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**STEM education and cognitive activity of pre-school-age children**

**Abstract**

The research issue of the article focuses on presenting the specificity of STEM education as a space conducive to the development of cognitive activity of a child at pre-school age. The aim of the research is to recognize the dimensions of the child's reality, which are important scientific experiences for him/her. The subject of the analysis was the termination of 54 older preschool children from the metropolitan environment. The children's utterances took the form of questions. The research method was content analysis. The background for the research is the presentation of the essence of the transformations taking place in the space of education. The direction of change is determined by the STEM concept, which was created to increase the effectiveness of education and improve its quality. Its scope includes science, technology, engineering and mathematics. STEM education emphasises the ability to respond flexibly to change and to cope with its unpredictability. It is desirable to develop an interest in STEM education from an early age. Education based on STEM themes becomes a space that triggers creativity and involvement of learners. It becomes a generator of ideas and an impulse for innovation. The last part of the article presents reports from research on the cognitive curiosity of older preschool children expressed in the questions of the respondents. In order to illustrate the content of children's experiences related to science, the respondents' statements were referred to. The conducted analyses show the scientific potential of the child and constitute a recognition in the direction of personalization of the content in education.

 **Keywords:** STEM education, cognitive curiosity, scientific potential of a child

***Specificity of learning about reality in the 21st century - implications for education***

Reality is changing at an unimaginable pace, the way it is known is changing, and so is education. It is necessary and necessary to change the way we think about education. Education cannot focus only on preparing for life in the world (education for the needs of the labour market). It must be more "flexible" and relate to the environment. The need for an education that is interdisciplinary, that combines and integrates knowledge from different fields of science and technology, that remains open to the dimensions of art, creativity and innovation. Both in literature and in educational practice, solutions referring to the educational goals of the 21st century defined on a global scale in the document can be indicated: "Transforming our world: An Agenda for Sustainable Development 2030" (ONZ (UN) 2015). Efforts are being made to ensure that..: "Provide quality education for all and promote lifelong learning.”[[1]](#footnote-1) (ONZ (UN) 2015: 16). The model of "flexible civic education" also promotes in its book *The Power of the Imagination. Education, Innovation and Democracy* Agnieszka Rothert (Rothert 2015: 8). In her opinion, education has a huge influence on shaping the "vision of the future" and future worlds (Rothert 2015: 12), including, of course, building the society of the 21st century, referred to as the "flexible society". (Rothert 2015: 14). The author believes that nowadays it is necessary to "learn flexibility" (Rothert 2015: 175). It is a specific challenge that requires breaking down barriers of thought, crossing the boundaries of thinking through the involvement of imagination. There is a great need for thinking and acting that will be adequate both to the needs of modern man and to the expectations of society. It turns out that modern society has great demands. It expects creative and innovative solutions that will not only meet the values of functionality and usability, or cope with the world, but will be the result of design with the involvement of imagination. All products must have a specific "creator's stigma" and be the result of his creativity. The novelty that emerges in this context as a result of creative work cannot be a "mere" novelty, but something that will be able to delight and arouse interest in growth as a driving force for technological development (Compare Rothert 2015: 160, 165). The author also refers to the notion of "resilience" - in the meaning of “resilience, elasticity and flexibility” - as skills that prove effective in overcoming life's problems (Rothert 2015: 175). In the context of education, it is important that people learn these skills from an early age, either by growing up in an environment saturated with certain values or by experiencing threats to these values. According to her: "*Resilience* is a running reaction." (Rothert 2015: 175), is something that will be possible only if a person learns certain skills beforehand. Only then will it be able to react appropriately, but this does not mean that it can somehow become immune to emerging risks (Rothert 2015: 175).

