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STEM ACTIVITIES IN WORKING WITH CHILDREN OF EARLY AGES*

Abstract: Education is a vital part of any society, and it plays a critical role in shaping the future of young learners. Because traditional teaching methods are not always effective in engaging and motivating students, especially in an increasingly digital and fast-paced world, teachers should develop and implement new, innovative teaching strategies that promote and involve active learning. The STE(A)M concept is also part of the modern teaching paradigm and represents the fusion of science, technology, mathematics, engineering and art. At the same time, STEM is much more than any individual subject. It is the culture we should be building with children. At the core of this concept are active practical work, children's engagement and exploratory learning, based on experimental or project engagement and work. STEAM is not only an introduction to science, scientific phenomena and concepts, but also children's attitude towards creativity, challenges, solving challenges and ways of reaching (finding) solutions. In this paper, we present the essence and specifics of organizing STEAM activities with children of early ages, the importance and necessity of applying such a way of working in early childhood and the possibilities of organizing STEAM activities with children in preschools.

Keywords: *STEM concept, early childhood education, preschool teachers, STEM activities.*

INTRODUCTION

Almost until the end of the 18th century small children were regarded by society as miniature adults. They were only expected to play, but in that period children's play did not have the role and importance it has today. It was believed that children of early ages were not capable or mature enough to study scientific concepts. New knowledge during the 20th and early 21st centuries in the field of psychology, pedagogy, neurology, sociology of childhood about the nature of learning and development of early-age children contributed to an increase in faith in

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the capacities of preschool children to actively participate in their own learning and development. Since then, the child is seen as rich in potentials and competent participant in his/her own learning and living. Children at an early age are curious, ask questions, explore and experiment, which is why their play and joint participation with adults in research and learning have great importance and influence on their overall development. Therefore, it is the right period for them to be exposed to interesting scientific concepts and to encourage cooperation and research. The purpose of the new educational paradigm is to create and design an educational process in which the child will feel joy due to overcome difficulties in learning, cognitive conflicts, new discoveries and knowledge.

What is STEM?

STEM is an interdisciplinary approach to the learning process based on the integration of various scientific disciplines. The word STEM itself is an acronym of the English words for *S*cience, *T*echnology, *E*ngineering and *M*athematics, and it means a unique model (concept, approach) of learning that integrates these areas into one system. STEM fields are well-connected, “interwoven”, project- and question-based, with an emphasis on interdisciplinary learning. With this way of learning, skills are acquired in a way that will be used both in the workplace and in life in general.

It is necessary for children to acquire the skills needed in the modern world, learn to be ready for the changes brought about by time and to quickly adapt to them. By participating in various project tasks and activities, children develop logical, hypothetical, analytical thinking, the ability to reflect, observe, connect, conclude and find solutions to real-life problems in a creative way. STEM invites and encourages, challenges, provokes and leads children to make mistakes, try out many ideas, consider alternative solutions, exchange opinions and ideas, make mistakes and try again. In this way, they create a base of knowledge that is applied in everyday life.

The key feature and characteristic of STEM is integration. Instead of separate teaching of academic disciplines and their content within individual subjects, STEM activities are conceived, the content is “rounded” (connected, intertwined so that they form a unique whole), based on projects and inquiries (problem questions and situations) with an emphasis on interdisciplinary learning. STEM is teacher’s a way of thinking at all levels – including parents – to help children integrate knowledge across disciplines, encouraging them to think in an integrated and holistic way (Sneideman, 2013).

STEM education has been attracting attention of the world public for more than ten years. The concept was created by the American National Science Foundation in the 1990s to promote integrated learning in science, technology,

engineering and mathematics (Sanders, 2009). Such an educational concept includes the acquisition of knowledge about natural, scientific and technical laws and rules, the practical application of that knowledge when solving problems and the development of skills that include an analytical way of thinking, developing and making logical conclusions. Meaningful connections are established between similar aspects of different disciplines, disciplines are mutually integrated, permeated and synthesized into a new whole, contributing to the construction of a comprehensive picture of reality, which, in order to function in real life, needs to be realistically viewed (Jovanović i Kovčić, 2017).

