

The impact of stem approaches on the development of hard skills in primary school

O impacto das abordagens stem no desenvolvimento de habilidades difíceis na escola
primária

El impacto de los enfoques stem en el desarrollo de habilidades duras en la escuela primaria

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Abstract: This article deals with the urgent need to use STEM approaches for developing the so-called hard skills in primary school. The current demand for information technologies necessitates the development of technical education. Therefore, the implementation of STEM methods is especially relevant in our time. The aim of the study is to determine the impact of STEM approaches on the development of technical and other skills necessary for solving real problems. The study is based on practical methods: questionnaire surveys, research tasks, project activities, game modelling, and group work. This once again confirmed the positive impact of STEM approaches on students' interest in the exact sciences and the development of skills necessary in the 21st century. The academic novelty of the study is the identification of specific mechanisms that develop technical skills using methods adapted to primary school that contribute to the acquisition of knowledge, skills, and abilities at a young age of students in grades 3-4. Special attention is paid to the development of the New Ukrainian School (NUSh) competencies.

Keywords: Critical thinking. Project activities. STEM approach. Teaching methods. Technical skills.

Resumo: Este artigo trata da necessidade urgente de usar abordagens STEM para desenvolver as chamadas habilidades técnicas na escola primária. A demanda atual por tecnologias da informação exige o desenvolvimento da educação técnica. Portanto, a implementação de métodos STEM é especialmente relevante em nosso tempo. O objetivo do estudo é determinar o impacto das abordagens STEM no desenvolvimento de habilidades técnicas e outras necessárias para resolver problemas reais. O estudo é baseado em métodos práticos: pesquisas por questionário, tarefas de pesquisa, atividades de

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projeto, modelagem de jogos e trabalho em grupo. Isso mais uma vez confirmou o impacto positivo das abordagens STEM no interesse dos alunos nas ciências exatas e no desenvolvimento de habilidades necessárias no século XXI. A novidade acadêmica do estudo é a identificação de mecanismos específicos que desenvolvem habilidades técnicas usando métodos adaptados à escola primária que contribuem para a aquisição de conhecimento, habilidades e capacidades em uma idade jovem de alunos nas séries 3-4. Atenção especial é dada ao desenvolvimento das competências da Nova Escola Ucrâniana (NUSH).

Palavras-chave: Abordagem STEM. Atividades de projeto. Habilidades técnicas. Métodos de ensino. Pensamento crítico.

Resumen: Este artículo aborda la urgente necesidad de utilizar enfoques STEM para desarrollar las llamadas habilidades duras en la escuela primaria. La demanda actual de tecnologías de la información requiere el desarrollo de la educación técnica. Por lo tanto, la implementación de métodos STEM es especialmente relevante en nuestro tiempo. El objetivo del estudio es determinar el impacto de los enfoques STEM en el desarrollo de habilidades técnicas y de otro tipo necesarias para resolver problemas reales. El estudio se basa en métodos prácticos: encuestas de cuestionarios, tareas de investigación, actividades de proyectos, modelado de juegos y trabajo en grupo. Esto confirmó una vez más el impacto positivo de los enfoques STEM en el interés de los estudiantes por las ciencias exactas y el desarrollo de habilidades necesarias en el siglo XXI. La novedad académica del estudio es la identificación de mecanismos específicos que desarrollan habilidades técnicas utilizando métodos adaptados a la escuela primaria que contribuyen a la adquisición de conocimientos, habilidades y capacidades a una edad temprana de los estudiantes en los grados 3 y 4. Se presta especial atención al desarrollo de las competencias de la Nueva Escuela Ucraniana (NUSH).

Palabras-chave: Actividades de proyecto. Enfoque STEM. Habilidades técnicas. Métodos de enseñanza. Pensamiento crítico.

1 INTRODUÇÃO

The modern world is rapidly changing under the influence of the scientific and technological process, thereby putting forward new requirements for the NUSH education system, which is the basis for primary school in Ukraine. It provides for one of the key tasks of modern education: the development of so-called hard skills in students, which include scientific, technical, natural, engineering and mathematical knowledge.

The emergence and active implementation of STEM has become a response to the growing demand for competent specialists. The modern market requires technical and scientific specialists who have deep knowledge and are able to apply it in practice.

The importance for primary school is determined by the fact that at the age of 6-10 years old students can lay the foundations of future professional competence. Most countries, including those that have achieved significant success in the field of technology and science, are already actively introducing elements of the STEM approach into the education of primary school children. They provide primary school students with the opportunity to en-

gage in applied tasks, explore environmental phenomena in practice, and develop logical, analytical, and systems thinking skills. All these elements form the basis for “hard skills,” which later become important elements of students’ academic and professional success.

