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INTRODUCTION OF STEM-EDUCATION THROUGH PROJECTACTIVITIES AT SCHOOL

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Literature analysis revealed the basic concepts and provisions, showed the advantages and disadvantages of STEM-education through project activities and created a basis to form a holistic view of how to effectively implement project activities within STEM-education in a modern school setting. The survey of 9th grade students (52 people) highlighted their interests, preferences and identified the level of STEM competencies and established experience and preference in the field of project activities. Based on the survey results, a 9th grade STEM-project program aimed at developing STEM and project competencies was developed. The experimental part of the study included diagnostics of initial knowledge and skills, conducting lessons and extracurricular activities, using the developed program, final diagnostics and subsequent analysis of all results, to the extent of the experimental and control group. Overall, the experimental part of the study showed how project activities can be used effectively in STEM education, and the comparative analysis of the results provided valuable information for improving educational programs using project activities. Recommendations have been developed to expand the use of STEM-education in school education, beyond exclusive project activities and proposed to integrate them with humanities disciplines, using the development of an interdisciplinary approach and the highest priority socially important competencies.

Keywords: *STEM-education, project activity, school education, STEM-project, STEM-competencies, technical disciplines.*

МЕКТЕПТЕГІ ЖОБАЛАУ ҚЫЗМЕТІ АРҚЫЛЫ STEM-БІЛІМ БЕРУДІ ЕНГІЗУ

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Әдебиеттерді талдау негізгі ұғымдармен ережелер талқыға алынып, сараланды, жобалық қызмет арқылы STEM-білім берудің артықшылықтары мен кемшіліктері ашылды және STEM-білім беру шеңберінде жобалық қызметті қалай тиімді жүзеге асыру керектігі туралы біртұтас идеяны қалыптастыру үшін негіз жасады. Сауалнама барысында 9-сынып оқушыларының (52 адам) қызығушылықтары, қалаулары анықталды, STEM-құзыреттіліктерінің қалыптасу деңгейі, сондай-ақ жобалау қызметі саласындағы тәжірибе мен артықшылықтар анықталды. Алынған нәтижелер негізінде STEM және жобалық құзыреттіліктерді дамытуға бағытталған 9-сынып оқушыларына арналған «STEM–жоба» бағдарламасы әзірленіп, жүзеге асырылды. Зерттеудің эксперименттік бөлігі бастапқы біліммен дағдыларды диагностикадан өткізу, әзірленген

бағдарлама негізінде сабақтармен сыныптан тыс іс-шаралар өткізу, қорытынды диагностика жасау және эксперименттік және бақылау топтарындағы барлық нәтижелерді кейіннен талдау жұмыстарын қамтыды. Тұтастай алғанда, зерттеудің теориялық және практикалық нәтижелері STEM – білім берудегі жобалық қызметті қаншалықты тиімді пайдалануға болатынын көрсетті және нәтижелерді салыстырмалы талдау жобалық қызметті пайдалана отырып, білім беру бағдарламаларын жетілдіру үшін құнды ақпарат жасалды. Мектеп білімінде, жобалық қызметтен тыс STEM-білім беруді пайдалануды кеңейту бойынша ұсыныстар әзірленді және оларды пәнаралық тәсілді және неғұрлым басым әлеуметтік-маңызды құзыреттерді дамытуды пайдалана отырып, гуманитарлық пәндермен біріктіру ұсынылды.

Түйінді сөздер: *STEM-білім беру, жобалық қызмет, мектеп білімі, STEM-жоба, STEM-құзыреттер, техникалық пәндер.*

ВНЕДРЕНИЕ STEM-ОБРАЗОВАНИЯ ЧЕРЕЗ ПРОЕКТНУЮ ДЕЯТЕЛЬНОСТЬ В ШКОЛЕ

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Анализ литературы по исследуемой теме раскрыл основные понятия и положения, показал преимущества и недостатки STEM-образования через проектную деятельность и создал основу для формирования целостного представления о том, как эффективно реализовать проектную деятельность в рамках STEM-образования в современной школе. В ходе анкетирования учащихся 9-х классов (52 человека) были выявлены их интересы, предпочтения, определен уровень сформированности STEM-компетенций, а также опыт и предпочтения в области проектной деятельности. На основе полученных результатов была разработана программа «STEM-проект» для 9-го класса, направленная на развитие STEM и проектных компетенций. Экспериментальная часть исследования включала в себя диагностику исходных знаний и умений, проведение уроков и внеклассных мероприятий с использованием разработанной программы, итоговую диагностику и последующий анализ всех результатов, в объеме экспериментальной и контрольной группы. В целом экспериментальная часть исследования показала, насколько эффективно может быть использована проектная деятельность в STEM-образовании, а сравнительный анализ результатов дал ценную информацию для совершенствования образовательных программ с использованием проектной деятельности. Разработаны рекомендации по расширению использования STEM-образования в школьном образовании, за пределы исключительно проектной деятельности и предложено интегрировать их с гуманитарными дисциплинами, используя развитие междисциплинарного подхода и наиболее приоритетных социально-значимых компетенций.

