

# *Analysis of Good Practices in STEM Education in the Schools of the Veliko Tarnovo Region in the Second Year of the National Program*

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**Abstract.** In the current National Program for the construction of STEM centres in the schools of Bulgaria, the basic parameters for the requirements for the construction of modern teaching laboratories, offices, etc. are laid down. 16 schools from the Veliko Tarnovo region have been approved for the various stages of the program and for the second year have successfully implemented training in the built STEM centres. The centres built in some of the schools, their orientation and their use in the education of the students are shown. In these schools, the newly built centres are already used by the teachers of the relevant subjects for training in modern conditions with the aim of increasing the success rate of the students and practical application of the acquired knowledge. Construction of such centres in other schools is also planned for the next academic year.

**Keywords:** *classroom, laboratory, learning, school, STEM centre, students.*

## I. INTRODUCTION

The National Program "Building a School STEM Environment", launched 2 years ago, aims to increase students' interest and achievements in the field of science and technology by supporting the creation of school centres with a focus on STEM. This program aims to increase the engineering thinking of students, to awaken in them the interest in discovering and implementing new knowledge and skills. In these centres there will be built laboratories, offices, corners depending on the level of education in the respective school and the focus of the built centre. They will provide all the necessary conditions for conducting modern and high-quality STEM education

at school. The program will finance projects for the construction of school STEM centres in two categories: small (up to BGN 50,000) and large (up to BGN 300,000). In this way, there will be some fairness and equality of schools of different sizes [1, 2, 3].

The national curriculum emphasizes learning in mathematics, science, modern technology and engineering thinking. This theory developed at the end of the 20th century, and we can look for its roots in the middle of the last century with the development of the movement for technical and scientific creativity of the youth. The emphasis is on developing the thinking and creativity of the younger generation and practical application of knowledge in real conditions.

In the study, an attempt was made to evaluate the effectiveness of training in the newly built centers in the school network. Cardinal assessments can be made after at least 5 years, but this study and its analysis provide initial attitudes and results after the first year. After each subsequent year, further surveys and analysis of them will be made to monitor the development of the process, and not after 5 years to make the first surveys and report results. The purpose of the study is to capture the dynamics of the development of the processes and to be able to adjust, if necessary, some activities under the program.

Various methods were used in the conduct of the research: surveys, information gathering, discussion with teachers and students, comparison of expectations and actual results, comparison of results from different periods, analysis and others.

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When conducting the research, a restriction was made that only schools that are participants in the national program from the first stage are approved. In subsequent research, the restrictions will be changed and research will be done in other schools that have joined the program in subsequent stages.

This program is important because:

1. Young people will acquire the necessary knowledge and skills to successfully implement themselves in the professions of the future and will be able to work in an environment close to the one in which they will implement their knowledge and skills in the future;

2. The students will be trained in an environment and through methods close to business and real life and thus will be prepared for future realization in the chosen profession;

3. School education will promote learning through creativity and the creation of innovative solutions to real-life problems;

4. More young people will choose to train and realize themselves in professions related to science and technology and will be directed to engineering activities;

5. Young people can have a successful future and a decent life in Bulgaria. They will be significantly better prepared for real life after completing the training, gaining knowledge, skills and technical literacy.

The national program is aimed at the creation of new school centres in more and more schools in the Republic of Bulgaria - an integrated set of specially created and equipped learning spaces with a focus on the study and application of competences in the field of natural and mathematical sciences in state and municipal schools in the country. Each school centre will include a change in the following elements: physical environment (improvement of internal architecture and furnishing of existing spaces), technology, learning content, teaching methods and management of the educational process, carrying out real activities with concrete results. After the completion of the second year of the program, good results are reported and the program will develop with the opening of STEM centres in all schools, with more than 50 million BGN allocated for the construction of these centres [4, 5, 6, 7].

## II. MATERIALS AND METHODS

According to their scope, projects are divided into large and small.

### ➤ Activity I: large projects (up to BGN 300,000)

These projects are complete unified centres with a specific focus (among those proposed below) that include several classrooms as well as their adjacent common spaces. The total cost of the project may include a combination of construction and renovation activities for conversion of existing spaces, furniture, equipment, teacher training, creation of integrated educational content, etc [1, 2, 8, 9].