So, we see that using a STEM approach in primary school has many advantages. First, integrated tasks that relate to several subjects at once enable children to think about problems in an interdisciplinary way, rather than within a single subject. Second, a STEM approach can be used to better understand the principles of working with technology, such as the basics of robotics, computer programming, and the basics of programming.

However, the effective implementation of STEM approaches in primary school requires special methods. Programmes should be adapted to the age specifics and psychological characteristics of primary schoolchildren. In particular, practice has shown that the most effective in achieving the goals is the use of game methods, interactive tasks, project activities, and work in groups. At the same time, it should be noted that educational tasks should be aimed at ensuring that students can move from simple tasks to complex ones.

The aim of the study is to determine the impact of STEM approaches on the development of technical and other skills necessary to solve real problems.

The aim of the research involved the fulfilment of the following research objectives:

Analyse the impact of STEM approaches on the development of analytical thinking and basic scientific knowledge in primary school children;

Determine the effectiveness of using games and interactive methods in the development of technical skills and understanding of technical processes;

c) Assess the role of group work and project activities in the development of the ability to solve real problems and learning motivation.

2 LITERATURE REVIEW

The reform of school education in Ukraine, known as the New Ukrainian School, includes innovative approaches, in particular the introduction of STEM education, which prepares students for the challenges of a modern high-tech society. Most scholars (Rifandi et al.) argue that STEM approaches contribute to the development of knowledge and skills.

These approaches enable students not only to learn, but also to acquire the hard skills and basic knowledge that are necessary for further education. Researchers have determined that a primary school is a favourable environment for arousing interest in science and technology.

Rifandi and Rahmi (2019) noted that STEM education can significantly improve students' ability to solve their problems, be independent, etc. In his opinion, they should be able to do this during everyday activities, not only at school (Rifandi; Rahmi, 2019). The author noted that it will also solve the problem of low scores on Trends in Mathematics and Science Study (TIMMS) and Programme for International Student Assessment (PISA). All this will lead to student success in all school subjects, especially mathematics and technology.

Mintii (2023) holds a similar opinion, who believes that the STEM approach has an impact

on 4 clusters: STEM education, teacher training, and primary education, electronic learning and computational thinking in the preparation of future STEM teachers. As Sergiienko (2024) notes, this approach integrates with all subjects, requiring teacher support and active student cooperation.

Instead, Zoria (2020) noted that this forms research skills that are appropriate for the child's age. According to the author, STEM approaches provide greater autonomy, as well as independence, decision-making, responsibility, etc. The same idea is found in the works of Tretiak, O. Antonova, K. Carter, etc. The authors noted that STEM approaches allow for a clear transfer of knowledge, skills, and abilities, promote independence, etc. The teacher's role is minimized, which means that students are the main persons. Thus, according to Nesmith and Cooper (2020) STEM education is divided into the following categories: robotics, makerspace, and integrated lessons (Antonova; Antonov; Polishchuk, 2022; Balyk; Shmyger; Vasylenko; Oleksiuk; Skaskiv, 2019). In this case, STEM for hard skills is only positive. This contributes not only to the acquisition of basic technical skills, but also forms a sustainable interest in science, technology, engineering, and mathematics from primary school age.

In their studies, Baimakhanbetova, Stambekova, Bayraktar, Sikhimbayeva and Ibragimova (2023) and Kadkhoda, Ahmadi, Hamidi and Nowroozi Larki (2023) noted that these approaches also help in overcoming gender stereotypes. They contribute to increasing interests in girls who like technology by developing their confidence, determination, etc. Besides, the researchers emphasize the role of gaming technologies, which underlie STEM approaches. These methods are part of what makes learning more interesting and allows students to absorb information (Firdaus; Rahayu, 2019; Zengin; Kavak; Keçeci; Zengin, 2022).

So, the analysis of literature shows that STEM is a promising approach in primary school for developing 21st century skills, including hard skills. All this has a significant impact on students' success and their social adaptation.

3 METHODS AND MATERIALS

The study was conducted in several stages using mixed methods, which involved the collection and analysis of quantitative and qualitative data.

The first stage is preparatory. At this stage, the target group of the study was determined — students of grades 3-4, aged 9-10. A questionnaire was developed for the quantitative study, covering the development of technical, mathematical, natural science, and information skills. The reliability of the results was ensured through the creation of the control group (CG) and experimental group (EG). The CG studied according to the standard curriculum provided by the NUSh, and the EG studied according to the STEM methodology. The number of participants in each group was determined by age, gender, and level of knowledge.

