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Monitoring And Analysis Of The Achieved Results Of Using The STEM Offices In Veliko Tarnovo Region After The Launch Of The National Program

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Abstract. **Research has been done on the expectations and implementation of training in the newly built STEM centres under the current national program of the Ministry of Education and Science in Bulgaria. Initially, 14 schools on the territory of the Veliko Tarnovo region were selected for the construction of STEM centres with different orientations. They have been working for 2 years now, and based on observation and research among students and teachers, analysis and proposals for improving their effectiveness have been made.**
Based on the achieved results, the Ministry of Education and Science has expanded the national program for the construction of STEM centres and there will now be such in all schools, which eloquently speaks of their effectiveness and the increase in academic results. The results of conducting the training in the newly built centres and the satisfaction of the trainees and teachers are indicated.

Keywords: national program, results, STEM centre, school, student, teacher, training

I. INTRODUCTION

STEM is an abbreviation of the first letters of science, technology, engineering and mathematics (from English: Science, Technology, Engineering and Mathematics), combining chemistry, physics, biology, astronomy, statistics, etc. Although STEM has a very literal meaning, today the acronym is used to direct the focus to the development of algorithmic, logical, engineering thinking and a new learning methodology based on project-based learning. In STEM education, the student is at the centre of the learning process. Creativity is encouraged and traditional teaching dynamics and teacher-student relationships are changed. It is learned through experience, experiments, solving problems and the practical application of the developed skills and acquired knowledge is sought. In addition, STEM builds on traditional education by focusing on cross-curricular connections and teamwork not only among students but also among educators [1].

Education needs to respond to dynamic reality, and the jobs of the present and the future increasingly involve artificial intelligence, working with algorithms, invention and engineering. That is why the interest in STEM is increasing and logically, more and more schools are betting on STEM centres as a place to hold classes. It is not by chance that the Ministry of Education and Science expanded the scope of the STEM centres being built, and after the completion of the second year of the operation of the National Program for the construction of STEM centres, money was allocated for the construction of such centres in all schools [2], [3], [4].

STEM education has a number of benefits for students. If the educational goal is for students to become adaptable and critical thinking young people, then we help build the following skills in them on which the concept of STEM is based, namely:

- Creative thinking;
- Critical analysis;
- Teamwork;
- Initiative;

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- Mathematical literacy;
- Algorithmic thinking;
- Social-emotional skills [1], [5].

The present study was conducted at the initial launch of the National Program and after the second year of the project, when the built STEM centres actually function and classes are held in them. At the end of this year, a further survey will be conducted in order to be able to compare expectations, results after the second year of the start of the program and the second year of using the offices and laboratories. Due to the COVID epidemic, the STEM centres could not be used practically in the first year and therefore there is a difference between the second year of the program (first for use of the offices) and the second year of use (third year of the project). Teachers from 14 schools from the Veliko Tarnovo region, who teach general education subjects in junior high and high school, and teachers of profiling and professional subjects in secondary education participated in the survey. Approximately 80 teachers from the three categories participated.

II. Materials and methods

In the Bulgarian educational environment, STEM began to be actively implemented through the STEM program (NP "Building a school STEM environment"), under which funds were allocated for the implementation of STEM projects, the use of "STEM technologies" (higher class equipment, suitable for the performance of more complex tasks) and the study of STEM subjects. However, the space for innovative and creative practices requires more than just funding [2], [6].

After the launch of the program, many schools prepared projects and participated in the selection of the Ministry of Education and Science. 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 approved schools were 7 in the first group or activity 1 with a budget of up to BGN 300,000, namely: PMG "Vasil Drumev" town of Veliko Tarnovo, OU "Bacho Kiro" town of Veliko Tarnovo, PGSAG "Angel Popov" town of Veliko Tarnovo, PGT "Dr. Vasil Beron" town of Veliko Tarnovo, SU "Vicho Grncharov" town of Gorna Oryahovitsa, SPG "Aleko Konstantinov" town of Svishtov and SU "Dimitar Blagoev" town of Svishtov. From the second group or activity 2 with a budget of up to BGN 50,000 were: PGE "Alexander Stepanovich Popov" Veliko Tarnovo, SU "Vladimir Komarov" Veliko Tarnovo, OU "Petko Rachev Slaveikov" Veliko Tarnovo, PGLPI "Atanas Burov" Gorna Oryahovitsa, OU "St. St. Kiril and Metodii" village of Polikraishte, OU "Elin Pelin" village of Parvomaytsi and PDTG "Dimitar Hadjivasilev" town of Svishtov.

