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Review Article

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Primary school teachers' perceptions of using STEM in the classroom attitudes, obstacles, and suggestions: A literature review

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ABSTRACT

The present study aims to capture the perceptions of primary education teachers about the possibilities of applying STEM education. It refers to teachers' attitudes towards science, technology, engineering & technology (STEM), which arise before and after the implementation of STEM education as well as the contribution of STEM to students and teachers. The difficulties faced by teachers in the application of STEM in the daily life of their classroom are also recorded, as well as the reasons that lead to the creation of this difficult situation. In addition, ways to deal with the obstacles to the application of STEM in educational practice are proposed.

Keywords: perceptions, teachers, primary education

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INTRODUCTION

Many studies have shown that students learn more effectively when a variety of teaching methods are applied during instruction. For this purpose, there is an increasing need to enrich teaching in schools and universities with means of technology and information sciences (ICT), which offer new teaching methods and upgrade the quality of the education provided (Bell & Fogler, 1995). Science, technology, engineering & technology (STEM) education is very important for students' education, and it starts very early, as early as preschool. Globally, a small amount of research has been carried out on educational robotics in primary education. Most of them concern secondary and vocational education. In addition, limited research is available that examines educators' attitudes and perceptions regarding the use of robotic technology in primary education.

LITERATURE REVIEW

Primary Education Teachers and STEM

The need to implement STEM in primary education is now a common admission of the majority of teachers, even for those who express their concerns, due to a lack of adequate relevant training or due to a lack of experience.

More specifically, the majority of curricula aimed at elementary teachers do not adequately prepare them to acquire the ability to design instructional programs with the assistance of technology or STEM programs. Due to this inappropriateness of curricula, teachers seem to feel insecure and ineffective when they have to plan and implement lessons with the help of new technologies (Bers & Postmore, 2005).

In a research conducted by Fridberg et al. (2023), results from the Erasmus + botSTEM project are presented, including a theoretical framework for science, technology, engineering & technology (STEM) and robotics and teaching activities for preschool teachers and teachers of four-eight year olds students. In this research, Spanish and Swedish preschool teachers' self-efficacy and views on teaching STEM and robotics are presented, using a mixed methodology based on questionnaire and focus group interviews. The three-year project has improved preschool teachers' self-efficacy in teaching STEM and robotics, as described in a questionnaire that preschool teachers answered after the project. Educators speak of an increase in children's activity, knowledge and interest, and the obstacles they face in implementing STEM are mainly structural or technical. It is also reported that teaching robotics also supports children with special needs when interacting with peers. Results from botSTEM project demonstrate benefit of supported long-term professional development for teaching STEM and robotics in early childhood education.

Also, in a survey involving teachers of various specialties, mainly public elementary school teachers, they expressed a positive attitude towards STEM teaching, while participating teachers who had not been trained in STEM during their undergraduate education voluntarily wanted to receive this training in the context of in-service training

(Ozdemir et al., 2018). However, the majority of teachers believe that they will not be able to implement the new programs in a systematic and organized manner, due to the pressure they are under from the increased workload (Papagiannopoulou, 2022).

Furthermore, teachers teaching students with disabilities seemed to understand the positive contribution of robotics, and the need to use it more in their teaching (Putnam & Chong, 2008).

In a research by Kappou (2020), the opinions of special education teachers on the use of robotics in mathematics were investigated. The results of the survey showed that teachers, in their majority, recognize the importance of mathematics in everyday life and are interested in finding new ways to help children with disabilities. On the other hand, they stated that they do not consider educational robots sufficient for face-to-face teaching of the whole course.

The aim of another study by Ivanova (2022) was to determine the level of awareness and implementation by teachers in Bulgaria of STEM approach and its variations in teaching. Specifically, the subject of the study was the general conditions, qualities and standards in the implementation of STEM approach supported by the 76 Bulgarian teachers of preschool and primary education, who participated in the research. A large proportion of the interviewed teachers were familiar with STEM as a concept and activity, but a small percentage had experience in implementing it in the classroom. 44% of the surveyed teachers claimed that the use of educational innovations (software applications, online platforms, cloud technologies, new methodologies, curriculum, etc.) makes it easier for them to implement STEM activities and improve their teaching.