The second stage was the collection of quantitative data. At this stage, pre-testing in mathematics, computer science and natural science was conducted with students in grades 3-4. The tests included tasks that assess the development of so-called hard skills, such as mathematics, logic, technical thinking, and problem solving. Online forms were used to collect standardized data, and parental consent was obtained for their children's participation in the study.

The third stage is the implementation of the STEM approach. The EG students studied for a certain period according to a specially developed STEM programme, which included natural sciences, technology, and mathematics. The educational material focused on real-life situations and was aimed at developing technical thinking and practical skills. The CG continued to study according to the NUSh programme without a STEM component, which ensured the purity of the experiments.

The fourth stage was the integration of the results. The obtained data were processed using quantitative and qualitative methods. SPSS and Excel software were used to analyse the data and identify general trends. The results of both groups were compared using statisti-

cal methods to assess the significance of the impact of the STEM approach on the development of hard skills. This comparison gave grounds for drawing conclusions about the effectiveness of the STEM approach and its potential for implementation in primary school.

3.1 RESEARCH METHODS

Quantitative analysis: The survey data were processed using statistical methods to identify trends and patterns of students, average values, and percentages. This gave grounds to draw general conclusions about the level of knowledge and skills of students in grades 3-4.

Comparative method: This method assessed the impact of the STEM approach on the development of hard skills. The results of the initial, intermediate, and final testing were used for comparison. This made it possible to trace the dynamics of skill development during the experimental period.

Observation: Observation methods were used to track how students interacted and applied their knowledge in practice during the implementation of the STEM approach. Observations were conducted both directly and remotely.

Questionnaire survey: It helped to explore the views of students and teachers on the effectiveness of STEM approaches through questions on the perception of interest in the implementation of STEM subjects (the questionnaires themselves can be found in the appendices hereto).

Content analysis: This method was used to analyse the responses of students, parents, and teachers in the survey, which helped to identify key trends in the perception of STEM initiatives.

3.2 SAMPLE DESCRIPTION

The research base is two general educational institutions in Ukraine: Roman Huryk Lyceum No. 23 in the Ivano-Frankivsk region and Chernivtsi Gymnasium No. 8 of the Chernivtsi City Council in the Chernivtsi region. Our sample, which was selected from the above-men-

tioned institutions, consists of children of primary school age (9-10 years old). We selected two schools for the study that have the same location, similar educational programmes in order to obtain high-quality representative data and minimize external influence on the research results.

The study involved a total of 100 students, who were divided into 2 groups: the EG (50 students) to whom the STEM approach had already begun to be implemented during the academic year, and the CG (50 students) who studied under the NUSh programmes developed by O. Savchenko and R. Shyian.

A sample of 100 students in each group (CG and EG) was selected for the study, which is explained by several important factors:

First, such a number of students (50 people) was determined because of statistical requirements for obtaining valid and reliable results.

Such a number of people provides sufficient representativeness to identify significant changes in the development of hard skills under the influence of STEM approaches.

It also makes it possible to reduce the impact of random deviations and statistical errors.

Second, the following factors were taken into account when choosing the sample size: reliability of the results: a sample of less than 100 people may not reveal clear trends or the impact of STEM approaches because of the increased likelihood of random deviations; group balance: the same number of students in the CG and EG allows for a clear comparison of results and minimizes the impact of external factors.

The students were selected for the study according to a number of criteria that ensured equality of conditions between the CG and EG: 1) age range: students in grades 3-4 were selected in order to ensure that the study was conducted in primary grades; 2) initial skill level: students with the same level of hard skills were divided into CG and EG at the pre-test stage of the study to ensure equality of starting conditions.

The sample included students from different socio-economic population segments and

different schools, which ensured the representativeness of different population groups. This increased the external validity of the study and helped to apply its results to a wider range of individuals.

A stratified sampling method was used to determine the final sample, which reflects the diversity of children according to certain characteristics (age, level of knowledge, type of school, etc.). The number of students in the general population can be calculated as 100 people, so a sample with a low margin of error was obtained.

Therefore, these criteria were the basis for selecting 100 students to ensure a highly reliable representativeness of the general population as a whole.

The study lasted for one academic year — from September 2023 to May 2024. This period was chosen because it allowed us to study the long-term effects of implementing a new teaching approach for the EG. Primary school was chosen because of its key role in developing technological skills, which are formed at the stage of acquiring basic knowledge. In addition, primary school is an important stage for the implementation of new methods, such as STEM, which contribute to innovative approaches to education.