The schools selected at the first stage of the National Program are from the three largest municipalities in Veliko Tarnovo region - Veliko Tarnovo, Gorna Oryahovitsa and Svishtov. The opening of the various laboratories, offices, corners and others was in 2021 and 2022, and from the academic year 2022/2023 classes began to be held in them, although not in full volume and load. In the 2023/2024 academic year, the workload of the STEM centres increased and is over 75%, and in some schools it is close to 100%, as they are also used for extracurricular activities.

In this 2023/2024 school year, all classrooms are already in use and there is a repeat of the activities carried out in them for the second school year. At the end of the first school year, the author conducted a survey about the expectations and the results obtained in the first year, which were presented at the scientific conference "Environment. Technologies. Resources." in Rezekne in 2023.

After the built STEM centres have been fully used for the second year in these schools, a comparison of expectations and achievements can be made and a comparison can be made between the first and second year of training in the equipped centres. This was done by running a second survey and analysing the respondents' responses.

In this study, the results achieved during the first full academic year of study in the STEM centres are noted and only a comparison can be made between expectations and results, but not between achieved results. For this reason, no comparison and corresponding analysis has been made in the article, because there is still no data that can be compared and the corresponding conclusions can be drawn. On the basis of the answers received at this stage, only recommendations are made on the workload of laboratories and offices, on the optimization of the educational process, but not with regard to quality indicators [7], [8], [9].

III. Results and discussion

How does STEM happen in practice? To create a STEM center, the school must prepare a project and a concept based on four elements:

1. An environment that predisposes to innovative practices and creativity.

Changing spaces is the most visible sign to the outside eye that the school has embarked on the path of educational transformation. The STEM environment in modern schools should predispose to freedom, flexibility and creativity in the processes of learning and research. To stimulate communication and teamwork, as well as to offer corners for privacy and reflection [3], [10], [11].

This change includes the layout of the spaces, but also the colors, the furniture, the flooring, the lighting, the access to the space. It is not enough that the environment is simply updated, modern and beautiful. It must functionally contribute to the learning process.

The planning of the working environment must be subordinated entirely to the educational objectives and the type of methodology to be used [3], [12], [13].

It is important that the change in the environment does not happen for its own sake. To fulfil its function as a pillar, it must be planned in harmony with the other three pillars – content, qualification, technology.

In order to be carried out in the best possible way, it is recommended that the planning and implementation process take place together with specialists - architects, designers. There are already good examples in Bulgarian schools from which inspiration and experience in implementation can be drawn.

The school is a shared space for students and teachers. Therefore, in the process of making decisions about it, we must involve the students and take into account their opinion, wishes, needs and expectations.

2. Content that places the student in the role of an active leader in the learning process.

Quality learning is not a one-way process in which the teacher feeds information to students and assesses their ability to reproduce it. It is transformed into researching information, researching and analysing problems and proposing possible solutions to them.

Therefore, the educational content is a pillar without which the STEM transformation cannot take place. We need to answer the questions: what content will we go through; does it meet the educational goals we have set for ourselves; how it corresponds to the environment in which we will examine it.

Project-based learning often involves the work of more than one teacher within a learning project. This challenges teachers and school principals to have interdisciplinary content that includes knowledge from different subject areas within the project.

However, creating new learning content is a methodical process that takes more time.

To overcome this difficulty, it is important to include in the planning process an investigation of what already developed solutions we can reach and what can be usefully taken from other projects and schools.

For example, it is necessary to find out whether:

- Robots, 3D printers, VR glasses to be purchased are accompanied by educational content already developed for them;
- Content is applicable to students' environment and culture;
- Teachers have the necessary skills to handle it;
- The content is in the language in which we conduct the training;
- It has rights to use it and what is our access to it [14], [15].

