

# Need and Expectations for Learning in a Stem Environment

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**Abstract.** In the last decade, the need for specialists in the field of engineering and exact sciences emerged in Bulgaria and around the world. This led to the launch of a National Program for the construction of stem centers in schools. From the Veliko Tarnovo region, 16 schools joined the program at different stages, where STEM centers are being built or are already functioning in various subjects, which significantly support the preparation of quality personnel for the Bulgarian economy. A review and analysis of the expectations of teachers and students from work in centers with an engineering focus and training in natural sciences was made. At the next stage, an analysis and evaluation of the effect of the implementation of these innovative centers will be done.

**Keywords:** effect; engineering sciences; experiments; natural sciences; STEM center; students.

## I. INTRODUCTION

With Decision No. 285 of April 30, 2020 of the Council of Ministers, amended by Decision No. 937 of December 17, 2020, twenty-one national programs (NP) for the development of secondary education were approved. One of them is the NP "Building a school STEM environment". It is aimed at schools with innovative practices and those with the potential to develop innovations in the field of natural sciences, digital technologies, engineering thinking and mathematics (STEM) [1], [2], [3]. The program was born from the need to create, furnish and equip dedicated spaces for applying the competence approach in the field of natural-mathematical sciences and technologies. This space should have an unexpected and attractive design that will attract children and keep them in school even after their classes are over. They should always feel welcome in the

STEM center, which, with its welcoming and modern atmosphere, invites them to create, communicate and use it in unexpected ways [4], [5].

By building a school STEM environment, it is aimed to achieve not only a change in the physical environment - improvement of the internal architecture and the furnishing of existing spaces, but also the use of new technologies in the educational process, integrated educational content, innovative methods of teaching and management of the educational process. The set goals are related to increasing students' motivation for learning science and mathematics, increasing their commitment, skills and achievements and creating conditions for project-based learning. Schools with a built-in STEM environment must become a model for implementing a new educational process that goes beyond the classroom-lesson system, according to which disciplines are taught separately, without a clear connection to each other [6], [7], [8].

## II. MATERIALS AND METHODS

The change is connected on the one hand with the physical environment - areas for STEM activities, furniture and interior design supporting learning and creativity, and on the other hand with the skills and preparedness of teachers to implement integrated lessons, apply modular learning, introduce integrative or new subjects, extracurricular activities with a focus on science, mathematics, engineering and technology. The change should affect the preliminary planning of the lessons, their conduct, the assessment in the lessons and the methods and tools used to achieve a project-based or problem-based educational process [2], [9].

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The physical environment and the activities in it should be accessible to a significant number of students in the school, including those with special educational needs, should not tolerate discrimination based on gender, economic situation, culture, racial or ethnic affiliation, mother tongue, etc [10], [11], [12].

The program of the Ministry of Education and Science lists in detail the types of projects by Activities (Activity I: Large projects - up to BGN 300,000 and Activity II: Small projects - up to BGN 50,000) and by stages of education (for primary, for junior high school and high school stage) [1], [13], [14].

In the country, program activities started in the summer of 2020 with an application and selection procedure. Out of a total of 81 schools in Veliko Tarnovo district, 25 schools submitted project proposals and 14 were approved. External experts appointed by order of the Minister of Education and Science carried out the organization, selection and ranking of the projects. The following schools have been approved by the Veliko Tarnovo region [2], [15]:

TABLE 1. SCHOOLS FROM THE VELIKO TARNOVO REGION, APPROVED UNDER THE NP "BUILDING A SCHOOL STEM ENVIRONMENT"

№	Populated place	Name of the school	Type and name of the constructed STEM environment
Schools under Activity I under NP "Building a school STEM environment", Veliko Tarnovo district			
1	Veliko Tarnovo	PMG "Vasil Drumev"	Center for Natural Sciences, Research and Innovation
2	Veliko Tarnovo	"Bacho Kiro" Elementary School	Center for Natural Sciences, Research and Innovation
3	Veliko Tarnovo	PGSAG "Angel Popov"	Center for Technologies in the Creative Industries - BIM Center
4	Veliko Tarnovo	PGT "Dr. Vasil Beron"	Center for Natural Sciences, Research and Innovation
5	Gorna Oryahovitsa	SU "Vicho Grncharov"	Center for Natural Sciences, Research and Innovation "STEM researchers - we have the future"
6	Svishtov	LNG "Aleko Konstantinov"	Center for Technology in the Creative Industries STEM Center for Careers of the Future
7	Svishtov	SU "Dimitar Blagoev"	Center for Natural Sciences, Research and Innovation "STEM Center Pitko"
Schools under Activity II under the NP "Building a school STEM environment", Veliko Tarnovo district			
1	Veliko Tarnovo	PGE "Alexander Stepanovich Popov"	A classroom for creative digital makers
2	Veliko Tarnovo	SU "Vladimir Komarov"	Classrooms for creative digital makers

