GAME TECHNOLOGIES FOR STEM/STEAM EDUCATION IN KINDERGARTENS

Dr. Borislava Ivanova, Assist. Prof.
St. Cyril and St. Methodius University of Veliko Tarnovo (Bulgaria)

Abstract. The article considers the need to apply innovative educational models in modern education. A brief scientific review is made of the emergence of the STEM/STEAM education, the latter currently being one of the priority approaches for application in educational policies around the world. The basic integrating factor for the STEM and STEAM education is games. Through games, children apply their real-life experience, and they favour their overall cognitive development. Game technologies for STEM/STEAM education in kindergartens are aimed at developing the skills of modern children for critical and creative thinking, design and coding, communication and interest in science, technology, engineering, arts, and mathematics. The connection between the traditions and innovations of the more-than-a-century-old tradition of preschool pedagogy in Bulgaria is emphasized.

Keywords: game technologies; STEM; STEAM; kindergarten; early childhood

Introduction

The modern educational process is dynamic and requires new approaches to the cultivation of knowledge, skills, attitudes, and relations, dictated by the society's need for qualified professionals in the field of emerging innovative technologies. The ability to think critically, find alternative models for problem solving, and create new directions for further progress requires changes in the traditional educational paradigm, which is not only expressed in updating and modernizing educational institutions, but gives rise to the need to reconsider the content, methods, and goals of teaching to cultivate key competences necessary for the life in the 21st century. This finds expression in testing new innovative educational models that place individuals in a priority position and focus on their overall intellectual and harmonious development.

Preschool education is a fundamental stage of the development of individuals and the start of lifelong learning. Early childhood is the fundamental period in which new concepts should be proposed and integrated in education to prepare generations for the challenges dictated by the Fourth Industrial Revolution, characterized by convergence and complementarity of emerging technological fields. In this context, modern

educational policies are aimed at approaches for organizing pedagogical and game interaction in kindergartens, related to the transition of society to scientific and technical progress and informatization in all spheres of human activity.

Exposition

Striving for innovation in Bulgarian education is a condition for applying modern pedagogical and game interaction technologies. The integration of the STEM and STEAM models into the educational process in kindergartens is a growing trend in preschool education. The practice is dictated by the adopted Recommendation of the Council of the European Union and Parliament – Framework for Key Competences for Lifelong Learning, where one of the eight key competences is exactly the improvement of skills in the mathematics, science, technology, and engineering domains (abbreviated as STEM)[1].

In scientific literature, the STEM acronym was introduced in 2001 in a report by Rita Colwell, the first female director of the National Science Foundation (NSF) of the USA, but the term can also be found in scientific articles of university professors of the 20th century. America and Europe have been promoting the STEM education for years as a guideline for updating the system of education of modern engineers and researchers in universities (Li, Wang, Xiao 2020).

The STEM abbreviation stands for Science, Technology, Engineering, and Mathematics and denotes a practically oriented approach to reconstructing the content of education and the organization of pedagogical process. Nowadays, a series of countries around the world are joining their efforts to officially include the approach in the curricula of educational institutions from kindergartens to universities.

When integrating the approach into the educational process in kindergartens, the paradigm is aimed at stimulating children's interest in science, technology, culture, cultivation of creative thinking, initiative, and ability to think critically. The intersection of knowledge focuses on the integrative connections between the science, technology, engineering, and mathematics domains and their importance for children's long-term academic success, well-being, and personal development.

Against the background of developing interest in the STEM education, the STEAM (Science, Technology, Engineering, Arts, Mathematics) abbreviation appeared, enriching the concept with an important aspect by including arts in its structure and adding an emphasis on creativity and innovations, which are "...a leading factor for the formation of consciousness, and hence for building independence as an important prerequisite for the overall development of children's personality" (Nikolova 2022, p. 222).

According to P. Legkostup: "...combining different types of art is a typical approach in organizing and self-organizing children's activities. Various approaches to creative thinking and activity enrich children's experiences and introduce them to the contradictory rich world of beauty" (Legkostup 2001, p. 188). The integra-

tion of arts in educational process not only favours creative thinking, but also provides an opportunity to apply knowledge and skills from all areas of children's knowledge and solve various creative and cognitive tasks. Thus, the STEAM approach supports the formation of young innovators and entrepreneurs ready to face the complex challenges of the modern world.

STEM and STEAM-based education is an attractive factor for the heads of educational institutions in their efforts to implement innovative models prioritizing the transformation of academic knowledge into skills. The basis of the model is the integration links between all educational domains and forms of interaction in kindergartens, which is not really an innovation for Bulgarian education. Innovative achievements in preschool educational institutions are possible thanks to the fundamental basis of the more-than-a-century-old tradition of preschool pedagogy in Bulgaria.

