Adv Mobile Learn Educ Res, 2022, 2(1): 268-277
DOI: 10.25082/AMLER.2022.01.011

REVIEW

The teaching of Natural Sciences in kindergarten based on the principles of STEM and STEAM approach

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Received: February 7, 2022;
Accepted: March 18, 2022;
Published: March 21, 2022.

Citation: Kastriti, E., Kalogiannakis, M., Psycharis, S., & Vavougios, D. (2022). The teaching of Natural Sciences in kindergarten based on the principles of STEM and STEAM approach. *Adv Mobile Learn Educ Res*, **2**(1): 268-277.
https://doi.org/10.25082/AMLER.2022.01.011

Abstract: Across all levels of education, Natural Sciences is a scientific field that is gaining considerable research interest. However, in recent years a growing interest in the introduction of Science in Preschool Education can be seen among scientists, as they realize that the children's first experiences will be the cornerstone of the relationship they are going to develop with this scientific field in the future. It is accepted that children approach and understand the new knowledge taught in the classroom in the context of what they already know. Their pre-existing beliefs and experiential knowledge are the foundations upon which the new concepts will be merged. Based on these perceptions, children approach, "decode," and understand new knowledge through the interaction of the two cognitive systems, the pre-existing and the taught new enriched cognitive patterns. The kindergarten environment cannot remain isolated and uninfluenced by the developments in a constantly changing world. The goal of Kindergarten is to properly prepare its students to become active citizens of their country by helping them get all the necessary skills. In this way, the STEM and STEAM approach seems to be progressively gaining ground in Preschool Education. Various researchers emphasize the importance and positive outcomes of implementing a STEM education program in Kindergarten, as children can acquire at an early age all the necessary resources that will play a decisive role in their later life. According to the above, this study is a literature and article review with its primary purpose to verify the above assumptions. More specifically, this article showcases the importance of teaching Science in Preschool Education and its practicability at this age group. There is also a presentation of the holistic educational STEAM approach. The main goal of this presentation is to emphasize the contribution of this educational approach towards a more effective teaching of Science in Kindergarten and in-depth learning and understanding of natural concepts by preschoolers.

Keywords: STEAM educational approach, Natural Sciences

1 Introduction

This article was written by studying and synthesizing various scientific researches and books. The writing of this article and literature review took place in 2021-2022 and took into account data from various recent and older studies. The selection criteria were their relevance to the topic developed in this article and the validity of the sources. The study results of all these sources helped us realize the importance of using appropriate teaching strategies by the teachers to achieve learning and understanding of science from preschoolers. It was also emphasized that holistic STEAM education is the most appropriate educational approach to understanding Natural Science. Finally, it is pointed out that implementing STEAM education in Kindergarten is beneficial since it helps children develop all those necessary skills in our days. In this way, they will be able to be active citizens and respond to the demands of their times.

The natural and biological world and the social environment are primary experiences for preschoolers (Ampartzaki et al., 2021). The stimulation of the children's interest in what is happening in the natural world that surrounds us and the acquisition of the knowledge of the Natural Sciences both start from their attendance in Kindergarten (Ampartzaki & Kalogiannakis, 2016; Ampartzaki et al., 2021; Kalogiannakis et al., 2018; Skaraki, 2021). For this reason, the organization and implementation of activities related to the Natural Sciences become necessary in Preschool Education, as young children from an incredibly early age form the first ideas,

interpretations and theories about concepts or phenomena of the natural world, which proves that they can approach relevant issues at a first level (IEP, 2014).

The continuous exposure of preschoolers to the content of the Natural Sciences seems to be beneficial for their development. Natural Sciences help children satisfy their curiosity, as they provide children with the opportunity to explore the natural world around them and lay the foundations for the development of scientific literacy. They are trained in the systematic investigation and understanding of essential functions in problem-solving, and they also acquire critical thinking and decision-making skills. They discover the interdependence of science, technology, and society through this process. Finally, the engagement of preschoolers in Natural Sciences activities helps them to develop positive attitudes towards science, to be able to organize their experiences systematically and to realize that science is a cultural product in constant development (IEP, 2014).