The transformation of the learning content does not mean to exclude knowledge from it. In the educational project, children acquire the knowledge they should have for the respective age and educational level. In addition to these, they understand how this knowledge relates to the real world and how they could put it into practice.

With this, the learners form skills to solve the problems of the present, as well as the not yet existing problems of the future.

3. Equipment and relevant technologies to carry out tasks and develop digital and technological skills.

Technology is the third major foundation. The answer to the question of which technologies to choose lies in what tools are needed for innovative content in the transformed environment.

When they are thought of separately, there is a significant risk that the end result is that the technology and the environment do not work well together. And in connection with this, it is necessary to make additional changes and spend an additional resource to adapt one to the other or vice versa.

An example of this is the classic information and communication technology classrooms. Usually there are computers located on the periphery of the rooms and the students have their backs turned to the space, to the classmates and to the teacher. Although the technique is available, it does not correspond well with the environment and does not predispose to group work, to easy adoption.

Technology is the most dynamically developing pillar compared to the other pillars of the STEM transformation. Every month, technology companies make updates to their products and even come up with completely new solutions. Therefore, it is important to look at the choice of equipment as an investment that can fully meet the objectives and the other elements of the plan.

A technological solution is meaningless if there is no place to use it, but also if teachers are not trained to use it.

The tools used to achieve the set goals can include technology – computers, tablets, robots, smart screens and whatever other equipment is needed. All that is specific as a technology is subservient to the content and woven into the environment [1], [4], [10].

4. Training for teachers to help them confidently handle new technologies and methodologies.

It is the ability of teachers to skilfully handle them that is the engine that makes the environment, content and technology "come alive".

In the development of the STEM project, the training of pedagogical specialists should not be omitted, so that they are skilful and confident to take advantage of all the advantages of the transformed environment and the introduced new technologies.

It should be borne in mind that training the team is a process that requires time, and it is advisable to take place in parallel with the work on the other three pillars, and not only at the end of the process, when valuable time for preparation will have already been lost.

It is a good practice to involve the teachers in a STEM working group for the construction of the project. In this way, the team is part of the transforming process from its first steps, recognizes it as its own, participates and contributes to its implementation.

Another option to support the teacher qualification plan is cascading. A group of teachers undergo training and themselves, working in a team, pass on the skills to their colleagues.

The qualification of the teachers must be tailored not only to the educational goals, but also to the personal characteristics and wishes of each of them, to the needs of the students and to the readiness, motivation and digital competences of the team as a whole. A long-term plan of steps to develop the team and team members ensures a smoother and smoother development of skills [5], [16].

When determining the effectiveness of the use of STEM centres, the following should also be taken into account:

- Whether and how STEM lessons will be integrated into the curriculum;
- What preferences and needs do all three parties have - teachers, students and parents;
- The organization of the learning process in the context of the entire school day and term;
- Effective allocation of roles and management of the STEM centre;
- Initiating partnerships and working together with business and the community.
- These are the main criteria that are included in the assessment of how the newly built STEM centres are linked to the training and the learning process [17], [18].

In the second year of the operation of the built STEM centres in 14 schools in the Veliko Tarnovo region, all the laboratories, offices, halls and others were already in use, and real classes were held in them, and the workload of these units was very high. In different schools, the conduct of classes in a STEM environment was different, but everywhere the utilization schedule of the newly built STEM rooms was over 60%, and in 3 schools it was over 90%.

Expectations of achieving good results among teachers who teach vocational subjects and participated in the survey after the first year are expressed in fig. 1. On the graph in fig. 1 presents the percentage ratio of the grades given by teachers for the results achieved when working in a STEM environment. None of the respondents gave the lowest rating of 1, while 67% gave the maximum rating of 5 for the quality of the training. Satisfactory (2) and good (3) ratings were given by 2 and 3.5% of those who participated in the survey, respectively.

