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INTERDISCIPLINARY APPROACH IN MATHEMATICAL EDUCATION BASED ON MATERIALS SCIENCE RESEARH

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Abstract: Interdisciplinary approach in education attracts significant attention in the contemporary education due to its beneficial effect on teaching-learning process. It is noticed that interdisciplinary approach help students in developing knowledge, increases problem solving skills, supports self-confidence and passion for learning. In this work we explained interdisciplinary approach that was based on mathematics, as a school subject and materials science as a scientific discipline. The combination of the two disciplines is not usual, since materials science is not part of middle school curriculums, even though it is known as an interdisciplinary field that combines many aspects of science and provide results important for everyday life. Polymers, adhesives, coatings, rubbers, ceramics, solar cells are widely used in every day, but they are rarely explored in the classroom. The main reason is that problems in materials science are highly advanced, but with the careful planning there are many possibilities to make them understandable to students. In this work we selected different problems from the materials science field which could help students to develop their modeling competences, since many problems relate to the mathematics. The examples have been derived from the practice applied with students from 10 to 18 years. They illustrate connection of materials science to school mathematics in order to enrich educational process. Educational process benefits in many segments, from developing students' knowledge to promotion of scientific disciplines and jobs in the field of science. Examples show how authentic context support students' engagement and their learning become meaningful and purposeful. Also, we highlight the different perspectives explored during the interdisciplinary approach and stress development of critical thinking skills during researching across disciplinary boundaries. That increase transfer of student knowledge trough disciplines and give them wider prospective of knowledge that they gain in the regular lessons which lead to creativity and production of new ideas. Examples follow elements that are common for interdisciplinary approach of instructions recommended by Fink taxonomy for significant learning. Those elements are foundational knowledge which assume understanding ideas, application of skills, integration and connection of ideas, human dimension and caring, and learning how-to learn which is important for obtaining insight into process of learning. Those instructions are leading to meaningful and lasting experiences for students and fully illustrate importance of school mathematics in scientific disciplines such as materials science.
Keywords: mathematics, materials science, modelling, interdisciplinary education

INTRODUCTION

The term of interdisciplinary teaching assumes integration of two or more subjects into relevant connection in order to enhance and enrich learning process and gain substantial knowledge about subjects (Cone et al., 1998). Interdisciplinary education is closer to the real-world phenomena since they are usually based on complex natural systems and one-side subject prospective might lack the deeper insight to many problems. What is more, scientific disciplines are connected and its separation to the school subjects may seem artificial (Hasni et al., 2015). Interdisciplinary approach in education attracts significant attention in the contemporary education due to its beneficial effect on teaching-learning process. Contemporary education finds interdisciplinary education valuable and beneficial, but also necessary for science and mathematical education (Riordain et al., 2016, Munier & Merle, 2009, Glynn & Winter, 2004, Czerniak, 2008, Boix Mansilla & Lenoir, 2010). It is noticed that interdisciplinary approach helps students in developing knowledge, increases problem solving skills, supports self-confidence and passion for learning (Repko, 2006, Newell, 2001). Thought interdisciplinary approaches in education many topics could be examined from the variety of involved discipline aspects. Interdisciplinary provides synthesizing and

integrating ideas into more complete frameworks and concepts and overcomes limitations of one discipline. The most significant cognitive attributes that could be fostered trough interdisciplinary approach are: ability to understand different aspects of a given topic, development of procedural and declarative knowledge and integration of conflict insight from different disciplines (Repko, 2009).