According to the principles of modern didactics, the most effective way to teach science is the constructive approach (Kalogiannakis et al., 2021; Zourmpakis et al., 2022). According to this approach, learning is not perceived as simply imparting information but as active construction of meaning resulting from cognitive processing (Driver et al., 1994). In other words, children are not treated as passive recipients of the knowledge transmitted by their teachers but take an active role by participating in experiments and interacting with their classmates and teachers (Kruckeberg, 2006; Vosniadou et al., 2001).

At this point, despite the apparent advantages of the involvement of preschoolers with science, the question arises as to whether Science teaching can be achieved in Kindergarten, whether preschoolers are at the appropriate age and cognitively ready to grapple with the principles of physics, mathematics, engineering and technological concepts or skills, and also, which teaches didactic approaches or methods will enable this process. Therefore, according to all of the above and what will follow next in this paper, it will be shown that infants can come into contact with physical and mathematical concepts and understand them in depth. Also, a suitable educational approach to achieve this goal is holistic STEAM education, through which students acquire all the necessary skills and knowledge so that in the future, they will be able to meet the requirements of their times.

In the course of this article, we will emphasize the importance of pre-existing perceptions of preschoolers in Natural Sciences, and we will analyze the terms STEM and STEAM educational approaches and the benefits that infants acquire by receiving this type of education. Finally, the crucial role of teachers in this whole process will be highlighted.

2 Children's perceptions in Natural Sciences

Children learn both in and out of school. Especially in infancy, most experiences come from the family environment in which they grow up. The language and culture of the family take the role of filters through which children interpret the world around them and acquire new knowledge (IEP, 2014).

The family, the natural environment, and the school, all of them act as learning environments. Through the natural environment, infants receive the first stimuli from life around them and the world. The family and its primary role in each child's life has the advantage of helping them form the first perceptions about the world around them and thus form their interpretations. Then comes the school that offers the children a structured framework that either verifies their existing perceptions or demolishes them. This is done by selecting successful strategies and teaching methods by teachers and the active involvement of children in the activities carried out in the plenary of the class.

From the fact that children learn in both informal and formal environments -each of which has its advantages- the need arises for these environments to systematically complement each other and coordinate their course in the same direction by setting common goals and following common practices (IEP, 2014).

The ideas that children form before they join the Kindergarten should be recorded and used during the teaching by the teachers for the benefit of the learning process. The teacher of each class takes on the role of mentor and directs the educational process taking into consideration the earlier knowledge of their students (Kalogiannakis, 2010; Poultsakis et al., 2021). They can choose the necessary teaching aids and instructional tools and develop the appropriate teaching model to change children's perceptions and understand scientific concepts (Tsoukala, 2021). By detecting the pre-existing students' ideas, teachers can identify and prevent possible obstacles in the teaching process and avoid expected difficulties in implementing their organized activities. In this way, we can create an authentic learning environment and effective teaching (IEP, 2014; Papadakis et al., 2021).

Children's pre-existing perceptions of various subjects of the Natural Sciences influence how they perceive and interpret phenomena. This can determine the teaching process where a typical/traditional teaching model cannot always lead students away from their misconceptions and learning. When teachers notice that the children already have some ideas about the subject, they place them at the forefront of their teaching and highlight them (Foti, 2021). Although these perceptions differ from the scientifically accepted way, they have an internal coherence and organization (Christidou & Hatzinikita, 2006; Christidou et al., 2009).

Through cognitive conflicts that occur during the educational process and with their guidance, teachers highlight their students' ideas and draw their attention to various social or physical phenomena (Papadakis et al., 2021). The necessary functions for acquiring knowledge are attention, observation and processing, which, however, are not always used by children on their own (Chaldi & Mantzanidou, 2021). Teachers will enable their students to explore and solve various problems through teaching and guidance. Thus, they will help them develop metacognitive skills and reflect (IEP, 2014).

In conclusion, the teaching of Natural Sciences in Preschool Education is workable, as long as the appropriate teaching strategies and methods are applied, which will make it possible to transform children's primary perceptions into scientific concepts of Natural Sciences. Children in the preschool age can formulate scientific concepts while developing elementary concepts of understanding science, a process that plays a vital role in their cognitive development (Christidou et al., 2009).