1. Games as an integrating factor for STEM and STEAM education in kindergartens

Games occupy a central place in the pedagogical interaction in kindergartens and are the dominant activity of preschool-age children. Through games, children develop cognitive processes, including abstract thinking, visual representation, and problem-solving skills. Game activities help to form cognitive structures and concentration, which are fundamental for the future development of children. By playing, they „establish specific communication with the world, and ask questions which activate their thought processes and imagination and stimulate communication with others. In the various game context, growing individuals feel safe, protected, and free to choose, change, and improve their experience" (Tsaneva 2022, p. 256).

The main integrating factor for STEM and STEAM education in early childhood is games, through which children apply their real-life experiences to hands-on exploration in the educational process. Research shows that game interaction provides children with a better understanding of the STEM educational content. Incorporating real-life experiences into children's game activities allows teachers to make STEM education possible and meaningful (Wai 2023, p. 2).

Games stimulate creative activity and creative thinking, which are important for the development of innovative skills and adaptation to more complex intellectual challenges. Taking a key place at the core of STEM and STEAM education in kindergartens to stimulate research activities in an interactive and engaging way, games contribute to children's cognitive development by allowing them to apply abstract concepts to concrete situations. Thus, "the traditional educational technological process acquires an innovative character through positive, supportive, and stimulating creative interaction based on the dialogue between teachers and children and between children and other children" (Petrova 2022, p. 10).

According to P. Konakchieva: „games focus the attention of engaged pedagogical subjects who join their efforts to overcome the contradiction between the possibilities and limits of preschool childhood and preserve its uniqueness by categorically not allowing any schematized and regulated school-type models of education and guaranteeing the quality of education and care in early childhood" (Konakchieva 2022, p. 155).

2. Game technologies for innovative educational design in kindergartens

Modern educational approaches are closely related to established traditional game technologies with proven significance in the educational space of kindergartens, which need to be integrated with pedagogical mastery in the creation of a complete pedagogical system for STEM/STEAM education.

The phrase *game technology* covers a wide range of methods for organizing interaction with children through a variety of ***creative games and games with rules***. What is common of game technology when comparing different types of games is that it has "...the following components: game concept, game content, game action, and game rules" (Petrova 2001, p. 201). Game technology should meet psychological and methodically justified requirements for using game situations and provide an opportunity for children to enter the game roles of researchers and discoverers in the science, technology, engineering, mathematics, and arts domains. For the fundamental foundation of game technologies for STEM and STEAM education in kindergartens to be laid, the following conditions must be met:

– project form of organizing game interaction, where children are united in groups and enter roles for joint solving of research problems;

– practical nature of game activity in the context of solving specific cognitive tasks, requiring specific rules of the games;

– interdisciplinary nature of game interaction: game activities should be organized in a way to allow the use of knowledge acquired by children during pedagogical interaction, in all educational areas, in the science, technology, engineering, mathematics, and arts domains.

Project-based education implies an appropriately furnished STEM/STEAM game educational space that allows children to experiment and acquire new knowledge through the prism of their own experience, to collaborate, invent, and create. Such a variable space allows „...the transfer and transformation of knowledge about the environment and development of interpersonal skills. The redo of game areas contributes to increased cognitive activity as well as possibilities for dynamic transition from one activity to another when solving didactic and creative tasks" (Chuhovska 2022, pp. 256 – 257).

The project-based form of game-educational organization and the practical orientation of the STEM and STEAM approaches create motivational and subject-specific conditions for children's engagement, which are a prerequisite for the:

– organization of active educational and cognitive game activities.

– participation in socially significant activities and acquisition of hands-on experience.

– cultivation of the ability to use hands-on experience.

– cultivation of communication competence in the communication and cooperation with peers and adults.

– orientation in the world of professions and cultivation of cognitive interests as a basis for the future choice of profession.

The main goal of the STEM approach is to overcome isolation from solving practical problems inherent in traditional education and build connections between new and unfamiliar educational content with the already acquired knowledge, skills, and attitudes, which is a prerequisite for the children's smooth transition from kindergarten to school. According to R. Hristova-Kotseva: „... the preservation of enthusiasm and motivation, cognitive and emotional attitude, success, and satisfaction with school achievements is largely determined by children's readiness for school education, the cultivation of which begins in the years of preschool childhood" (Hristova 2022, p. 177).

Experiential learning is an essential part of children's preschool education, which, in turn, is one of the fundamental prerequisites for STEM/STEAM activities to be successfully implemented in early childhood education. The innovative approach activities, which include experimenting, discovering, and building, are ideas for learning based on games, the latter being the children's favourite and main activity. Little researchers, experimenters, and discoverers enjoy the game process, which is a prerequisite for increasing motivation and striving for new knowledge leading to success and confidence of children at school.

The implementation of hands-on research game activities is a fundamental factor for the overall connection between all priority domains in the model. Science-related games include the study of various types of substances and materials, comparing their physical and chemical properties. The overall examination of the objects and phenomena of the environment should be carried out in an interactive and casual way using outdoor games whenever possible. Thus, children immerse themselves in the roles of natural discoverers and experimenters, and game activities bring more enjoyment and pleasure.

