DOI: 10.46793/STREAM25.355M
UDC: 373.3.046-021.64

FUTURE IMPACT OF STEM CONCEPT APPLICATION ON REPLACING AND/OR RECONSTRUCTING MISCONCEPTIONS

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Abstract: This paper presents the results of a preliminary study conducted in two fourth-grade classes at Primary School "9. Oktobar" in Prokuplje. Based on the results of some previous research, we wanted to examine whether and how the application of the STEM approach in lower primary school grades affects students' misconceptions about electric current. Although the teaching and learning programs in Serbia do not sufficiently allow for the implementation of the STEM concept, by comparing students' knowledge before and after lessons where such an approach was applied, we found that the application of the STEM approach positively influences the elimination and correction of students' misconceptions about electric current, electrical circuits, electrical conductivity, conductors, and insulators.

Keywords: STEM concept, misconceptions, primary school, electric current

INTRODUCTION

The purpose and goal of modern education are to equip students to be prepared for the changes that time brings and to adapt to them quickly. Due to numerous scientific discoveries, changes, and transformations at all levels, it has become necessary for students to develop logical, hypothetical, and analytical thinking, the ability to observe, compare, connect, draw conclusions, and find efficient and creative solutions to everyday life problems during their education. It is essential to educate them scientifically, providing them with as many opportunities as possible to explore and experiment, and it is precisely the STEM concept that can contribute to the development of students' educational

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competencies for lifelong learning, literacy, and mental, motor, and emotional development (McClure et al., 2017).

The STEM concept was created by the U.S. National Science Foundation in the 1990s with the intention of connecting and integrating the learning content from science (S), technology (T), engineering (E), and mathematics (M). It involves the integration of various disciplines (STEM fields), which are well-connected, „interwoven", project-based, and problem-oriented, with an emphasis on interdisciplinary learning (Sanders, 2009; Golubović-Ilić, 2023). This concept "today, in addition to the original, also has many sub-variants" (Miljački, 2020: 103), where, knowledge is also integrated from the arts (STEAM - Art), reading (STREAM – Reading), physical education (STEPAM – Physical education), and others. 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 excel at the skills needed in the modern world, learn to be ready for the changes brought by time, and to adapt to them quickly (Golubović-Ilić, 2023).

Although the STEM concept has been known and present worldwide for more than 30 years, it arrived to our country with a delay and has gained relevance only in the last few years (Ilić, Škorić, & Subotin, 2020; Stantić Miljački, 2020; Cekić-Jovanović & Gajić, 2022; Filipović, 2023; Golubović-Ilić, 2023). Given that the theoretical foundations and empirical research on the various effects of this concept are very much needed and significant, national scholars are increasingly focusing their attention to this topics, while the direct implementers of the educational process, as is often the case with other innovative approaches, models, and concepts, remain on the sidelines. Class teachers and teachers, who are supposed to apply and directly implement this method of teaching, are deprived of systematically designed and organized professional training, development, and enhancement of professional competencies for STEM education. The development and strengthening of their abilities to apply the STEM approach are left to their personal affinity, enthusiasm, initiative, and desire to modernize and innovate their direct work with children, as only three professional development programs[1] on this topic are available to them in the ZUOV Catalogue. Furthermore, research results show that teachers have positive attitudes toward the use of modern technology and the STEM approach in teaching, but that the majority of respondents (45.6%, N=160) "have not attended any professional development seminar on the application of STEAM" (Cekić-Jovanović and Gajić, 2022: 193). Such data indicate a problem with the

[1] ZUOV – Institute for the Improvement of Education of the Republic of Serbia (catalog numbers of the programs: 1128, 394, and 893)