The profile of the teachers who participated in the study and work in these STEM centers should also be noted. These are teachers from "Vasil Drumev" PMG, Veliko Tarnovo, "Angel Popov" PGSAG, Veliko Tarnovo, "Dr. Vasil Beron" PGT, Veliko Tarnovo, "Vicho Gruncharov" University, Gorna Oryahovitsa, "Aleko" Konstantinov" Svishtov, PGE "Alexander Stepanovich Popov" Veliko Tarnovo, SU "Vladimir Komarov" Veliko Tarnovo, PGLPI "Atanas Burov" Gorna Oryahovitsa and PDTG "Dimitar Hadjivasilev" Svishtov. Due to the specificity of each school and the training carried out, we can summarize that these are teachers of informatics, computer science, construction, design, hotel management, economics, electronics and a number of other disciplines specialized for the specific specialty. Often, in a STEM center, classes in related disciplines are also held, but teaching of radically different disciplines is also observed, because students in different classes study multiple subjects, some of which build on previously studied ones.

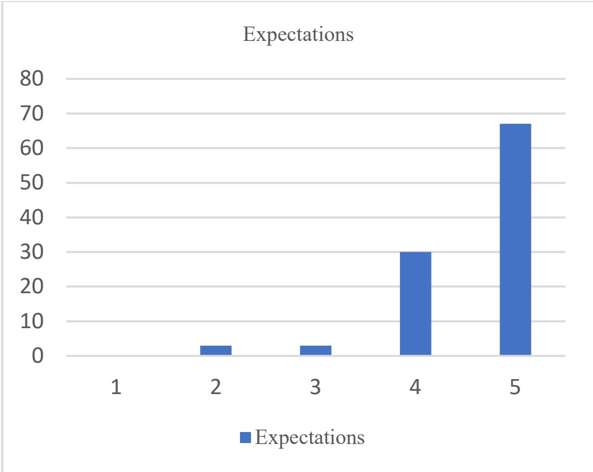

Fig. 1. Expectations of teachers of professional subjects for achieved results in learning in a STEM environment.

STEM education is mainly related to engineering and technical sciences and that is why the expectation is so high. This is also due to the fact that the built STEM centres have modern techniques and equipment and the students carry out practical activities in a real environment. All schools used the program to purchase and equip laboratories, offices and others with equipment that will bring training as close as possible to real production conditions. This is the reason to expand the scope of the program to more schools in the following years, and even now all schools from this year have joined this program. This is particularly important for vocational training, where the equipment of classrooms, laboratories and workshops is, to put it mildly, outdated and it was absolutely necessary to re-equip them.

In fig. 2. a similar study is shown, but with teachers who teach a general education subject in junior high school. Here, 26% of respondents teach natural sciences (physics and astronomy, chemistry and environmental protection, biology and health education, man and nature), 30% are teachers of mathematics and information technology and the remaining 44% are teachers of other subjects. In the last group, the teachers are the most diverse and teachers of Bulgarian language, English and other foreign languages, history and civilization, geography and economics and others also participate here. In the last group, heterogeneity determines the diverse use of the built centres and each teacher adapts them to the subject he teaches.

Here, teachers rate the achieved results very highly, with the grades being very good (24%) and excellent (76%). This is due to the opportunity to conduct quality laboratory and practical classes, the opportunity for demonstrations and visualization of the taught educational content, which in the previous form of conducting classes had already exhausted its resource. Teachers from all schools participated in this study.

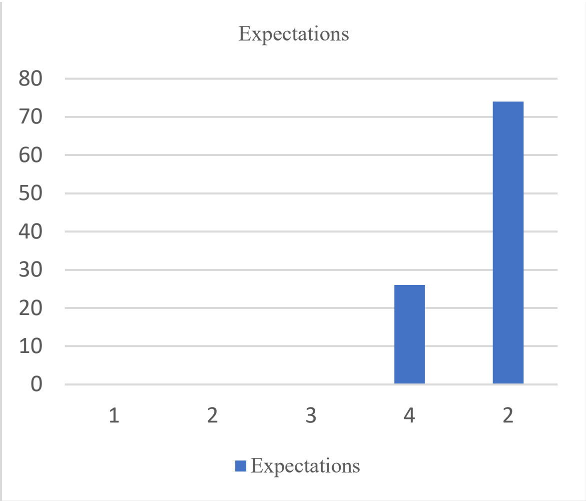

Fig. 2. Expectations of teachers in general education subjects at the junior high school stage of education

During the survey, the teachers also indicated what skills the students would develop when working in a new environment. The most common answers are:

- Digital skills, working with technical means, teamwork
- Communicativeness and inventiveness
- Flexibility, variability
- IT skills
- Group work, observation, critical thinking, analysis, problem solving, etc.
- More focused and interested.
- Team work, communication
- They will improve communication and the level of communication; They will acquire purely practical skills for working with technical and specific means and equipment
- They will improve their motivation to learn
- To observe and study the surrounding environment more deeply, to build skills for creative and critical thinking.
- Responsibility and independence, critical thinking, initiative
- To take responsibility, make decisions, develop leadership skills [1], [15], [16].