The "flexibility concept" goes beyond linear thinking and refers to specific thinking in the sense that it has the power of the mind, which at the same time influences and shapes the environment. This concept takes into account relativity aspects and evolves towards an emergent system (Rothert 2015: 177). Flexible thinking and action means going beyond the shaped order of experiencing reality. Being flexible means, among other things, being open to change. Contemporary reality is characterized by a great concentration of changes, their dynamics and scope. The result is a great diversity of reality, its complexity in the real and created dimension, which translates into unpredictability. The perception of reality in a linear and orderly way through the prism of rules, norms and procedures impoverishes its image in the mind enormously (Compare Rothert 2015: 174). There is therefore a need for learning (including the skills needed) to respond flexibly in a rapidly changing world and this is a task for education. Many authors dealing with the issue of early childhood education speak in a similar tone. According to Józefa Bałachowicz and Anna Witkowska-Tomaszewska, the task of education - although the authors admit that it is very difficult - is to help children understand the essence of the changes taking place, to help them read the changing living conditions, to meet the challenges (Bałachowicz and Witkowska-Tomaszewska 2015: 8). The aim of education is to create conditions for the development of potential learning opportunities for learners. It includes searching for and reading the meanings that children give to the elements of reality. This is possible through the analysis of the child's experiences. The integration of knowledge into a child's mind is not the same as the integration of content (Klus-Stańska and Nowicka 2014: 236-240). Dorota Klus-Stańska and Marzenna Nowicka convince us of this. According to the authors, the quality of content (Klus-Stańska and Nowicka 2014: 240-247), which must meet certain conditions, is important for the integration of knowledge: "novelty, science, problem-solving and exploration.... Only their co-existence makes it possible to integrate knowledge (...)" (Klus-Stańska and Nowicka 2014: 247). Without considering the perspective of the child, its experiences and personal knowledge, it would be difficult to talk about subjectivity in the sphere of education. All educational activities must be accompanied by subjective treatment of the child, observance of its rights, including "(...) recognition and respect for the right of the child to his or her own way of thinking. (Chauvel and Michel 1999: 8).

***Education "STEM" - an attempt to outline***

The STEM concept[[2]](#footnote-2) (Chyrk 2015: 162) is the result of actions aimed at improving competitiveness and economic growth. It is a solution in the field of education policy, the creation of which can be treated as a kind of remedy for the ills of the education system in the United States. The concept fits into the broadly understood space of innovative education for improving its effectiveness and quality. It is a source of inspiration for the initiators of changes in education. STEM education is currently the most desirable in the world, it is scientific, technological, engineering and mathematical education (Gonzalez and Kuenzi 2012). The STEM Agenda covers four categories relating to science, technology, engineering and mathematics. However, the definitions of STEM vary according to the perspective of education policy. A narrower definition refers rather to science and covers mathematics, physics, chemistry, computing and engineering, while a broader definition covers physical and natural sciences, engineering (including e.g. physics, chemistry, biology, mathematics) and psychology and social sciences (Granovskiy 2018: 2). The impact of STEM in education is based on the synergy effect that arises from the interpenetration and interaction of fields of science and technology. The educational strategies developed at the programme level are based on common curriculum areas. Depending on the adopted educational policy perspective, educational goals refer not only to natural sciences, but also to social sciences and art. STEM education is close to life and contemporary reality (Chyrk 2015: 162-164). It enables the acquisition of the skills required today, which translates into individual success, increases the level of competitiveness and contributes to economic growth. This is a desirable direction of thinking and educational activity. The STEM areas complement each other and provide a stimulus for development. The resulting scientific space is becoming a platform for the exchange of experience and knowledge, but also for cooperation and innovation. Appealing to different disciplines gives better results in the process of solving real problems, which in fact are very complex in nature. Complex efforts generate thinking "above objects"[[3]](#footnote-3). In fact, STEM is a generator of changes in the education space, an impulse for innovation.

STEM education goes beyond the disciplines that define STEM. Educational projects and programmes are interdisciplinary, multidisciplinary and based on the idea of transdisciplinarity as a solution that integrates science but also goes beyond the boundaries of scientific disciplines (Compare Rothert 2015: 167-168). In this context, the Rothert, which was mentioned earlier and which deals, inter alia, with shaping the space for innovation, refers to the term "transforming" in relation to education, which in its opinion is the most appropriate for forms of education that encourage creativity of learners (Rothert 2015: 168-169). In the space of transdisciplinarity there is room for a new type of knowledge production, which is not limited only to the sphere of scientific institutions. Society and social institutions also play an important role in this process. The idea of transdisciplinarity allows to include in the spectrum of research interests also areas situated outside the centre of a given scientific field. In this way, areas of interest resulting from the production of knowledge and its practical application can be scientifically penetrated (Compare Włodarczyk 2011: 57-63).

STEM education aims to raise awareness (through education) about the importance of STEM and the importance of science. It covers various fields of activity related to scientific activities. In these areas, emphasis is placed on the acquisition of life skills and the development of critical thinking that are important from the perspective of the requirements of the modern world. Children have the opportunity to learn and practice both in the classroom (kindergarten room) and outside. STEM education also focuses on creating a safe and sustainable learning environment. It stresses the importance of dialogue with parents, with the family environment, in order to support and encourage young people's interest in science, engineering, mathematics and information technologies and, in the future, to study STEM. Cooperation and partnership to improve the quality of STEM education is multi-sectoral and involves different actors: teachers, researchers, entrepreneurs, business people, administration employees. The STEM education above all emphasizes gender equality (UNESCO 2017). STEM achievements are promoted and the interest and involvement in STEM is developed from an early age. It is important to provoke cognitively, evoke children's fascination with science, propose and encourage various activities and inspire them. In this way, it liberates the creativity of children, creates conditions for exploring and studying reality by themselves. Education based on STEM themes gives children the space to reveal their own ideas for action, share what is important, interesting and delightful to them. It provides an opportunity to study learning problems from a child's perspective.

