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THE ROLE OF THE STEMS CONCEPT ON THE DEVELOPMENT OF LANGUAGE ABILITIES AND THE FUNCTIONALITY OF KNOWLEDGE FROM MATHEMATICS AND NATURE AND SOCIETY[1]

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Abstract: Scientific literacy is one of the shared aspirations of numerous educational systems. The importance of learning is reflected in the student's acquaintance with the key concepts and laws on which the world in which we live is based, and then in the development of a scientific way of thinking necessary for satisfying personal and social needs (Antić, Pešikan, & Ivić, 2015; Rutheford & Ahlgren, 1990, according to Marušić Jablanović & Blagdanić, 2019). For a student to be considered scientifically literate, he or she must exhibit measurable behaviors that are recognized on international knowledge tests (such as TIMSS or PISA). When it comes to the lower primary schools in Serbia, two school subjects primarily deal with the development of scientific literacy: Mathematics and Nature and Society. The goals of the STEMS concept are to enhance reading comprehension skills via different types of texts used in Mathematics and Nature and Society, to encourage students to connect the grammatical concepts covered in The Serbian Language course with the content proscribed for Mathematics and Nature and Society, to promote the proper use of orthographic and grammatical rules in open-ended questions used in Mathematics and Nature and Society, and to improve the understanding of vocabulary used in textual tasks to teach the content of Mathematics and Nature and Society. This paper demonstrates that the lexico-semantic abilities and knowledge in Mathematics and Nature and Society can be improved through integrated activities. We present the possibilities for integrating the content of The Serbian Language course with the scientific content taught in Mathematics and Nature and Society.

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INTRODUCTION

Scientific literacy, i.e. learning natural sciences, is one of the shared aspirations of numerous educational systems, including Serbia. The importance of learning science manifests as students' acquaintance with the key concepts and laws that the world in which we live is based on, and then as the development of a scientific way of thinking necessary for satisfying personal and social needs (Antić, Pešikan & Ivić, 2015; Rutheford & Ahlgren, 1990, according to Marušić Jablanović& Blagdanić, 2019). For a student to be considered scientifically literate, he or she must exhibit certain measurable behaviors that are recognized on the international knowledge tests used globally to determine the level of scientific literacy (such as TIMSS and PISA). The PISA (Programme for International Student Assessment) measures 15-year-olds' ability to use reading, mathematics, and science knowledge and skills to meet real-life challenges (OECD, 2023). TIMSS (Trends in International Mathematics and Science Study) can be considered a better tool for measuring school effectiveness, as it relies on the knowledge levels proscribed by the national curricula of the countries participating in a study (Mullis & Martin, 2017).

TIMSS results are an essential source of data since it is the only international research on the scientific literacy of students attending lower primary schools in which Serbia participates. In addition, they allow us to observe and identify the factors of better achievements. When it comes to lower primary schools in Serbia, the development of scientific literacy two school subjects primarily deal with the development of scientific literacy: Mathematics and Nature and Society. When the TIMSS survey results are analyzed, one can determine the factors contributing to the students's achievements in natural sciences. The factors differ: some stem from the characteristics of students, some depend on teachers, and some originate from the school itself (Marušić Jablanović & Blagdanić, 2019). The TIMSS survey conducted in 2019 demonstrates that the knowledge of the mother tongue and language skills impact the understanding of the content taught in mathematics and science (Đerić, Gutvajn, Jošić, & Ševa, 2021). The analysis of incorrect answers in biology, taught in all four grades through science, indicates that a multitude of errors results from misunderstanding the lexicon in the tasks; additionally, open-ended tasks abound in vague answers that, inter alia, suggest insufficient verbal competence among students (Stanišić, Blagdanić& Marušić Jablanović, 2021: 212). Weak lexico-semantic abilities lead to misunderstanding instructions given in

a task and poorer achievements in solving the tasks that require language production. According to the findings of a recent study, fourth-grade students have difficulty understanding the lexical metaphors used in their science textbooks; however, the curriculum does not include the explanations of metaphoric concepts that should serve as a semantic bridge, i.e. to establish a parallel between abstract contents that cannot be understood through the everyday experiences (Blagdanić, Cvetanović, & Lukić, 2022).

