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# CURRICULUM POTENTIALS FOR THE STEM/STEAM APPROACH IN THE FIRST CYCLE OF ELEMENTARY EDUCATION IN SERBIA[1]

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*Abstract:* Serbia is in the early stages of introducing STE(A)M into the educational system. Although the STE(A)M approach is not clearly emphasized in strategic educational documents, some primary education goals that are complementary to this approach. The Erasmus Plus project STE(A)M in Primary School: *Mission Possible* (2023-2025) is underway in Serbia, Bulgaria, and Slovenia. This paper presents some of the results of this project that focuses on a content analysis carried out on the teaching and learning program for four subjects within the first cycle of primary education: The World Around Us/Nature and Society (Science), Mathematics (Mathematics), Digital World (Technology and Engineering) and Visual Arts (Arts). The project *STE(A)M in Primary School: Mission Possible* aims at targeting the educational standards, learning outcomes, and topics that allow for two or more subjects to be co-integrated and developing brief scenarios for teaching activities. The analysis shows that the knowledge and skills needed in everyday situations (not just in a school context) have the greatest STE(A)M potential based on the defined standards/learning outcomes/topics. Such themes include: Materials (Science), Measurements (Mathematics), Safe Use of Digital Devices, Algorithmic Way of Thinking (Digital World), and Communication (Visual Arts). These potentials are more noticeable in the first and second grades, while they are somewhat less conspicuous in the third and fourth grades. The time mismatch of complementary topics is one of the greater issues in using the STE(A)M approach since it disturbs the effective planning and implementation of STE(A)M activities. Thus, additional efforts are needed to harmonize the teaching and learning programs of STE(A)M subjects, i.e. their learning outcomes, topics, and time compliance, and to provide clearer teaching instructions.

*Keywords:* STEM, STE(A)M, teaching and learning programs, learning outcomes, topics

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## STEM/STEAM EDUCATION IN SERBIA

STEM employs the skills that generally use the left half of a brain and is, thus, logic-driven, while research suggests that art expands the right hemisphere of the brain where creativity and innovation are fostered (Daugherty, 2013). STEM fields are focused on convergent skills, whereas art concentrates on divergent skills. Adding art to the STEM "equation" can further strengthen this concept, making it more accessible to a larger number of students and providing greater opportunities for self-expression (Land, 2013). STEAM education generates an arena for solving problems "outside the box" and thereby fosters innovative thinkers needed in the future (Areljung, 2023), which aligns with the demands of employers who "...prefer the creative employee with technical skills related to the job... Yet, there is a gap between understanding the need for creative employees and putting into place education and training systems that result in creative employees'' (Daugherty, 2013:11).

The integration of STE(A)M (Science, Technology, Engineering, Arts, Mathematics) education into primary schools in Serbia aims to enhance learning through an interdisciplinary approach to problem-solving and to encourage the development of various soft skills in students. These skills include critical thinking, practicality, creativity, innovation, collaboration, a propensity for research (curiosity), project management skills, and teamwork in problem-solving. The need to introduce the STEM approach also stems from the need to introduce STE(A)M education, which is also indicated by the results of international research (TIMSS) and scientific studies that point to conceptual misunderstandings of terms at younger school age that continue at older ages.

One of the goals of primary education in Serbia complements the STE(A)M framework: "Developing key competencies for lifelong learning, developing interdisciplinary competencies for the needs of modern science and technology" (*Rulebook*, 2017). The same document clearly states that teachers should be guided by an integrated approach with horizontal and vertical connectivity within the same subject and different subjects while planning lessons in the first cycle. According to the teachers, STEAM education serves cognitive, academic success, and permanent learning, but it also develops children's peer relationships directly or indirectly. Three themes were identified that are in line with the teachers' opinions: 1) opportunities for collaborative learning with friends, 2) values, and 3) opportunities for skill development (Erol & Erol, 2023).