At the Global Education and Skills Forum (Dubai 2014), a worrying drop in student interest in natural sciences and technical disciplines was established, and it was concluded that STEM education should start early in childhood development. Preschoolers have a natural drive and need to explore STEM fields. Their natural curiosity and curiosity "leads" them to find information, check data, and find solutions – research. They often ask questions like: "How can we all get the same number of cookies?", "How can I make my building made of cubes as tall as possible without it collapsing?" (2013 STEM Smart Brief). STEM creates a safe environment for declaring, expressing and practically testing their ideas, which encourages children to think outside the box, i.e. to use non-standard, unusual – divergent thinking (Strutynska& Umryk, 2019).

A 2014 study by the American Society for Engineering in Education identified several characteristics of quality STEM programs (Glancy, Moore, Guzey, Mathis & Siverling, 2014). These are:

1) the content is motivational, applicable and including,

2) children integrate and apply significant and important mathematical and scientific content,

3) learning methods are exploratory and aimed at children,

4) children are involved in solving engineering challenges, using engineering design,

5) teamwork and communication are the most important focus.

Throughout the program, children have the freedom to use critical, creative and innovative thinking, the opportunity to fail and try again in safe environments. The problem, however, is that a significant number of educators are not sufficiently qualified to apply the STEM approach and/or do not want to put in the greater effort that this way of working implies and requires. Therefore, continuing professional development of teachers is necessary (Cekić-Jovanović i Gajić, 2022). On the other hand, through play and persistence, driven by curiosity, early-aged children pour liquids from bowl to bowl, build sand towers, dissolve substances, form buildings

(home for dolls, garage for trucks etc.) and show a willingness to engage in STEM activities very early in life (McClure at al., 2017a).

WHY STEM TURNS INTO STEAM?

Over time, the STEM concept has expanded to include the letter A. STEAM education was created by combining art, creative way of thinking and expression with the original STEM concept. The letter A in the STEAM acronym stands for *Art* and includes music, painting, drama and literary elements. Adding different forms and elements of art allows children to manifest their creativity, to express in different ways their view of scientific concepts, technical and engineering ideas, to express themselves through movement, music, painting, acting... (De Jarnette, 2018).

The arts are an indispensable part of a comprehensive education and just as important as STEM subjects. Children are involved in painting, symbolic games, music and drawing activities. Art is sensory exploration – research and expression through the senses. During STEAM activities, children can feel color on their fingers, see how color changes the look of paper, create and apply different art techniques, paint textile, glass, ceramics, but also paint on sand, coffee grounds, using colored ice cubes, crumpled nylon or paper bags, magnets, etc. As they grow older, they include symbols representing real objects, events and feelings in their artistic expression. Drawing, symbolic games and acting allow them to express what they know and feel, even before they learn reading and writing. Music is also, as a special form of art, an integral part of the STEAM concept. Many studies have shown that early experiences with the creative arts support cognitive development and improve self-confidence (Ferkany, 2008; Wan Mak & Fancourt, 2019).

In today’s fast-paced world, creativity and art have become more important than ever before. Early exposure to art and creativity provides young children with a range of benefits that can positively impact their cognitive, social, emotional and physical development. Creating art also helps children learn about colours, shapes, patterns, and textures, which are important elements in visual learning. By creating art, children learn to observe and interpret the world around them. If children are given the proper opportunities to practice and develop their creativity through art, the trait will become stronger and feel more natural. Numerous ways and forms of artistic expression, often considered unimportant, nurture children’s imagination, inventiveness, innovation, flexibility and fluency in thinking, have a positive effect on the development of children’s emotional, mental and physical abilities.

Adding art to the STEM concept in early childhood contributes to the all-round development of children – from emotional (doing art, children explore and gain control over their emotions), mental (thet expand and deepen their knowledge about the world around them), to physical (they practice fine motor skills, precision,

they use different materials for creative expression – movement, role play, colors, plasticine, clay, costumes, etc.). For children, doing art is more than just fun. Through role play, writing poetry, drawing, dancing, children explore their emotional range so that, as they grow up, they can more easily and successfully deal with ups and downs that will be part of their lives. In this way, they develop their emotional abilities. As children age, their artistic expression includes different symbols – objects, sounds, words, and letters. Research and participation in creative play stimulates imagination, new ideas, opens new questions, dilemmas which in turn stimulate and expand children mental capacities. In addition, Van Mak and Fancourt found a relationship between children's artistic engagement and self-esteem (Wan Mak & Fancourt, 2019).