Another recent study demonstrates that in teaching biology, the STEM approach can increase students' performance and involvement, reduce students' mental effort, and improve both the quality of the acquired knowledge and its preservation (Županec, Radulović, & Lazarević, 2022). Elsayed (2022) explored the effectiveness of teaching mathematics by developing mathematical proficiency through the five components: conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition (Elsayed, 2022). The findings showing the higher mean scores for the experimental group taught mathematics with the STEM approach prove significant differences in mathematical proficiency between the experimental and control groups. Similarly, in a study conducted by Nursafitri and Anriani, the students learning mathematics via the STEM approach scored better than the students taught with the traditional approach (Nursafitri & Anriani, 2023). Eshaq determined that the inclusion of STEM education into the curriculum encourages students to think critically, collaborate with their peers, and utilize their creativity to solve complex problems (Eshaq, 2024).

Furthermore, games have a great impact on developing mathematical proficiency and improving inclinations toward mathematics (Russo, Kalogeropoulos, Bragg, & Heyeres, 2024).

The results of the studies focusing on lexical-semantic abilities of children with developmental dysgraphia are the starting point for our paper. Namely, the students attending the third, fourth, and fifth grades were tested with *the semantic test* (Vladisavljević, 1983) and *the fluency test* (Vasić, 1988). The results show that insufficiently developed lexico-semantic abilities must be recognized in time and that through appropriate exercises, we can prevent further progress of language disorders and their unfavorable outcomes on children's ability to read and write (Ćalasan, Vuković, & Arsić, 2021: 121).

The activities presented in this paper aim to facilitate the proper development of lexico-semantic abilities in third- and fourth-graders that would concurrently enhance the development of scientific literacy.

From STEM to STEMS

STEM concept is commonly defined as an approach to learning in which science, technology, engineering, and math are co-integrated and applied to real-world problems that connect school and community, promote student achievement, and prepare them for global competitiveness (Dell'Erba, 2019: 2). Many hybridized forms of the STEM approach have been described in the current literature, such as STEAM (i.e., science, technology, engineering, arts, and mathematics) (Herro & Quigley, 2017), STREAM (i.e., science, technology, reading, engineering, arts, and mathematics) (Qu et al., 2021), and iSTEM (i.e., integrated STEM) (Struyf et al., 2019), among others (Canlas, 2023).

In this paper, we propose a novel model of the STEM approach: the STEMS approach where the last letter *S* stands for *speech*. It represents an improvement of the existing approach since it co-integrates speech, science, and mathematics via Web 2.0 technologies. The STEMS approach, as a unique integration of science, technology, engineering, mathematics, and speech, aims:

- to promote reading targeted at understanding the texts of different types that are used in Mathematics and Nature and Society;
- to enable students to connect the grammatical concepts taught in The Serbian Language course with the content covered by Mathematics and Nature and Society;
- to promote the proper use of orthographic and grammatical rules in open-ended questions used in Mathematics and Nature and Society; and
- to enhance the understanding of the vocabulary used in textual tasks in both Mathematics and Nature and Society.

How to Apply the STEMS in Teaching?

This paper presents the model activities for the integrated lessons of The Serbian Language, Mathematics, and Science, which include language games that can be used in a classroom setting to improve the lexical-semantic abilities of fourth-grade students.

The games presented here integrate the content taught in The Serbian Language with other subjects. They concurrently promote learning through entertainment, collaboration among students (can be played in pairs or groups), and different learning styles. In other words, they promote learning through different forms of work and integrate knowledge, while respecting age and prior knowledge of students.

The first lesson model refers to the unit entitled *Botanical World of Serbia* taught within the subject of Nature and Society. The main goal is for students to

acquire knowledge about the botanical world of their country through the integration of grammatical concepts (The Serbian Language) and science terms with digital language games. The games are available to be used in a classroom setting and can be used to improve the lexico-semantic abilities of fourth-graders. Language skills are crucial in other contexts where science teaching takes place. During any research activity, such as a trial and an experiment, in addition to data collection techniques (such as observation, measurement, and experiments), students are required to seek, explain, conclude, and present research results to others. The lesson model is presented below.