Ключевые слова*: STEM-образование, проектная деятельность, школьное образование, STEM-проект, STEM-компетенции, технические дисциплины.*

Introduction. STEM (science, technology, engineering and mathematics) education is becoming more and more famous in modern conditions due to the rapid evolution of new technologies. All this leads to the fact that the education system needs to prepare children who could later get the most popular and promising professions. Since in modern conditions on the labor market there is a growing need for young people prepared for life in modern society, which is already now rapidly reorienting to an innovative approach, taking into account new technological advances. Such conditions require an interdisciplinary approach in the education system, which allows students to acquire skills to solve multifaceted problems. As a result, STEM-education is becoming one of the important directions, which is already being actively used in schools as a tool for fosteringin students such flexible skills as critical thinking and creativity, as well as the ability to apply in practice the obtained academic and applied knowledge.

In order to implement STEM approach in education, various methods are used. One of the most effective methods for its implementation is project activities. Since the use of such activities gives an opportunity to activate integration of different subjects and thus develop skills of planning and problem solving, using real examples.

The relevance of the research topic is determined by the problems related to the need of the education system to modernize school education, according to the requirements of the XXI century. Alsomodern school needs to prepare graduates needed by the market, who should have such abilities that allow to work more effectively in a rapidly changing world. Given the fact that the world is constantly technologically developing, it will be necessary to be able to make informed decisions and solve rather complex problems using a comprehensive approach. In this process, it is project activities within STEM education that can help schools develop such important and necessary competencies as systems thinking, teamwork, project management, and the ability to analyze large amounts of information. Project activities also stimulate students' interest in science and technology, which is especially important for solving such an important problem as raising the level of technical and engineering education, which is a priority for the country's economic development.

The degree of development in the field of the research topic can be called relatively high, as the issues of STEM implementation in education through project activities are actively researched. The works of many authors who have made a significant contribution to understanding the role of the activity approach in the education system are known. They include the following foreign authors: Howard Gardner, John Dewey, Jean Piaget [1], L.S. Vygotsky and A.N. Leontiev [2]. Modern Kazakhstani researchers consider separate sides of the problem under study: A. Omiruzakkizy – organization of project activities at school through STEM startups [3]; S.A. Muravyeva – STEM – as a type of project activity [4]; E. Ergobek- the importance of STEM-lessons based on project activities [5]. We should also note the studies

of foreign researchers on the assessment of the spatial transition of the teacher and student from a traditional classroom to an innovative learning environment [6]. And also scientists of CIS countries: V. Lazarev [7], C.Hu, Y.Yang, Y.Cheng, N.Chen[8],S.M. Konyushenko, M.S. Zhukova, E.A Mosheva [9],T.Y. Gavrilova [10], who considered the possibilities of integration of STEM approach in school education and some aspects of the impact of project activities on the development of students' cognitive abilities. At the same time, despite the availability of scientific research, the question of how the introduction of project activities within STEM-education can contribute to improving the quality of learning and motivation of schoolchildren remains insufficiently studied. This necessitates further research in this area.

The problem of the research should be defined through the insufficient development of scientific approaches and methods for the implementation of project activities within the development of STEM-education in schools. There is a lack of practical recommendations and examples of successful application of these methods in school educational institutions. All this leads to the fact that many schools face difficulties in implementing STEM-related projects in the study of important academic disciplines, which reduces the effectiveness of the entire learning process.

Purpose and objectives. The aim is to investigate the peculiarities of STEM-education implementation in secondary school through project activities and its significance in the formation of important competencies in students and improving the quality of the educational process.

The object of the study is the process of implementation of STEM-education in school.

The subject of the study is the organization of project activities in the framework of STEM-education.

Objectives:

1. Considermain approaches to the implementation of project activities in STEM education, determining the effectiveness of using project activities in STEM education.
2. Establish interest and proficiency in STEM competencies and project activities in high school.
3. Develop a program of implementation in STEM-education through project activities, taking into account the specifics of school disciplines and the peculiarities of development of important rigid and flexible competencies in students.
4. Conduct a study on the effectiveness of the proposed program.
5. Evaluate the experimental results obtained and identify factors that influence the success of the implementation of project activities.
6. To develop recommendations on how to improve the implementation of STEM education through project activities at school, through integration with humanities disciplines and interdisciplinary approach.

Hypothesis of the study: if project activities are used systematically in STEM education, it is possible to increase students' interest in subjects and develop important STEM competencies.

The methodological basis of the study was scientific theories in the field of activity approach and scientific ideas of integrative learning. Research methods: literary analysis, as well as observation, survey, testing conducted as part of the pedagogical experiment.

