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THE USE OF NEW TECHNOLOGIES AND ROBOTICS (STEM) IN THE TEACHING OF SCIENCES IN PRIMARY EDUCATION: THE CONCEPT OF MAGNETISM: A BIBLIOGRAPHIC REVIEW

Vasiliki Samara[1i],
Konstantinos T. Kotsis[2]
[1]PhD Candidate,
Department of Primary Education,
University of Ioannina,
Greece
[2]Professor,
Department of Primary Education,
University of Ioannina,
Greece

Abstract:
The literature on the characteristics of STEM research in primary education (kindergarten and primary school) is limited in Greece. Also, studies on teaching the concept of the magnet with STEM activities in preschool education have been found to be quite insufficient (Büyüktaşkapu et al., 2012). This study presents the theoretical framework related to the clarification of the ICT and STEM concepts, as well as the effectiveness of their integration in Primary Education both in Greece and abroad, in the teaching of Natural Sciences and specifically in what concerns the concept of magnetism. In order to investigate the effectiveness of ICT and STEM, the existing perceptions of K12 children on which the planning and implementation of the teaching interventions were based are listed.

Keywords: STEM, magnetism, primary education

1. Introduction

Learning about magnetism is an important component of science education (Van Hook, Huziak - Clark, 2007). Students' understanding of magnets has been studied extensively over the past 20 years, covering a wide range of age groups, from elementary to university level. Although the National Research Council (NRC, 1996) considers magnetism a core concept for young children, limited research has been conducted on younger children in preschool (Van Hook, Huziak - Clark, 2007). Despite the lack of

[i]Correspondence: email samaravasiliki05@gmail.com

relevant research, the topic of magnets was chosen because it is usually discussed at the preschool level, and it is a very attractive topic for young children. As simple as the phenomenon of magnetism may seem, it is complicated for preschoolers.

2. Literature Review

2.1 ICT and STEM in Education

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) that offer new teaching methods and upgrade the quality of the education provided (Bell, Fogler, 1995).

ICT is considered to enhance the interaction between students and educational content, whether it is the use of programmed educational texts, learning environments or internet-based content (Sofos, 2014-15a).

In the era we live in, technological developments require students to acquire not only knowledge but also skills necessary as tomorrow's citizens of the 21st century. All occupations now require workers who have the ability to think critically, work as part of a team and independently, and possess STEM skills (Jang, 2016). Deep, continuous, varied learning is the key to STEM education.

The first time the term STEM was used was by the NSF (National Science Foundation) in 1998 and was used to demonstrate the interconnection of the fields of Natural Sciences, Technology, Engineering Sciences, and Mathematics in a teacher education program called STEMTEC (Teacher Education Collaborative, Sirecietal, 2001). In the UK, the 'Aim for Success' education program (Treasury, 2002) argued for the importance of training people with STEM skills and its necessity in shaping future professions. At National Governors Association (2007), the United States of America promoted the STEM approach and linked future national prosperity to students' acquisition of STEM skills. To realize this goal, they advocated the existence of STEM educational majors to teach related subjects (Wang, 2012).

In Europe, countries that want to develop the industry are trying to integrate the STEM approach into education and pedagogic departments. From surveys conducted in European institutions and educational research institutions, the skills required by graduates were classified into the following categories: (https://www.onetonline.org/find/descriptor/browse/Skills).

Basic skills:

- Development of capabilities that facilitate learning or faster acquisition of knowledge (interactive learning, active listening, critical thinking, learning strategies, mathematics, assessment, reading comprehension, physics, oral expression, written expression).

- Complex Problem-Solving Skills: Complex Problem Solving - Identify complex problems and review relevant information to develop and evaluate options and implement solutions.
- Social skills: Developing capabilities used to work with others to achieve goals (coordination, command formulation, negotiation, persuasion, service delivery, social perception).
- Technical skills: Developed abilities used to design, set up, operate, and correct malfunctions involving machinery or technological systems (equipment selection and maintenance, programming, program operation, and control, analysis, quality control, and repair).
- System skills: Developed competencies used to understand, monitor, and improve socio-technical systems (system analysis and evaluation, judgment, and decision-making).
- Resource management skills: Developing capabilities for the effective allocation and management of resources (human resources, material resources, financial resources, and time).

The STEM approach is an approach to education designed to introduce the sciences of Technology and Engineering into the teaching of Mathematics and Science. It focuses on solving authentic problem situations through an interdisciplinary approach through concepts, methodologies, and tools of various scientific fields (construction, code generation, collaboration). It teaches innovation and allows students to explore all subjects better by practicing the skills acquired through it.