3.3 RESEARCH PROGRAMMES

Several tools were used to conduct the study, which facilitated data collection and analysis. Google Forms were the main tool for collecting information, which allowed for the creation and distribution of a questionnaire among the study participants. The results were analysed using Excel for primary data processing and visualization, as well as SPSS for statistical analysis and hypothesis testing. Each of these tools was selected due to its effectiveness in the respective stages of the study. The following tools were also used to collect and analyse data:

First, students were tested using standardized tests to assess technical skills such as mathematics, logical reasoning, as well as basic science and technology knowledge. Testing

was conducted almost every month to monitor student progress and identify skill development dynamics.

Second, special exercises from the STEM programme were used for the EG. They involved integration and project activities with elements of robotics, computer modelling, and the application of mathematical concepts.

Accordingly, it was necessary to use special software: t-tests for independent samples, the Mann-Whitney tests for nonparametric data and effect size estimation using the Cohen's d.

Statistical significance was assessed by using t-tests, which allow comparing differences between the CG and EG, as well as standard formulas for nonparametric criteria, such as the Cohen's d formula:

$$d = \frac{\bar{X}_1 - \bar{X}_2}{S_{pooled}}, \text{ where } \bar{X}_1 \text{ and } \bar{X}_2 - \text{average}$$

values in the EG and CG, S_{pooled} – total sample deviation.

So, it can be noted that our study has a solid basis and a clear methodology, which involves the use of standardized tests and statistical tools for data analysis, which made it possible to assess the impact of the STEM approach on the development of hard skills in primary school children.

4 RESULTS

After the school year ended in May 2024 and the implementation of the STEM approach to learning in the experimental group of students, re-testing was conducted to assess the development of technological skills, the main elements that we took into account for the assessment:

After the school year ended in May 2024 and the implementation of the STEM approach to learning in the EG of students, re-testing was conducted to assess the development of technological skills, the main elements that we took into account for the assessment:

Mathematical skills — measure the speed and accuracy of performing arithmetic tasks;

Logical thinking (solving logical problems).

Natural science skills (understanding simple natural phenomena and principles)

Technical skills (performing simple design tasks).

The test results were compared between the two groups using an independent sample t-test. As the data were normally distributed, they were tested using the Kolmogorov-Smirnov test. Table 1 developed by the author shows the mean scores and standard deviations for each category for the two groups (CG and EG):

Table 1- Mean scores and standard deviations of the CG and EG

Category	Control group	Experimental group	t-value	p-value
Mathematical skills	78.3 ± 10.2	85.7 ± 9.5	4.32	< 0.001
Logical thinking	70.5 ± 8.3	80.2 ± 7.8	5.13	
Natural science skills	65.4 ± 9.7	74.8 ± 10.1	4.01	
Technical skills	60.2 ± 7.5	72.9 ± 8.2	6.28	

Source: Developed by the authors (2025).

So, the results of Table 1 demonstrate that the EG in all categories has a certain growth rate, which indicates that the STEM approach has a positive impact on the development of technical and mathematical skills.

4.1 EFFECT SIZE ESTIMATION

In order to estimate the effect size, we needed to calculate the percentage coefficient using Cohen's d. It estimated the practical significance of the differences between the groups. The results of the effect can be found in Table 2.

Table 2- Effect size (Cohen's d)

Category	Cohen's d
Mathematical skills	0.74
Logical thinking	0.95
Natural science skills	0.80
Technical skills	1.51

Source: Developed by the authors (2025).

Analysis of the table, which provides data on different types of skills gave grounds to identify key points:

First, Cohen's d demonstrates a significant effect size for all studied skills, which indicates the high effectiveness of the STEM approach in the development of hard skills in primary school.

In particular, the largest effect is observed in the development of technological skills (1.51), which indicates a significant impact of STEM on students' mastery of the basic principles of working with technology.

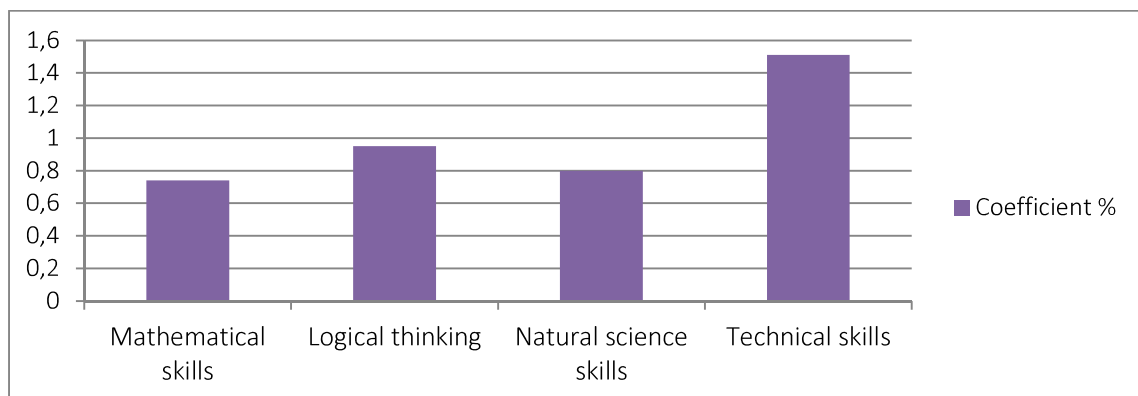
Second, the development of logical thinking has a high Cohen's d (0.95), which emphasizes the effectiveness of the STEM approach in stimulating analytical skills and cognitive

abilities. This is especially important for preparing children for more complex educational tasks in the future.