WHY IS IT IMPORTANT AND NECESSARY TO IMPLEMENT STE(A)M IN THE EARLY CHILDHOOD?

The STEAM approach is very important because of the five disciplines that are combined during learning, but also during everyday activities. Introducing a child to the STEAM concept and way of learning is never too early to start. Research shows that children can and should engage in STEM learning even in the earliest years of life (McClure at al., 2017b). It is important to provide them with multiple and varied opportunities to engage in science exploration and discovery. Whether it is building a birdhouse, doll's room and bed, building military forts, playing with paper kites, or turning into a pet food and equipment vendor, kids are showing a clear willingness to engage in STEM learning early in life.

The STEAM way of working can start with simple examples from everyday life (e.g. when something falls to the ground, it is necessary to explain to the child that the object fell due to the influence of gravity; if he/she slips on the parquet, use the opportunity to draw the child's attention to the difference when moving on different surfaces – smooth/rough). STEAM learning is experiential learning that children should be using every day. The essence of acquiring content is not, as before, on memorizing data, but on understanding the process during which children, through practical activities, discover certain laws, phenomena, processes, relationships. STEAM learning includes examining forms (sculpting, modeling, shaping using different materials and techniques), building forms from wooden or plastic blocks, cubes, cardboard boxes and other recycled materials (arranging and making arbitrary, utilitarian, given constructions); symbolic role play (children "transfer" from reality to an imagined situation, imitate, disguise, objects acquire different functions and meanings, actions take place on an imaginary plane, and they become a salesperson, a veterinarian, a pilot in an airplane, a bunny in the forest, etc.); filling and emptying shapes of different sizes, mixing colors to get a third one, etc.; research through direct sensory experience and practical manipulation through visual, tactile, sound and smell stimuli" (Breneselović, Krnjaja, Backović, 2022: 51).

Children are naturally motivated to solve problems, search for answers to certain questions, check their ideas and assumptions. When they have an active role in learning, they make their own decisions about what, how and with what they will learn and do. When they are interested in the outcome of the procedure, they independently create theories that they try, test and adapt. While exploring and experimenting independently, children correct mistakes and develop strategies, which is one of the advantages and characteristics of the STE(A)M concept. When and as they play, children explore and develop STEAM skills. They take various objects in their hands and by touch, unplanned and unintentional, they discover that stuffed toys are soft, and that stone, metal bowls, wooden boxes are hard. The simplest research activities involve children's direct contact with interesting objects (pots, fruits, toy cars, water, soil, etc.). Through everyday activities and play, children often encounter situations in which they have to come up with solutions on their own and should be let go, because this is the best way to develop independence, self-confidence and a sense of self-worth. There is no functional and effective knowledge without the child's personal involvement and activity during learning, so it is necessary to let them face problems through personal experience and spontaneous research behavior, encourage them to think and propose different ideas and solutions, to use previous knowledge and experiences, and proactive behavior towards the difficulties they encounter along the life way.

Children do not acquire knowledge from adults, but construct it based on their own activity and experience, discussing what they think and know with other children and adults. From birth, children explore, examine, investigate, inquire, test, try – they are engaged in science, whether we like it or not, with or without our help. Innate internal motivation prompts and encourages them to explore their natural and social environment (Eshach & Fried, 2005).

While investigating, children give objects another, symbolic meaning (a cardboard box is a parking for cars, a bed for dolls, a house for a pet, etc.). This means that children are capable of symbolizing, which depends on the children's experience, their imagination and creativity. In an age-appropriate way, children study the situations in which they find themselves, passing through scientific stages. They explore while playing, they have the freedom to choose the ways to reach the goal, the means, without any pressure, to make mistakes, try again, solve the problem, and change the rules. In playing with other children, they mature emotionally and expand their social experiences, adopt new forms of behavior, adapt to new situations and make different decisions (Kopas-Vukašinović, 2006). For effective research, children need a positive climate, a provocative and stimulating environment, a space that, with its equipment, allows them to find answers to questions, discover what they are interested in and find solutions to problems (Golubović-Ilić & Ćirković-Miladinović, 2020). The environment should be flexible, inspiring, challenging, and receptive to provide the child with challenging and stimulating experiences.

