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Evaluation of the Effectiveness of Using STEAM Projects in Teaching Physics: Student Interest in the Field of Solar Energy

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ABSTRACT: Recent scientific works have shown that students' interest in physics is declining. Given the importance of physics in the development of science and technology, it is obvious that a reduction in the number of specialists in this field causes concern in the economy of any country. Therefore, at present, the organization of advanced STEAM experiments and the effective use of STEAM educational software are becoming increasingly important in the education systems of developed countries. The purpose of this study is to assess the impact of using the STEAM project method, integrative scientific and technological, engineering, art, and mathematical education (STEAM), on the development of interest among students in the field of physics. The study was attended by 212 second-year students from Kazakh-Turkish University named after Khoja Ahmed Yasawi and South Kazakhstan University named after M. Auezov. Research work was carried out in both groups during the training of the course "Alternative energy sources." In the control group, this course was taught in a traditional way, and in the experimental group, classes based on STEAM projects were conducted. The educational process continued for 15 weeks. Pre- and post-participation calculations, especially surveys and progress calculations, are used to create student scores. The results of the study indicate that STEAM products developed by the authors together with students and used in the educational process are effective. The increase in progressive results in the observation of the physics parse was high, and the progressives were included. Student relationships in physics increased by 35% in the experimental group compared to the previous 10%. Through the implementation of the STEAM projects, it was noticed that students' interest in physics increased significantly. This article presents STEAM educational resources and materials developed by the authors and recommendations for their use in the educational process.

Keywords: STEAM/STEM education, STEAM project, Physics teaching, Student interest, Solar energy.

I. INTRODUCTION

The constant development of science and technology in the world and in the country requires revision of the education system and training of future specialists who can successfully compete in the international market. Developed countries link their economies to the future of their workforce in the engineering and technical sectors. Concerns regarding this connection are also growing in our country. This is due to the fact that over the past 2 years, there has been a significant shortage of students in a number of engineering and technical educational programs of Kazakhstani universities. In 2023, the indicators of school graduates in engineering and technical specialties were even lower than those in the previous year. Therefore, in such a situation, an important question arises as to how to develop the process of training competitive personnel to serve the relevant sectors of the economy.

The following student activities are recommended to improve student learning in physics: interactive simulations and virtual laboratories can help students explore physics concepts. Hands-on experiments, such as creating a small electromagnet, can demonstrate the principles of physics in a simple manner. Long-term projects, such as building modern energy models, can facilitate learning. Group activities and learning can lead to greater development and communication. The flipped classroom model, in which study materials are studied at home and engaged in class, can enhance learning. Posting physics demonstrations, such as physics principles, can increase students' attention. Scientific trips and technological proposals can also promote modern learning. Learning real and students' questions can increase their enthusiasm for science.

Developed countries use many of the professional development-oriented programs offered by the associations "International Technology and Engineering Educators Association (ITEEA)," "International STEM Education Association (ISEA)" in the education system. These communities sponsor a growing interest in engineering, technical, and technological literacy through innovation [1].

Adopting the idea of "Leaving no one behind" until 2030, UNESCO, within the framework of the "EDUCASTEM2030" project, aims to encourage students' awareness of life projects through the pedagogical vision of STEAM at school and prioritize STEAM education among students [2].

According to the research topic, the scientific literature has shown that scientists emphasize the nature of STEAM knowledge in a more individual discipline. Developed countries in Western Europe emphasize equality and systematic integration in education, while developing countries pay more attention to teaching practices. Eastern countries emphasize humanistic leadership and cultural integration in STEAM education [3-5].

Importantly, studies on the problems of maintaining economic stability are based on the relevance of STEAM science and the development of science on solar energy, one of the important themes of physics, in world trends. At this time, when the world economy is seriously increasing and we must change ourselves to meet new technical and scientific challenges, studies on monitoring and maintaining economic stability in the scientific foundations of STEAM are important. Studies and knowledge of STEAM, at the latest end of all the things that are important in the production of solar energy, in relation to the relevance of the scientific relevance that makes it even easier in the arms of physics, comes to world trends. These studies were validly related to the preservation of economic stability and the scientific relevance of STEAM, and they were of little importance in new areas of physics.

The process of active development in the field of STEM education began in the Republic of Kazakhstan along with developed countries. From 2023 to 2029, it is planned to open at least 7,000 modern school classrooms in robotics, chemistry, biology, physics, and STEM [6]. The concept of the Government of the Republic of Kazakhstan for the development of higher education and science also states the need to involve young people in science through the creation of children's technoparks and STEM laboratories.

It is especially important that STEAM technology is used in educational materials for Environmental Protection, the integration of knowledge on alternative energy, and solar energy in science. STEAM technology is very important in a large amount of education, especially for environmental protection and the integration of knowledge on alternative energy and solar power in science. This technology could play a key role in the creation of educational materials for new energy and environmental protection. Through STEAM technology, we can increase new knowledge on the relevance of science and related practices, and these academic and educational developments on solar energy significantly contribute to environmental protection.