3	Veliko Tarnovo	"Petko Rachev Slaveikov" Elementary School	School Center for Energy Efficiency and Innovation - "STEM Learning in the Natural Sciences"
4	Gorna Oryahovitsa	PGLPI "Atanas Burov"	A school STEM center for creative digital makers
5	Polikraishte village	OU "St. St. Cyril and Methodius"	"Classroom for Creative Digital Makers" / physics and robotics /
6	Parvomaitsi village	"Elin Pelin" Elementary School	A classroom converted into a workshop area
7	Svishtov	PDTG "Dimitar Hadjivasilev"	Center for Creative Digital Creators "STEMB - STEM + Business"

The study was done by filling out a survey using Google forms with teachers and students from the approved 14 schools in the Veliko Tarnovo district. The survey was conducted in the months of May-June 2022 at the start of the projects. In April-May 2023, a new survey will be conducted in order to reflect the dynamics of the use of the STEM centers and the results obtained. At the end of the next school year, a new survey will be conducted and the extent of the expected and obtained results will be reflected.

109 teachers and 358 students participated in the survey in 2022. The survey was divided into 5 sections and had 50 questions, and they were different for the categories of teachers and students, due to the specifics of their activity.

The approved schools are from the three largest municipalities of the region - Veliko Tarnovo, Gorna Oryahovitsa and Svishtov (table 1).

### III. RESULTS AND DISCUSSION

Results of the monitoring of the educational process of schools from the Veliko Tarnovo region with a built STEM environment: Of the total of 14 built STEM environments in 8 schools, they functioned more than three months ago during the monitoring period 05/05-24/06/2022. In the remaining 6 schools, the training in them it started later due to objective reasons, e.g. renovation at the school (PGSAG "Angel Popov", PGT "Dr. Vasil Beron", PGE "Al. St. Popov"), absentee training due to the Covid-19 pandemic, delayed delivery of equipment [1], [3], [13], [16].

The subject of the performed monitoring is the organization and activities during the educational process in the constructed STEM environment in the school.

Objectives of monitoring:

- to follow the organization of the educational process by using the opportunities and resources in the dedicated STEM environment;
- to track the implemented activities during training in the STEM environment;
- to track the satisfaction and learning outcomes of the students in the subjects when using the constructed STEM environment [13], [17].

The center is not just a renewed learning space with new technologies, but a model for an open, inspiring and creative learning environment. The successfully built school STEM center unites:

- a space adapted for learning through experience, creation and experimentation;
- learning content supporting the development of STEM competencies (e.g. integrated learning content modules, integrated lessons, new subjects, extracurricular activities, etc.);
- innovative teaching methods, encouraging creativity and critical thinking among students;
- organization of the learning process, allowing full and in-depth learning;
- technologies tailored to the goals of the curriculum and creating conditions for practical work with modern tools and programs;
- effective leadership and management of the STEM center;
- active cooperation with business and the community [3], [14], [18].

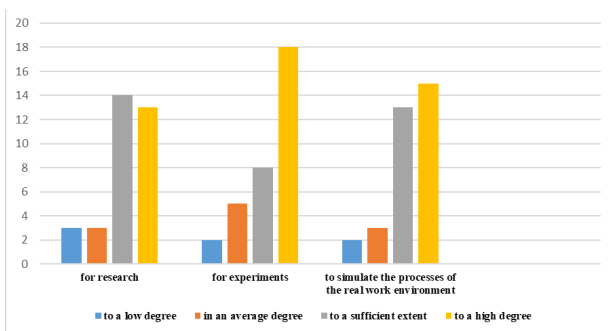


Fig. 1. To what extent does the STEM center facilitate learning

The dedicated STEM environment in the schools of the Veliko Tarnovo region represents a transformation of school classrooms, corridors and other spaces by creating conditions for teamwork, encouraging practical experiments and interactive learning, and developing students' social contacts. The environment may focus on the study of natural sciences, engineering sciences, mathematics, technology, or a combination thereof (fig. 1).