Third, natural science skills and mathematical skills also show a significant effect (0.80 and 0.74, respectively), indicating an overall positive impact of STEM methods on the acquisition of fundamental knowledge in science and mathematics.

So, the results obtained confirm that the STEM approach significantly increases the level of hard skills among primary school students, especially in the field of technology and logical thinking, which can serve as the basis for further research and implementation of this approach in the education system. These data are shown in percentage terms on the graph (Figure 1).

Figure 1- Effect size (according to Cohen's d)



Source: Developed by the authors (2025).

Figure 1 only confirms the above, which means that technical skills (1.51), logical thinking (0.95), and mathematical skills (0.74) are key in NUSh.

4.2 ANALYSIS OF NONPARAMETRIC DATA RESULTS

As the data in Table 1 do not follow a nor-

mal distribution, nonparametric analysis methods were also used to test the results.

The Mann-Whitney test, which was used to compare these results, is nonparametric. That is why it enables comparing two independent samples without requiring that the data be normally distributed, and it also determines whether there is a significant difference between the EG and CG. This test will be used

in those moments where deviations from a normal distribution can be observed. So, Table 3 shows similar results with statistically significant differences between the EG and CG.

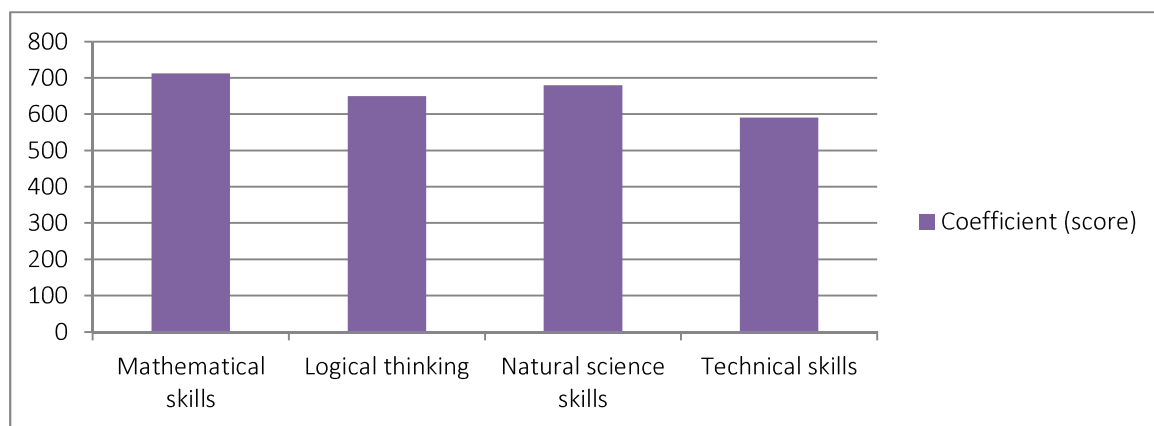
Table 3- Mann-Whitney test between the EG and CG samples

Category	U-value	p-value
Mathematical skills	712.5	< 0.001
Logical thinking	650.0	
Natural science skills	680.0	
Technical skills	590.5	

Source: Developed by the authors (2025).

As Table 2 shows, all of the above categories were confirmed by the Mann-Whitney test: there is a significant difference between the results of the two groups. Therefore, it can be confidently stated that the implementation of the STEM approach has a significant positive impact on the development of students' technological skills, even when the data are not normally distributed (Figure 2).

Figure 2- Mann-Whitney test between the EG and CG samples



Source: Developed by the authors (2025).

So, the Mann-Whitney U test (by score) provides additional verification of the results and confirmed the statistical significance of the differences between the EG and CG.

4.3 PROJECTING LONG-TERM OUTCOMES

Based on the obtained data, additional modelling was conducted to assess how long STEM would have an impact on the development of technical and mathematical skills. Regression analysis was used for this purpose, which estimates the potential growth in technical skills at the beginning and end of the experiment. At the same time, the growth rate

of the results in the EG was taken into account, and therefore- rapid growth in skills in the medium and long run. Based on this model, it was concluded that students who regularly use STEM approaches are more likely to achieve greater success in the following areas:

Mathematics: Regression analysis shows that students who consistently engage in STEM programmes can improve their math skills by 20% compared to traditional teaching methods. This is explained by STEM's active development of the practical application of mathematical knowledge through solving real-world problems. Table 4 shows this difference.