In order to prepare successful lesson based on interdisciplinary approach Repko and Welch (2005) nine steps for educators' preparations and six for the classroom applications. To be successful in interdisciplinary approach application educator need to: define interdisciplinary problem, topic, issue or question; list reasons for the application of the interdisciplinary approach, including both advantages and disadvantages; identify key disciplines that chosen problems could rely on; conduct a literature review or thorough preparation; grade disciplines according to their relevance to the problem; research about problems and generate insights; identify possible problems, differences and similarities; develop cohesive framework and common ground; combine disciplinary insight in order to get more integrated understanding of the problem. The basics steps for interdisciplinary classroom are shown in the Figure 1. Steps that should be applied in the interdisciplinary classroom in order to introduce students to the approach are following: necessary and substantial preparation of the lessons; detailed explanation of interdisciplinary approach to students, highlighting the importance of integrating approaches form multiple disciplines and forming a framework that would lead students to rich understanding of complex questions; model how to explore questions from interdisciplinary perspectives; practice interdisciplinary thinking in order to develop higher order of cognitive skills; provide feedback; and create engaging, challenging assessments, with integrative ideas.

Figure 1 The sheme of activities in the interdisciplinary classroom

IMPORTANCE OF MATERIALS SCIENCE

Materials science encompasses the science, technology and engineering of materials. It is an interdisciplinary field which involves the properties and structure of materials with application to the design and manufacture of real products. This field was formed by the integration of materials science disciplines, macromolecules science, metallurgy, ceramics and solid state physics. For the research in the field understanding importance of interaction such as mathematics–materials science cooperation is highly valued. This kind of interdisciplinary aspect could be successfully used in the mathematical classroom because possibilities of highlighting mathematical ideas and procedures that can be applied to materials problems. Also, introduction of some examples of specific studies — for example polymer network formation theories can be used in the classroom as illustration to many concepts. Materials science focuses on the relationship between the materials atomic and molecular structure , the materials properties (such as thermal stability, strength, elasticity, conductivity, or biocompatibility), and methods how the different materials are processed into a desired product having in mind the cost, environmental efforts, and quality considerations. With attention concerned on new areas such as nanotechnology, smart materials, electronic and optical systems, and biomaterials this scientific field has been very important for the education where knowledge from many fields is used, including, in our case mathematics. Due to the needs of modern life, the outcomes of

material science experiments are useful in many aspects of our everyday life. Scientists from this field work every day on developing new materials that could have broad range of usage. They are conducting experiments where they made measurements and observations about chemical and other properties of materials.

MATERIALS SCIENCE AND CONNECTIONS TO SCHOOL SUBJECTS

The combination of the two disciplines is not usual, since materials science is not part of middle school curriculums, even though it is known as an interdisciplinary field that combines many aspects of science and provide results important for everyday life. Polymers, adhesives, solar cells are widely used in every day, but they are rarely explored in the classroom. The main reason is that problems in materials science are highly advanced, but with the careful planning there are many possibilities to make them understandable to students. In this work we selected different materials science problems which could help students to develop their modeling competences, since many problems relate to the mathematics. With three different examples we have illustrated how could materials science be applied on primary, middle and high school education level. The examples have been derived from the practice applied with students from 10 to 18 years in Primary and secondary school Petro Kuzmjak in Serbia. Examples follow elements that are common for interdisciplinary approach of instructions recommended by Fink taxonomy for significant learning (Fink, 2003). That are foundational knowledge which assume understanding ideas, application of skills, integration and connection of ideas, human dimension and caring, and learning how-to learn which is important for obtaining insight into process of learning. Those instructions are leading to meaningful and lasting experiences for students and fully illustrate importance of school mathematics in scientific disciplines such as materials science. The first example that we called "Expedition that bridged gap between materials science and mathematics", promoted journey trough the labyrinths of materials science and mathematics. Based on high school mathematics knowledge students started interdisciplinary research that had a goal to examine mathematical model application in materials science. The first step was the visit of laboratories at Faculty of Technology in Novi Sad and at Faculty of Forestry in Belgrade. At this encounter students had an oportunity to talk with scientists, collaborated on some experiments and grasped contemporary materials science researh. The materials science contentent was connected to highschool mathematics and mathematical functions learned during lessons of mathematics. What was more, students found connection between mathematical theory and real life phenomena materials science and learned how to approach to problems by mathematical modeling. One of the parameter that was analyzed from the side of materials science and mathematics was the activation energy (AE). The definition of AE is that represents the minimum of energy needed to be provided to the reactants in order to start a chemical reaction. It can be determined using experimental measurement. Applying mathematical knowledge, students explored features of materials such as wood, clay, plastic, rubber. They worked on the determination of activation energy for thermal curing using mathematical models for differential scanning calorimetry experiments. Gained experience made students aware how mathematics can be applied and how important it is in the world of science (Budinski et al., 2017). In Table 1 shows the materials science and high school mathematics contents that could be connected in the classroom.