Teacher education in Serbia is not based on the introduction of the STE(A)M concept. It is predominantly focused on the content of individual sciences and how they can be made understandable to students. The emphasis remains

on the content of school subjects, with less emphasis on applying knowledge and reasoning in instruction. However, there are projects and professional development programs aimed at improving the competencies of STE(A)M teachers (for example, projects *Schools for Better Air Quality: Citizen Air Quality Monitoring, STEM Education, and Youth Activism in Serbia*[2], *Supporting STE(A)M Education in Serbia*[3], *professional development programs STEM education in the function of developing key competencies in students* and *STEM activities and challenges*[4]). These programs are supported by the Ministry of Education, the Center for the Promotion of Science, and the European Union. While there are suitable training programs for teachers in the STE(A)M fields, the long-term and systematic effects of these projects and programs are not monitored after their completion.

## S. TEMPO PROJECT

The aim of the Erasmus Plus project *STEM/STE(A)M in Primary School: Mission Possible (S.TEMPO)* is to support the introduction of STE(A)M education at the primary education level in Bulgaria, Slovenia, and Serbia. The project partners are three faculties from Bulgaria, Slovenia, and Serbia that educate teachers (Sofia University, Ljubljana University, and Belgrade University) and three publishing houses (Klett Bulgaria – Project coordinator, Rokus Klett, Slovenia, and Klett Belgrade, Serbia).

The project runs from October 2023 to August 2025. The expected results of the project are developed and academically validated. They include the design methodology for STE(A)M /STEM activities, training 45 primary-school teachers (15 per country) to use the methodology, developing 45 STE(A)M / STEM activities, and developing 45 pilot STE(A)M activities in a real classroom environment. All activities will be published online and promoted across primary teachers' communities for further use in their classrooms. The project team will collect preliminary data on the first effects of implementing the methodology and based on it, draft policy recommendations for the future development of STE(A)M in the primary education context.

[2] https://decazavazduh.rs/o-projektu/

[3] https://www.divac.com/Vesti/2983/Kakva-je-buducnost-STEAM-obrazovanja-u-Srbiji.shtml

[4] https://zuov-katalog.rs/?action=page/catalog/all

## METHODOLOGY

The goal of the conducted research is to analyze the potential of the curriculum for primary grades in Serbia for the realization of STE(A)M education. Curriculum refers here to educational standards and the teaching and learning programs for the first cycle of primary education in Serbia. A content analysis focusing on the teaching and learning programs for four subjects within the first cycle of primary education was carried out – The World around Us/Nature and Society (Science), Mathematics (Mathematics), Digital World (Technology and Engineering), and Visual Arts (Arts). We searched for the educational standards, learning outcomes, and topics that can connect at least two of the selected school subjects during the same school year. It was used as a basis for creating STE(A)M activities. The validity of the selected learning outcomes and content was checked within the S.TEMPO project by creating the scenarios for STE(A)M activities that will be published in the future.

## RESULTS

A graphical representation of STE(A)M school subjects in the first cycle of primary education is shown in *Table 1*:

*Table 1. STE(A)M school subjects*

| | **S** | **T** | **E** | **(A)** | **M** |
|---|---|---|---|---|---|
| **School subjects** | World Around Us/ Nature and Society | Digital World (World around Us/ Nature and Society) | | Visual Arts | Mathematics |
| **Number of hours per week** | 2 | 1 | | 1 or 2 | 5 |
| **Educational Standards (for the end of the First cycle)** | Yes | No | | No | Yes |
| **Learning Outcomes (for the end of each school year)** | Yes | Yes | Yes | Yes | Yes |

As a concept of teaching/learning, STE(A)M is not visible in the existing National Educational Standards in Serbia since they are subject-specific. What can be observed is a sporadic potential for connecting the topics across the subjects. We shall present below an example of such educational standards for Mathematics and Nature and Society:

- **Mathematics:** 2.4.2. Students know units of time (second, minute, hour, day, month, and year), can convert larger units into smaller ones, and can compare time intervals in simple/complex situations.
- **Nature and Society**: 1.4.4. Students know units of time measurement: day, week, month, year, decade, and century; 1.4.5. Students can read requested information from clocks and calendars.