A study by Smyrnova-Trybulska et al. (2016) conducted with the participation of 91 primary school teachers and future teachers in Poland, Ukraine and Borys Grinchenko Kiyv University contained 15 questions on the pedagogical research "robotics and children". The purpose of the study was to determine the needs of modern education for the introduction of the basic elements of robotics in the educational process of the primary school. The results of the study carried out in Poland and Ukraine among in-service teachers and future teachers show that more than 50% of respondents understand the important role of STEM education and the necessity of introducing it in primary school with workshops and other activities. Thus, students will be able to successfully develop twenty-first century skills in particularly basic competencies. The study, however, points out that the question remains open regarding the comprehensive STEM education of teacher candidates attending pedagogic programs, especially in the specialization of early childhood education. The teachers in the majority of them argued that the construction of robots by the children is an ideal pedagogical activity in primary education and helps them to develop, motivate to work and gain continuous interest. Also, almost half of the respondents indicated that during the robotics course the following useful life skills were formed: the ability to learn independently, the ability to work in groups and share experiences, the ability to formulate their own goals and the personal ability to model objects as an essential skill shaped by the science of robotics.

The purpose of Kanadli's (2019) study was to examine the views of teachers and students involved in STEM education. A very large percentage of the survey participants (80%) stated that STEM education is most suitable for teaching or learning topics about learning natural phenomena. They also pointed out that STEM education contributes to the improvement of life skills, the development of psychomotor skills, problem solving, scientific process, engineering and design skills, the cultivation of imagination, the development of inquiry skills, critical thinking skills, as well as the skills of 21st century. Regarding the contribution of STEM education to the emotional dimension, it was emphasized that STEM education attracts attention and interest, arouses curiosity and provides learning desire and motivation, enhances students' self-confidence, and helps students to realize both real-life problems as well as their own knowledge and skills. Also, STEM education has been found to contribute more to career awareness in students and enables them to learn while having fun, resulting in effective and lasting learning and collaborative and student-centered learning by providing active participation and relevance of course content to everyday life.

The aim of a study conducted by Bal and Bedir (2021), was to reveal the views of teachers implementing STEM education in physics and mathematics lessons. The study sample consisted of four teachers who stated that STEM education is related to the fields of physics, mathematics, engineering and technology. They also argued that STEM is a necessity of our time and includes basic skills. In addition, they emphasized that STEM education increases students' success, improves their self-confidence, makes learning easier and more permanent, connects lessons to everyday life, and promotes collaborative learning. However, during the implementation of these activities, the teachers stated that they mostly encountered problems with the management of the classrooms, with the implementation of the activities, due to the insufficient level of preparedness of the students and with the lack of equipment. The teachers participating in the research suggested the implementation of practical seminars for STEM education to overcome such problems, especially during the preparation of the activities.

The purpose of an earlier survey conducted in America (Coppola, 2015), in the context of efforts to disseminate a new curriculum, was to record the opinions of secondary school teachers and educators about the obstacles they face in implementing STEM education in their classrooms. In particular, the experience of the teachers, their opinion on the appropriate age for the implementation of engineering curricula and the obstacles to the teaching of engineering in primary school and secondary education were investigated. The research sample consisted of 70 teachers. Teachers expressed an interest in teaching more engineering, while time and lack of support were presented as barriers to implementing engineering, issues to consider in developing new curricula.

Another survey conducted in Turkey showed that teachers' perceptions of STEM education, although there are some problems, criticisms and suggestions, are positive (Kizilay, 2018). The main result of the research is that educators have approached STEM education as an interdisciplinary approach. Educators defined STEM as "the combined use of science, mathematics, technology, and engineering disciplines," which suggests that they have a general idea of STEM education. They also pointed to the positive effects of STEM education on students, the main ones being key 21st century skills such as problem solving, teamwork, critical thinking and creativity, skills that help train people who can adapt to the century in which they live. As a negative part of the research were mentioned the generally negative perceptions of teachers regarding the implementation of STEM in their country, which they characterized it insufficient and that it is only done for demonstration purposes. Another result of the research is mistakes and problems in STEM education. Most of the teachers expressed the

opinion that the biggest mistake in STEM education is the incorrect understanding of STEM education, the traditional classroom layout, time constraints and the compliance with the curriculum. Also, STEM educational applications require a lot of time and a budget. It was emphasized that the schools, where it will be held should have a minimum level of technological infrastructure. On the other hand, some teachers believe that expensive robotic sets are not needed for STEM education (Hebebci, 2021).

