Analysis

The data analysis was performed using the statistical software SPSS (statistical package for social sciences) version 21. Descriptive statistics were employed to summarize the data, and the results were presented using appropriate tables and graphs created with Microsoft Excel. The statistical test χ^2 (Pearson Chi-square) was used to examine the relationship between the respondents' answers and their specialty, courses, training, education track, and gender, with a significance level of α=.05.

RESULTS OF ANALYSIS

According to **Figure 1**, the overarching conclusion is that educators, in the majority of cases, agreed with the questions they were presented. Specifically, 70.7% of respondents exhibited a positive attitude towards gaining further insight into STEM education. Among pre-service teachers (PSTs), 62.5% were aware of the interdisciplinary nature promoted by STEM education. Furthermore, a relatively high percentage, reaching a total of 55.4%, acknowledged the linkage between STEM education and the job market.

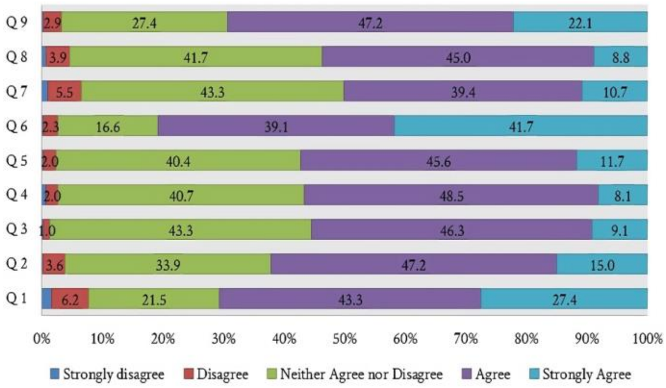

Figure 1. Distribution of participant responses (Source: Authors' own elaboration)

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

Questions	G	S	ET	STEMC	RC	RRT	CSC
1. I would like to learn more about STEM education.	.456	.824	.897	.333	.678	.255	.227
2. STEM education focuses on connecting different scientific fields.	.862	.158	.113	.262	.137	.588	.739
3. STEM education can help link education to the labor market.	.486	.386	.007*	.911	.468	.488	.986
4. Educational robotics can contribute to effective STEM education.	.196	.075	.047*	.767	.444	.881	.745
5. The curriculum must clearly integrate robotics into STEM education.	.447	.079	.230	.921	.071	.605	.026*
6. For effective implementation of educational robotics in STEM education, teacher training is necessary.	.190	.007*	.224	.266	.697	.671	.448
7. Educational robotics is a teaching tool with which STEM can be applied to preschool & primary students.	.654	.177	.873	.547	.029*	.164	.193
8. Educational robotics in STEM education can be applied in a student's real-world environment.	.609	.059	.573	.360	.075	.061	.047*
9. Educational robotics finds application in all scientific fields of STEM.	.551	.760	.768	.295	.067	.427	.773

Note. G: Gender; S: Specialty; ET: Education track; STEMC: STEM courses; RC: Robotics courses; RRT: Robotics related training; CSC: Computer science courses; & * χ^2 test (Pearson Chi-square) & p<.05

A notable 56.1% stated that detailed school curricula should explicitly incorporate educational robotics and STEM education. Regarding the necessity of educators receiving training for STEM education, 41.7% fully agreed, while a total of 80.8% of prospective educators held a positive perspective on this matter. Concerning the integration of educational robotics into the realms of STEM, both in pre-primary and primary education, 43.3% expressed a neutral stance. In terms of applying educational robotics within the context of STEM education in a student's real environment, 53.8% of participants indicated agreement. Finally, the majority of prospective educators, with an overall percentage of 69.3%, concurred that educational robotics finds applicability across all scientific domains within STEM.

Continuing with the data analysis, as per **Table 2**, the gender of the respondents does not correlate with any of the questions posed to prospective educators. Regarding the specialization of the educators, it was found that there is a correlation with the statement about the necessity of educators' training in STEM matters with $\chi^2(4, n=307)=14.053$, $p=.007<.05$. Moving on to the background education track of the participants, a correlation was observed with question 3, relating to the connection between STEM education and the job market, with $\chi^2(8, n=307)=21.245$, $p=.007<.05$, and with question 4, concerning the linkage between robotics and STEM, with $\chi^2(8, n=307)=15.704$, $p=.047<.05$. The attendance of STEM education courses was not found to be associated with any of the given responses. However, attendance of robotics courses was observed to correlate with the feasibility of its application, both in pre-primary and primary education, with $\chi^2(4, n=307)=10.777$, $p=.029<.05$. External workshops apart from university courses do not seem to impact the respondents' answers. Lastly, computer science courses were found to correlate with question 5 and question 8, with $\chi^2(4, n=307)=11.055$, $p=.026<.05$ and $\chi^2(4, n=307)=9.636$, $p=.047<.05$, respectively.