The teaching and learning programs for each subject/grade include the learning outcomes. The learning outcomes for the corresponding grade/subject were used to determine possibilities for cross-curriculum integration (possible relation with other subjects) more precisely in a curriculum mapping.

The goals defined for the subject World Around Us (Nature and Society) are to get students acquainted with themselves and their natural and social environment and to develop the ability for them to live responsibly within them. The educational standards for Nature and Society at the end of the first cycle of primary education are grouped into six themes: *Nature –Living and Nonliving*, *Ecology*, *Materials*, *Movement and Space Orientation*, *Society*, and *Serbia and its History (Past)*. The themes in the curriculum for *World Around Us* (*Nature and Society*) are somewhat similarly formulated –*The Self and Others*, *Materials*, *Diversity of Nature*, *Natural and Social Characteristics of Serbia*, *The History of Serbia*, etc. Through the analysis of the educational standards for *Nature and Society*, we found that two of these themes are suitable for planning STE(A)M activities:

1. *Nature – Living and Nonliving* and
2. *Materials*.

The other themes can also be the core content of these activities, but they are somewhat more challenging to implement. Through the analysis of the program for World Around Us (Nature and Society), we also identified the themes that have the highest integrative potential in this context and are, consequently, particularly suitable for STE(A)M activities:

1. *Diversity of Nature*;
2. *Materials*;
3. *Movement in Space and Time*; and
4. *Health and Safety*.

Given that the themes addressed in World Around Us (Nature and Society) are directly connected to students' everyday lives, these themes often form the core around which STE(A)M activities are built in the first cycle of primary education and upbringing.

The goals defined for the subject Digital World are to develop students' digital competence necessary for the safe and proper use of digital devices for learning, communication, collaboration, and algorithmic thinking. As we have already emphasized, there are no educational standards for this subject, so we analyzed the learning outcomes. Across all four grades, the learning outcomes are achieved through three themes: *Digital Society*, *Safe Use of Digital Devices*, and *Development of Algorithmic Thinking*.

Based on the analysis of the content available in the teaching and learning program for the Digital World, we identified topics (from the second and third themes) that are particularly suitable for STE(A)M activities and interdisciplinary integration:

1. *Breaking down Problems into Smaller Units;*
2. *Designing Steps that Lead to the Solution of a Simple Problem;*
3. *Identifying and Correcting Errors in an Algorithm;*
4. *Identifying and Correcting Errors in a Simple Visual Program; and*
5. *Benefits and Risks Arising from Communication via Digital Devices.*

When it comes to algorithmic thinking, teachers should interpret the term *algorithm* as an instruction for solving a problem or carrying out a procedure. Students should be presented with problems to decompose and express their solutions in a series of steps, relying on their existing educational experiences. Among the problems that can be encountered are those that require repeating certain steps several times or consistently.

The primary objective of the subject Mathematics is to enable students to develop fundamental skills in abstract and critical thinking, cultivate a positive attitude towards mathematics, and enhance their proficiency in mathematical communication, both verbally and in writing. This educational process aims to empower students to utilize their mathematical knowledge and skills at higher educational levels and when addressing real-world problems, thereby laying a solid foundation for the continued exploration and understanding of mathematical concepts. The educational standards for Mathematics at the end of the first cycle of primary education are grouped into four themes: *Natural Numbers and Operations with Them*, *Geometry*, *Fractions*, and *Measurement and Measures*. The themes in the Mathematic curriculum are similarly formulated –*Numbers*, *Geometry*, and *Measurement and Measures*. Through the analysis of the educational standards for *Mathematics*, we found that the most suitable themes for planning STE(A)M activities are as follows:

1. *Measurement and*
2. *Geometry.*

Through the analysis of the teaching and learning program for all four grades, we identified the topics that are particularly suitable for STEM/STE(A)M activities:

1. *Geometric Figures, Symmetrical Figures*;
2. *Measuring Length (with Non-standard and Standard Measuring Units)*;
3. *Measuring Area*; and
4. *Measuring Time*.