When selecting research methods, a constructive approach is taken into account, which emphasizes the creation of conditions in which students can actively participate in the learning process, including through project activities (use of project tasks, case methods, simulations and role-playing games, etc.). This approach allows students to interact with each other and apply the acquired knowledge in real-life situations. At the same time, the use of practical project tasks, where students themselves create hypotheses and test them, gives an opportunity not only to solve practical problems, but also to receive feedback from the teacher and team members. In addition, the use of constructivist approaches in the research on the implementation of STEM education through project activities in school education allows the teacher to create conditions in which students become active researchers who solve complex practical problems taken from real life. This approach allows students to develop practical skills in adapting to real and changing conditions, as well as teamwork, critical thinking and self-organization skills. Thus, the methodological foundations of constructivism allow us to justify the choice of research methods on the topic of introducing STEM-education through project activities at school, as they allow us to create more effective learning tools that meet modern requirements and challenges.

The results of the study showed that the introduction of project activities within the framework of STEM-education really helps to increase students' interest in subjects, improve their academic performance, etc. The developed program proved to be effective and can be recommended for use in other educational institutions. The article can also contribute to the development of education, as the results of the study show how the introduction of modern educational approaches affects the formation of modern competencies in students and shows their readiness for future challenges posed by society.

Materials and methods. The research materials were monographs, scientific articles and other publications on the research topic. 19 sources were considered. The materials of the study were also educational materials, workbooks, journals, projects, summary sheets on the results of the research.

The research methods included literature analysis, surveys and testing of students, pedagogical experiment, methods of analytical and statistical analysis

At the first stage of the work, a literature analysis aimed at establishing the main theoretical and practical approaches to the implementation of project activities within STEM education at school, which determine the effectiveness of project activities in STEM education was conducted.

In the second stage, survey methods, testing and analyzing the results are used. These diagnostic tools were chosen because they provide a comprehensive approach to assessing students' interests, preferences, and STEM competencies.

A survey was conducted to learn about their interests, preferences, and level of STEM competencies. A questionnaire survey is the most appropriate method of data collection because it provides the opportunity to reach a diverse range of respondents and allows for the subsequent simple quantitative analysis of the results.

As part of the survey of 9th grade students (52 people) to find out their preferences and interest in STEM education, the following questions are included in the questionnaires:

— which school program subjects do you like the most;
— how often do they engage in extracurricular activities related to science and technology;

— are you interested in modern technology and its application in everyday life;
— what aspect of STEM education do you enjoy the most.

Reasons for choosing the survey questions. The interest and preference questions are designed to identify which STEM disciplines are of interest to students. Such knowledge is important for developing recommendations for programs and projects that target students' interests. Questions about the frequency of classes provide insight into how engaged students are in additional classes and may indicate their motivation and willingness to participate in project-based STEM activities. Questions about interest in current technology used by students in their daily lives provides an opportunity to establish the extent to which students are aware of and interested in current technology trends. Such data can be investigated in order to design instructional lessons that implement activities that address current real-world conditions. Asking which aspects of STEM subjects appeal to students provides information to better differentiate instructional materials in project-based activities.

Questions are asked to determine overall STEM competency proficiency:

— assess your proficiency in math, physics, chemistry, biology, and computer science;
— assess the overall level of STEM competencies (from 1 to 5, where 1 is low, 5 is high)?

The STEM competency assessment questions are selected and formulated to obtain information about students' subjective self-assessment of their knowledge and skills in each of the STEM disciplines (math, physics, chemistry, biology, and computer science). The self-assessment helps to understand how confident students are in their abilities and to establish in them the need to improve their mastery of some STEM competencies. While assessment of overall STEM competencies provides an overall picture of students' perception of their level of STEM proficiency, and usually provides results to understand the need for remediation and further development.

A survey was conducted to establish experience, preference for project activities.

The questions in relation to experience and preferences in project activities were:

— have you ever participated in project activities before;
— how comfortable you feel presenting the results of your project in front of an audience;
— do you prefer to plan and structure your work or act intuitively;
— how much time are you willing to spend on the project;
— what project topics are of interest to you.

The reasons for establishing experience and preferences in project activities was to find out how familiar students are with project work, which affects their readiness and motivation to participate in future projects. And it was also necessary to determine how they their level of public speaking and confidence, which is most important for successful presentation of project results and self-confidence. While the question about preferences regarding planning or intuition, allows to establish the basic style of work of the students, and helps to adapt the methods of project management to the individual characteristics of each participant.

Establishing the time and effort that students are willing to invest in project activities provides an opportunity to plan the timing and scope of work for real-world based project work. It was also important to clarify students' thematic preferences, which allows for the development of STEM projects that match their interests and can increase their motivation to participate in projects.

In general, the survey questions were aimed at obtaining important information needed to develop and implement effective STEM education programs through project work during the experiment and further in school education.

The experimental part of the study included diagnostics of initial knowledge and skills, conducting lessons and extracurricular activities, using the developed program, final diagnostics and subsequent analysis of all the results, in the volume of the experimental and control groups.

9th grade students were chosen for the pedagogical experiment since this age enables to use project activities within several subjects, as it is provided by STEM education.

A total of 52 students participated in the experiment and were divided into two groups: experimental group (or EG) and control group (or CG). Provided that the EG would implement the developed STEM-education program through project activities, and the CG would be taught traditionally.