Contemporary research shows that experiences in early childhood have a decisive influence on the brain architecture, and thus also on the types and degree of future opportunities in adulthood. The period of early childhood is a sensitive period of development in which there are optimal opportunities to depend on experiences that teach something, and early STEM experiences can contribute to the development of educational competencies for lifelong learning, literacy development, mental, motor and emotional development of a child (McClure at al., 2017b).

Attitudes towards science, the need and desire to engage in science are formed early in childhood. STEM activities in that context influence children's choices, attitudes and later successful pursuit of science. If early-aged children are engaged in some sort of "science talk" during and after the STEM activities, children will build a science vocabulary and acquire the knowledge necessary for a deeper understanding of science topics. Early exposure to science phenomena leads to a better understanding of the science concepts and their deeper studying during formal education. Early and previous experiences have a significant influence on the acquisition and development of new knowledge. In this regard, educators should be flexible, adaptable to sudden and unexpected changes, creative to cautiously and carefully "follow" children's interests, provide adequate materials and be collaborators, partners with children while researching. If children are exposed to scientific concepts through exploration and play during their early childhood and apply the STEM approach to learning, their scientific literacy begins, i.e. the seeds of science are sown (Eshach & Fried, 2005).

Due to all the mentioned benefits of science education at an early age, many people who deal with the education of children of pre-school age, as well as many studies have shown that children can and should engage in STEM learning, even in the earliest years of life.

STE(A)M ACTIVITIES WITH PRE-SCHOOL AGE CHILDREN

The results of numerous studies show that there is a correlation between early experiences with STEM activities and later success in certain school subjects or in school in general. Some of the findings of those studies are that young children:

– have the capacity to deal with scientific terms and develop understanding at a conceptual level;

– need multiple and diverse opportunities (stimulating space, inspiring environment, diverse materials) in order to practice research and discovery of scientific phenomena;

– develop scientific skills and knowledge in both formal and informal environments, engaging in experiential learning (McClure, 2017b; Golubović-Ilić & Ćirković-Miladinović, 2020).

The entire perspective of knowledge and experience of children in kindergarten is determined by parents and teachers. Children do not acquire knowledge from adults, but construct it based on their own activity and experience, discussing what they think and know with other children and adults. An essential part of science education and STEAM concept is learning via the scientific method, of which experimentation is the central component. Children, with the help of educators or parents, explore objects and their immediate environment with their senses – touch, smell, taste, hearing and observation. Adults join the game only when children want it or when the game dictates it (McClure, 2017b). Learning and experimentation should be interactive, collaborative and exciting.

STEM activities usually start with a question or problem for which an answer or solution is sought. A problem is worked on for a certain amount of time in order to investigate the problem and discover (find) a solution. The preschool teacher's role is to be the leader and to encourage the children to take full control of the project from start to finish. At the base of every research is a game, but while children, for example, make a windmill out of paper, pins and a plastic tube or a paper kite, through practical work and play they will learn a lot: wind is air that moves; it can move at different speeds and be weak or strong, stormy; that time when we notice that the windmill spins or we can play with a paper kite is windy; that the paper is flexible, that the pin can stab them, so they should be careful or seek the help of adults or friends who are more dexterous, etc. By investigating water, its properties, forms of appearance in nature, precipitation, changes in state during heating and cooling, solubility, etc., children can examine what water can do and in what ways water power can be used, hydrostatic pressure (science), to construct a mill from different materials (engineering, technology), check the influence of the size and number of paddles (science, mathematics) on the speed of rotation of the mill wheel. At the same time, there is no "final" and unique solution – ideas, proposals, used means and materials can be very different, and products from very simple to complex to the extent that the mill represents a system.

STEAM activities allow children to connect previous and new experiences in a creative way, to explore together and learn from children of different ages. In STEAM activities,each child contributes with their authentic experience: some things make sounds, some things flow, some things can be put in other things. Experiences in and with the material world are the starting point of cognitive development (Van Keulen, 2018).