3 STEM and STEAM approach

3.1 The definition of STEM Educational Approach

The acronym STEM was introduced in the 1990s by the National Science Foundation (NSF) of the United States of America. It was used to group the fields of Science, Technology, Engineering, and Mathematics into a teachers' education program called STEMTEC (Teacher Education Collaborative) (Sireci et al., 2001).

In education, the acronym STEM (Science, Technology, Engineering, Mathematics) was first used in 2001 by biologist Judith A. Ramaley. STEM is an approach that aims to integrate Technology and Engineering into the teaching of Science and Mathematics. This term is commonly used in education policy and school curricula to improve science and technological development (Gonzalez & Kuenzi, 2012; Koonce et al., 2011). According to the President's Council of Advisor on Science and Technology (2010) (PCAST, 2010), STEM is a learning environment where students can explore, discover, build knowledge using real-life problems or situations and relate it to their experiences.

In STEM education, the children's active participation and involvement in discovering knowledge and problem solving are paramount and necessary (Chatzopoulos et al., 2021; Chatzopoulos et al., 2020). This process takes place through interdisciplinarity, where students using knowledge from various fields of education (Science, Technology, Engineering, Mathematics) can learn (PCAST, 2010). Numerous studies show that STEM education is applicable at all levels of education and therefore at all ages, starting from Kindergarten and up to the University level. However, it is also practical for all students with or without special educational needs (Gonzalez & Kuenzi, 2012; Ioannou & Bratitsis, 2016).

According to the above, a STEM education offers all those knowledge, skills and abilities that a student must have to become an active member of a modern society in the future. However, it is easy to see a lack of creativity in STEM education. For this reason, the integration of the Arts in STEM education becomes necessary to be characterized as a holistic form of education. By adding the Arts to STEM education and converting it to STEAM (Science, Technology, Engineering, Arts, Mathematics), students will acquire all those necessary skills and knowledge to find solutions to various problems they will encounter.

STEM education is characterized by objectivity and logic, while the characteristics of Art are subjectivity and intuition. Science and Art complement each other, as science gives children the scientific tools, while Art teaches them how to use them creatively. In our everyday life, people can use the features of both Science and Art. Therefore, the development and cultivation of both of these types should be included in education. For example, when an architect designs a building, he must be creative to make a building that will be functional and looks attractive and enjoyable to those who enter it.

3.2 The definition of STEAM Educational Approach

Various researchers show that the involvement of children with the Arts from an early age leads to the acquisition of necessary skills for their cognitive development. Through the Arts,

children learn to rely on their curiosity, observe accurately, perceive objects even when presented to them in a different form, construct meanings and express their observations accurately, collaborate with others effectively, and think of objects spatially and perceive kinesthetically (Katsaris & Vidakis, 2021). Children use symbols that express natural objects, events, and emotions through the arts. For example, dramatization and drawing allow them to express their thoughts and feelings before reading and writing. The Arts help them develop creativity, critical thinking, communication, initiative, collaboration, and critical thinking skills, essential to a future active citizen (Oner et al., 2016).

The exhibitions Next Gen (Livingstone & Hope, 2011) and Creative Industries (CIF, 2015) feature the contribution of the Arts in the educational process, stating that the Arts help students cultivate innovation. Based on financial arguments, this shift led to STEM to STEAM. In a report of The Department for Culture, Media, and Sport, it is stated that "the crucial role of art subjects in a contemporary education must be recognized and art subjects should be added to STEM subjects, changing STEM to STEAM" (DCMS, 2013).

The integration of Arts, such as dramatization, music, drawing and dance, has led to the enhancement and enrichment of the STEM program. The importance of their existence and their interconnection to the other sciences is proved by the examples of successful personalities such as Leonardo Da Vinci, Galileo and Albert Einstein, through whom the long history of the connection between the Sciences and the Arts is revealed. Although the qualities of the Arts and the skills required by those who practice them seem to have no connection to STEM, they create a new way of thinking that promotes innovative ideas and actions. The integration of the Arts in the STEM approach creates a more holistic way of thinking, taking it to a higher level, as it introduces new skills and concepts, which are necessary for the comprehensive development of children (CLA, 2017; CIF, 2015; Colucci-Gray et al., 2019).