In the course of the experiment, a testwas carried out to assess the initial and final level of knowledge in the main technical disciplines: mathematics; physics; chemistry; biology and computer science.

The assessed parameters are defined asmathematical literacy; physical literacy; computer literacy; chemical literacy; biological literacy; technical skills based on the ability to work with technical devices and equipment; participation in group projects and interaction with other team members; effective communication and presentation of work results; ability to find compromise solutions.

The material obtained from the survey and testing was processed using statistical and mathematical methods of analysis.

Analytical analysis is aimed at obtaining qualitative generalized data based on the subjective opinions and impressions of the survey participants.

The comparative analysis allowed us to determine the effectiveness of STEM education project activities.

Results and discussion. Results of the literature analysis. Project activity, is based on the term "project", comes from the Latin word "projectus", which translates as "thrown forward" [11]. Project activity is deemed as an activity focused on achieving the result, which is determined in advance and appear in the form of some product or service. Project activity is carried out in different industries, including education. The main goals and objectives of project activity in modern education, including STEM education are development of flexible skills (critical thinking, teamwork, creative approach to problem solving); development of the level of academic knowledge [12].

The main principles of project activity are important and in STEM-education are defined as research character; independence; practical orientation [13].

The concept of STEM-education is broader than the basic abbreviation, as it aims to give students the opportunity to understand the world around them more holistically, to eliminate the barriers traditionally established between the core academic disciplines included in STEAM education [14].

It is necessary to note the works of Kazakhstani authors. Thus, A. Omiruzakkizy in her article points out the importance of organizing project activities through STEM methods, which allows schoolchildren to effectively implement important interdisciplinary educational startups [3, p.18].

While considering STEM-education as the main type of research activity in the format of projects, S.A. Muravyeva came to conclusion that STEM-education provides a basis for the formation of schoolchildren's skills of independent planning and prospects for choosing a future profession, according to their abilities [4, p.39].

E. Ergobek describes the features of STEM-lessons and project activities at school, their features and advantages. He also points out that it is easier to do science through these tools. The author also notes that STEM-lessons are based on teamwork and digital skills [5, p.85].

STEM acts as an integrated approach in the learning process, in the scope of which academic subjects are studied in the context of actual life. The goal of STEM in education is to develop STEM-literacy by creating sustainable links between school, future work, society and the world [15]. The advantages and disadvantages of STEM education are reflected in Figure 1.

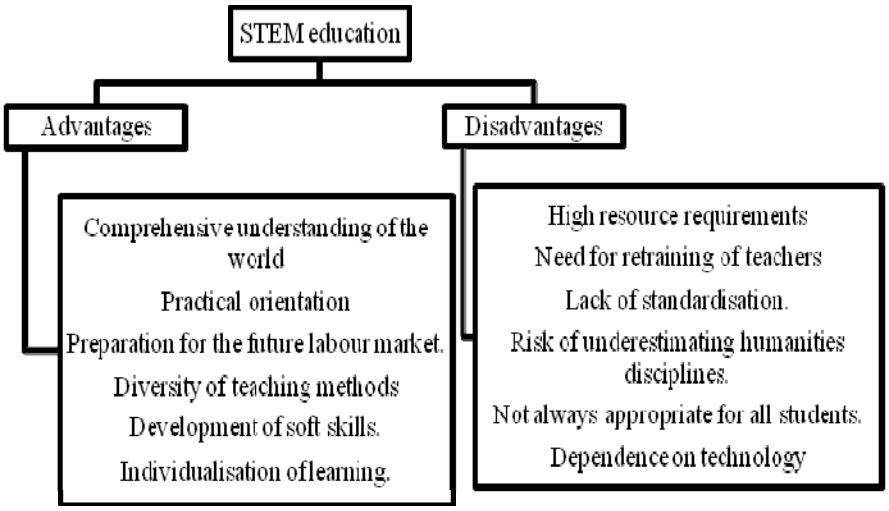

Figure 1 – Advantages and disadvantages of STEM education [16]

Advantages and disadvantages of STEM-education are related to the fact that it is a complex phenomenon based on a practice-oriented approach, which is actively used to prepare students for future life, based on the requirements of the labor market. The implementation of STEM education is characterized by both advantages and difficulties related to the high costs of retraining or professional development of teachers and others [17].

When implementing STEM-education, it is possible that humanities academic disciplines will be underestimated. Therefore, the successful implementation of STEM education, including through project activities, requires a balanced approach, taking into account both its strengths and possible limitations [18].

Project activities in STEM education are based on many methods and approaches that help students to acquire and apply knowledge in a practical environment. Let us identify the main ones: project method; engineering design; inquiry-based learning (IBL); Five Stages of Design model; active learning methods; collaborative learning; interactive technologies; game methods; real-world projects. All of them have their own characteristics and are united by the fact that they are aimed at providing students with the opportunity to participate more actively in the learning process, which allows them to solve real problems and apply their knowledge in practice. Most often, a combination of different methods is used to create a versatile learning space [19].