STEAM learning does not only take place at pre-schools or kindergardens. For young children, the family is the most important learning environment. In addition to peers and other children, co-researchers in the project are parents,

educators and other adults with whom the children collaborate. Quality interaction with adults, peers and older children is as important as rich material experiences. In the various social relationships which children established with people in their environment, they become socialized, develop communicative skills, enrich and expand their vocabulary, get to know the material world and scientific phenomena through play and research (Van Oers, 2013).

Young children have the capacity and are able, in accordance with their age, to make observations, simple experiments, observe and predict, check their assumptions, collect data and begin to understand what they have discovered. Such experiences help them understand the characteristics, needs, and life cycle of plants, animals, etc., and it prepares them to make predictions and generate ideas about new facts they find. They are involved in STEM learning every day, without even realizing it, because it is experiential learning that children practice every day. STEM learning includes examining the form, solubility of materials; pouring, emptying and filling containers of different sizes with dry (sand, pebbles, shells, macaroni, etc.) and "wet" (water and other liquids) materials; mixing colors to get other colors, comparing the sizes, lengths, shapes of certain means of construction (wooden blocks, cubes, containers, boxes, etc.); a symbolic game of trade, imagined journeys, certain professions – a game of imagination or roles (architect, builder, astronaut, archaeologist, etc.).

The basis of work with children of early ages should focus on active, practical work, children's engagement and exploratory learning based on experimental work or project engagement. STEAM concept and innovative teaching strategies not only make learning fun but also help young children to develop a lifelong love for learning. Because STEM activities are interactive and inquiry-based, they provide children with many opportunities to learn and be actively involved. At the core of STEM activities are children's curiosity, desire and need to explore and understand their environment in order to function successfully in it. The "trigger" for the beginning of any study and research is actually the desire to discover the way or reason for some event, process, and phenomenon. Adults can support children's engagement in STEM activities by encouraging and enabling children to solve problems, use their imagination, ask questions, collaborate with others, experiment, make, build, construct and try different things in different ways. While playing, children develop STEM skills about the world around them, develop and strengthen their technological, scientific, engineering, mathematical, but also communicative, social and emotional competencies and abilities. When they are allowed to explore the things of nature and science according to their own desire, they are encouraged to ask questions and find ways to synthesize and formulate their thoughts about what they see. Their explorations may seem or become messy and unpredictable, children can ask questions that are difficult to answer, but it is important that adults (educators and parents) find a way to provide them with learning opportunities and materials that support exploration and discovery. So, it is vital to start teaching STEM at an early age and teach it well (Van Keulen, 2018).

To initiate problem-based learning and STEM activities, the preschool teachers can also use certain life-practical situations. For example, if the children have tea with breakfast that day, teacher can start a conversation with questions related to sweetening, that is, putting a certain amount of sugar in the tea John poured 2 teaspoons of sugar into the tea, and Mary one cube. Whose tea will be sweeter? In whose tea will the sugar dissolve first? Why? What would happen if Mary stirred her tea and John waited for the sugar to dissolve? In whose cup would the sugar dissolve faster? With these and similar questions, the children would spontaneously investigate solubility and the factors that affect the speed of dissolution, increase and decrease the amount of sugar (number of cubes, teaspoon), vary the temperature of the tea (hot, warm, lukewarm), used sugar of different sizes (powdered sugar, crystal and cubes). The bottom line is that the organization of STEM activities does not require special conditions, means and ‘‘equipment’’, but a little imagination, creativity and enthusiasm.

In order for children to acquire and maintain an interest in STEM fields, it is necessary for the educator to design, that is, create such an environment in which they understand the concepts and can apply them to real actions. A successful organization of STEM activities requires an inspiring environment that encourages children to explore. The role of pre-school teachers is to act as a medium of knowledge between the children and the concepts being studied, to act as a “guide” whenever the child is not sure how to approach a problem or task, and to obtain all the necessary material for work. First of all, he/she checks and determines if any of the children already know something about a certain problem (e.g. Why and where do rain puddles disappear when the sun warms them?), what they know, and what can be of help to them in solving a certain problem, what ideas and suggestions they have to investigate the problem and find a solution, and what materials and resources they need during the research. The problems and questions on which STEM activities are based and from which they start should be challenging, provocative and slightly more difficult, complicated (in the zone of subsequent, the one that is next in development, according to Vygotsky) than the age-related capabilities of children, i.e. formulated in such a way that it is necessary for children to make a mental effort to come up with a solution. In addition, it should be remembered that the STEM concept does not prioritize finding definitive answers and original solutions. In the first place, it is the process, participation in research, exchange of ideas, cooperation, individual achievements and progress, because research is a personal achievement of the one who participates in it, even when what he/she is researching is known to others.

