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THE ROLE OF THE COMPETENCY-BASED APPROACH IN STEM EDUCATION*

KRASIMIR V. HARIZANOV, DANIELA I. LAZAROVA

ABSTRACT: *The purpose of this article is to present the role of the competency-based approach in STEM education, emphasizing its importance for developing key skills and preparing students for the challenges of modern society. Attention is paid to the teacher and his function as a mediator in the learning process, in solving real-world tasks in STEM education, through the application of knowledge from different subject areas.*

KEYWORDS: *STEM education, competency-based approach, Project-based learning*

2010 Math. Subject Classification: 97P20 и 97B20

РОЛЯТА НА КОМПЕТЕНТНОСТИЯТ ПОДХОД В STEM ОБУЧЕНИЕТО†

КРАСИМИР, В. ХАРИЗАНОВ

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1 Introduction

STEM education (science, technology, engineering and mathematics) is gaining increasing importance in the modern world, preparing students for the challenges of the future. In this context, the competency approach plays a key role, as it places emphasis not only on the acquisition of knowledge, but also on the development of skills, attitudes and abilities that are applicable in the real world. The competency approach differs from other approaches by emphasizing the practical application of knowledge. In STEM education, this means that students do not simply memorize theoretical information, but use it to solve real problems using scientific methods, engineering thinking and technological solutions.

STEM environment, develops critical thinking, creativity, teamwork, problem-solving skills and technological literacy. These skills are essential for the personal and professional development of students in the dynamic world of the 21st century. The competency-based approach includes integrated learning through projects in which students apply knowledge from different disciplines simultaneously. This creates conditions for deeper understanding, engagement and active participation in the learning process. This approach takes into account the individual progress and learning style of each student. The competency-based model places emphasis on the outcome of learning and the acquisition of skills, which allows for more flexible and effective learning.

Exposition

The application of the competency-based approach in education emphasizes how students can solve practical problems based on the theoretical knowledge they have acquired in a specific discipline. Unlike traditional approaches that require knowledge of theoretical learning material, the goal here is for students to apply what they have already learned in real problem situations, cases or tasks. Through this approach, many authors are united around the idea that it develops

"initiative, critical thinking, creativity, independence, confidence and other qualities useful for modern man" [4].

What is competency and what is expressed in it, there are different definitions in the literature. Some authors define competency as "when we need to characterize the professional-personal profile of the specialist and the quality of his attitude to the subject of his professional work" (Rasheva-Merdzhanova, 2010), and according to others as "a set of knowledge, skills and attitudes" (Stoyanova, 2022).

Practice shows that the competencies for each person are strictly individual. Some of the factors that influence the development of competencies are related to the level of acquired knowledge, social and family environment, life and professional experience, personal qualities, etc. According to Bizova, personal competence can be divided into “social competence, emotional intelligence, cognitive, civic and professional competence” [3].

The construction of all these competencies creates a foundation that can be built on by solving practically oriented tasks, tasks related to solving real problems, searching for creative and innovative solutions. In order to achieve all these goals, it is necessary for the learner to have knowledge from different fields that he can apply and gain experience. It is precisely the acquisition of such practical experience that makes him a competent and reliable partner in teamwork.

All these skills can be very well mastered through STEM training, where science, technology, engineering and mathematics interact. STEM lessons include various knowledge, combined in the implementation of applied projects, which “maintains the interest and curiosities of students in complex scientific subjects” [1]. To solve these practical tasks, teachers use a specialized STEM center, and where there is none, classrooms. Some teachers also use more non-standard methods, through outdoor learning or as the idea of “the real world as a learning space” [2].

The implementation of STEM projects requires better preparation in order to determine the goals, tasks (individual or team),

duration, as well as what the final result will be. Of course, first of all, it is necessary to specify what the technical capabilities are, and then the level of competence of the students. According to the Strategy for STEM Education at the Ministry of Education and Science [10], projects can be oriented towards the areas of "Mathematics and Informatics, Natural Sciences, Green Technologies and Sustainable Development, Design and 3D Prototyping, Robotics and Cyber-Physical Systems".

For example, if a thematic project on the topic of "Green Garden" is to be implemented, the teacher can approach it in several ways, depending on the level of knowledge of the students. For this project, the students must know some basic knowledge related to the disciplines "Computer Modeling and Information Technologies" and "Physics and Astronomy", which are included in the curriculum from grades 5 to 9. In order to properly connect all the components and work with the necessary electrical power supply, the students must have gone through the areas of competence indicated in Table 1.

Table 1. Expected competencies in "Physics and Astronomy" in grades 7 and 9 [13, 14]

Area of competence 7th grade	**Knowledge, skills and attitudes**
Electric Current and Voltage Electrical Circuits Electrical Energy	Defines current as the electric charge that passes through the cross-section of the conductor per unit time and voltage as a measure of the energy that electric charges give to the consumer or receive from the source. Measures electric current with an ammeter and electric voltage with a voltmeter. Applies the formula for the resistance of a conductor (consumer) as the ratio of voltage to current.