The technology-related game-cognitive activities are tailored to the age characteristics of children and include elementary technological competence. It should be emphasized that in the context of the issue considered a daily interaction with digital devices is not necessary, but the focus is on the technological and, to some extent, basic media literacy and the application of technology in the daily life of individuals. With a good level of competence on the part of educational specialists, game activities can also include elementary coding skills, where children learn how to program small robotic toys to carry out simple commands. Within the STEM

education of children, educational robotics turns out to be the area in which the economic requirements for the development of high-tech industries and the natural interest of children in the sphere of innovation intersect most successfully. As a result, today's educational specialists around the world actively use kits to construct and program robots.

Engineering game technologies are implemented with the help of various constructors, cubes, mosaics, etc., through which children plan and design different types of structures. Outdoor sandpits in kindergarten yards also offer conditions for the development of children's engineering thought. Based on the maxim that good engineers are good mathematicians, too, game activities based on children's mathematical competences are easily implemented with an appropriate set of didactic materials and tools.

Game technologies in the science and mathematics domains are a prerequisite for researching and understanding specific educational problems, and game technologies in the engineering and technology domains are traditionally concerned with finding (inventing) solutions. Art and design, on the other hand, turn such inventions into meaningful children's experiences. The significance of integration of art in the STEM approach is expressed in the creation of a human connection around the solution of research problems. Thus, through the prism of integration of arts, children express their ideas, creative dispositions, and creativity.

The focus on interdisciplinarity within the STEM/STEAM game interaction is a vector value for applying knowledge from all educational directions when solving creative and cognitive tasks; for developing elementary skills for formulating hypotheses, for planning and conducting experiments, evaluating the results obtained from children's research activities in the course of the game; for realizing the importance of science, technology, mathematics, and art in the daily life of individuals, etc.

The conceptual application of the STEM/STEAM approach in preschool educational institutions in Bulgaria gives rise to the need for good planning of the organization of game interaction and setting clear and specific goals, tasks, and expected results. Game technologies integrating the educational domains (science, technology, engineering, arts, and mathematics) should be skilfully implemented in a comprehensive methodological system tailored to the age characteristics of children. This requires a high level of competence of educational specialists in kindergartens.

Critical to the success of the integrated STEM approach in early childhood education is professional development and ensuring that the complex nature of the integrated STEM context is to some extent tailored to the early childhood teachers' knowledge of it. Therefore, teachers must possess professional knowledge having a positive interrelationship with children's results. Accord-

ing to the concept of STEM knowledge, activities should be planned and implemented between teachers in the pedagogical content (Shulman 1986), and this turns out to be a common contemporary reference for the desired qualification on the part of educational specialists (Michelsen et al. 2020, pp. 44 – 45).

Modern educational environment "... creates a need for the cultivation of adequate, social, professional, and personal competences in the work of teachers" (Vasilev 2022, p. 10), and "... in-depth knowledge of pedagogical theory and practice is necessary for the provision of conditions for quality and innovative activity" (Koleva 2021, p. 45).

Intra-institutional, inter-institutional, and international projects on which preschool teachers often work create a favourable condition for the integration of elements of the STEM/STEAM model of interaction in kindergartens. The comprehensive implementation of the approach requires support not only from the heads of educational institutions, but also from the Bulgarian Ministry of Education and Science currently focused on school education. The involvement of parent community in kindergarten activities is also a key factor in the implementation of the STEM/STEAM approach.

Conclusion

STEM education is much more than a modern innovative approach to early childhood education; it is a holistic educational philosophy that helps preschool-age children develop 21st century skills and be prepared for the future. The pedagogical philosophy of the model covers all stages of education from preschool to higher education. Age characteristics as well as psychological characteristics of adolescents are a key factor in differentiating educational programs for STEM/STEAM education for the various educational stages.

In this context, pedagogical strategies for its integration in preschool education are crucial for the organization of basic and additional forms of interaction in the STEM/STEAM education. The integrated approach and interesting game activities develop children's curiosity, cognitive activity, and creativity. STEM education teaches preschool children to quickly navigate the flow of information, apply knowledge gained in game interaction, take initiative, and skilfully use technology. By studying the basics of exact sciences, children begin to understand the connection of events and rediscover their environment.

Children are creative and instinctive designers by nature, possessing an active imagination. While the sparks of these skills are often naturally seen, the priority remains to encourage and further enrich and develop them to support educational success after kindergarten. The goal of STEM/STEAM education at the preschool level is to promote an early positive relationship with science, technology, engineering, arts, and mathematics and create favourable conditions for the future professional development of adolescents.

NOTES
1. See Competencies and Education. Available at: https://mon.bg/bg/100770. [Viewed 19.09.2023].

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✉ **Dr. Borislava Ivanova, Assist. Prof.**
ORCID iD: 0000-0003-3023-8901
St. Cyril and St. Methodius University of Veliko Tarnovo
Veliko Tarnovo, Bulgaria
E-mail: b.ivanova@ts.uni-vt.bg