A study conducted on primary teachers in China revealed the mechanism for computational thinking skills and provided substantial evidence-based support for the training and assessment of in-service teachers in STEAM, which is an extension of STEM, in the K-12 student age group (Sun et al., 2023). The study showed that STEAM teachers have significant differences in terms of gender, age, teaching experience, grade, subjects, and nature of school. Specifically, the computational thinking skills of male teachers are slightly higher than those of female teachers. In addition, teachers aged 30-40 years had the highest level of computational thinking skills. Also, the level of computational thinking of the teachers was proportional to their teaching experience. Furthermore, the study showed that interdisciplinary integrated courses and teaching methods are the factors that contribute most to the improvement of teachers' computational thinking skills. Regarding the degree of mastery of computational thinking by teachers, the results of the study showed that primary school teachers had the highest computational thinking skills compared to preschool and secondary school teachers. In addition, the computational thinking skills of elementary school teachers appeared to be higher than those of teachers of other disciplines, which may be related to elementary school science being a core and comprehensive discipline. Furthermore, the nature of the school appeared to influence the computational thinking skills of STEAM teachers, as the computational thinking of private school teachers was higher than the computational thinking of public school teachers.

In a survey conducted in Malaysia (Wai Leng et al., 2023), in-service and non-preschool teachers, they considered teachers' lack of expertise as the most challenging issue in implementing STREAM education, which is an extension of STEM, in preschool education . They also indicated that they really need STREAM-related training, workshops and conferences so that they can enrich their knowledge of STREAM training and improve their skills and attitudes towards it. The survey also revealed that in service kindergarten teachers had greater concerns regarding the implementation of STEM in the classroom than their non in service colleagues.

A survey of kindergarten teachers and teachers in Turkey (Ultay & Ultay, 2020) explored their views on STEM, the implications of STEM approach, its applicability in preschool education, and the requirements for its applicability in Turkish educational system. Most teachers had positive attitudes towards STEM approach and argued that its use in schools keeps the country advanced in science and technology. The vast majority of participants believe that STEM approach can be applied in early childhood education. Some of the participants in this survey stated that STEM activities support all areas of children's development, such as curiosity, creativity and cognitive development. In addition, with STEM activities, children can actively participate in lessons and produce unique and innovative products. In this way children develop a positive attitude towards mathematics, science, technology and engineering. However, there were also some educators who said they did not support STEM, citing reasons such as the fact that it requires a lot of preliminary work and research, and that technology is harmful to preschoolers. Some of the preschool teachers argued that STEM approach is not sustainable at this age. The majority of participants stated that prospective teachers should be trained in STEM approach. In addition, some of the participants suggested the introduction of some STEM-based courses in the university curriculum. However, kindergarten teachers and prospective teachers trained in STEM approach stated that schools in Turkey lack the proper infrastructure to implement it. Also, the necessity of informing the families of preschool children in which STEM education is to be implemented, was emphasized.

In a study conducted on prospective teachers (Kaygisiz et al., 2020), physics class was highlighted as the most appropriate class for the use of robotics. The reasons given by the teachers are that the science course is "too abstract for the students" and that "it is difficult for the students to understand it". They also argued that coding could contribute to students' thinking and collaborative working skills, such as problem solving, algorithmic thinking, multiple thinking and awareness of details. And this is because robotics involves programming and is directly related to algorithms.

As mentioned in the above research, there are some factors that prevent the integration of new technologies and educational robotics in primary schools. One factor is the financial crisis, financial resources (Mumtaz, 2000), while other factors are, in the case of robots, according to Benitti and Spolaôr (2017), the fact that schools do not have infrastructure for all students and teachers do not have the knowledge to integrate it into their practices. Also, for Greece, the training of teachers in educational robotics is not implemented free of charge by the Ministry of Education, but the teachers who wish to be trained are forced to bear the cost of the seminars they attend themselves (Batsios, 2021).