Table 4- Difference in predicted outcomes before and after STEM approaches

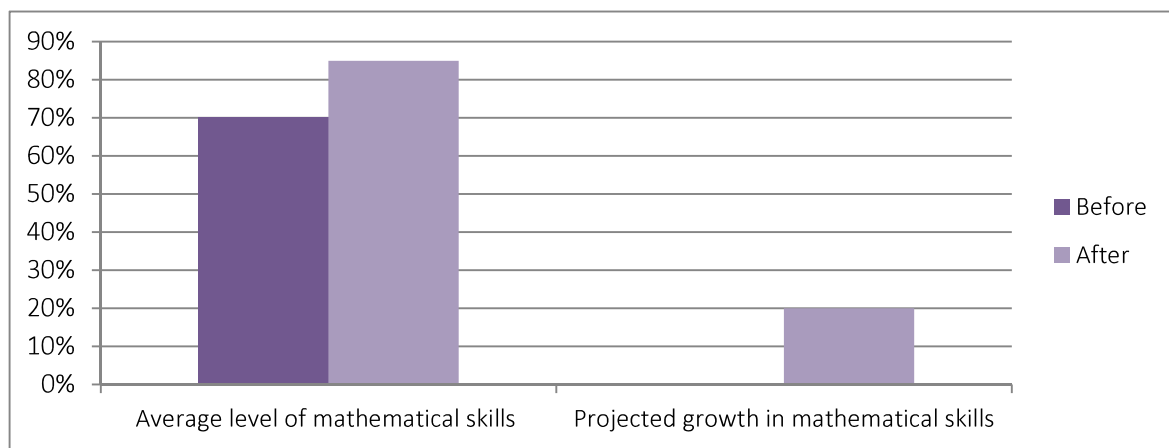
Indicator	Before STEM approach (%)	After STEM approach (%)
Average level of mathematical skills	70%	85%
Projected growth in skills	0%	20%

Source: Developed by the authors (2025).

A bar chart (Figure 3) is created to visually display this information that will indicate the difference in results. Each bar will indicate a separate category or variable that will reflect the difference in the results of the study. This chart helps to identify which indi-

cators have the highest values and compare them with others. This will help not only visualize the data, but also facilitate their analysis, as it becomes possible to quickly see trends, correlations or differences between groups.

Figure 3- Improving math skills depending on the learning method



Source: Developed by the authors (2025).

Technology: Projections for the development of technical competencies have proven to be unusual. Given the interactive nature of STEM education, which includes practical work,

projects related to design and programming, it is predicted that high school students will show 25-30% better results than their peers with traditional engineering training (Table 5).

Table 5 - Projections for the development of technical competencies using the STEM approach in primary school

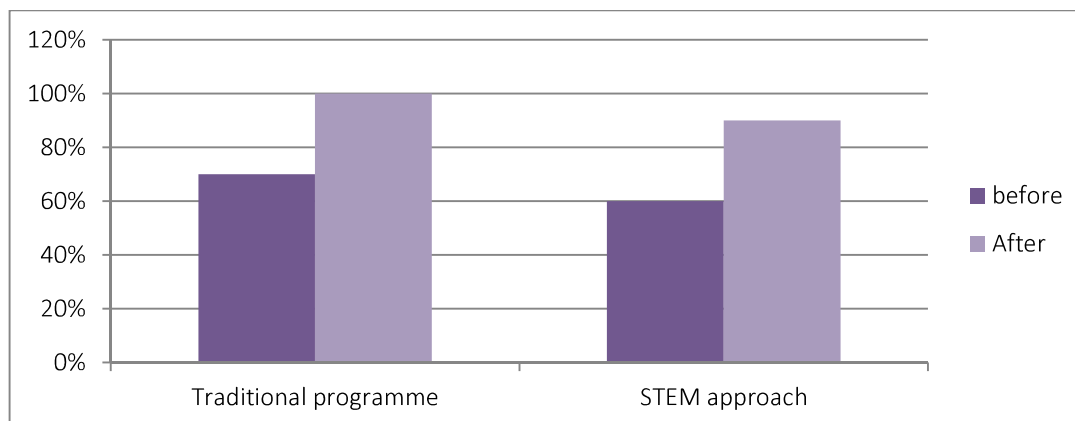
Indicator	Before STEM approach (%)	After STEM approach (%)
Traditional programme	70	100
STEM approach	60	90

Source: Developed by the authors (2025).