diffusion of the STEM concept as a pedagogical innovation within the education system of our country (Filipović, 2023). The demand for STEM education is constantly increasing, and some predictions suggest that STEM competencies will become a key element in future employment. This is because future workers are expected to be ready for the challenges of the 21st century, to have innovative, creative, and inventive potential, and to possess technologically sophisticated skills and the ability to connect science, art, engineering, and mathematics more deeply. In Serbia, however, many studies and analyses "point to a continuously insufficient level of knowledge and skills acquired by students in primary schools, underdeveloped essential competencies for further education and daily life, and low student motivation for learning and intellectual work (Education Development Strategy in Serbia by 2020)" (Ilić et al., 2020:85). This may be due to the fact that the curricula of primary schools and high schools do not include a STEM subject that implies the integrated study of content from different areas (science, technology, engineering, mathematics, art), but rather these "subjects are studied exclusively in isolation" (Ibid., 86). On the other hand, there is a problem that class teachers and teachers who are supposed to deliver this subject do not have adequate competencies, and their level of readiness to apply the STEM concept in direct work with children/students is unsatisfactory. Additionally, the class teachers themselves do not feel prepared for STEM teaching and believe that their theoretical knowledge from different disciplines is not sufficient for integrating content and implementing such a method in real conditions (Filipović, 2023).

WHY IS THE APPLICATION OF THE STEM CONCEPT SIGNIFICANT AND NECESSARY?

The application of the STEM concept positively affects various aspects of personal development— it encourages curiosity about the world, openness, and readiness for collaboration, and in well-designed problem situations, "contributes to the development of all competencies for lifelong learning" (Miljački, 2020:107). The STEM approach helps students to understand more deeply the importance of scientific concepts; it enables them to understand how to approach and solve problems from both teaching and everyday life. Technology within the STEM concept helps students become aware of the technological demands of the world we live in and apply some technological solutions in their professional work and daily life. STEM ensures that students achieve high academic goals by primarily understanding the subjects they learn, finding their application in everyday life, and managing to connect them with the demands of rapid and modern living (Educational Center STEM[2]). This concept involves acquiring knowledge about the functioning of natural, scientific, and technical laws and principles, developing skills that include problem-solving, analytical and divergent thinking, "developing and making logical conclusions, and acquiring practical knowledge" (Ilić, Škorić, Subotin, 2020:84) with the aim of solving everyday problems from the real world through practical work (Cekić-Jovanović and Gajić, 2022). STEM learning environments promote creativity using the inquiry approach, offer opportunities for teamwork, and emphasize inquiry rather than the memorization of information (Wang et al., 2011). During STEM activities, besides cognitive skills, students also develop social competencies, as problem-solving work involves collaboration, "interaction and communication among students, as well as providing support in situations where there is a need" (Filipović, 2023: 183). We can also understand the STEM approach as play, especially in early childhood education, as it represents a fun activity that, through experimentation, hypothesis formulation, and testing, leads to certain knowledge and conclusions. It contributes to holistic education, stimulates imagination, allows children to try out and execute whatever they envision, and is a key factor and method of working and learning that prepares them for life. 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 (Golubović-Ilić, 2023).

MISCONCEPTIONS OF PRIMARY SCHOOL STUDENTS

Guided by curiosity and interest, young children explore their environment and create concepts and ideas based on their everyday experiences. The way they describe and explain the world is often driven by logical but scientifically inaccurate understandings. Experiential, scientifically unfounded, and unverified knowledge represents the spontaneous concepts with which children begin their schooling. Over time, and under the influence of education, these concepts are modified, developed, and become pseudo-concepts, eventually maturing into true scientific concepts by the age of 11–12 years (Petrović, 2006).

Students come to a classroom with prerequisite knowledge (existing schemas), and as they progress through their education, these schemas are progressively (or sequentially) built upon (Thompson & Logue, 2006). "Although spontaneous concepts, or experiential knowledge, are of fundamental importance for children's understanding of their environment and the relationships within

[2] 7 reasons why STEM must be part of every teacher's instructional approach - stemzbornica@gmail.com

it, their meaning is often, to a greater or lesser extent, in conflict with scientific facts and can pose a barrier to the acquisition of scientific concepts, especially in the natural sciences" (Blagdanić, Radovanović, Bošnjak-Stepanović, 2019:17). Based on unfounded generalizations and assumptions, experiential concepts can be found in the literature under various names-prejudices, alternative ideas, naive beliefs, and misconceptions. The term misconception is used to describe a situation where students' ideas differ from scientists' ideas about a concept (Smolleck & Hershberger, 2011).