Another interesting study in Turkey explored teachers' views on design-skills workshops and STEM education (Arslan, 2021). The sample consisted of 12 teachers. Participants stated that design-skills labs contributed to their development and that schools could integrate design-skills labs into education if they improved their infrastructure. They also argued that universities should provide undergraduate students with courses in design-skills labs and schools should provide teachers with ongoing training in these labs. Survey participants supported the benefits of STEM education but emphasized that they did not know enough about STEM education and that the curriculum was not aligned with STEM education. They also reported that the curricula in Turkey were not suitable for STEM education and suggested that the Ministry of National Education shall undertake projects to improve the curricula related to this education. The participating teachers in the research also claimed that they had not received undergraduate training in designing skills workshops, while others had received undergraduate training for them in different courses. In addition, due to the large number of students, it is not possible to reflect on the processes, while there is a lack of methodological support, and the school community is not convinced of the positive results of the application of robotics (Papagiannopoulou, 2022).

In a research by Batsios (2021), it is mentioned as another factor that makes it difficult to integrate robotics in primary schools the time required, both during the lesson (construction, design, testing and cleaning) and during preparation outside the classroom (creating new

lesson plans, collecting materials, setting challenges and preparing computers). Also, other factors that concern teachers are the cost of materials and the limited space in the classroom, as well as a very small number of primary schools has equipped robotics laboratories, most of which were created at the expense of the parents' and guardians' associations of the schools (Batsios, 2021).

STEM education is not only important for students, but also for teachers. In a study by Simsar et al. (2023), it was shown that physics with STEM activities positively influenced conceptual changes related to physics regarding non-in-service teachers. Teachers' conceptual shifts increased regarding the concepts of stone and soil, living and non-living things, force, motion, and balance. Also, this training helped correct teachers' misconceptions in various science subjects (e.g., earth and space science, life science, and physical science) and encouraged them to use concepts correctly. In this way, teachers were properly prepared to be ready when called upon to teach in classroom.

On the other hand, another study by Annawati et al. (2022) investigated whether there was a significant difference between perceived attitude, knowledge, and application of STEM, before and after implementation of STEM training, by a group of 77 kindergarten teachers in Indonesia, who they already had experience applying STEM in the classroom. These kindergarten teachers joined a professional development program consisting of a one-day introductory seminar, a two-month online course, and a one-day final seminar. Findings of this study revealed that there were no significant differences in teachers' attitudes before and after online professional development program, as teachers in Indonesia already had high attitudes toward STEM education, prior to their participation in specific professional development program. A high correlation was also observed between attitudes towards STEM and knowledge regarding it.

The non-correlation of experience in STEM and teachers' attitudes towards it is also expressed by a literature survey conducted in Russia (Martynenko et al., 2023) with the aim of investigating the opinions of teachers towards STEM approach. Teachers' STEM attitudes were characterized as favorable, somewhat positive, and moderately positive. Studies of teachers report no gender differences. Also, private school science teachers are more supportive of STEM education than their public school colleagues. University students' attitudes were favorable toward STEM, while high school students' attitudes were moderate. University and pre-university attitudes towards STEM did not appear to be influenced by gender. However, some pre-university studies show gender differences in their attitudes towards STEM. STEM training and practice increased college students' STEM attitudes. Additionally, pre-university STEM programs positively influence attitudes toward STEM. However, there is research (Tang et al., 2020) that argues that teachers who come from non-technological fields may not have the technological skills to use educational robotics. Many educators also feel uncertain and fearful about STEM content, which affects their confidence in STEM education (MacDonald et al., 2020).

In research by Papadakis et al. (2019) it was found that more experienced teachers are more concerned and have a rather negative feeling and attitude regarding the use of educational robotics in the formal curriculum. On the other hand, younger teachers believe that incorporating robotics into preschool education improves student learning outcomes. Furthermore, the investigation of prospective teachers' knowledge of STEM (Zdybel et al., 2019), showed that teachers' knowledge of the essence and subject of STEM education was rather superficial and not based on scientific knowledge. Although the majority of respondents stated that they were aware of the term STEM, they associated it with a broadly understood holistic education rather than a problem-solving strategy or scientific thinking.