There is a noticeable dominance of the topics within the theme *Measurement and Measures* since the knowledge and skills acquired are necessary for the activities found in other subjects, i.e. Science, Art, or Digital World.

The goal of the subject of Visual Arts is to encourage students to develop their creative thinking and appreciation of beauty through hands-on activities. This helps them become effective communicators and fosters a deep appreciation for the cultural and artistic heritage of their own and other cultures. As we have already emphasized, there are no educational standards for this subject, so we analyzed the learning outcomes. The learning outcomes, across all four grades, are achieved through the following themes: *Relations in the Visual Field*, *Shaping*, *Composition*, *Materials*, *Communication*, *Heritage*, *Scene*, etc. Based on the analysis of content available in the teaching and learning program for *Visual Arts*, we identified topics that are particularly suitable for STE(A)M activities and interdisciplinary integration:

1. Visual Characteristics of Plants and Animals, Signs, Symbols, Flags...
2. *Properties of Materials;*
3. *Ornament, Symmetry;*
4. *Shapes, Position of Shapes in Space and Plane;*
5. *Transformation;* and
6. *Reading Visual Information.*

Although the course *Visual Arts* provides numerous opportunities for expressing the results achieved through STEM activities, it is also an essential part of STE(A)M activities around which *Science* and/or *Technology and Engineering* and/or *Mathematics* are grouped. It is important to understand that the role of art is not only to serve as a visual representation of achieved results but also to support the creative process of students, respecting the goals of art education in primary school.

## DISCUSSION

The curriculums in Serbia are discipline-oriented so there are separate teaching and learning programs for the Serbian Language, Mathematics, World Around Us (Nature and Society), Visual Arts, Digital World, Foreign Language, etc.

School subjects in primary schools that can be used with the STE(A)M approach are: 1) World Around Us (the 1st and the 2nd grade) and Nature and Society (3rd and 4th grade) (Science and Technology and Engineering – less dominant); 2) Digital World (Technology and Engineering); 3) Mathematics (Mathematics) and 4) Visual Arts (Arts). The World Around Us (Nature and Society)is specific compared to other school subjects, as it is interdisciplinary and, hence, has the greatest potential to become the core for creating STE(A)M activities. In other words, the contents of this subject come from various disciplines (biology, physics, chemistry, geography, history, traffic, technology, sociology) that are presented in the everyday life context. Thinking about STE(A)M learning, we had in mind that in primary schools, we should try the "true STE(A)M education (that) should increase students' understanding of how things work and improve their use of technologies" (Bybee, 2010).

Based on the analysis of the teaching and learning programs for the early grades of primary schools in Serbia, the cores that enable the realization of STE(A)M activities can be singled out – STE(A)M topics and STE(A)M skills.

**STE(A)M topics**:[5]

- **Nature***: Diversity of Nature (1); Visual Characteristics of Plants and Animals, Signs, Symbols, Flags... (3);*
- **Materials***: Materials (1); Properties of Materials; Transformation (3);*
- **Shapes, Figures and their Transformation***: Geometric Figures, Symmetrical Figures (2); Ornament, Symmetry; Shapes, Position of Shapes in Space and Plane; Transformation (3).*

**STE(A)M skills** (based on the competencies for the 21st century):

- **Problem-solving procedures**: Breaking Down Problems into Smaller Units; Designing Steps that Lead to the Solution of a Simple Problem; Identifying and Correcting Errors in an Algorithm; Identifying and Correcting Errors in a Simple Visual Program (4);
- **Communication**: Benefits and Risks Arising from Communication via Digital Devices (4). Reading Visual Information (3); Health and Safety (1);

[5] (1)World Around Us/Nature and Society; (2) Mathematics; (3) Visual Arts; (4) Digital World

- **Measuring** (as a procedure in science): Measuring Length (with Non-standard and Standard Measuring Units) (2); Measuring Area (2); Measuring Time (2); Movement in Space and Time (1).