Types of projects for the initial stage that can be implemented under this type of project are:

### • Centre for young researchers

A guiding principle in shaping the innovative physical environment is that it is suitable for the stages of development and learning of the youngest students. The centre for Young Researchers aims to promote the research approach in education and the integration of subject knowledge from various scientific fields with the aim of developing students' 21st century skills, basic and functional literacy, creative and digital skills, coping skills in different situations, positive thinking.

The centre will promote creativity and work on project-based learning in digital and non-digital environments; the development of skills for working in teams and in various group roles. Learning spaces can be organized into corners and zones, allowing for a different, flexible curriculum and organization of the day. The environment can include hands-on outdoor areas, zoos, robotics stations with age-appropriate tools for students, and more. The new environment allows and encourages group planning among teachers and joint implementation of lesson units, hours of the whole day organization of the school day, extracurricular activities, as well as activities in partnership with external organizations (museums, libraries, observatories, research centres, etc.).

The types of projects for junior high school and high school stage are:

### • Centre for Technology in the Creative Industries

This type of centre may have been inspired by the expanding share of creative industries as part of the value-added economy. The centre will provide a technological learning environment for students interested in digital/video game development, mobile applications, media products, product development, digital marketing, graphics and design, and more. The purpose of this type of environment and content is to encourage the development of creative digital skills in a motivating way, incl. to direct students to professions related to the creation of video content, video games and digital tools, digital platforms and mobile applications or the development of new products and services in a technological environment. The centre may include equipping classrooms with computers and specific software in accordance with the needs of the creative industries (for drawing, animation, modelling, editing, assembly, 3D design, etc.); creative corners and spaces; video studio and filming equipment; recording studio; simulation technique, virtual and augmented reality [2, 10, 11].

### • Centre for Digital Creators

The centre creates conditions for work in some of the following areas: Application programmer and System programmer, profile Hardware and software technologies, etc. The centre aims to foster students' interest in digital sciences and the creation of digital content with a wide range of applications in real-world environments. It is important that it simulates a real work environment in a technology company, incl. a place for creative activity, individual work and work in teams, non-traditional learning and working environment, high-speed Internet connectivity, etc.

The centre could provide students with work on creating applied projects that solve real cases and problems of business and life of modern man and society. Using electronics and robotics, research, experimentation and analysis, students will be able to create economic and technological solutions based on the premise of intelligent integrated and inclusive management of natural resources and infrastructures.

According to the vision and needs of the particular school, this kind of centre can offer 3D technology, electronic boards and microcomputers, a set of programming tools and robotics. The centre may also include the creation of maker space workshops [3,12].

- Centre for Natural Sciences, Research and Innovation

The centre could provide students with work on applied projects that solve real business cases and problems, research, experiments and analysis. The goal is to use new methodological concepts related to problem-based learning, learning expeditions, case studies, simulations. The centre will provide an environment that could be used both in general education and profiled training, as well as in dual classes in vocational schools for training related to the content and processes of the real work environment in the partner companies. The centre may contain hands-on laboratories in the traditional natural sciences as well as more specific environments such as laboratories in biotechnology, genetic analysis, pharmaceuticals, elements of food production, etc. according to the need of the particular school. It is important that the overall project is a combination of a new learning environment, learning content and practical and applied teaching methods [3, 13, 14].

- Activity II: small projects (up to BGN 50,000)

These projects will transform and equip smaller scale physical spaces – one or two classrooms or corners in an existing space. Although smaller in terms of funding, these projects have the same goals as the larger ones: creating conditions for developing skills related to creativity in digital technologies; experimental work; developing engineering thinking and problem-solving abilities; work on projects and assignments with a practical orientation in science and technology [15].

The total cost of the project can include a combination of construction and repair activities, furniture, equipment, teacher training, etc. in the following type projects:

- Corners of the "workshop" type

The project may include the creation of designated spaces in rooms or study (corners) for creativity and digital technologies or the conversion of a classroom into a similar place. These projects aim to stimulate the interest of a wide range of children in creative activity and the creation of solutions (a combination of hand-made and digital products). Activities in this school space should focus on solving real-life problems such as (but not limited to) creating effective engineering solutions to

environmental problems, 3D-printing industrial prototyping, solutions for social causes, etc.