Considering that the exploration of the world (phenomena, processes, and relationships in the environment) begins well before primary education, it is important to note that the spontaneous concepts a child forms through direct interaction with their environment represent the experiential base upon which scientific concepts are built in the educational process (Blagdanić, Radovanović, Bošnjak-Stepanović, 2019). Children's interpretations, although spontaneous and intuitive, do not consist of individual, immediate perceptions related to a given phenomenon; their content exceeds the meanings present in immediate perceptual data to the extent that these are interpreted according to intuitive principles (or knowledge) that children have previously acquired through their practical experience (Petrović, 2018). In their effort to understand the world around them, students create an intuitive explanatory framework that often operates outside their conscious control during the school learning process and limits their understanding and proper acquisition of new information, leading to various learning failures throughout their education. Considering that students' previous experiences serve as the foundation and context for further learning, and that partially accurate ideas can either present a barrier or be used as a basis for further development and "building" of scientific knowledge, teachers should not ignore or underestimate the power of misconceptions. The problem is that once a misconception is formed, it is extremely difficult to change (Eggen & Kauchak, 2004), and possessing incorrect understandings (misconceptions) can have serious consequences for learning. According to Fischer (1985), misconceptions have some common characteristics:

1. They are in contrast with scientific concepts;
2. There is a tendency for the same misconceptions to frequently occur among a larger number of people;
3. They are very resistant to change, especially when traditional lecturing methods are used in teaching;
4. They sometimes involve entire alternative systems that are logically coherent and are often used by students;
5. Some are historical, meaning they arise from theories that have been superseded in science;

6. They can result from the automatic processing of linguistic structures without correction of meaning; and
7. They can be the result of certain experiences that are typically common to a larger number of individuals, or they can arise from classroom instruction, specifically due to incorrect interpretations of textbook material or misunderstandings (Lukša et al., 2013).

There are several ways in which children develop misconceptions. Some sources of incorrect understandings include everyday observations, religious or mythological teachings, and so on. Additionally, there are multiple contexts in which young learners encounter information that promote misconceptions. First, not all experiences lead to accurate conclusions, or they lead students to see all possible outcomes. Second, when parents or other family members are faced with the children's questions, instead of admitting they do not know the answer, it is common for them to provide an answer that is inaccurate, incomplete, or unclear. Other sources of misconceptions can be various written, audiovisual resources, media, the internet, and even teachers. The fundamental issue is that students consider all these sources to be "trustworthy," leading to their ready, uncritical acceptance and absolute belief in the truthfulness of the information received (Pine, Messer, St. John, 2001). Younger learners are capable of providing correct answers to certain questions but may simultaneously hold misconceptions in which they strongly believe. One way to correct these misconceptions is through teaching for conceptual change. "Misconceptions are rarely expressed verbally or in writing and therefore often remain undiscovered... but before the process of disputing and correcting misconceptions begins, the teacher must uncover the misconceptions that their students have" (Shultz, 1987: 21). By understanding the concepts and misconceptions of younger learners, teachers can better tailor their teaching methods, strategies, and approaches in an attempt to guide students toward accurate and more sophisticated understandings of science (Hoi, 2021).

In Serbia, fourth-grade primary school students, although they have not officially covered the topics of electricity and electric current in the previous three grades according to the curriculum, have prior experiences and some background knowledge on the subject. However, foreign researchers believe that misconceptions about electric current are nearly universal, resistant to change, and maintained by teachers, textbooks, and collective experience (Hasanah, 2020; Şenyiğit, 2021). Considering previous research on the possibilities and methods for addressing students' misconceptions (Taufiq, Muntamah, Parmin, 2020; Uswatun, 2020; Aligo, Branzuela, Faraon, Gardon, and Orleans, 2021), we selected content from the Nature and Social sciences[3] curriculum

[3] Official Gazette of the Republic of Serbia – "Educational Gazette," No. 11/2019

program. Specifically, we used the teaching theme of *Materials*, and within it, the teaching units: *Charging Objects with Different Materials*, *Electrical Conductivity – Conductors and Insulators*, *and Rational Use of Electrical Energy and Proper Handling of Electrical Appliances in the Household.* With the intention of examining the impact of applying the STEM concept on addressing and correcting students' misconceptions about electric current, electrical circuits, electrical conductivity, conductors, and insulators, we designed the implementation (processing) of these contents using the STE(PA)M concept.[4]

RESEARCH METHODOLOGY

Considering that most "domestic" research on the application of the STEM concept pertains to subject teaching and working with high school students, our research focused on the misconceptions of fourth-grade primary school students about electric current and the possibility of correcting these misconceptions using the STEPAM concept.[5] The aim of the research was to examine whether and how the application of the STEM approach in younger grades of primary school affects students' misconceptions about electric current, specifically to determine the impact of using the STEM concept on correcting and removing these misconceptions.