These STE(A)M topics/skills are the segments of some of the STEM competencies – scientific concepts, scientific thinking, inquiry practice, information literacy competencies, and attitudes and accountability (Hu & Guo, 2021). The themes related to knowledge and skills applied in real-life problems (McDonald, 2016), not just in a school context, clearly stand out as the ones with the greatest STE(A)M potentials. Such topics include: *Materials* (Science), *Measurements* (Mathematics), *Safe Use of Digital Devices*, *Algorithmic Way of Thinking* (Digital World), and *Communication* (Visual Arts). We believe that the STE(A)M activities based on these topics can promote active learning that engages students in the learning process cognitively and emotionally while taking into account their experience.

These potentials are more noticeable in the first and second grades, while they are somewhat less in the third and fourth grade. Although it would be logical for more STE(A)M activities to occur at older ages (as students then have more knowledge and experience, making the potential for integration greater), the educational standards/teaching and learning programs in Serbia show the opposite. One reason for this discrepancy could be that there is more subject-specific content in the higher grades, i.e. the content belongs to specific sciences and is less related to everyday life skills.

Other factors limit the application of STE(A)M activities. This results from the inadequate time coordination of similar and complementary content across various school subjects. This disrupts the effective planning and execution of STE(A)M activities. For example, finding new uses for objects made of various materials is considered to be one way of demonstrating responsible behavior towards the environment in World Around Us during the second grade. A year earlier (first grade), students explore the possibilities of reshaping damaged objects and materials, discarded items, or packaging in Visual Arts.

## CONCLUSION

Serbia is in the early stages of introducing STE(A)M into the educational system to adapt to societal and economic changes. The competencies for lifelong learning (adopted by the European Commission) represent the framework for defining educational standards and learning outcomes in Serbia. Although STE(A)M education is not essentially nor officially an integral part of the educational system in Serbia (which is based on relatively isolated school subjects),

this curriculum analysis demonstrates the potential for creating STE(A)M activities in the lower grades of primary schools in Serbia through the subjects such as Mathematics, World Around Us (Nature and Society), Visual Arts and Digital World.

As shown in this paper, there is potential for applying STE(A)M activities with students aged 7–11, but there is no systematic support for integrating STE(A)M disciplines with different school subjects. Consequently, the implementation of these activities in the first cycle of primary education in Serbia is mostly reduced to individual ideas and initiatives. One such opportunity is the project-based teaching/learning approach. It is one of the recommended methods of learning in primary school as emphasized in the programs for teaching and learning various subjects and extracurricular activities. Unfortunately, there is no clear and systematic data on the implementation of this approach or STE(A)M activities in primary schools in Serbia.

Also, the STEM concept is more familiar to teachers in Serbia than the STE(A)M concept. The introduction of art into the field of the sciences has been only sporadically discussed in scientific and professional circles and it has become somewhat more intense in recent years. Only a few scientific papers published in Serbian, individual elective courses in the university programs for teacher education, and a few projects testify to this. Private schools and institutions for informal education promote the STE(A)M approach much more, while the state system, which includes a significantly larger number of children and teachers, needs more support in this regard.

Consequently, we believe that one of the key prerequisites for the wider application of STE(A)M activities is to implement changes in the current university teacher education, i.e. all faculties educating future teachers and the methodologies for teaching individual disciplines included within the STE(A)M concept. In addition, it is necessary to create integrative study subjects that would promote this approach. We believe that this could be one of the most effective ways to introduce STE(A)M education into primary schools, along with further supporting projects and professional development programs for teachers who are already employed.

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