- Research laboratories

These are small or complementary projects for hands-on equipment and science stations; provision of research needs; applied research and laboratory work. This project aims to equip one office space/storage/classroom for a laboratory or laboratory stations in several offices. The project may include mobile/portable digital laboratory kits, technical equipment, access licenses to platforms with electronic content in the sciences, etc., necessary for the students' applied work.

- A classroom for creative digital makers

This project aims to promote students' interest in digital science and digital content creation, as in the large project category, but is smaller in scale – for example, one classroom with adjacent common spaces. The project aims to build an innovative learning space and can include various hardware and software technologies, according to the needs of students, robotics and engineering science kits, 3D printer, electronic boards and microcomputers, creative corners, zoo corners, etc.

### III. RESULTS AND DISCUSSION

The National Program "Building a School STEM Environment", launched 2 years ago, aims to increase students' interest and achievements in the field of science and technology by supporting the creation of school centres with a focus on STEM. This program aims to increase the engineering thinking of students, to awaken in them the interest in discovering and implementing new knowledge and skills. In these centres there will be built laboratories, offices, corners depending on the level of education in the respective school and the focus of the built centre. They will provide all the necessary conditions for conducting modern and high-quality STEM education at school. The program will finance projects for the construction of school STEM centres in two categories: small (up to BGN 50,000) and large (up to BGN 300,000). In this way, there will be some fairness and equality of schools of different sizes [15, 16].

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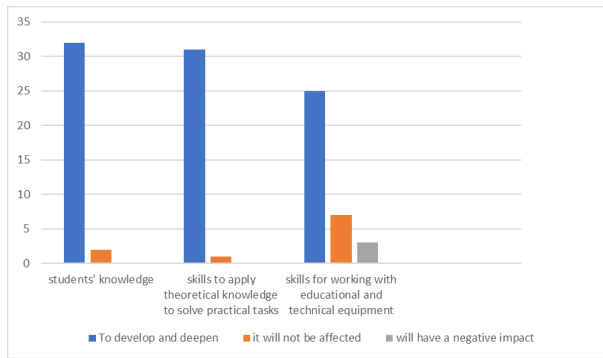


Fig. 1. Expectations of learning in a STEM environment

The national program will create "models" in some Bulgarian schools to demonstrate the process of successfully investing in a comprehensive idea, including learning environment, technology, management, integrated content, qualification and teaching methods. Successful practices will be able to be used by other schools in implementing the training.

Investment in innovation with a focus on STEM has the following objectives:

- Significant increase in students' motivation for learning natural sciences and mathematics;
- Creating opportunities for project-based learning, connection with business, integrative knowledge, learning on specific scientific topics and changing the existing educational paradigms;
- Enhancing student engagement, skills and achievement (digital literacy; digital arts and creativity; skills relevant to industry requirements; skills to solve real-life and business problems; mathematical thinking; skills to create technological solutions; work in team, critical thinking, etc.);
- Stimulating students to create and improve technological solutions in the field of mechanics, programming and artificial intelligence;
- Skills for creating new technologies and their automation; - Increasing the number of students interested in university majors and jobs in technology industries;
- To contribute to the growth of technology industries and their share of GDP.

The expected learning outcomes in a STEM environment are shown in fig. 2., where it is evident that 97% of the respondents indicate that they expect the interest and motivation of learners to increase as a result of the introduction of training in a STEM environment.

As end products, the program aims to create innovative learning centres with a focus on STEM, which will include change in a number of elements of the educational process.

The educational environment (physical environment inside and outside the classroom through conversion of existing learning spaces, common spaces, outdoor areas for STEM activities) will be most significantly changed. This includes furnishings and interior design that support

learning and creativity; integration of digital and non-digital technologies in the physical environment, in administrative and teaching and learning processes, providing opportunities for active participation of students with Special educational needs (SEN) and a number of others that are tailored to the specific school and the direction of the training [18].