Step 1. At the beginning of the lesson, students are asked to solve the Plants crossword using the frontal form in order to increase their motivation and spark their interest.

Figure 1. Interactive game: Plants Crossword.

Step 2. The central part of the lesson is reserved for processing the new content by using the multimedia through various forms of work organization. Students are divided into groups, and each group is provided with a tablet or a phone that they are supposed to use to play the game. Handouts with the content and tasks should be distributed. The matching game is launched by scanning a QR code. Students are expected to match the words with their definitions. This material is used to revisit the third-grade content and gain new knowledge about natural habitats and living communities.

Figure 2. Interactive game: Matching Words and Defining Terms.

Step 3. The handout contains the names of deciduous and coniferous plants. After reading the information from the handout, students play the game

in groups. They are expected to match botanical terms of the flora found in their country with the appropriate word category. As evident, this game combines grammar and biology.

Figure 3. Interactive game: Matching Plant Life and Word Types.

Step 4. The world-known game Hangman is used here to discover the names of the plants inhabiting Serbia. Students are expected to solve the task in groups based on the hints provided as brief descriptions. These hints also rely on the rhyming, antonymous, and homophonic words to support students in their quest for the correct answer.

Figure 4. Interactive game: Discover the Names of the Plant Life in Serbia (Hangman).

Step 5. Consolidating the new knowledge through question-answer interaction.

Step 6. A short animation presents a drawn 2D character and a task expecting students to discover the meaning of the word *treasure* when used literally and as a lexical metaphor in *A forest is our green treasure*.

Figure 5. A short animation: Understanding the Lexical Metaphor "Forests are our green treasure."

Step 7. Homework: Students are assigned a homework assignment to write a poem on plants. They are expected to describe their favorite specimen of the Serbian flora. They are allowed to use the rhymes they hear or invented during the class.

Through the integrated activities, students can learn about the flora and fauna in Serbia. The multimedia content can contributes by expanding the knowledge on Serbia's national parks and the importance of preserving the rare and endangered animal and plant species.

The second lesson model refers to the mathematics unit for fourth graders, which focuses on geometry. Language games created with Web 2.0 technologies can facilitate the process of overcoming the common obstacle of memorizing and differentiating fundamental mathematical concepts with similar names. An example of a class consolidating the knowledge about a square, a cube, a net of a cube, the area of a square, and a rectangle is presented below.

Step 1. At the beginning of the lesson, students solve anagrams, as a warm-up activity in which they create the names of geometric concepts by moving the given letters.

Figure 6. Interactive game: Anagrams with the Names of Geometric Concepts.

Step 2. During the central part of the class, students' geometry knowledge is consolidated by using technology. Students work in pairs, and each pair is supplied with a worksheet containing a printed task and a tablet that they are expected to use. Using the GeoGebra application, students can view a graphic representation of the problem given in the task. The graphic display serves to facilitate the visualization of the problem and the relationship between the quantities given in the task, and, finally, to simplify the process of solving the problem (Milikić, Maričić, & Vulović, 2022).

Step 3. Between solving more demanding problems, students are given a brief break when they are expected to play the game *Faces of Geometric Bodies*. In this game, they are required to connect the graphic representation of a geometric solid and the corresponding name of its face.

Figure 7. Interactive game: Faces of Geometric Solids.

Step 4. The language game *Who Wants to Learn Geometry?* is inspired by a world-known TV show *Who Wants to Become a Millionaire?*. Students use this game to test their knowledge of geometric concepts.

Figure 9. Interactive game: Who wants to learn geometry?

Step 5. Students' homework assignment is to write a story about geometric figures and solids. The story can describe what will happen if a square and a cube collide (e.g. the cube will break into six squares). What would a rectangle say to a cube? Students are encouraged to invent humorous dialogues between the characters. If artistically inclined, students may be inspired to make a comic.

The digital games proposed here are subject to modifications and can be adapted to different units and topics. They can also be altered to match the capabilities and interests of our students.