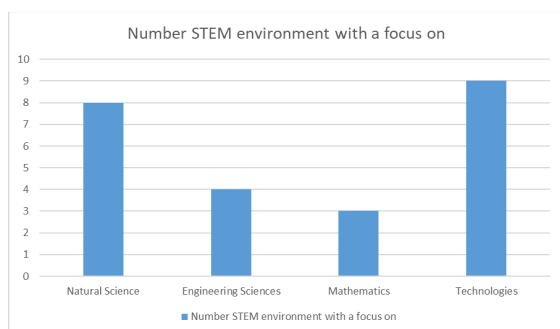


Fig. 2. Number of STEM environments with a focus on the four strands

The STEM environment has a focus on one or more of the four areas, with four schools focusing only on science (fig. 2). These are "Bacho Kiro" Elementary School - Veliko Tarnovo, "P. R. Slaveykov" - Veliko Tarnovo, SU "Vicho Grncharov" - Gorna Oryahovitsa and SU "Dimitar Blagoev" - Svishtov. In these schools, there is an opportunity for the integration of natural science knowledge. The teams for organization, management and implementation of school processes claim that through the integration of the learning content of man and nature, biology and health education, physics and astronomy and chemistry and environmental protection, students have the opportunity to understand the connections between the disciplines and get answers to questions such as: "Why do I need to know this?", "Where will I use what I am currently learning?" and others. In "Vicho Grncharov" SU, the integration is between the curriculum of biology and health education and information technologies. Key competences in natural sciences and IT are developed through transdisciplinary project-based learning based on hands-on work in groups with virtual reality software and laboratory research. The Center for Natural Sciences, Research and Innovation is also used for teaching the newly introduced subject "Virtual Biology" in section A of the curriculum in grade XII for the academic year 2021-2022.

In two high schools, the focus of the environment is only on technologies - PDTG "D. Hadjivasilev", Svishtov and PGLPI "Atanas Burov", Gorna Oryahovitsa. In them, digital competences are integrated with mathematics in programming classes and general-purpose application programs, as well as with the educational content of vocational training subjects.

An innovative learning environment with a focus on STEM involves a change in one or more elements of the educational process: educational environment, learning content, and organization and management of school processes (fig. 3).

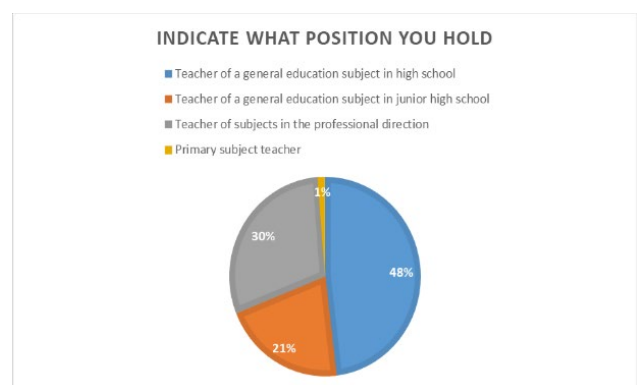


Fig. 3. Duties of subject teachers

All schools indicated that the change covered more than two elements. There is definitely a change in the educational environment, which is most often associated with a change in the teaching methodology. The change in the educational content is interpreted as the study of subjects in the school curricula of the innovative schools

and with the order of the subjects studied in the curricula. According to the Preschool and School Education Act, Innovative schools are schools that achieve improvement in the quality of education, such as:

1. develop and introduce innovative elements regarding the organization and/or content of training;
2. organize in a new or improved way the management, training and learning environment;
3. use new teaching methods;
4. develop educational content, curricula and study plans in a new way [2].

It can be seen that the inclusion of the school in the List of Innovative Schools provides ample opportunities to achieve very good results from the educational process. Very similar and complementary activities are implemented in the innovative and in the schools with an established STEM environment. Of the fourteen schools from the Veliko Tarnovo region under Activity I and Activity II of the NP "Building a school STEM environment", a total of 10 are included in the List of Innovative Schools for the academic year 2021-2022, adopted by Decision No. 523 of the Council of Ministers of 22.07. 2021

In order for the built STEM environment to function effectively, the need for a change in the organization and management of school processes has been realized. In schools, a team has been formed for organization, management and implementation of school processes. Team members are the principal and/or deputy principal and teachers, with the total number varying from 2 to 5. Each member of the team has clearly defined tasks at the various stages of building and functioning of the environment.

There is an effort to use the built STEM environment by more students in the school. In a conversation with the directors, the idea arose of preparing time schedules (for a month) for its use, which will ensure optimal access to the equipment of the largest number of classes.

Most often, the furnished STEM environment is used in the compulsory study hours of general education/professional/profiled training. In vocational high schools, the centers are also used for educational practice. Two schools ("Elin Pelin" Elementary School - Parvomaitsi village and "Vasil Drumev" Primary School - Veliko Tarnovo) indicate that interest-based activities are also held in the middle.

About 45% of primary school students in Activity I and Activity II of the NP "Building a school STEM environment" also conduct lessons in these centers/classrooms. Over 120 teachers teach in the built STEM environment of these 14 schools from the Veliko Tarnovo region.

As used methods and tools for teaching and learning in the STEM environment, the "Flipped Classroom", project-based learning, "learning by doing" model, innovative methods and tools for planning and teaching lessons are

indicated. This also necessitates the application of different types of assessment.