The starting point of the research was the fact that the education and learning programs in Serbia do not sufficiently allow for the application of the STEM concept. Therefore, both in the everyday practice of class teachers and in our case, it was necessary to first select content and choose appropriate teaching units/themes that could be integrated from specific subjects. The second phase in applying the STEM concept involves "fitting" or designing ways to implement STEM activities during regular lessons without disrupting the existing schedule. We addressed this problem by planning a double class (90 minutes) during which the mentioned content from the Nature and Social Sciences subject would be realized using the STEPAM concept, scheduled during the regular classes of that school subject and Physical Education. The research was designed as an experiment with parallel groups, where the students of one fourth-grade[6] class represented the experimental (E) group, and the students of another class represented the control (K) group. The research consisted of three phases: (1) initial testing of both groups' knowledge about electricity and

[4] Detailed structure and organization of the class can be found in the Journal Uzdanica, vol 22/1, 2025..

[5] STEPAM = S - Science, T - Technology, E - Engineering, P - Physical Education, A - Art, M - Mathematics

[6] Primary School "9. Oktobar" from Prokuplje

electric current, (2) teaching using the STEPAM concept with the experimental (E) group and using the conventional method with the control (K) group, and (3) re-testing the E group's knowledge to determine the impact of this teaching method on previously identified misconceptions. The research objectives were: 1) to identify existing misconceptions among primary school students about electric current, and 2) to determine if there are significant differences in the number and type of misconceptions about electric current before and after the Nature and Social Sciences classes where the STEPAM approach was applied. Knowledge tests (initial and final) contained 12 questions of varying levels of difficulty (basic, intermediate, and advanced), both open and closed-ended, with a maximum of 20 points. Based on the responses to the initial test, we identified characteristic misconceptions about electricity and electric current for both the E and K groups. We then compared the results (responses) of the E group with those of the K group in the final test to determine the differences in the number and type of misconceptions before and after the Nature and Social Sciences classes where the STEPAM approach was applied (E group), compared to the conventional teaching method (K group).

RESEARCH RESULTS

Although this is a study of smaller scope and with a small sample[7], the data indicate that, after the research, the extent and quality of knowledge about electrical phenomena among students in both groups significantly increased. Before the start of the experimental part of the study, that is, before the implementation of the double lesson with the E group and the conventional teaching of the same content with the K group, the results of the initial testing showed that the knowledge of both groups of students about electricity and electrical phenomena was very limited, at a level of recognition, guessing, and with significant "gaps" regarding objects that can be electrified, methods of using and generating electric current, and dangers of electric shock. The reason for this is that students in the first three grades have not studied electrical phenomena in any subject, so the results were entirely in line with our expectations. For the question of why we should be cautious when using electrical devices and appliances, 55% of students in both groups selected one of the incorrect answers[8] (options *a* and *v*). A large number of incorrect answers (60%) were also given for the question, "Which of the listed devices can operate without electrical

[7] This is a preliminary study research preceding a doctoral dissertation.

[8] Suggested answers: a) because it is dangerous to use electrical devices without gloves; b) because it is dangerous to use electrical devices with wet hands; v) because it is dangerous to use electrical devices at a great height.

energy?[9]" Additionally, for question 4, which required students to recognize and name the instrument used to measure electric current, there were no correct answers. Although this is a closed-type question (with options: *voltmeter*, *electromagnet*, *ammeter*, and *wattmeter*), the misconceptions of students across the entire sample stemmed from everyday life on one hand, and logical reasoning at that age on the other. The most frequent answer (82%) chosen by the students was "wattmeter."[10] A considerable number of students in both groups gave partially correct answers[11] to the question, "What is a source of electrical current?" because they had not previously learned about this concept within their schooling. For the same reason, a large number of students (75%) gave a negative response to the question, "Can you make a circuit?| Some of the characteristic answers included: "No, because I'm not an electrician;", "No, because it requires knowledge;", "No, because I don't know what materials I need;", "Yes, but I'm not sure: battery, plastic, thread..."