The revealed concepts of project activities and STEM-organization and their separate characteristics help to form a holistic view of how improve efficiency of implementation of project activities in STEM-education in order to provide better education and prepare competitive students.

Results of a survey of 9th grade students to identify their preferences and interest in STEM competencies. A total of 52 9th grade students participated in the survey. The questions were aimed at identifying students' interests in various subjects and in science and technology related activities, as well as assessing their own level of proficiency in STEM competencies. Table 1 shows the results of the survey to identify students' interests in various subjects and science and technology related activities.

Table 1 – Preferences and interests of 9th grade students

Questions	Answer options	Amount (people)	Percentage
What are your favorite subjects from the school program?	Math	12	23%
	Physics	10	19%
	Informatics	15	29%
	Biology	8	15%
	Chemistry	5	10%
	Others (indicated)	2	4%
How often are you involved in extracurricular activities related to science and technology?	Often	18	35%
	Sometimes.	24	46%
	Never	10	19%

Continuation of table 1

Would you like to participate in science and technology clubs or clubs?	Yes	30	58%
	No	14	27%
	I'm not sure.	8	15%
Are you interested in modern technology and its application in everyday life?	Very interesting	28	54%
	It's a little interesting	20	38%
	It's not interesting at all	4	8%
What aspect of STEM education appeals to you most?	Solving complex math problems	11	21%
	Experimental work in laboratories	13	25%
	Programming and creation of computer games	16	31%
	Study of nature and living organisms	7	13%
	Design and invention	5	10%
Which do you like better: theory or practice?	Theory	8	15%
	Practice	26	50%
	Both aspects are equally important	18	35%
Do you have any hobbies related to science or technology?	Yeah, I'm into, uh.	22	42%
	No, I have other hobbies	30	58%

The results show that the main preferences of students were informatics (29%), followed by interest in mathematics (23%) and physics (19%), then biology and chemistry. This suggests that the program should include more projects related to programming, solving mathematical problems and physical experiments, and less projects in biology and chemistry.

Regarding engagement, nearly half of students (46%) are involved in extracurricular activities related to science and technology at times, indicating the potential to increase this activity. More than half (58%) would like to participate in science and technology circles or clubs, indicating a need for activities to introduce STEM education through project-based activities. Most students (92%) have an interest in modern technology and its application in everyday life, which emphasizes the importance of incorporating current technological issues into the educational process. The most attractive aspects of STEM education according to students were programming and creating computer games (31%), as well as experimental work in laboratories (25%). These aspects should be considered when developing projects.

Half of the students (50%) prefer practice, which means that more emphasis should be placed on hands-on activities and real-world projects, although a significant number (35%) consider both aspects equally important.

Table 2 and Figure 1 show the results of the STEM competency survey (score from 1 to 5, where 1 is low, 5 is high).

Table 2 – STEM competencies proficiency level

Questions (number of people)/assessments in points	1	2	3	4	5
Math proficiency level	5	12	17	9	9
Level of physics proficiency	7	14	18	8	5
Informatics proficiency level	4	10	20	12	6
Level of proficiency in biology	6	15	16	9	6
Chemistry proficiency	8	22	14	5	3
General level of STEM competencies	5	12	17	9	9

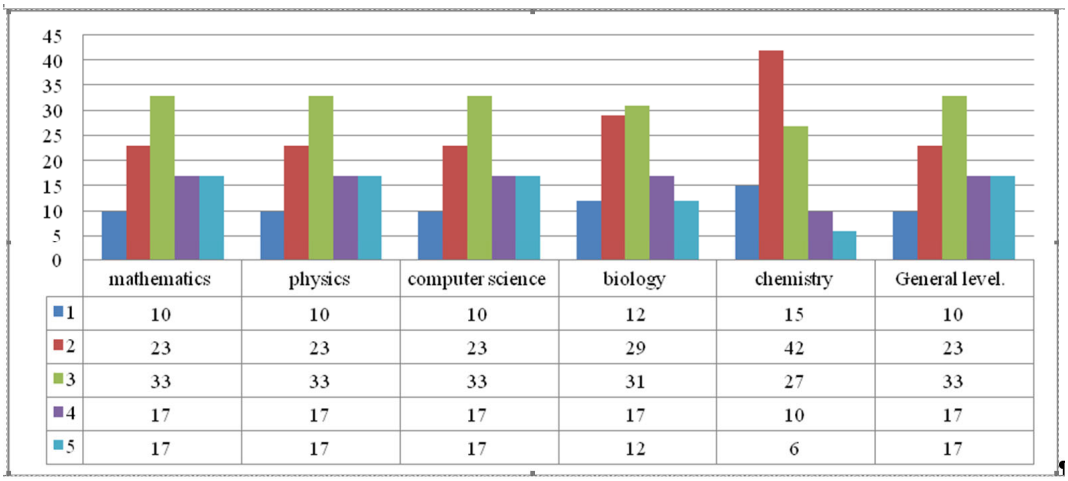

Figure 1 – Results of self-assessment of STEM competency proficiency in percentages