***The child's curiosity as an impulse for educational activities - research approach***

In order to meet the challenges of modern education, it was decided to carry out a study aimed at recognizing the dimensions of the reality of a child, which from his or her perspective, in a subjective sense, are important scientific experiences[[4]](#footnote-4). The recognition of both the content of the child's experiences and the contexts of these experiences in this respect will be very valuable from the point of view of educational practice. It will give the opportunity to refer to what the child is familiar with, close to and therefore also to his or her ideas and fascinations. A manifestation of a concrete action in this area is the disclosure of the child's cognitive curiosity by asking questions. By expressing his curiosity in the form of a question, the child fills it with content and at the same time communicates with the dawn, which is currently the subject of his scientific curiosity. It is a situation that allows you to recognize what content is currently important, interesting, cognitive useful to the child, so they are used to build his or her knowledge. The research method was content analysis (Silverman 2009: 145-150). According to A. Rothert "Curiosity is the desire to learn, see or experience something that leads/stimulates the acquisition of new information" (Rothert 2015: 30). The author referred to above believes that while searching for answers to basic questions, we touch the essence of explaining the world (Rothert 2015: 33).

When asked what is interesting about them ("What are you interested in the world?"), older preschoolers formulate several types of questions starting with *How? Why? What for? And why? From what? Whethert? Where? When? What? How many?* Their questions are gender-differentiated. Differences relate to the types of questions asked, the form and content, as well as the number of questions asked. It turns out that most often children ask questions such as *How*? This group is dominated by boys, who do it almost twice as often. The curiosity hidden in the boys' questions concerns especially the technological and construction sphere. They need information on technology and engineering. These are questions such as: *how to make everything new and nice; how to make bottles; how to get the key to Atlantis, which is sunk in Iceland*. They are interested in the sphere of designing and constructing, where knowledge is to solve a specific problem, e.g. functionality or usefulness of objects. They ask about solutions that in the world of technology and engineering are created on the basis of scientific and technical knowledge, but also on the basis of experience, the choice of a suitable method of operation or the use of imagination: *What are the houses; What does a rabbit look like without legs, ears and tails*? They ask questions about existence itself: It'*s like it's all over the world*. They want to find out: *What are the other countries and what is the situation in other countries; what is the situation in Greece and England*. The curiosity of the girls in this respect is manifested primarily in the questions about the world: *How the world was created; How big is the globe*. They want to get information on natural sciences: *How trees grow; How the sun shines; How spiders make a net*. Children's curiosity is not only about the outside world, but also about themselves, who they are, and even what meaning life has (Compare Rothert 2015: 33). Jolanta Kruk's design activity refers to the sphere of practical activity, but preceded by a series of decisions that affect the final effect (Kruk 2008: 185). By building structures, children learn about planning skills (Dolya 2007: 120), but they also learn about the properties of objects, their structure and the material they are made of. The size of the elements, their shape, colour or quantity will also be important. All of this is reflected in the child's language in a functional context, i.e. in a given situation when the child makes an effort to create a given structure (Dolya 2007: 119-120).