Table 1 The connection of material science and advanced high school mathematic concepts.

Materials science models	High school mathematics concepts
Arhenius equation; Ozawa-Flynn-Wall model; Kissinger model	Definition of function; Linear function; Exponential function; Logarithmic function; Graphic of function; Growth of the function;

The second example was presented to the middle school students (12 years) and it was called “My sustainable dream house”. The example consisted of several activities such as solving mathematical tasks related to area of square and rectangle, but also to the real-life situation of house building. Another task was exploring sustainable house concepts and presenting students’ ideas for materials and shapes required of that kind of houses. Students presented their ideas with the help of technology and game-based program called Minecraft and trough art expression. In Figure 2 we can see students’ work.

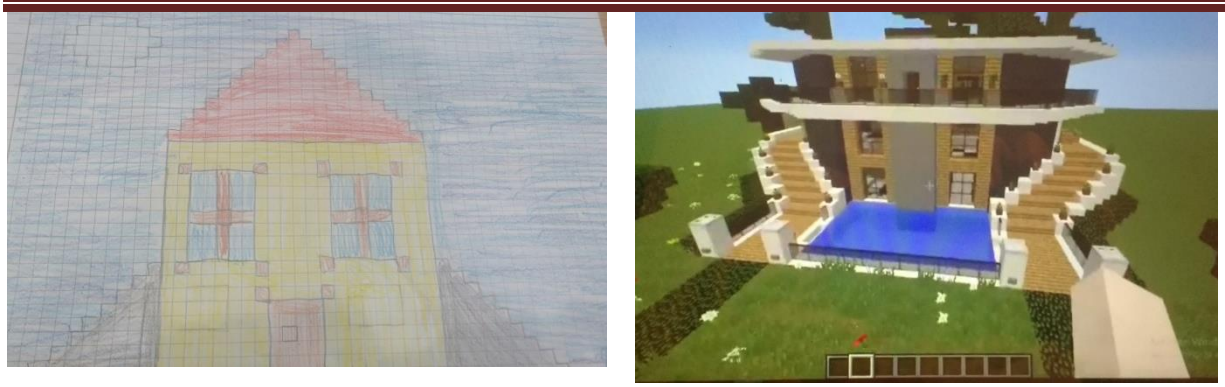

Figure 2 Students' ideas of sustainable houses presented trough art-drawings and Minecraft

Third example presented to the primary school students (10 years) was called "Mathematics of plastic bottle". That was multidisciplinary project where students had different tasks and activities in order to explore recycling plastic. The activities were based on multidisciplinary, multimedia, mathematical modeling and usage of different materials. The problem of plastic materials was researched from the aspect different disciplines such as mathematics, mathematical modeling, chemistry, materials science, economy and technology (Budinski & Milinković, 2018).

CONCLUSION

In this paper we illustrated connection of materials science to school mathematics in general, but also to other school subjects, in order to enrich educational process. Educational process based on the interdisciplinary benefits in many segments from developing students' knowledge to promotion of scientific disciplines and jobs in the field of science. Examples showed how authentic context support students' engagement and their learning become meaningful and purposeful. Also, we highlighted the different perspectives explored during the interdisciplinary approach and stressed development of critical thinking skills during researching across disciplinary boundaries. That increased transfer of student knowledge trough disciplines and gave them wider prospective of knowledge that they gain in the regular lessons which lead to creativity and production of new ideas. It also helped students to identify insights from materials science and mathematics that contribute to an understanding to wider scientific prospective and helped students to integrate concepts and ideas to the content that they learn in the school.

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