The STEAM educational approach consists of Natural Sciences, Technology, Engineering Sciences, Arts and Mathematics. STEAM programs also include Art in the STEM curriculum. In this way, students can use the principles of design, are encouraged to find creative solutions, and gain a new perspective on the phenomena around them by gaining knowledge and information from different scientific fields. This holistic education provides children with all the resources they need for their comprehensive development and connects the acquired knowledge to their daily lives through interdisciplinarity (Papadakis & Kalogiannakis, 2020). In addition, their active participation during the lesson and their involvement in group work enables them to develop collaborative skills and help them invoke pre-existing knowledge and experiences that will play an essential role in building their new knowledge. That means we are talking about a form of modern interdisciplinary education that equips children to manage all the challenges of their time adequately and become active citizens in the future (Psycharis, 2018; Chatzopoulos et al., 2019).

3.3 Purpose and aims of STEM and STEAM Education

The primary purpose of the educational model of STEM is to prepare and help students get all the resources and skills required in modern times (PCAST, 2010). Through STEM education, children can apply their knowledge in their daily lives and thus understand how the world around them works (Vlasopoulou et al., 2021). They become literate at the scientific and technological level, find answers to complex problems, propose solutions, and develop their communication and collaboration skills (Maryland State Department of Education, 2012; Morrison, 2006).

Students learn to understand, design, and create technological objects through STEM education, which is happening by using various scientific applications and methods (Mechanical Literacy). Another goal of STEM education is that the students learn how to explain, interpret, solve, analyze, and communicate their ideas and thoughts in a mathematical way, in different cases each time (Mathematical Literacy) (Asunda, 2012). Through STEAM education, children face various problems called to solve. In this process, they will have to recall their earlier knowledge, make analyses or syntheses of data, hypotheses and at the same time to be able to understand human behaviour, as they will have to cooperate with other people and develop a team spirit. In other words, children through STEAM holistic education can develop their computational thinking, which is a mental process that involves the formulation of a problem and the expression of its solutions, in such a way that the individual can manage it effectively (Psycharis, 2018; Psycharis et al., 2020).

STEAM education aims to innovate and oversee various issues more creatively. Students become able to take risks, actively participate in experiential activities, and collaborate effectively with others. The integration of Arts in STEM education enables children to cultivate their creative imagination and composition skills. They can also perform mathematical or technological activities more efficiently, as they can approach them more creatively, for example, by using

visual aids, metaphors, proportions or performing role-plays and dramatization. Education in the Arts is the foundation for developing children's creativity, and creativity is the key ingredient in promoting innovation.

In conclusion, STEAM holistic education lays the foundation for students to acquire knowledge, skills, and abilities to become inventors and innovative scientists in the future (PCAST, 2010).

3.4 Teaching methods in STEM Education

In the educational reality, in order to achieve the implementation of STEAM education effectively, teachers need to apply appropriate teaching methods which are going to lead students to develop various necessary skills, such as critical and creative thinking, innovation and the ability in finding solutions to various problems that they may encounter in their daily lives (Papadakis et al., 2021). In addition, in this type of teaching, students have the opportunity to collaborate with others, lead a team, set goals and present the results of their work (Erdogan & Stuessy, 2015).

Several effective educational practices promote STEAM training. Some of these are the use of manipulatives and hands-on learning, collaborative learning, discussion and exploration, the formulation of questions and hypotheses, the reasoning of thinking, the recording of problems and the solution of problems, the integration of technology, the involvement of the teacher himself as a coordinator or facilitator, and the process of evaluation as part of the teaching process (Zemelman et al., 2005).

Three teaching methods are followed, considered the most effective for the STEAM educational approach. These methods are project, Problem Based Learning, and Inquiry-Based Learning (Erdogan & Stuessy, 2015; Hakim et al., 2019). The project method has its roots in the Discovery learning method of teaching. However, this method focuses on children's participation in group work (projects) and finding solutions to real-world problems from their environment. Through this method, students can collaborate with others and develop internal motivation for learning. Also, children learn to take the initiative and thus deal with any problematic or problematic situation (Hakim et al., 2019).