Like many other children’s games, STEM activities involve noise, mess, intense movement and action. Children talk and listen, agree, design and create. When they are engaged in collaboration and occupied with multi-sensory, hands-on and discovery activities, explorations that enable different approaches, differentiated solutions, predictions and hypothesis testing, children are satisfied, fulfilled and happy. It is important that the preschool teacher during the children’s play notices

the problems that the children face, the problems that they want to solve, the phenomena that they want to investigate and explain, because these are actually opportunities to engage their thinking and inspire them to continue the research spontaneously, through the game that he/she “channels” and directs.

For such a way of working, it is necessary for preschool teachers to create and develop a space in which children will comfortably and without hesitation explore, experiment and make mistakes. Some projects will fail or be contrary to their or our expectations, so we should use such an opportunity to develop children’s persistence, patience and perseverance, the ability to accept defeat, talk with children about what went wrong and in what ways we can change things next time. The essence of the STEAM concept consists of trials and errors, searching for scientific truth, checking ideas and assumptions. Every mistake for children is a new beginning and a challenge because there is no other period in people’s life where there are so many possibilities, where a person has so much energy, perseverance and enthusiasm, and where he/she masters and develops complex capacities for necessary for his/her future opportunities, personality and successful functioning in further life (De Jarnette, 2018).

IN LIEU OF CONCLUSION

Children of early ages have an innate need to explore, incredible curiosity and the need to explain events, phenomena and processes in their environment, which the STEAM concept can generally adequately respond to. The problems that most often arise during the implementation of the STEAM approach concern the professional competencies of preschool teachers (Van Keulen, 2018) and, in general, their lack of self-confidence and courage to study science with children (Ferkany, 2008). Today’s preschoolers are tomorrow’s inventors and future problem solvers. However, in order to effectively and adequately engage early-aged children in STEM activities, educators need “more serious training and professional development” (McClure at al., 2017a; Wan Mak & Fancourt, 2019).

A good and successful preschool teacher will support children by following their interests, organizing various research activities, providing children with a stimulating environment for work, providing various didactic tools, video and audio recordings, encyclopedias, and encouraging work with different materials. The above-mentioned information confirms that the dilemma of whether to use the STEAM approach at an early age does not exist. The answer to the question *Should Science be Taught in Early Childhood?* is positive: Yes, it should.

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СТЕМ АКТИВНОСТИ У РАДУ СА ДЕЦОМ РАНИХ УЗРАСТА

Резиме

Образовање је витални део сваког друштва и игра кључну улогу у обликовању будућности младих ученика. Пошто традиционалне наставне методе нису увек ефикасне у ангажовању и мотивисању ученика, посебно у свету који је све дигиталнији и који се брзо развија, наставници би требало да развијају и примењују нове, иновативне наставне стратегије које промовишу и укључују активно учење. СТЕ(А)М концепт је такође део савремене наставне парадигме и представља спој науке, технологије, математике, инжењерства и уметности. Истовремено, СТЕМ је много више од било ког појединачног предмета/области. То је култура коју треба да градимо са децом. У основи овог концепта је активан практични рад, ангажовање деце и истраживачко учење, засновано на експерименталном или пројектном ангажовању и раду. СТЕАМ није само увод у науку, научне појаве и појмове, већ и дечји однос према креативности, изазовима, решавању изазова и начинима долажења до (проналажења) решења. У овом раду представљамо суштину и специфичности организовања СТЕАМ активности са децом раног узраста, значај и неопходност примене оваквог начина рада у раном детињству и могућности организовања СТЕАМ активности са децом у предшколским установама.

Кључне речи*: СТЕМ концепт, рано детињство, васпитачи, СТЕМ активности***.**