A bar chart can be created to graphically represent this data, that shows the percentage of competency levels before and after the STEM approach, both in the traditional programme and in the STEM-based one (Figure

4). The figure clearly displays the percentage of competency levels before and after the implementation of the STEM approach, comparing the results of the traditional programme with the STEM-based programme.

Figure 4. Prediction of the development of technical competencies of primary school students before and after the implementation of the STEM approach



Source: Developed by the authors (2025).

This will show not only the overall effectiveness of the STEM approach, but also enables assessing its impact on the development of specific competencies under research.

The modelling results showed that the implementation of STEM approaches not only provides students with basic technical skills, but also lays the foundation for further successful education in secondary school. This is especially true for areas that require precise

thinking and technical knowledge. Regression analysis shows that students who start studying STEM at the initial stages have a higher chance of succeeding in higher education, especially in technical and engineering majors.

Two groups were formed at the beginning of the study, and the CG studied according to the traditional programme. At the end of the study, a comparative analysis was made before and after the experiment, which is presented in Table 6.

Table 6- Comparison of average scores (before and after the study)

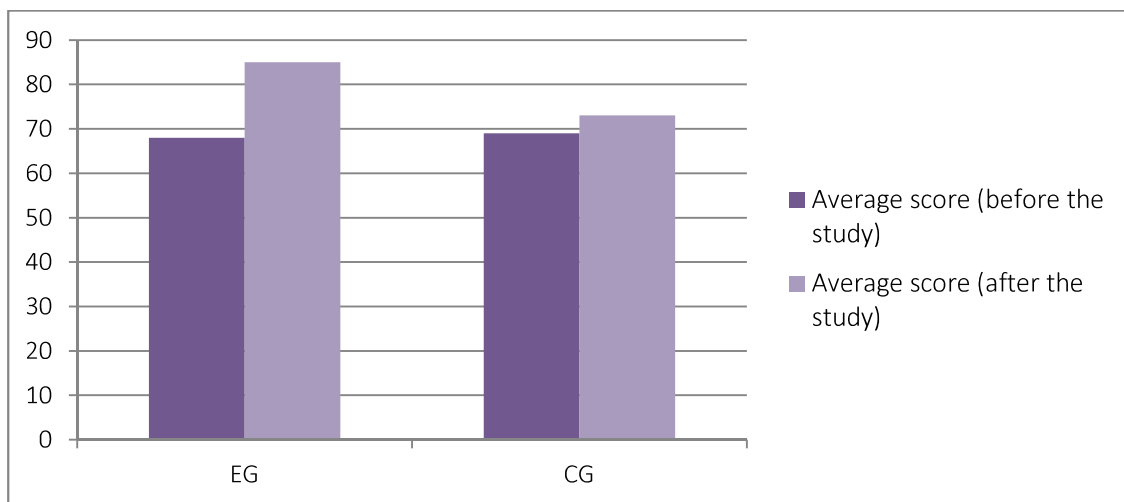
Group	Average score (before the study)	Average score (after the study)	Change in %
EG	68	85	+25%
CG	69	73	+6%

Source: Developed by the authors (2025).

The EG students show a significant improvement in their results after the introduction of STEM methods (+25%), while in

the CG this indicator was significantly lower (+6%). Figure 5 displays the obtained results.

Figure 5- Comparison of average scores (before and after the study)



Source: Developed by the authors (2025).

This suggests that the use of STEM approaches contributes to the significant development of technical skills, which can be the basis for further success in studying more complex subjects in secondary and higher school. In this case, commitment to STEM education not only has a positive short-term impact, but can also lay a sustainable foundation for further success in technical fields.

Modelling shows that students who study using STEM programmes are more likely to achieve higher academic results and acquire important skills throughout secondary and even higher education. This study showed that the STEM approach has a significant impact on the development of technical skills in primary school. The EG students show significantly better results than the CG students, which indicates the effectiveness of these approaches. This emphasizes the effectiveness of these approaches. So, the obtained results confirm that STEM education has a positive impact on the development of hard skills in primary school students, and provide grounds to recommend the implementation of these approaches in the broader educational process.

5 DISCUSSION

It was noted above that the implementation of STEM approaches provides positive moments, but it is necessary to look other

researchers' view of this problem. According to Shkurenko and Lobyreva (2023), the implementation of STEM approaches in primary school is a difficult stage for the development of humanity, because this area has certain prospects in the preparation of students and the population for STEM education. One can agree with this proposition, at least with the statement that computer knowledge is important for successful professional activity in the modern world. However, the author draws attention to the possible difficulties of implementation, although the use of the STEM approach, in her opinion, will only improve the atmosphere of the NUSh. Indeed, for the effective implementation of this methodology, teachers need to master the skills of working with robotics and integrating STEM into the educational process. (Shkurenko; Lobyreva, 2023).