Self-assessment of proficiency level has shown that the average level of mathematics proficiency among students is 3 points (33% of respondents assessed themselves in this way). However, there is a significant proportion of those who rate their ability above average (a combined 34% at grade 4 and 5 levels). The average score in physics is slightly lower than in mathematics at around 3 points (35% of students chose this level). About equal number of students assessed their knowledge at levels 2 and 4 points, which indicates some difference in knowledge in physics. Computer science proficiency is rated higher, as many students rated their knowledge above average (a combined 35% at levels 4 and 5 points), while the largest percentage of students rated their abilities at the average level (38% at level 3 points). Biology proficiency is rated fairly evenly between levels 2, 3, and 4, with a slight bias toward the intermediate level (31%). The lowest average score is noted for chemistry (15% assessed it as 1 point). The majority of pupils assess their knowledge at the level of 2 points (42%), which indicates the need to strengthen teaching of this discipline.

The overall level of STEM competencies is assessed by pupils as average (33% – 3 points, and 23% – on 2 points). At the same time, 18% of students rate their competencies at 4 and 5 points, which shows that there is potential for further development.

Table 3 shows the results of experience and interest in project activities.

Table 3 – Results of the survey on experience and preferences in project activities

Questions and answer options	Quantity	B %
1.Have you participated in project activities before?		
Yes, more than once.	20	38
Once	18	35
Never	14	27
2.Do you like working in a team on common tasks?		
Yeah, I like teamwork	32	62
I prefer to work independently	12	23
It all depends on the task at hand	6	15
3- How comfortable do you feel presenting the results of your project in front of an audience?		
Rather comfortable	16	31
It's hard, but I can handle it	24	46
I'd rather not do the project	12	23
4. Do you prefer to plan and structure your work or act intuitively?		
I like to plan and follow a plan	22	42
I act according to the situation, without a strict plan	18	35
Mixed approach	12	23
5. How much time are you willing to spend on the project?		
A few hours a day	10	19
One hour a day	28	54
In class only, no homework	14	27
6. What project topics are you interested in?		
Energy	7	13
Ecology and environmental protection	13	25
Mobile application development	14	27
Robot creation and automation	10	19
Research in the field of medicine and health	8	15
Others (specify)	-	-
7. What project do you think would be useful and interesting for your school or community?	-	-
Your suggestion	-	-

Evaluation of indicators showed the following average indicators: experience in project activities: repeatedly -38%; once – 35%; never participated – 27%. More people like working in a team – 62%; prefer to work independently – 23%; and depending on the project task – 15%. Quite comfortable with the project is noted by – 31%; a little exciting but manage almost half or 46%; prefer not to perform – 23%. About half or 42% like to plan and follow a plan; usually act according to the situation, without a strict plan – 35%, use a mixed approach – 23%. Use time for projects: more than half or 54% one hour a day; only in class, no homework – 27%; several hours a day, total 19% of students. Interested project topics: mobile app development – 27%; ecology and environmental protection -25%; robotics and automation – 19%; medical and health research – 15% and energy – 13%. Useful and interesting projects for the school or local community were not identified. Responses to the questions gathered important information about student preferences and proficiency levels, and provided a basis for planning and adapting a program to introduce STEM education through project-based activities.

The Program "STEM-projects in the 9th grade" has been developed. Program goal: to develop students' interest in science, technology, engineering and mathematics through project activities. Expected results: development of students' analytical and problem-solving skills; improvement of students' knowledge in the field of science, mathematics and technology; formation of skills to work in a team and present their projects; stimulation of interest in research and innovation.

The following thematic areas of projects have been proposed:

1. Projects in mathematics: e.g., creating a mathematical model of object motion, calculating cost minimization for the production of goods; geometry in architecture, and others;

2. Robotics projects: for example, creating simple robots to perform everyday tasks in society (e.g., a garbage-sorting or cleaning robot).

3. Environmental projects: e.g. monitoring the environment at school and in the schoolyard (water or air quality, creating an eco-filter for water and so on).

4. Energy projects: e.g. alternative energy sources (building a solar panel model, e.g. to charge a phone, building wind models and others).

5. Medical projects: e.g. health monitoring (development of a heart rate monitor or blood pressure meter).

6. Urban infrastructure projects: for example, designing smart city elements (smart traffic lights and others).

7. Bioengineering projects: e.g. creating bioplastics from waste or utilizing the power of microorganisms to treat wastewater, growing plants without soil (hydroponics) and others.

8. Programming projects: e.g. development of social mobile apps (to track class schedules, classic games like "Snake" and others).

The main stages of realization of project activity:

1. Preparation and planning (first week): selecting a team; choosing a topic for the project; defining its goals and objectives; drawing up an activity plan; assigning roles to each team member.

2. research phase (next two weeks); gathering information; analyzing already existing technologies and examples of problem solving; conducting research and experiments (if necessary).

3. Development (next two to three weeks): creating schematics and drawings; construction; testing and adjustments.

4. Preparing a presentation of the project and its defense (one week) in front of teachers and classmates. Discussing the results and getting feedback on the project.