Questions about causality type *Why*? *What for*? They're more of a boys' domain. They're particularly interested: *Why dinosaurs are extinct,* but also: *Why is the sun shining*, or: *Why does anyone know everything*? Girls, on the other hand, ask about the causality of living beings in the world, e.g., in the world of the living: *Why are there animals in the world*, or: *Why is there a man in the world*, they also ask questions about the very essence of existence, such as, for example: "*Why is there a man in the world? Why there is a world in the world*. Mathematical and natural sciences are conducive to building explanatory knowledge in children's minds, based on cause and effect thinking (Klus-Stańska and Nowicka 2014: 243). The emerging problematicness is reflected in the child's question. Questions on how to resolve a particular issue are a large group. These are questions starting with the *Whether.* By asking these questions, children expect a specific answer at a specific time. Twice as often as girls ask them. The problems which, according to girls, need to be resolved immediately concern both very complex issues: *Whether the devil is good or bad*; *whether I would go to heaven*, as well as those whose solution in the short term poses, at least, difficulties, such as *Whether there are mermaids*; *whether there are any strange creatures on earth*. There are also questions requiring knowledge of inanimate and animated nature: *Whether Jupiter or Mercury are closer to the Sun*; *whether green flowers are growing*. The girls also want an unambiguous and immediate answer to questions from the area of mathematical-natural sciences, engineering sciences, e.g.: *Can you build large houses of sand*, *is the hedgehog square, is the sun square, or are the teeth round, because I do not know*. Difficult questions in this respect are also asked by boys. Among those which, in their opinion, require an immediate response or an unequivocal decision are: *Could it be the same as before*, or: *Are there aliens*; *Can I meet a dinosaur*? Both boys and girls demand answers, which will simultaneously constitute a solution to an important life problem, such as, e.g.: *Will my colleague recover* or: *Are the parents healthy*? Questions that point to children's cognitive inquisitiveness also concern other issues: *What's the blood, bones and brain made of,* or: *What's the snow made of*? A special group of questions due to their content are questions about space (*Where*?). In order to satisfy their curiosity in this respect, the girls formulate questions relating primarily to space in the geographical and natural sense. They are interested in issues related to the spatial management of a given area as a habitat for people or animals, e.g: *Where other people live*; *Where are the houses*; *Where are the meadows*; or: *Where is the jungle*. Boys are more interested in geographical location and the definition of a place in space, e.g.: *Where is Italy*; *Where is Malbork*; *Where is* *Germany*. They also want to get information about the places where unusual characters live, such as: *Batman, where is he*? The preschoolers are very inventive when it comes to taking into account the aspects of reality which, in their opinion, can be expressed in mathematical language, e.g.: *How many stars are in the sky*; *How many leaves are in the tree*. The question: *How much will I be able to live*? An example of a question that reflects a child's cognitive curiosity about time can be, for example, the following *In what year was the globe created*? When children ask questions, they want information or help to solve a problem they are currently struggling with. They ask for advice and guidance on how to behave, how to act, what to do, and what to do about their lives: *What should I do to be kind; what does it take to become a Spider-Man?* The question about information (containing in its content the value of novelty, science, problemativeness and exploration at the same time, is e.g: *What's going on up there*?

The presented questions indicate that children experience a number of difficulties in recognizing and understanding reality when they experience it. The child will be facilitated by the ability to use tools such as mathematical language, mathematics concepts, properties of objects, relationships and relations between objects as elements of reality[[5]](#footnote-5) (Dolya 2007: 71-72). The answer to the question how to use these tools in the child's learning process to provide valuable cognitive value for the child will be easier if the child's learning is placed in the context of STEM education.

***Conclusion***

On the basis of the conducted considerations, the final reflection raises the question: How to develop the scientific potential of a preschooler? What should be done to make children interested in science, to encourage them to participate actively in discovering processes and phenomena, to make them willing to learn about the mysteries of the world they live in? In trying to answer these questions, we have to admit that the most important task in this respect will be to make the child's education important to him or her, to make it related to what surrounds him or her, to his or her experiences, problems, joys and sorrows. The impulse for educational activities may be the "personalization of content" (Compare Guzik 2015a: 14-16; Guzik 2015b: 34-36; https://www.stem.org.uk/news-and-views/opinions/science-capital-making-science-relevant [access: 29.08.2019]). Referring to the reflections mentioned in the text on the role of content quality in building knowledge, it must be admitted that this quality is of great importance in the process of learning and integration of knowledge (Klus-Stańska and Nowicka 2014: 240-247). In order to trigger the cognitive curiosity of a particular child, it is important whether the content will be new to him or not, whether it will allow him or her to experiment independently, conduct research (a condition of science), whether it will be able to cause a cognitive conflict in the child's mind (a condition of problematicness), and finally whether it will be interesting enough to trigger an unflagging desire to explore reality (Klus-Stańska and Nowicka 2014: 240-247).

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1. This is Objective 4 of the 17 UN Sustainable Development Goals for 2016-2030, which are related to the achievement of the objectives. [↑](#footnote-ref-1)
2. "STEM" is an acronym derived from the first letters of the names in English: Science, Technology, Engineering, Maths. (Chyrk 2015: 162). [↑](#footnote-ref-2)
3. "Over the Objects" is the theme of one of the cyclical "Education Congresses" in Katowice. The Education Congress under the slogan "Above Objects" took place in the space of the Silesian Museum on 10 April 2018. [↑](#footnote-ref-3)
4. For the purpose of the article, the research material obtained through free interviews with children, narrowed down in terms of content due to the purpose of the study, was used. Older preschool children from metropolitan areas participated in the study. The children's statements are part of a larger research project. For the purposes of the study, 54 children aged 5 and 6 (28 girls and 26 boys) were analyzed for notice of termination. [↑](#footnote-ref-4)
5. According to Galina Dolya, these are important mathematical skills. [↑](#footnote-ref-5)