According to Ozturk (2021), research is an effective pedagogical practice that is widely recognized in America, European countries, etc. The author believes that research is an important pedagogical practice in modern classrooms. However, teachers themselves must have the necessary skills for this approach.

The researchers Martínez-Borreguero, Naranjo-Correa and Mateos-Núñez (2022) and Ültay, Zivali, Yilmaz, Bak, Yilmaz, Topatan and Kara (2020) also confirm that real learning requires the ability to use science and tech-

nology, which will improve the memorization of facts, but also transform information into knowledge. They believe that scientific and technological literacy is the most important hard skill that needs to be developed. In their study, the team of researchers led by Ültay, Zivali, Yilmaz, Bak, Yilmaz, Topatan and Kara (2020) found that primary school students have many misconceptions about particular knowledge.

That is why the STEM approach helps students to correct incorrect information by checking their knowledge. We agree with the that, as it will enable identifying the positive aspects of STEM approaches (Ültay; Zivali; Yilmaz; Bak; Yilmaz; Topatan; Kara, 2020). A similar opinion is held by Wei and Chen (2021), Stehle and Peters-Burton (2019), and Amran, Bakar, Surat, Mahmud and Shafie (2021), Ichsan, Suharyat, Santosa and Satria (2023), and Šimunović, Reić and Burušić (2018).

A similar opinion is also mentioned in the article by Wu and Rau (2019) and Kalinova (2019), Bertrand and Namukasa (2020). According to Baran, Baran, Karakoyun and Masikan (2021), there are several skills that need to be developed in primary school students: critical thinking, teamwork, adherence to ethical values, mastery of information technology and problem-solving skills, effective use of communication skills, global awareness, creativity, embracing other cultures, and decision-making. On the one hand, one has to agree, while on the other hand, each student is an individual who needs to be listened to and develop their hard skills. The same opinion is expressed in the articles of Braund and Michael (2019), Hussin, Jiea, Rosly and Omar (2019), Alalwan, Cheng, Al-Samarraie, Yousef, Alzahrán and Sarsam (2020), which once again confirm the idea that pedagogy is not only focused on the development of intellectual skills, but also on their improvement.

Therefore, we can say that each author has his own understanding of the impact of these approaches (STEM) on the development of hard skills in primary school students.

The implementation of STEM approaches in primary school may be limited by insuffi-

cient teacher training and the lack of special resources and materials adapted to the age specifics of primary school students. Besides, difficulties with the integration of interdisciplinary tasks may be a problem in primary school, where it is important to take into account the students' level of cognitive development.

In order to increase the effectiveness of these approaches, it is recommended that teachers undergo in-service training to develop their ability to teach science in an interactive learning format. Moreover, schools should be provided with the necessary teaching materials and equipment, such as simple laboratory equipment and educational construction kits, so that students can learn through practical activities.

6 CONCLUSIONS

Therefore, the impact of STEM approaches on the development of hard skills is a promising direction that is needed by primary school children, in particular technical and mathematical ones. In the modern information society, these skills are becoming necessary for further educational and professional growth, especially in the field of innovation, technology, and engineering. The study demonstrates that STEM methods develop students' critical thinking, increase their interest in science and lay the foundations for a systematic approach to solving problems.

The use of game techniques, group projects, and interactive methods contributes to better learning of the material, allowing children to adapt to complex concepts. However, there are several limitations that complicate the implementation of STEM approaches in primary school. Among the main ones are insufficient teacher training and lack of appropriate educational equipment, which negatively affects the quality implementation of these approaches.

These issues can be successfully addressed through the development of professional development programmes for teachers and provide schools with the necessary resources to

support the practical application of knowledge. So, the implementation of STEM approaches in primary school is a key element in building key skills that will ensure the development of future specialists.

Research prospects include the analysis of the impact of specific STEM teaching methods on students of different age groups and the development of individual training programmes that take into account the psychological and cognitive characteristics of each child. This study confirms its scientific novelty by identifying specific mechanisms for the development of technical skills using adapted methods that contribute to the acquisition of knowledge, skills, and abilities.

The practical value of the research is the recommendations for the implementation of STEM approaches in primary school, which will help teachers, educational supervisors and school leaders in creating innovative curricula. The study also presents practical ways to adapt to the age-related needs of younger schoolchildren, promoting the development of technical and analytical skills through game technologies, project activities, and group tasks. This will allow them to more effectively develop strong skills that will become the basis for further research in the field of science and technology.

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