5. Evaluate the results obtained and plan further development paths, taking into account the successes obtained and the difficulties identified.

The evaluation methods are defined as: compliance with the set objectives; quality of the project; ability to defend one's point of view; participation of each team member.

The results of diagnostics of initial and final indicators of knowledge and required competencies within the framework of STEM-education implementation through project activities in grades 9 are shown in the table.

Table 4 – Results of comparative analysis of knowledge indicators and required competencies in grades 9

Indicators	Before		Difference	After		Difference
	EG	KG		EG	KG	
Mathematical literacy	68	69	1	85	70	15
Physical literacy	62	63	1	80	65	15
Biological literacy	60	59	1	82	62	20
Chemical literacy	59	60	1	78	61	17
Computer literacy	65	64	1	79	65	14
Scientific literacy	60	61	1	90	63	27
Technical skills	49	50	1	72	52	30
Teamwork and communication	74	73	1	92	76	16

The obtained data show that the initial level of definition of knowledge and competencies required for STEM-education and project activities, before the experiment, indicators in both groups (experimental and control) were similar, with small differences within one point, which allows us to recognize the initial conditions of both groups as approximately the same. After the experiment in the experimental group are noted in comparison with the control group significant improvements in all indicators: from 14% computer literacy, 30% technical skills. These indicators show that the introduction of STEM-education through project activities had a positive impact on the level of knowledge and competencies of 9th grade students, especially in the field of science and technology. It is important to note that the greatest increase is noted in the indicators of scientific literacy (ability to plan and conduct simple scientific experiments, critical thinking and analysis) – +27% and technical skills (working with tools and materials, safety, design and modeling skills, setting up and working with equipment, use of digital technologies, etc.) (+30%), which suggests that project activities are particularly effective for the development of scientific thinking and technical creativity skills.

Regarding the connection with other studies, it should be noted that many have considered the integration of STEM in the educational process and they also showed the importance of interdisciplinary approach. The role of project work in this type of education is also noted, as it develops critical and creative thinking and teamwork skills. While the present study is comprehensive, it extends the previously explored context by pointing to the broad possibilities of using project-based activities specifically for STEM education. Overall, this study builds on the accumulated experience and knowledge, deepens the study of the integration of STEM concepts and project activities in school education, and suggests new approaches and methods to enhance the effectiveness of the learning process.

Conclusion. The scientific novelty of the conducted research lies in the fact that the main theoretical and practical approaches to the implementation of project activities in the framework of STEM-education have been established. The combination of different research methods to obtain a complete picture should be considered an important scientific contribution.

The practical value lies in the diagnosis of students' interests and preferences, which made it possible to find out students' interests and preferences regarding STEM education and assess the level of STEM competencies. The subjective information obtained was used to develop a STEM curriculum designed to meet the interests and needs of students.

Testing at the test and control stages of the experiment made it possible to assess the dynamics of changes in students' knowledge and skills and to obtain valuable information about which aspects of the program were most effective.

The developed Program of experimental lessons and extracurricular activities using project activities in the framework of STEM-education has an important practical contribution and its effectiveness was tested in real conditions.

Analyzing the results of the experiment makes it possible to draw valid conclusions about the impact of project activities on the development of STEM competencies in students. These conclusions can be used to improve existing programs and develop new ones.

Self-assessment results show that the majority of students have an average level of proficiency in core STEM subjects, but there are significant differences in assessing their knowledge in different disciplines. Students have the greatest difficulty in physics and chemistry, while computer science is of greater interest and confidence. These findings can guide the design of educational programs to improve knowledge and skills in the weakest areas and to support interest in computer science and other attractive aspects of STEM education. STEM-education program through project activities at school really improves the quality of learning, develops in students the necessary competencies that they will need in a successful life, taking into account the requirements of the modern world. Since the programs are aimed at forming students' interest in science and technology, as well as at developing skills that develop during project activities. The latter skills include independent search for information and decision-making, as well as the ability to work in a team and present their ideas.

The effectiveness of the implementation of STEM-education through project activities is confirmed by the results of comparative analysis, which shows significant improvements in the experimental group. Such indicators testify to the high efficiency of STEM-project program implementation. As EG students who participated in the project demonstrated higher results in all key indicators, which confirms the success of the chosen approach. The experimental part of the study clearly shows how project activities can be effectively used within the framework of STEM-school education.

It is recommended to expand the use of STEM-education in school education beyond project activities and integrate it, for example, into humanities disciplines, using an interdisciplinary approach and the development of the most important socially important competencies. For this purpose it is proposed to:

1. to supplement the project activity within STEM education, it is necessary to add some orientation to interdisciplinarity and integration with humanities. Since adding elements of the humanities to project activities that focus in STEM education mainly on technical aspects allows students to develop more integrated skills. Such an example could be a project where students design a simple robot and then have to write an essay on the social implications of robotization or conduct additional research on ethical issues regarding the outcomes that will result from the introduction of artificial intelligence.