In STEM, students learn best when they discover concepts and relationships using their hands and minds and then explain the discovery.

STEM teaching, learning, and assessment cycle are:

1) Reinforcement - Involvement: The starting point of the process. Connection of related experiences. Engage mentally with the idea, the process, and the skill they need to learn.
2) Exploration: There is an active exploration of the environment or manipulation of materials. Children are provided with the same experiences, which develop concepts, ideas, and skills.
3) Explanation: Ability to express the concepts explored or demonstrate new skills or behaviors. In this phase, teachers introduce formal terms and definitions.
4) Processing: Students who have understood the concepts practice skills and behaviors. They understand concepts more deeply, gain more information and practice their skills.
5) Evaluation: It is done both by the students for themselves and by the teachers.

The STEM methodology fully responds to the achievement of this purpose, as students, through the mediation of problem-solving situations and with the help of appropriate guidance, develop their critical thinking, are encouraged to observe, hypothesize, experiment, not to be disappointed when they make mistakes, to be creative, to collaborate and to understand that there is not just one universal solution to a problem, but many more, as long as they can be solved logically and methodically.

> "*The STEM approach is a way of thinking about how educators at all levels – including parents - will help and support students to acquire knowledge from all scientific fields, encouraging them to think in a more connected and holistic way*" (Sneideman, 2013).

The STEM methodology offers the possibility for educators and teachers to use teaching-learning strategies based on programs that involve all 4 areas-fields (natural sciences, technology, engineering sciences, and mathematics). The contribution of this methodology to the educational contribution of all students without exception is very important, as the exclusion of some students is thus abandoned and the integration of all in the educational process is encouraged.

In addition, the implementation of STEM education in kindergarten is done in a flexible way, taking into account the age, the characteristics of children's thinking, the needs, and the interests of the group.

On the other hand, there is a disagreement in the literature review on whether preschool children are capable and ready to be educated with the STEM approach, as they are considered to lack abilities and skills, such as expressing their experiences, formulating predictions, and hypotheses, asking research questions and drawing conclusions (Katz, 2010).

But research has shown that they can ask research questions, justify their opinions, and formulate interpretations about how the physical, social, and biological world around them works (NSF, National Science Foundation, 2012). In addition, they have an innate curiosity for inquiry, like to engage in experimentation and use a variety of tools (e.g., magnifying glasses), solve problems and puzzles, compare phenomena and objects (Sharapan, 2012) and investigate facts, and patterns, and rules.

Additionally, STEM education aims to develop problem-solving skills (Bagiati, 2011). Children who acquire this skill at an early age become adults who can easily overcome the difficulties they encounter (Akcanca, 2020a) and this provides added value both individually and socially.

STEM education seems to be an approach that improves the knowledge and experience of individuals (Günşen, Fazlıoğlu, Bayır, 2017), predisposes them to solve problems by making interdisciplinary connections for situations they face in their daily lives (Tosmur - Bayazıt et al., 2018) and enhances their creativity (Tozlu et al., 2019). In addition, research has shown that including STEM in primary education provides strong motivation for students and improves the speed of learning (Scaradozzi et al., 2015).

According to the above, STEM is a seed for cultivating critical thinking citizens for a digital tomorrow, and it seems that early childhood is the perfect "*seeding time*" (McClure et al., 2017). Children are born scientists, and every child wonders about the objects that surround him and about the events that happened (Aktürk, 2019; Alan, 2020).

Technology is emerging as an important tool in STEM education at the preschool level. Aronin and Floyd (2013) stated that there are supportive tablet applications that can be integrated into STEM-related fields of Physics, Engineering, and Mathematics.

In a study conducted by Alade et al., in 2016, it was revealed that using tablets in the context of games and watching videos had positive effects on preschool children's acquisition of scientific concepts. While science enables us to understand the outside world, the field of Engineering serves to change the outside world according to our needs. Therefore, Physics and Engineering appear as one inseparable unity (Dilek et al., 2020). In research conducted by Başaran (2018), it was determined that STEM activities had a lasting positive effect on preschool children's Engineering and product design skills. In addition, DeJarnette (2018) stated that simple Engineering skills can be effectively acquired in preschool through STEM activities, and it is important to consider the environment as the third teacher in terms of material supply and physical equipment.

As Physics, mathematics is also a crucial part of preschool children's daily life. For example, children can notice the size and shape of an object they are examining or make a comparison with another object in terms of its characteristics (Ültay, Aktaş, 2020). Studies of preschool STEM education suggest that mathematical terms and concepts can be easily incorporated into tablet applications (Aronin, Floyd, 2013), reading stories (Kalogiannakis et al., 2018), or product design activities (Torres - Crespo et al., 2014). At the same time, math outcomes can be seen as the physical phase of STEM education. In other words, mathematical conversations can be heard from children in each substage, or mathematical concepts can be included in pre-planned activities by the teacher in an improvised way.