DISCUSSION

Professional development for educators and proper training in STEM education constitute the driving force of STEM education. Particularly, the elimination of misguided perceptions and the fear among educators regarding the use of technology posed a barrier. However, the research revealed that there were also specific problems that needed to be addressed within STEM education and the integration of educational robotics (Polgampala et al., 2017). Technological advancements' escalation underscores the urgent need for robust STEM education. As a result, there is an increasing emphasis on comprehending the perspectives of STEM educators and tools like educational robotics, as these directly influence their pedagogical approaches (Samara & Kotsis, 2023). Scholars have devised interventions to enhance STEM perceptions among educators across various educational levels (Zhang et al., 2023). Based on quantitative research outcomes, certain valuable conclusions can be drawn while concurrently addressing the research questions posed. Upon initial overall analysis of the results, it can be stated that prospective educators in early childhood and primary education exhibit a notably positive attitude towards STEM education. This finding aligns with previous research that also documented positive attitudes toward the interdisciplinary approach of STEM (Margot & Kettler, 2019; McMullin & Reeve, 2014; Smith et al., 2015).

Even those respondents who had not participated in any STEM education or educational robotics programs expressed a positive disposition toward training and acquiring knowledge. It is significant to note that educators' perceptions of the importance of STEM education affect their capacity to learn and develop as STEM teachers (Bell, 2016). Furthermore, a teacher with a positive attitude toward STEM appears to be the most pivotal factor in successfully implementing and accomplishing the STEM program (McMullin & Reeve, 2014; Papanikolaou et al., 2023).

Indirectly, we ascertain that PSTs favor emerging technologies, as these constitute an integral component of STEM education and educational robotics (Negrini, 2020). This stance significantly differs from that of veteran educators who were notably negative towards these technologies (Bas et al., 2016; Cavas et al., 2009; Galanouli et al., 2004; Mwalongo, 2011; Qasem & Viswanathappa, 2016). Although most educators lack training in educational robotics, a significant number acknowledge the potential it holds, enriching their approaches to teaching in STEM education (Durbin, 2022; Sanchez et al., 2019). Advantages of incorporating educational robotics for students are unquestionable, as evidenced by an abundance of research conducted across various educational levels throughout years (Arocena et al., 2022; Gavrilas et al., 2024a; Kerimbayev et al. 2023; Scaradozzi et al., 2021).

PSTs appear to possess limited knowledge about STEM education, yet they desire to be informed about this pedagogy. They recognize the interdisciplinary nature that STEM education aims to promote and acknowledge its goal of linking education with job market. Educators in this study and those in other research studies highlighted the need for a clear integration of STEM education into curriculum frameworks (Margot & Kettler, 2019). It was further noted that teachers also express concerns about incorporating STEM curricula into existing programs due to their often rigid standards, hindering the smooth integration of STEM (Lesseig et al., 2016; Margot & Kettler, 2019).

Moreover, a well-designed curriculum can bolster educators' self-efficacy in teaching STEM (Lehman et al., 2014; Van Haneghan et al., 2015). Teachers believe that the availability of a quality curriculum would enhance the likelihood of success for STEM initiatives (Asghar et al., 2012; Stohlmann et al., 2012; Wang et al., 2011). Effective professional development or ongoing education should allocate time and structure for educators to explore how STEM can be integrated into their curriculum, while simultaneously focusing on increasing content knowledge and experiential learning (Lunenberg et al., 2014; Nadelson et al. 2013). The integration of new technologies into education, training has been a necessary element for their effective integration into the educational process (Gavrilas et al., 2024a; Papanikolaou et al., 2020; Rao & Jalil, 2021; Wang et al., 2011).

The survey participants strongly endorsed the notion that teacher training is essential for the effective implementation of educational robotics in STEM education. This reflects a consensus on the need to equip educators with the skills and knowledge necessary for successful integration, aligning with existing literature that underscores the pivotal role of teacher preparation in maximizing the advantages of educational robotics (Costa et al., 2022; Mury et al., 2022; Surahman & Wang, 2023; Wilson, 2011; Zhou et al., 2023). Regarding the perception of educational robotics as a teaching tool for preschool and primary school students within STEM framework, the results indicate a balanced perspective. This suggests a degree of uncertainty or variability in educators' opinions regarding the suitability of robotics for younger students. The correlation investigation revealed that training related to robotics influences educators' views, as they come into contact with educational robotics, recognizing its capabilities and requirements for implementation at younger ages (Anwar et al., 2019; Gonzales et al., 2021; Jung & Won, 2018).