Another student-centred teaching strategy considered adequate for implementing STEAM is learning through problem-solving. In this teaching method, students collaborate, interact, answer questions, and solve problems based on the ideas and knowledge they have gained from their already acquired experiences. Students work in small groups, and the teacher intervenes only to facilitate learning. Children can approach knowledge interdisciplinary (Crippen & Antonenko, 2018).

Finally, the discovery method is a student-centred teaching approach primarily based on students' search and questions. In this method, children make assumptions based on the subjective principles or generalizations that they have formed, making mental leaps and developmental shapes. The role of the teacher in such a form of teaching is to guide and inspire. The effectiveness of discovery learning depends on external and individual factors -such as the student's attitude and motivation- and their readiness for learning. According to Bruner, the desire to learn is an intrinsic motivation that, when activated, leads the student to acquire knowledge (Schunk, 2008).

STEAM education can be interpreted as a comprehensive approach to curriculum and educational instructions, content and skills. Thus, teachers approach all STEAM fields without segregation (Morrison, 2006; Morrison & Bartlett, 2009).

The most crucial idea for STEAM education is the concept of an integrated approach, in the sense that this kind of education is the targeted integration of various disciplines used to solve problems. Therefore, teachers should use teaching methods that will treat the separate disciplines of Science, Technology, Engineering, Arts and Mathematics as a unit and then teach them as a coherent entity (Breiner et al., 2012).

3.5 The teachers' role in STEAM Education

To be able to apply effectively STEM education, which is an interdisciplinary approach, teachers will have to switch from the most traditional teaching methods to the most student-centred ones, in which students play a leading role, while the role of the teacher is supportive of the acquisition of new knowledge by their students (Lazarinis et al., 2022). Through the educational strategies and methods they choose, teachers should help and support their students' efforts to research and innovate (Papadakis & Kalogiannakis, 2019). For example, they should use teaching methods mentioned above (project, problem-solving method, discovery learning), which are not teacher-centred, but instead focus on the student (Kennedy & Odell, 2014).

In addition, through interdisciplinary and multicultural approaches, teachers will promote collaboration between students and help them acquire the taught knowledge in depth. Finally, their students will be able to model concepts and situations of the natural world, with the consequent result that in the future, they will be able to apply their knowledge in the broader STEAM education community without being trapped within the narrow confines of the school or their local community (Kennedy & Odell, 2014).

4 STEAM in preschool education

From birth to the age of eight, children take their first steps in the life of knowledge, exploration, and questions. At first, their journey starts with the interaction they develop with their relatives and with the objects, which they process through their senses (Papadakis & Kalogiannakis, 2019). Then, this journey continues through the stimuli they receive from their wider environment, which may be their school and the society in which they live (Pasnik & Hupert, 2016).

Several types of research related to brain development emphasize the importance of Kindergarten in the development of children. It is commonly accepted that when children receive high-quality education and care and grow up in developmentally friendly environments, they are more likely to harness their innate curiosity and succeed in every area of their development (Kermani & Aldemir, 2015; Torres-Crespo et al., 2014).

According to researchers, children are born scientists, researchers, engineers, problem solvers, can work creatively with each other, lead a team project, and work creatively and innovatively (Stone-MacDonald et al., 2011). According to the above, it is demonstrated that investing in quality education in preschool is very important, as it will enable children to develop all their skills and talents. High-quality education reduces the future low performance of children in learning and lowers juvenile delinquency, enhances children's participation in secondary education, and their success in their introduction to higher education. Also promising are the data related to their subsequent work course. Appropriate learning environments in preschool education provide children with a structure that will support their natural tendency to explore, build, and challenge (Chesloff, 2013).

All those elements of quality education characterize STEAM education, as the involvement of preschoolers with natural sciences in combination with the fields of technology, engineering, arts, and mathematics, helps them to become aware, to increase their interest in the Sciences, but also to achieve high performance in school and their education in general. Therefore, researchers have suggested that STEAM education be applied to children's preschool education (Mantzicopoulos et al., 2009).

Regarding the practical application of the above, Christenson and James (2015) emphasize that the Block Center in Kindergarten can be a significant source for implementing STEM activities (Skaraki & Kolokotronis, 2022). More specifically, when dealing with the blocks, preschoolers try to set up their constructions with different heights and sizes, and during this process, most of the time, their constructions fall. As a result, children can conclude the height and stability of their buildings using mechanical, physical, and mathematical skills. In other words, in the Block Center, preschoolers learn to identify a problem, find solutions, innovate, share, collaborate with their classmates, and define their role in a group or society.