	Gives examples of different sources of electric voltage and the way they are connected in an electric circuit (batteries from the same sources, which are connected in series or in parallel). Connects simple electric circuits and applies safety rules when working with electric current. Establishes experimentally that when two consumers are connected in series, the same current flows through them, and the voltages add up, while when they are connected in parallel, the opposite is true and applies these dependencies (without calculating equivalent resistance). Applies the Joule-Lenz law for the amount of heat released (for one consumer only). Explains what the amount of heat released in a consumer depends on. Calculates the power of electricity for just one consumer. Calculates the electricity consumption of household appliances (consumers) and discusses ways to save it.
Area of competence 9th grade	**Knowledge, skills and attitudes**
Electricity and magnetism	Connects and analyzes simple electrical circuits.

	Applies basic laws of direct electric current (Ohm's law, formulas for equivalent and specific resistance, for work and power of electric current, Ohm's law for the entire circuit). Describes different sources of electric current. Distinguishes conductors (superconductors) and semiconductors according to their electrical properties and gives examples of their application.

The technical implementation of the project can be implemented technically in several ways. One of the most popular is through a microcontroller board. Microbit (Figure 1).

Figure 1. Microcontroller board Microbit [7]

It can be programmed using a block environment similar to Scratch, so students who have a good background in "Computer Modeling and Information Technologies" will be able to quickly and

easily create the necessary program code. Depending on whether the school has a ready-made project kit or not, there are also several ways to approach it. The first is to use additional sensors for humidity, temperature, light, an expansion board, a water pipe and a water pump, which, using cables, can be used to build the engineering part of the project. This option is more labor-intensive for teachers, but it is the

Figure 2. Sample set „Smart Greenhouse Kit“ [8]

only one if they do not have some of the ready-made kits for this project. (Figure 2)

For older students who have undergone training in Computer Science, this project could be implemented using an Arduino board (Figure 3). Its purpose is to implement more serious projects by programming in the Arduino language, which is based on the C language. Here, the

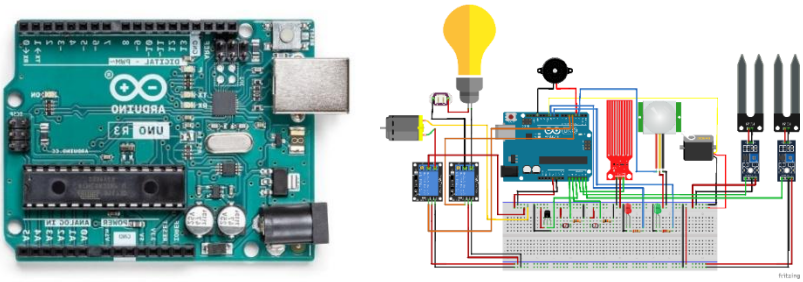

Figure 3. Arduino board [9]

implementation can again be done in several ways. The first is to use additional water pumps, sensors, buttons, resistors, a prototyping board, an OLED display, LED diodes and other suitable components.

The second is to use a ready-made kit (Figure 4), which includes a manual and everything necessary for its implementation. Depending on the level of competence that the teacher wants to check and apply in the project, one or the other option can be applied. When projects are implemented in which ready-made kits are not used, students have the opportunity to use their knowledge more thoroughly and gain practical experience that the ready-made kit cannot offer. The teacher's preliminary preparation should include, in addition to the necessary hardware and software, but also feedback on the level to which students have mastered the theoretical and practical knowledge in Mathematics, Physics and Astronomy, Informatics, Computer Modeling and Information Technologies.

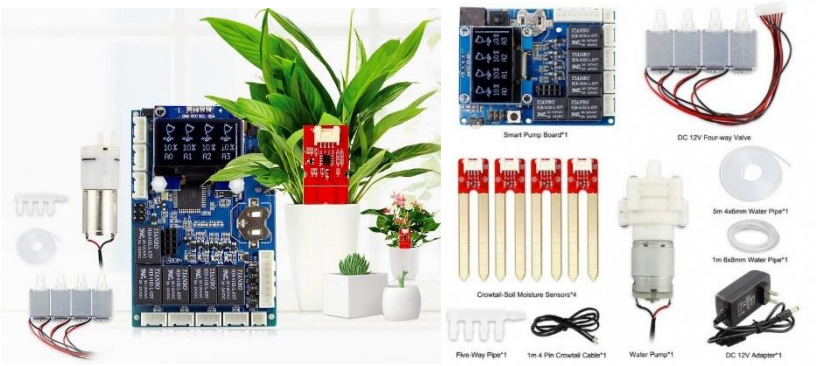

Figure 4. Sample set „Arduino Smart Plant Watering“

Creating a STEM project requires flexibility, creativity, and the ability to work in a team, with colleagues from other disciplines. The teacher plays a central role in developing key skills in students - such as critical thinking, communication, collaboration, and the use of

technology. He must not only master technology, but also integrate it effectively into the learning process.

2 Conclusion

STEM education with the application of a competency-based approach prepares students for the professions of the future, building them capable of adaptation, independent learning and solving emerging challenges. This is for the formation of responsible and proactive individuals. The competency-based approach in STEM education is a modern and effective model that combines knowledge, skills and attitudes in a single learning process. It is of key importance for the formation of future specialists, innovators and responsible citizens, capable of dealing with the challenges of the global world.

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Krasimir Valentinov Harizanov
Konstantin Preslavsky University of Shumen
e-mail: kr.harizanov@shu.bg

Daniela Ivanova Lazarova
PhD student, IntegrITy project, Konstantin Preslavsky University of Shumen
Specialized high school of natural sciences and mathematics “Nancho Popovich” Shumen
e-mail: d.lazarova.ppmg@gmail.com