In higher educational institutions, it is necessary to conduct research on the use of STEAM, modeling of solar energy phenomena, implementation of STEAM projects related to alternative energy, and development of student interest.

Such studies serve to develop results in the field of education about the physical processes of production of innovative forms of energy, to increase the culture of efficient, rational, and economical use of solar energy, thereby developing the country in socio-economic, scientific, and technical directions.

The relevance of this study involves finding solutions to new scientific and methodological problems:

- How to develop their interest in the training of students studying in the field of physics and solar energy through the integrated experience of STEAM?

- How is the possibility of solving complex engineering and mathematical-physical problems in the field of solar energy implemented in educational programs?
- What are the opportunities for students to implement classroom and extracurricular STEAM projects in the field of solar energy to provide educational research experience?

The purpose of this study was to increase students' interest in physics by developing STEAM projects and materials for its implementation in teaching the course "alternative energy sources," introducing them into the educational process.

We are ready with June to obtain the most built-in addition to the cracks and implement the STEAM network used in the study of physics, especially at the end of modern exercises. For the implementation of the projects, all the aspects of the STEAM project processes that are in the series of physics, in terms of safety and impact, can be a great study in particular. In this way, all things in the past are there, and we have shown with special honor how these STEAM projects are in the same way or within the definition of physics. In addition, we ran most of the resource content in studies that are STEAM processes.

II. LITERATURE REVIEW

1. BENEFITS OF STEAM EDUCATION

We can cite the scientific works of several scientists who have served as the basis for the effective implementation of the continuity of the interdisciplinary STEAM educational model.

Many teachers are interested in STEAM-integrated approaches; however, they are not well prepared to implement them effectively [7]. Comprehensive problem-based learning (PBL) for critical mathematical thinking skills in primary school students determines the effectiveness of the STEM model [8]. An in-depth study of the essence of STEAM education is based on the cumulative effect associated with problem-based and project-based learning [9]. Thus, STEAM education teaches students not only to simply apply their physical knowledge, skills, and experience but also to develop a qualitatively new result of educational activities – STEAM products [10, 11].

To be able to accept research with better resources, the basic problems from the literature on the work of STEAM in physics education need to be addressed in series. These articles have been reviewed under the editor's supervision, *Gaining More Hope* research on STEAM in physics education shows that STEAM projects, which result in more flexibility and ease of use for physics students, can lead to more success and optimism. As a result, STEAM projects are more easily used in work and knowledge and are also added to all the properties of physics. *Innovation and Understanding*: In the literature, there is evidence that the development of STEAM projects in physics education can promote innovation and the understanding of knowledge. On this basis, modern knowledge development and new games have helped. *Responsibility for Actions*: A review of the literature shows that the development of STEAM work in physics students can increase their responsibility for actions and plans. Follow-up of STEAM projects in physics education shows that they can increase the responsibility of physics students and provide for the development of knowledge and best practices.

2. CHALLENGES IN IMPLEMENTATION

One of the basic principles of teaching physics based on STEAM is training in mastering industrial practice and methodically complex research methods. The effectiveness of using the STEAM-based learning model is evidenced by the high indicators of students'scientific literacy [12, 13]. STEAM described the need for very popular practical classes to help open the way for teachers interested in teaching course content [14, 15]. Learning using the STEAM-PJBL model can improve higher-level thinking skills compared with traditional learning [16]. Through the use of the integration model of problem-based and project-based learning in teaching, students' ability to solve problems increases [17-19]. In physics, training based on STEAM projects has a beneficial effect on student creativity [20].

3. IMPORTANCE AND FUTURE DIRECTIONS

Our preliminary results on these issues [21] show the need to increase the number of creative students interested in STEM. Students' skills and abilities are in high demand in many sectors and positions, and the need to improve professional literacy in these areas is an urgent problem. Therefore, as a professional direction, the use of STEAM technology in the field of solar energy also has its own specifics [22].

Research by scientists in developed countries assures that renewable energy technologies will play an important role in the use of energy and economic prosperity in the future, and that more attention should be paid to the issue of training future specialists in this field for a faster transition to a developed society [23].

4. GLOBAL PERSPECTIVES ON SOLAR ENERGY

The U.S. Department of Energy's (DOE) Solar Energy Technology Office (SETO) invests in research and development in the "STEM and education" fields to reduce the cost of clean energy technologies, protect the private sector from financial risks, and ensure a fair transition to a decarbonized economy [24]. European countries, such as Germany, Belgium, and the Netherlands, consider the energy efficiency of photovoltaic systems to be high. A systematic analysis of scientific articles showed a statistically significant correlation between long-term orientation to the use of photovoltaic energy and training in its production [25, 26]. Asian countries are considering the introduction of educational materials, short courses and seminars, and advanced technologies for teaching special disciplines to train public policy makers and financial professionals, future engineers, and professionals in the field to expand the use of solar energy, using a huge amount of information available worldwide for training in the solar energy industry [27].