Other materials that could be used in the Kindergarten to implement STEM activities are literary books and various robotic sets. A comprehensive STEAM educational program seems to be successfully implemented in preschool education early, and this is because there is only one teacher in these classes who are called to integrate all the scientific fields into his teaching. In contrast, this educational approach cannot be implemented in secondary education, where teachers teach only one scientific field. With the help of the Curriculum, a qualified teacher enables his students to utilize their innate need for knowledge and learn the concepts of Science and Mathematics through the interdisciplinary approach offered by STEAM education (Roberts, 2012).

However, it should be noted that STEAM training can be enhanced even by simple everyday objects, such as batteries, magnets, scales, magnifiers, LED lights, electrical circuits, plastics, aluminium, paper or wooden objects. The teacher can motivate the children to experiment, try, think, and explore their processing subject by giving them such material. Also, this process can be achieved through chemical tests with the use of cooking materials such as soda, vinegar, pastry colour and salt. For example, by using these materials, children with their teacher can simulate the process of a volcano erupting (Stohlmann et al., 2012; Üçgül, 2020).

In other countries, various study programs provide the teachers with detailed instructions on implementing STEM education. One such program is the 'Collections: A STEM - Focused

Curriculum," addressed exclusively to preschool teachers (Bardige & Russel, 2014). Additional efforts to integrate STEM education in Kindergarten are carried out with the introduction of Engineering, where preschoolers, through technological means, seek to combine the knowledge they have acquired in Science and Mathematics (Pantoya et al., 2015).

5 Discussion and conclusion

The need to integrate the STEAM approach into the educational process is reflected in the benefits of education, employment, and the economy. The STEAM educational approach enables students to improve their knowledge and skills. Furthermore, an interdisciplinary and student-centred approach, such as STEAM, lays the groundwork for students to achieve higher levels of thinking and gain an in-depth understanding of the taught knowledge (Stohlmann et al., 2012; PCAST, 2010).

Students who participate in STEAM activities can solve various problems more effectively. They learn to innovate, gain ingenuity and belief in their potential, and develop rational thinking and technological literacy (Morrison, 2006). Several studies show that children's involvement in Mathematics and science has positive effects in various areas. For example, students display positive attitudes, are more interested in school, develop intrinsic motivation to learn, and strive to achieve their goals (Stohlmann et al., 2012).

To a considerable extent, the obstacles to implementing STEAM education arise from the lack of information and misunderstandings related to this educational approach. One such misconception is that Engineering and Technology are two additional subjects in the school curriculum that need to be taught. In addition, students and educators believe that technology is related only to technological means, such as computers, and their tasks, such as word processing (Morrison, 2006).

Another misconception is that having received this type of education, students must pursue professions such as engineering. This misunderstanding exists, as this educational approach does not mention the Philological courses. A fundamental misconception about the teaching of STEM education is that Mathematicians cannot teach Engineering or Technology, and vice versa. However, this contradicts STEM education's basic ideas and principles: interdisciplinarity (Morrison, 2006).

Other crucial factors that prevent the effective implementation of STEM education are the lack of preparation by teachers and their inadequate training on this educational approach, along with the inability of teachers to cooperate, the lack of support from the educational system, but also the lack of research cooperation in the scientific fields of STEM (Vidakis et al., 2019). Finally, the inability to implement such an educational approach is the lack of proper school facilities, material and technical infrastructure, and the limited time for workshops in class (Ejiwale, 2013).

Many factors can contribute either to the non-implementation of STEAM training or the failure of such actions. However, what matters more is that teachers have the will to innovate, dare to apply new teaching methods and strategies, and make a concerted effort to become better and more effective in their work, following the dictates of their times. In this way, they will be able to support the interest of their students throughout the lesson, lead them to in-depth learning, and help them develop in all aspects.

In conclusion, through STEAM education, students can develop all the skills that are considered essential in our days to live, work, and interact successfully in today's modern landscape. Such skills are adaptability, finding successful solutions to various problems, effective communication and cooperation, and systematic thinking (Radeva, 2020).

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