Considering that STEM education takes place in the context of Physics and that the concepts are abstract, illustrated stories (story books) are one of the effective methods by which preschool children can embody abstract concepts. In addition, it has been found that learning becomes more permanent when activities such as story reading and drawing are combined (Hu et al., 2020).

Also, an educational intervention carried out in a Greek kindergarten on the topic of marine pollution with STEM assistance highlighted the effect of educational robots on the development of digital skills of preschoolers, with the appropriate educational intervention and utilizing the nature of kindergarten children to investigate, express, discover and construct (Tallou K., 2022).

2.2. Children's Perceptions of Magnetism and the Contribution of STEM to Primary Education

Many researchers report that preschool children create theories about objects or situations through their intuition (Gopnik, 2012; Bonawitz, 2019; Wilkening, Sodian, 2005).

For example, some studies conducted have shown that children explain the attraction behavior of the magnet as an "*invisible force*" (Selman et al., 1982) and use the expression "*that sticks*" (Piaget, Chollet, 1973) (cited in Kalogiannakis et al., 2018).

According to Barrow (2000), children mostly only have perceptions of the attractive behavior of magnets and think that the attractive force of magnets will increase with their size. The fact that the children state that the magnet has "miraculous" characteristics and the use of incorrect conceptual expressions show us that invisible situations must be explained correctly and clearly for preschool children to understand the nature of science (Kalogiannakis et al., 2018).

The literature analysis reveals several non-scientific ideas about the magnet concept (Bar, Zinn, Rubin, 1997; Burgoon, Gülçiçek, 2004; Hickey, Schibeci, 1999; Lemmer, Kriek, Erasmus, 2018; Smolleck, Hershberger, 2011; Tanel, Erol, 2005).

The studies focused on students' views on the interaction between a magnet and a material. Smolleck and Hershberger's (2011) study revealed that 3-8-year-old children had the misconception that magnets attracted all materials. Furthermore, they believed that magnets attract all metals (Smolleck, Hershberger, 2011). The same misunderstanding prevailed among primary school students (Karabacak, 2014). Also, Güneş (2017) explained the reasons for misconceptions in the form of "*magnets only attract*" and "*magnets repel non-metals*" among students in his book.

The literature also points to students' need to be more accurate about understanding the effect of the magnetic force produced by magnets. "*Bigger magnets are stronger than smaller magnets*" is a popular misconception among students of all grades (Gülçiçek, 2004; Lemmer et al., 2018; Smolleck, Hershberger, 2011; Tanel, Erol, 2005). The opinion "*the magnet must touch a material to attract it*" was identified among students aged 9-18 (Bar et al., 1997). Studies have also revealed misconceptions about the distance magnets can attract materials among students of all educational levels (Bar et al, 1997; Barr, Zinn, 1998; Hickey, Schibeci, 1999).

However, children's science misconceptions appear persistent and exceptionally resistant to change (Driver, Squires, Rushworth, Wood - Robinson, 1994).

A review of the research literature reveals that there is only a limited number of studies on children's perceptions of magnetism, even though children are quite familiar with related phenomena, which are usually included in the curriculum of physics activities in kindergarten.

Regarding magnetic attraction, children tend to adopt two levels of thinking: according to the first level, they connect different events, while according to the second, they claim that an invisible force allows magnets to "*attract objects*" (Selman, Krupa, Stone, Jacquette, 1982). Most children under the age of 7 cannot distinguish between objects/materials that are or are not attracted to magnets. Children up to 10 years of age refer to 'forces' or 'currents' that pull or 'push.' They continue to draw their explanations from everyday life and attribute magnetic attraction to some 'electricity', 'air pressure', or 'some sort of gravity' (Barrow, 1987).

In addition, practices that are quite widespread in early education, namely theater, and storytelling, are considered valuable tools for teaching and learning science (Hadzigeorgiou, Stefanich, 2000). They motivate children's interest (Begoray, Stinner, 2005), connect scientific concepts with children's experience (Yoon, Onchwari, 2006), provide opportunities for anticipation and negotiation of different points of view, analysis and synthesis (Farrow, Bailey, 1998), and thereby enhance conceptual change (Resnick, Wilensky, 1998). An educational strategy considered to cause a conceptual change in this context is cognitive conflict (Skoumios, Hatjinikita, 2005/2006), i.e., the presence of a phenomenon or situation that cannot be explained by the students' initial understanding but can be explained by the concept which is the subject of teaching (Davis, 2001), which is caused by dissatisfaction with these initial concepts (Posner, Strike, Hewson, Gertzog, 1982). A conflict can arise from the individual's reflection, interaction with the natural environment, or from one's contradiction with another's a response to a problem, known as "*sociocognitive conflict*" (Doise, Mugny, Perez, 1998).