2. use methods of developing critical thinking and improving reasoning skills in project-based STEM education. This proposal is based on the fact that it is necessary to include in the process of such education the organization of discussions and debates, as they help to develop students' critical thinking skills and the ability to present more reasoned results and, in general, their ideas. For example, after completing a technical project, students could be asked to discuss the social and economic aspects that need to be considered when implementing a new technology (drones, green energy, etc.) that was discussed in the STEM project. A debate on “The ethics of using drones for military purposes” or a discussion on “Advantages and disadvantages of implementing green energy” or “Ethical issues in using biometric data” and so on could be suggested.

3. develop the social and cultural contexts of STEM projects used in school education. Since all technologies are realized in a certain social and cultural society. Parallel understanding and study of society and culture helps schoolchildren still understand how new technologies have an impact in general on society and human life in particular. For this purpose, it is possible to invite children to additionally consider the influence of, for example, modern information technologies on the development of culture in different countries. For example, conduct research and analyze the perception of the role of the Internet or artificial intelligence in different cultures.

4. realization of interdisciplinary team projects that include participants from different academic disciplines. They help pupils to study exact disciplines using real-life examples, as well as promote the development of interdisciplinary thinking and teamwork skills. As an example, we can suggest considering the project: “Development of an educational board game for teaching financial and economic literacy”. The disciplines used: economics, mathematics and pedagogy. The team members are: economist – responsible for introducing financial concepts into the game rules; mathematician – uses probability theory to calculate game mechanisms; designer – develops the appearance of the game and its components; teacher – advises the team on didactics and pedagogy to make the game as effective as possible for learning. This approach allows students to develop skills in game mechanics, elements of statistics, combinatorics and probability theory. This approach provides an opportunity to learn the basics of financial literacy and economics, which are incorporated into the rules of the game. Since game technologies make the project more exciting and educational at the same time. In addition, the project participants acquire skills of interdisciplinary cooperation and deepen their knowledge in economics and mathematics.

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3D МОДЕЛЬДЕУ ЖӘНЕ РОБОТОТЕХНИКАНЫ ПАЙДАЛАНА ОТЫРЫП, ОҚУШЫЛАРДЫҢ ЗЕРТТЕУШІЛІК ДАҒДЫЛАРЫН ҚАЛЫПТАСТЫРУ

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Бұл жұмыста 3D модельдеу және робототехниканы қолдану арқылы оқушылардың зерттеушілік дағдыларын қалыптастыру жолдары қарастырылады. Қазіргі заманғы ақпараттық технологиялардың қарыштап дамып жатқан кезеңінде 3D модельдеу мен робототехниканы үйретуді балалардың ерте даму жасынан, яғни балабақша мен бастауыш сыныптардан бастау алатын өзекті мәселе. Кіріспе бөлімінде 3D модельдеу мен робототехниканы оқытудың еліміздегі және шетелдік тәжірибеге шолу жасалады, осы саладағы негізгі түсініктер анықталады. Жұмыстың негізгі бөлігі тәжірибе нәтижелерінен тұрады. Онда 3D модельдеу және робототехника бойынша бастауыш сынып оқушылары арасында зерттеу тобының мүшелері жүргізген сауалнама нәтижесі беріледі. Сонымен қатар, аталған тақырып бойынша қосымша білім беру бағдарламасы әзірленіп, бастауыш сынып оқушылары арасында үйірме сабақтары ұйымдастырылады. Ұйымдастырылған үйірме сабақтарының нәтижесінде оқушыларға 3D модельдеу мен робототехниканы пайдалана отырып, олардың зерттеушілік дағдыларын қалыптастырудың тиімді жолдары анықталады. Оқушылардың зерттеушілік және шығармашылық дағдыларын қалыптастыруды қосымша білім беру арқылы, оның ішінде бастауыш сыныптарда жүргізудің маңыздылығы туралы айтылады. Бұл ретте 3D модельдеу және робототехниканы пайдаланудың маңыздылығы тәжірибе жүзінде келтіріледі. Бағдарлама Lego Mindstorms EV3 робототехникалық жабдықтары мен бағдарламалау ортасын негізге алып құрастырылды.

Түйінді сөздер: *3D модельдеу, робототехника, робот, бағдарламалау, Lego Mindstorms EV3, қосымша білім, зерттеушілік дағды.*

ФОРМИРОВАНИЕ ИССЛЕДОВАТЕЛЬСКИХ НАВЫКОВ УЧАЩИХСЯ С ИСПОЛЬЗОВАНИЕМ 3D-МОДЕЛИРОВАНИЯ И РОБОТЕХНИКИ

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В данной работе рассматриваются способы формирования исследовательских навыков учащихся с использованием 3D-моделирования и робототехники. В период стремительного развития современных информационных технологий обучение 3D-моделированию и робототехнике является актуальным вопросом с раннего возраста развития детей, то есть с детского сада и начальных классов. Во вводной части приводится обзор отечественной и зарубежной практики 3D-моделирования и обучения робототехнике, определены основные понятия в этой области. Основная часть работы состоит из экспериментальных