The responses from students to the third-level complexity questions (open-ended questions) are particularly interesting because they reveal the most pronounced misconceptions. For the question, "Why do birds that land on power lines not get shocked?" the students' answers included: "Because electricity is only in the wires, not outside;", "Because the wires are wrapped in something;", "Because they have a thin layer on their feet;", "Because magnets do not connect plus and minus, and birds do not stand on two wires." Two students from the control group wrote "I wonder too" instead of an answer, and only one student across the entire sample provided the correct answer. For the last two questions, which required students to consider and explain the dual nature of electricity - its ability to be useful when used correctly and dangerous when not used properly[12] - the responses were as follows: "Electricity is evil.", "Electricity can help us if we need something.", "It is good when you control it, not when it controls you." The fact that the students who participated in the study had many incorrect ideas, spontaneous and intuitive understandings, misconceptions, and opinions about electricity and electric current at the beginning is confirmed by the number of incorrect and partially correct answers (*Table 1*):

[9] Suggested answers: remote control, stove, hairdryer, refrigerator, heater, clock

[10] Electricity is measured by – a wattmeter, a note by the author

[11] Partially correct answers were considered to be responses to closed questions (with provided answers) where students select some, but not all, correct answers, or responses to open-ended questions that do not contain complete explanations, justifications, or interpretations – a note by the author

[12] Explain the proverb "Electricity is a good servant but a bad master" (Question 11) and explain the verses: "Where there is electricity, be wise and do not touch its wires; this way, you will never experience an electric shock!" (Question 12).

Table 1: Students' answers on the initial test

Question number	Correct answers	Incorrect answers	Partially correct answers	No answer
1.	13	7	-	-
2.	15	5	-	-
3.	9	11	-	-
4.	-	20	-	-
5.	17	1	2	-
6.	3	12	5	-
7.	4	1	15	
8.	3	2	13	2
9.	2	-	5	13 (don't know)
10.	3	8	5	1 + 3 (don't know)
11.	7	3	9	1
12.	16	-	4	-

The effects of applying the STE(PA)M concept in the E group can be observed based on the results of the final testing. On the final knowledge test, students in both groups generally did not have problems with basic-level questions – they recognized situations representing the consequences of electricity generation, correctly selected materials to charge a glass, and identified the characteristics of water that requires caution when using electrical devices. For second-level complexity questions, both groups of students performed better on the final test compared to the initial test; however, the number of correct answers from the E group students was significantly higher than that of the K group students. For the question that required students to recognize and name the instrument for measuring electrical current (an ammeter), all students in the E group provided the correct answer, while the number of such students in the K group was lower. Additionally, the number of E group students providing completely correct answers[13] to the question "Which of the listed vehicles can operate without electrical energy?" was also higher compared to the K group students, whose answers were partially correct. Thanks largely to the video material that students in the E group watched during the lesson using the STE(PA)M concept,

[13] Offered answers: electric scooter, tram, bicycle, car, roller blades.

their number of correct answers was higher compared to the K group, even for multiple-choice questions. Similar data are found for the questions related to the practical application of what was learned (Level III of complexity), as all students in the E group were able to correctly identify the necessary components and describe the process of creating a circuit. They also ruled out the possibility of using thread as a conductor, and, unlike students in the K group, precisely explained that thread cannot be a conductor because it is not made from a material that conducts electricity.