CONCLUSIONS

As it appears from the literature review, the majority of teachers have a positive attitude towards STEM education, especially the younger ones in contrast with the more experienced ones (Papadakis et al., 2019), although there are some surveys in which teachers have a negative attitude, which results from the difficulties of applying STEM in the reality of their school (Batsios, 2021) or due to the lack of appropriate relevant training (Arslan, 2021; Tang et al., 2020).

On the other hand, there are studies that indicate that there is no correlation between the education of teachers in STEM and their attitude towards this education (Martynenko et al., 2023). In summary, from the bibliographic review of the present study, it emerges that the difficulties in the implementation of STEM education in primary education are, as follows:

1. The time required, both during the lesson and during the preparation outside the classroom (Batsios, 2021, Sevimli & Unal, 2022) and the pressure teachers feel with the increased workload (Papagiannopoulou, 2022).
2. Large number of students in classes (Papagiannopoulou, 2022).
3. Materials's cost and the limited classroom space (Batsios, 2021), although there are some educators who believe that expensive robotic sets are not needed for STEM education (Hebebci, 2021).
4. The very small number of primary schools in Greece that have equipped robotics laboratories, which are created with the financial support of the Associations of Parents and Guardians (Batsios, 2021).
5. The uncertainty and fear of teachers coming from non-technology fields and fear about STEM content (MacDonald et al., 2020, Tang et al., 2020).
6. The lack of sufficient knowledge about STEM education and the non-alignment of the curriculum with STEM education (Arslan, 2021).
7. The economic crisis and the lack of financial resources, especially in Greece (Mumtaz, 2000).
8. The perception of some teachers that technology is harmful for preschool children (Ultay & Ultay, 2020).
9. Especially for Greece, the training of teachers in educational robotics is not implemented free of charge by the Ministry of Education, but the teachers who wish to be trained are forced to pay by themselves the financial costs of the seminars they attend (Batsios, 2021).

Despite the difficulties there are many benefits from the implementation of STEM, which could be summarized, as follows:

1. Increase of students' activity, knowledge and interest and students' with special needs support (Fridberg et al., 2023).

2. Development in students of twenty-first century skills in particularly basic competencies (Smyrnova-Trybulska et al., 2016).
3. It is the most suitable educational approach for teaching or for children to learn topics related to natural phenomena (Kanadli, 2019), as well as for students with special educational needs (Putnam & Chong, 2008).
4. Increases students' success, improves their self-confidence, makes learning easier, and more permanent, combines lessons with everyday life, and promotes cooperative learning (Bal & Bedir, 2021).
5. Keeps country advanced in science and technology (Ultay & Ultay, 2020).
6. Supports all areas of children's development, such as curiosity, creativity and cognitive development, encourages them to actively participate in lessons and produce unique and innovative products and develop a positive attitude towards mathematics, science, technology and in engineering (Ultay & Ultay, 2020).
7. Contributes to the correction of teachers' misconceptions in various scientific topics, so that they use them correctly, when they are called to teach them in classroom (Simsar et al., 2023).
8. Contributes to the development of students' thinking and cooperative work skills, especially when using robotics, which involves programming and is directly related to algorithms (Kaygisiz et al., 2020).
9. Contributes to the development of children's psychomotor skills (Kanadli, 2019).
10. Contributes to the development of preschool teachers' self-efficacy in teaching STEM (Fridberg et al., 2023).
11. The construction of robots by children is an ideal pedagogical activity in primary education and helps them to develop, motivate to work and gain continuous interest (Smyrnova-Trybulska et al., 2016).
12. Contributes to the effective and permanent learning of students (Kanadli, 2019).

In order to deal with the difficulties of implementing STEM, the following proposals are proposed by the same teachers:

1. The supported long-term professional development of teachers for teaching STEM in early childhood education (Fridberg et al., 2023).
2. The training of teachers, their participation in relevant workshops and conferences (Wai Leng et al., 2023).
3. The introduction of some STEM-based courses in the university teacher training program (Ultay & Ultay, 2020).
4. Integration of design-skills workshops in primary education (Arslan, 2021).

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