Moreover, the research delved into the practicality of incorporating educational robotics into a student's real-world environment. A significant percentage of respondents underscored a generally positive perception of robotics as a tool capable of bridging the gap between theoretical knowledge and real-world applications in STEM education. This discovery aligns with the constructivist approach, emphasizing hands-on, experiential learning (Papert, 1980). The correlation identified between respondents having attended computer science classes is rationalized by the fact that simulations, modeling, and algorithm optimization attempt to provide solutions to real-life problems, a knowledge domain likely known only to those well-versed in computer science (Amaran et al., 2016; Ferreira et al., 2018a, 2018b; Kartal & Basarmak, 2022; Kim et al., 2022; Smit et al., 2024).

The consensus among majority of educators was that robotics has relevance across all STEM fields. This underscores the versatility and interdisciplinary nature of educational robotics, in harmony with the holistic STEM approach that integrates science, technology, engineering, and mathematics (Bybee, 2013). To a certain extent, the prior experiences of educators who participated in the study, whether in an educational track as students or through courses attended at the university, have an impact on their perceptions of STEM education. Researchers observe that educators who underwent more science or mathematics courses at university or employed similar teaching methods believe that these experiences empowered them to advance reasoning advocated by STEM education in their teaching (Gavrilas et al., 2024b; Velychko et al., 2022). In essence, confidence in STEM pedagogy was bolstered by these preceding experiences (Bruce-Davis et al., 2014; Park et al., 2017).

While the university courses attended by prospective educators influence their knowledge and perceptions of STEM education, the same does not hold for educational robotics training programs typically provided by external entities. This prompts reflection on the quality of these training programs and may call for their redesign, with a focus on the fundamental principles of STEM education rather than merely presenting activities with educational robotics kits. The successful integration of educational robotics into STEM fields is crucial for students to benefit from the capabilities that modern education can offer them (Mwangi et al., 2022; Negrini et al., 2023; Papanikolaou et al., 2021; Wang et al., 2023).

The gender of the surveyed educators was not found to significantly influence their views on STEM education, as no correlations were observed with the questions they were asked. This finding contrasts with previous research findings, where female teachers were shown to perceive technology as less important within the STEM field and hold a more negative view in general compared to their male colleagues (Smith et al., 2015). A gradual balance may be emerging between genders, as goals often vary between genders, resulting in men having more opportunities for action and consequently more experiences, given their more frequent engagement with subjects and tools related to natural sciences. Conversely, girls often exhibit interest in and subsequently seek experiences and knowledge in areas such as cooking, caregiving, and the arts, aligning with long-standing societal stereotypes (Gavrilas et al., 2022b; Gontas et al., 2020; Tindall & Hamil, 2004). Finally, in terms of participants' gender on demographic data, it is apparent that majority of educators in preschool and primary education are women, indicating a significant gender disparity with men.

CONCLUSIONS

In summarizing the conclusions of this study, we posit that prospective primary education educators exhibit a positive disposition towards STEM education. They are cognizant of its potentialities, displaying a willingness to enhance their understanding and familiarity with its elements and applications. The training and education of educators will imbue them with the confidence needed to employ educational robotics in STEM fields effectively. Numerous challenges lie ahead, primarily stemming from educational system organization. These hurdles begin with educators' inadequate training and extend to the imperative for curriculum reform. A necessary overhaul is warranted to equip educators with the requisite resources and the time necessary to implement STEM education through applications, activities, and educational robotics challenges. This should be undertaken without the pressure of time constraints or the sole pursuit of syllabus coverage, thereby allowing students to ultimately benefit and evolve into proactive citizens of 21st century, armed with knowledge and ability to wield it effectively in their respective environments.

Limitations

The generalizability of research findings can be limited when the sample is not representative of the population of interest. Future studies could aim to include a more diverse larger sample of participants from different regions and educational specialties and backgrounds to improve the generalizability of research findings.

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Ethics declaration: The authors stated that obtaining ethical approvals or written consent was unnecessary for the research because a) the survey was anonymous; b) the participants were adults; c) anyone who did not want to participate verbally informed the researchers before receiving the questionnaire; d) anyone who wished to stop participating during the research informed the researchers and stopped. It was emphasized that participation in the research was both voluntary and anonymous.

Declaration of interest: Authors declare no competing interest.

Data availability: Data generated or analyzed during this study are available from the authors on request.

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