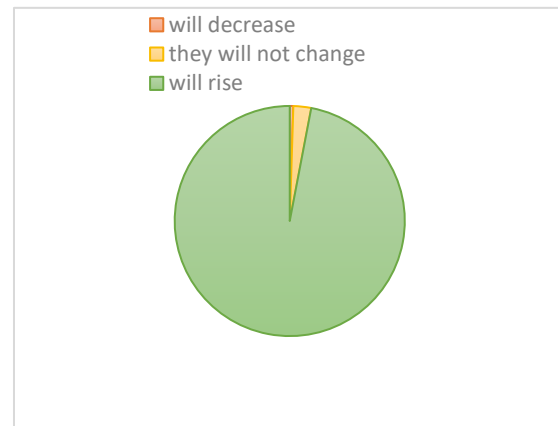


Fig. 2. Expected results of the introduction of STEM training

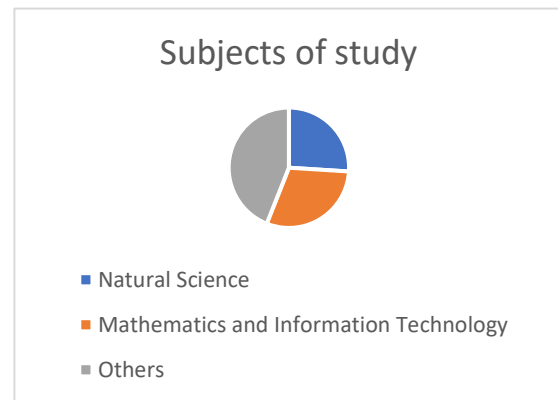


Fig. 3. Teachers' teaching sphere

According to what the respondents teach, their decisions to implement training in a STEM environment can be divided into 3 main groups. The first (26.1%) includes teachers of natural sciences - physics and astronomy, chemistry and environmental protection, biology and health education and man and nature. 30.4% are teachers who teach mathematics and information technology. 43.5% are the remaining teachers who teach other subjects, and here the circle is too wide and it is not possible to make a separate segment, because the profiles of the schools are different from there and the subjects taught are too wide (Fig. 3).

The learning content of the taught material will be expanded through the proper use of integrated lessons, integrated learning modules, integrative subjects, new learning content modules, new learning subjects, extracurricular activities with a focus on STEM, including educational resources for teaching students with Special educational needs (SEN);

Also, the ways of teaching the learning material will be significantly expanded through methods and tools for: lesson planning, teaching, ways of grouping students, project-based or problem-based educational process, types of assessment, including those for students with Special educational needs [19].

It is planned to create a new organization of learning and administrative processes and introduce school policies supporting STEM, giving feedback between pedagogical specialists, involving external partners and creating new partnerships for student learning in real production settings (Fig. 4).

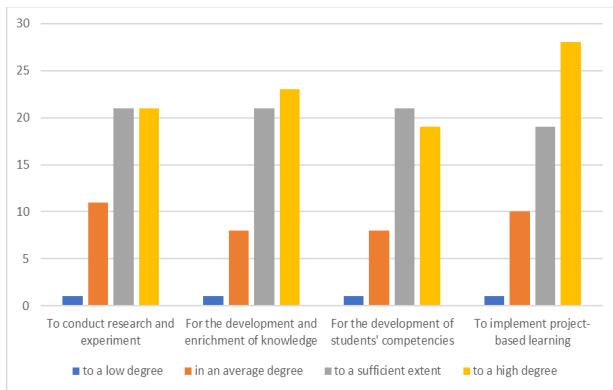


Fig. 4. Studying how the STEM environment will affect the provision of opportunities for the realization of learning objectives

The program is implemented on the territory of the Republic of Bulgaria and covers all state and municipal schools. Schools in the initial stage of the program prepared projects and applied for approval from the Ministry of Education and Culture. At the next stage, the number of admitted schools increased, and now work is already underway to build STEM centres in all schools on the territory of Bulgaria.

#### 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 channelled 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. There are also the highest results in schools from the Veliko Tarnovo region in the second year of the National Program.

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. Training in a real work environment will also be expanded in the final stage of high school education.

#### V. ACKNOWLEDGMENTS

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