The approach proposed here is an advanced derivate of the STEM approach in that it co-integrates speech development, science, and mathematics by using the available Web 2.0 technologies. We strongly believe that the utilization of these STEM-based models can improve reading comprehension skills with diverse texts present in the handbooks used to teach Mathematics and Nature and Society. The activities presented here can provide an opportunity for acquiring grammatical terminology concurrently with the concepts taught in Mathematics and Society. In addition, the activities can be used to promote core literacy. Namely, students must be required to comply with the orthographic and grammatical norms of their mother tongue while formulating their answers to open-ended questions checking their knowledge of Mathematics and Nature and Society. Finally, by raising their awareness of the figurative, i.e. metaphorical, use of language in the texts and textual tasks found in

Mathematics and Nature and Science handbooks, we can improve the reading comprehension skills of our students.

CONCLUSION

The main novelty of the approach proposed in this paper is two-fold. First, the lesson models presented here aim to teach science by integrating the topics relevant to The Serbian Language with the content relevant to natural sciences. Second, by integrating the material from two subjects (mother tongue and mathematics), teachers can support the advancements in language competencies and skills that are, inter alia, vital for solving open-ended science questions and comprehending the textual tasks in mathematics. Moreover, the reading comprehension of non-literary texts enhances students' abilities to formulate explanations and understand professional texts and instructions. All these skills are essential for further academic success and are indispensable for any occupation.

The teachers' roles in the STEMS approach are very important, as with STEM and any other derivate of the concept. One of the definitions of the STEM concept points out "the extent of the ability teachers have to take charge of STEM education" (Sulaeman et al., 2022: 70). The examples of the preparations proposed in this paper can help teachers develop their competencies and empower them to implement STEM-based activities so that they can improve students' lexical-semantic abilities and literacy and expand their knowledge in mathematics and natural sciences.

We advocate for an experimental program based on the proposed lesson models. It will be conducted with the students attending the fourth grade of primary school. The subsequent experimental research would provide more insight into the effectiveness of this approach. The emphasis should be placed on preparing the teachers for the implementation of STEM activities in primary schools since this is a prerequisite for the successful realization of the experiment. The students will be tested twice in both fields. Namely, two tests would be used to evaluate students' lexical-semantic abilities and two tests would be used to test the knowledge in science and mathematics.

The proposed research is significant because it may offer a model for connecting the contents and concepts of the subjects: The Serbian language, mathematics, and science. It is expected to enhance the development of scientific literacy. It is also believed to improve lexical-semantic abilities through language games created with Web 2.0 technology and consequently, to improve language production, i.e. the ability to express one's thoughts clearly and precisely, and reading comprehension skills. Without a doubt, these skills are essential for flourishing in any academic and workplace setting.

The research can be extended to teaching mathematics and natural sciences in the older grades of primary school and to the analysis of spelling and grammatical errors made by students during mathematics and science classes.

The STEMS approach can improve teaching practice and students' verbal competencies and scientific literacy at younger school age. Hence, this should result in better academic achievements and should positively influence their ability for lifelong learning. The proposed research should improve education in the field of natural sciences, specifically science and mathematics, in the younger grades of primary school, which is an important strategic goal of every country that strives for competitiveness in the international context (Stanišić, Blagdanić, & Marušić Jablanović, 2021). Through integrated games, students' achievements in the field of natural sciences can be improved, bearing in mind the importance of the position of language as the most basic semiotic and symbolic cultural support, crucial for understanding and building thoughts (Antić & Pešikan, 2015: 106). The proposed integration model can be applied to the mother tongue, mathematics, and natural sciences both in Serbia and in foreign countries. The offered lesson suggestions, but also a research proposal, are significant for society in a wider context because they can contribute to the development of literacy and understanding in a broader sense, which is one of the key competencies for lifelong learning. Comprehension of non-literary texts, ability to formulate explanations, and comprehension of professional texts and instructions are important for a large number of occupations.

Based on everything we stated in the paper, we believe that the STEMS concept, which integrates science, technology, engineering, mathematics, and speech, can promote the reading comprehension of different text types present in Mathematics and Nature and Society, the establishment of connections between concepts taught in The Serbian Language and those present in Mathematics and Nature and Society, the proper usage of spelling and grammar rules in open-ended tasks in Mathematics and Nature and Society, and the understanding of the vocabulary used in textual tasks in Mathematics and Nature and Society.

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