Significant safety improvement when working with electricity compared to the initial test was demonstrated by almost all students in the E group. They, in contrast to a few students in the K group, understood the importance of using insulating materials (e.g., rubber gloves) to protect against electrical shocks. The positive impact of the STE(PA)M concept on the development of cognitive skills and the ability to interpret abstract concepts among students is evident from the comparative analysis of answers from the IT and FT regarding metaphorical expressions, proverbs, and verses about electricity (e.g., "*Electricity plays its song in the wires, but if you're not careful, the risk multiplies...*" translated from Serbian). There were significantly fewer incorrect, incomplete, and inadequate interpretations by students in both groups on the final test compared to the initial test. However, students in the E group, compared to the K group, provided much more accurate answers—more complete explanations and justifications for why electricity should be used carefully and responsibly.

CONCLUSIONS

Fourth-grade students have a range of misconceptions, ideas, and inaccurate but logical understandings about electricity and electric current. To determine whether the application of the STE(PA)M concept would affect the correction and/or removal of observed misconceptions, we designed a study with parallel groups. One group (K) learned about electric current in the usual way as prescribed by the curriculum, while the other group (E) integrated content from science, technology, engineering, physical education, art, and mathematics. The results show significant changes in the understanding of electrical phenomena on one hand, and the acquisition of much "broader" and higher-quality knowledge among the E group compared to the K group on the other. Students acquired and expanded their knowledge about electricity, electric current, conductors, and insulators, understood electrical phenomena, and gained new skills that will be useful in everyday life. They also explored independently the components of an electric circuit and the materials needed for its construction, tested the electrical conductivity of various materials, understood the difference between conductors and insulators, and developed not only technical skills related to making circuits but also a deeper understanding of electricity concepts.

The implementation of the lesson in the E group confirmed that the STEM approach allows students to learn interactively, explore scientific concepts through experiments, and apply knowledge in real-world situations (Quigley & Herro, 2019). The students were active, focused, and engaged throughout the lesson; in certain parts of the lesson, peer and experiential learning were clearly observable. Elements of Physical Education helped prevent monotony, provided an unusual and active way of reviewing content globally, and combined mental with physical activity. The results confirmed that this approach fosters critical thinking, a deeper understanding of scientific concepts, problem-solving, and collaboration, while also contributing to the elimination of incorrect or inaccurate thinking and misconceptions. Based on the comparison of results from the initial and final tests, we conclude that lessons organized using the STE(PA)M concept significantly improve the quality of students' knowledge compared to traditional teaching methods. This approach in younger grades affects students' misconceptions about electricity, showing significant differences in the number and type of misconceptions about electricity before and after lessons in Nature and Social sciences using the STE(PA)M approach.

The results confirmed the hypothesis that applying the STEM approach positively impacts the removal and correction of students' misconceptions. However, for the validity of the results, the study should be repeated or conducted similarly with a larger sample. Additionally, a similar study should be designed and implemented with other content areas by selecting and integrating topics from different subjects according to STEM principles, to verify and determine the effects of this approach on other content and subjects. This would also create new examples of lessons—ideas and models for designing STEM instruction—that would contribute to the promotion and dissemination of the STEM concept in our regions, as teachers who incorporate such methods into their practice currently lack adequate resources and, in this context, any form of support. Furthermore, research has highlighted the need for considering students' misconceptions during the development of curriculum, teachers' learning methods, as well as the teaching materials. Instead of applying traditional teaching methods in science education, teachers should provide space for students to reflect on their thinking by discussing with a partner or by reporting back to a group or class (Hasanah, 2020).

STEM encourages, stimulates, provokes, and prompts students to solve problems, find answers to various questions, try different ideas, consider alternative solutions, exchange opinions and ideas, and make mistakes and try again, thereby creating a knowledge base and skills needed for everyday life. In this context, this approach represents one possible solution for low student motivation for learning and intellectual work, as it addresses common student questions such as "Why are we learning this?" and "When will we need this in life?". The STEM approach opens space for students to express and test their ideas, assumptions, and opinions, to share and exchange them with peers, thus encouraging them to think outside traditional frameworks (Strutynska & Umryk, 2019). For the STEM concept to be more frequently applied in our country, especially with young learners of primary school, it is necessary to not only reform and innovate the curriculum but also to create a support and professional development system to increase teachers' competencies and preparedness for implementing the STEM concept in their direct work with students. In this regard, we hope that this study and its results will encourage class teachers and future class teachers to embrace and surprise their students with STEM-based teaching.

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