Using the resources of the STEM environment enables the acquisition and application of 21st century skills (communication, collaboration, critical thinking, creativity, information and media literacy, technological literacy, initiative, flexibility, productivity, social and leadership skills). The time of their operation and use for the academic year 2021-2022 is relatively short, but it is planned to conduct classes and projects with practical experience and create

of "physical products" to encourage interest in STEM disciplines. Students will be engaged in solving real life problems and the world around them.

All schools have built effective cooperation with business representatives, with external organizations or individuals. The cooperation is expressed in the development of the project proposal, the delivery of the equipment, the holding of classes and consultations, the provision of monetary scholarships for the outstanding students. In one school, a local business representative was brought in as a speaker and held classes in the STEM center.

During the visits, the following findings were made:

1. PMG "Vasil Drumev", Veliko Tarnovo - built and functioning Center for Natural Sciences, Research and Innovation from the academic year 2019-2020. In the STEM center, classes are held in biology and health education, chemistry and environmental protection, computer mathematics, fundamentals of robotics with microcontrollers, programming for embedded systems. Employment is planned when preparing the weekly schedule. Part of the practical lessons of the professional education classes are also held there. In this environment, activities are also held according to the interests of the "Energy and Environment" club. Attended classes on "Fundamentals of Microcontroller Robotics" and "Introduction to Programming". The resources of the built STEM environment are fully utilized. A "learning by doing" model is observed in the classes. Students and teachers express satisfaction with learning in this environment and are willing to spend hours there;

2. LNG "Aleko Konstantinov", Svishtov - built and functioning during the II term of the academic year 2021-2022. It is a series of separate spaces with equipment and furniture for vocational training classes. In the STEM center, the practical lessons of the various specialties are held. Theory classes can be held at the center after prior request from the teacher, if availability allows. Practice lessons were observed in XIc (I group) - internal combustion engines, XIc (II group) - computer networks; educational practice in HB class; Mechatronic systems in motor vehicle technology in the 11th century. The technique used enables students to experience different situations representing real problems, solve case studies or develop project tasks. Students with interest work in class and demonstrate what skills they are acquiring;

3. "Bacho Kiro" Elementary School, Veliko Tarnovo - Center for natural sciences, research and innovation with

an emphasis on natural sciences. Attended classes in physics and astronomy in class VII. Full use is made of the equipment and furnishings - multi-touch display for monitoring objects in real time, portable computers for working in groups with a sky map in real time. For several hours, students work in small groups on an assigned task. Objects on the star map are tracked in real time, students' knowledge of the macro and micro world is integrated from a physical and chemical point of view. Views on the construction of building blocks, stars, and galaxies are examined. The built STEM center provides real opportunities to implement an integrated approach in science education. There is an opportunity to conduct laboratory exercises, as well as to work on research projects. Teachers and students express satisfaction and feel very good in this environment. The management of the school sets itself the task in the coming months to develop a concept for the work in the STEM center - organization, methodology, used resources. There is also a software product to be purchased to be used in science classes.

4. SU "Dimitar Blagoev", Svishtov - constructed and functioning Center for Natural Sciences, Research and Innovation "STEM Center Pitko". It is possible to conduct laboratory exercises on man and nature, chemistry and environmental protection, physics and astronomy and biology and health education. Demonstrations and simulations of real processes are used for visualization, discussions and debates can be held to solve case studies. Classes were attended in physics and astronomy in class X and in chemistry and environmental protection in class VII. On the day of the monitoring, 3 teachers work in the center. They are satisfied with the created working conditions. They say that they have everything necessary for a full-fledged educational process in natural sciences - tools, materials, electronic resources. The STEM center is put to full use in science classes. Provides excellent opportunities to achieve the expected outcomes of the study programs. Teachers and students share that the environment has a positive impact on their work. They want all classes in Man and Nature, Physics and Astronomy, Chemistry and Environmental Protection, and Biology and Health Education to be held there "...because they feel like explorers."

#### IV. CONCLUSIONS

I believe that the results achieved so far are related to both the renewal of the material base and the motivation of the students. By studying in a STEM center, they get a new experience and an opportunity to gain experience that takes them from accepting the new content and information, through its analysis and in-depth research, to its practical application and testing. It is through this process that the interest in the given knowledge increases, and once ignited, it can be easily channeled into the development of specific skills that will help the realization in a number of technological and other spheres.

The easiest integration of educational content is achieved in man and nature and in the subjects of the professional training of students in high school.

In the next academic year, a change in teaching methods in the STEM environment is to be sought. To apply more broadly the project-based learning principle, learning by doing, inquiry method and other interactive methods.

#### V. ACKNOWLEDGMENTS

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