On the other hand, critical features of instructional approaches, considered conducive to conceptual change include:

- discussions between students in a group about their predictions about a problem or an alternative explanation suggested to them.
- student experimentation and discussion of the experimental results within the group.
- symbolic representations of ideas.
- comparisons between the children's initial and newly acquired conceptions (Skoumios, Hatjinikita, 2006).

In a study guided by Kalogiannakis et al. (2018), the concept of magnetism and the characteristics of magnets were taught to preschool children through reading fairy tales. Research findings show that reading related picture books effectively teaches the concept of magnetism to preschoolers. In addition, Christidou et al. (2009) conducted a study involving three kindergarten classes, two of which served as experimental groups and one as a control group. In the first group, a social-cognitive method was adopted, emphasizing the children's alternative understandings of magnets and magnetic forces, how they cooperated in the experiments and the interactions within the groups and with their teacher. In the second experimental group, children's perceptions were emphasized, and specially designed activities were implemented with the help of storytelling, drama, and practical experiments. The research results show that the traditional approach could have been more effective in children's understanding of magnetic attraction (identification of all metals with iron). Also, the approach adopted in the experimental group that applied the storytelling and drama techniques was much more effective than the other experimental group, as the emotional involvement of the children played a very important role in stimulating their participation in the procedure.

3. Results and Discussion

It appears that preschool children are ready to engage in STEM activities. They should therefore be introduced to STEM approaches from early childhood. In preschool classrooms where STEM activities are conducted, children build and internalize scientific and mathematical concepts through experimentation and exploring various materials. In this way, STEM education provides them with meaningful learning and can lead to positive future educational experiences (Moomav, Davis, 2010).

Considering the above literature review, prevention of young children's misconceptions about magnets can be achieved by developing innovative programs to address them early.

A STEM-based program promises to be more beneficial for preschool children in learning abstract science concepts (Akcanca, 2020b). This is further supported by recent evidence from research with preschool children and STEM activities which points to the importance of STEM in the development of scientific skills (Akcanca, 2020a), curiosity (Aktürk, 2019), and mathematical "*speech-language*" as prior knowledge for deeper understanding of concepts (McClure, 2017).

4. Conclusion

Various attempts have been made from time to time to teach Primary Education various concepts of natural sciences, such as the concept of magnetism. From the evaluation of these efforts, it emerges that teaching natural concepts to children is much more effective when it is enriched with tools such as experiments, theater, storytelling, and equally STEM tools, as long as it is used with the appropriate technological equipment.

STEM is relatively easy for teachers to apply to children since no specialized technical knowledge is required. Still, the active participation of children throughout the educational process is required for the tasks to arise from the students themselves, and the teacher should have only an encouraging, facilitating, and mediating role between the students and between the students and the technological tools (tablet, pc, smartphone, video, robot, etc.).

Conflict of Interest Statement
The authors declare no conflicts of interest.

About the Authors

Vasiliki Samara is a PhD Student at the Pedagogical Department of Primary Education of the University of Ioannina, Greece. She graduated from the pedagogical department of Kindergarten teachers at the University of the Aegean in 2000. Then, she graduated from the pedagogical department of Primary education at the same university in 2003. In 2007 she obtained a master's degree with the title of 'Educational Sciences using New Technologies' from the pedagogical department of Primary Education of the University of the Aegean. In 2020, she obtained a master's degree in "Environmental Sciences and Education for Sustainability" Her research interests include teaching Physics in Primary Education through STEM and ICT and other alternative didactics (theater, storytelling, etc.).

Prof Konstantinos T. Kotsis studied Physics at the Aristotle University of Thessaloniki, Greece. In 1985 was an assistant researcher at Brooklyn University of New York. From

September 1987 to September 2000, he served as a Lecturer and Assistant Professor. He specializes in Solid State Physics and X-ray Diffraction at the University of Ioannina Physics Department. Since 2000 he has served as a Faculty Member in the Department of Primary Education at the University of Ioannina. He has been a Full Professor since 2012 specializing in the Didactics of Physics at the Department of Primary Education of the University of Ioannina in Greece. He is also the Head of the Physics Lab at the Department of Primary Education. His research interests are Didactics of Physics, Science, Education, Physics Teaching and Learning, Teacher Training, and Education Research.

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