The last group of surveyed teachers are those who teach a general education subject in high school. The results are shown in Fig. 3. Here, the ratio of grades is different from that of a junior high school class, with 5% giving a good grade, 41% giving a very good grade, and 54% giving an excellent grade. The lower scores are due to the degree of the educational stage and there is a significant difference in the quantitative assessment in different schools, which is not the subject of this report.

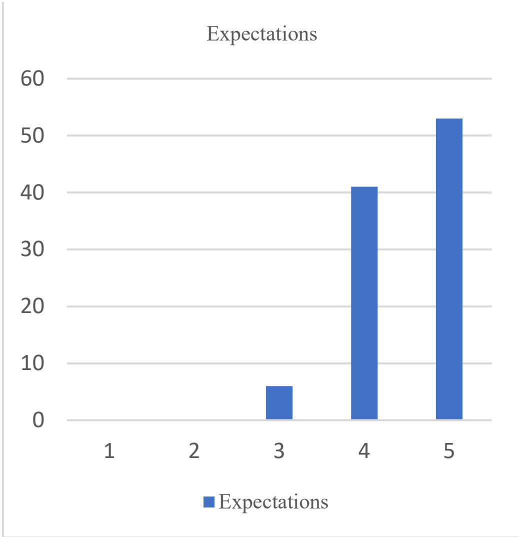

Fig. 3. Expectations for the learning outcomes in a STEM environment of teachers teaching general education subjects at the high school stage of education

In contrast to the junior high school stage of education, in the high school stage the expectations are to develop the following skills:

- Teamwork, leadership skills, good communication, creativity, creation of innovative solutions to real-life problems.
- They will become more confident in using modern technologies, they will be able to use more resources for learning a foreign language in and out of school.
- Team work, presentation skills
- Learning by doing
- Analytical, creative, ability to work in a team, etc.
- Communicative
- Communicative; practically
- Concentration skills, team work, reaching an expected result [10], [17].

In the second year of operation of the built STEM offices, laboratories, workshops and others, when the load percentage of the built units increased by 20-30% and the results of the training conducted in them increased. Here, 100% of the respondents unanimously expect an increase in the success rate and a better assimilation of the taught material. This is taken into account after the end of the second academic year. However, due to the fact that not all offices and laboratories were used already in the first year, it is impossible to compare the results achieved in the first and second year. At this stage, it can be noted that the results and the success rate have increased compared to the period before the construction and furnishing of this material base. And an increase in the success rate with from 0.2 to 0.8 units can be reported in different schools and subjects. The results are yet to be summarized and analysed.

IV. Conclusions

The national program "Building a school STEM environment" provides opportunities to build and equip classrooms, laboratories, workshops and other STEM centres in the school network, where quality lessons can be held. In this way, the quality of training is significantly improved in all stages of the educational process, as it is conducted in close to real conditions. When conducting the lessons, it is possible to conduct demonstrations, experiments and visualization of the taught material, thus increasing the success rate in the relevant academic disciplines.

Expectations and results after the first and second year of the program's work are very good, with different subjects and schools, the values of excellent results are more than 50%, and somewhere it reaches 80%. The results achieved raise the expectations and the percentages are even higher. A problem in the implementation of the national program was the COVID-19 epidemic, which had not yet subsided and not all classes were held in person. There were also delays in the delivery of the necessary equipment. After the completion of the second academic year of study in the STEM centres, a further study will be conducted, and then it will be possible to compare real results, not expectations and reality. In this way, specific results will be fixed and measures to improve training can be identified.

Through the implementation of the national program, the aim is to conduct quality practical classes that are close to the real conditions in the production processes. In this way, students acquire and consolidate new skills in real conditions and prepare for realization in life.

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