5. SUMMARY OF KEY FINDINGS

The literature review shows that STEAM projects in physics education have several important implications: *Increasing Engagement and Outcomes:* Recent research shows that STEAM projects significantly increase engagement and outcomes for physics students. STEAM projects not only make abstract ideas easier to understand, but also make it easier to bring the principles of physics to life in a more comprehensive way. First, teaching models on problems and projects, which is the place of SERAM, can work students with practical methods of knowledge [12, 13, 14, 15]. *Enhanced Critical Thinking and Creativity:* Studies indicate that engaging students in STEAM enhances their development and imagination. Underneath all of the different knowledge, STEAM education can teach and interpret students in an additional way. This relationship promotes a greater reduction in problems and innovative teaching of students in physics [16, 17]. *Improved Scientific Literacy:* The use of STEAM projects in physics education has the potential to improve scientific understanding. Students participating in STEAM projects are encouraged to increase scientific understanding and be relevant to research development and practice. This indicates that STEAM education is important for creating a more relevant scientific community [18, 19]. *Positive Impact on Long-Term Learning*: Long-term studies show that students who participate in STEAM projects have a much higher chance of continuing in STEM and history careers. This influence and continuity promote the development of STEAM in education and professionalism in physics and other sciences [20, 21].

Based on the research provided by the indicated sources, we propose the following hypotheses:

- **H1:** Student progress in physics will increase if STEAM makes better use of "alternative resource" projects.
- **H2:** Students in the control and experimental groups wrote questions to make their balance in physics easier.
- **H3:** In students, Students who are taught STEAM projects will show more enthusiasm and age in the construction and selection barriers.

This is the result of an analysis of foreign scientific literature, justifying the relevance of the research topic. However, research on the development and evaluation of solar energy in education is lacking. However, interest in training students in engineering and natural sciences through integrated STEAM experience is promoted by the lack of research on the issues of development and evaluation of solar energy in training.

Therefore, in accordance with the purpose of this study, we set up the following research tasks.

- Study of the effectiveness of the STEAM project module in the course "Alternative energy sources" based on the interests of 2nd year students;
- to determine the degree of interest of 2nd year students in the experimental and control groups using a questionnaire.

III. MATERIALS AND METHODS

1. DESCRIPTION OF RESEARCH METHODS

Research strategies and approaches differ in their degree of innovation. In accordance with the goals and objectives of this study, we used Google Forms to gather primary data. The Google Forms survey was designed using different types of questions to collect general data. The questionnaire includes questions on a Likert scale, which allows students to answer from 1 to 5 their percentage on related agreements by providing a series of open-ended questions, which offer space for simple answers and definitions. This set of questions was designed to collect quantitative data and specific information about the students' experiences. The Google Forms survey and its question forms contained the best demographic information of the participants, such as age, year of study, and any important academic information. The reliability and consistency of the research results were determined by the scientific validity of the theoretical provisions, clear logic of the study, and consistency and statistical significance of the accumulated empirical data.

A survey instrument was developed and tested to verify the truth. This questionnaire was tested by scientific students and the students' interest in the selection of the questioning method to apply the effectiveness of this instrument.

Depending on the follow-up study, chemical statistics or meta-analysis results (if available) can be identified from recent follow-up studies to help demonstrate the usability of STEAM.

The selection of research subjects was based on the specific questions and objectives of our research. In this study, we focused on increasing students' interest in learning physics through STEAM projects and the evaluation of those projects on learning about alternative energy sources.

1.1 Survey Method

Quantitative data on students' experiences and perceptions of the implementation of STEAM projects in physical learning. We followed a form of inquiry using Google Forms. The survey was conducted using Likert- and open-ended questions to obtain both quantitative and qualitative data. The questionnaire style was chosen because it helps collect data from a small number of students and their balance. Likert questions provide quantitative data on student engagement and interest, whereas open-ended questions provide qualitative insights. This was also our goal to evaluate the change in the interest and balance of students.

1.2 Statistical Analysis

Mathematical and statistical analyses were performed using SPSS. This analysis involved processing the data obtained in the pedagogical experiment to assess the level of development of students' interests. The t-criterion was applied to evaluate the effectiveness of the dependent variable between the control and experimental groups, based on the survey results. The experimental design describes how the participants were assigned to the control and experimental groups and if there was randomization.

The survey data were evaluated by managing STEAM and traditional learning styles. The data were analyzed using SPSS. We used a t-test to compare the pre- and post-experimental results between the experimental and control groups. Statistical analysis with SPSS was chosen because it provides accuracy with less data on groups. This method evaluates the effectiveness of STEAM features and the goal of developing student' enthusiasm.

1.3 Modeling Methods

Modeling variations: Simulation and design methods were used to develop students from a new scientific perspective in the field of solar energy. STEAM has had an impact on printing, design, and product development within projects.

Development and evaluation of new scientific perspectives in the field of solar energy using STEAM projects. STEAM modeling techniques have been used in project design and development to engage students with hands-on projects and understand solar energy. Modeling techniques were chosen to provide practical learning and research in the design and testing of solar energy solutions. This is consistent with our goal of increasing the practical understanding and application of physical concepts.

1.4 STEAM Problem-Based Learning Method

STEAM problem-based advanced learning methods are methodologically implemented in selected disciplines. This method has been used in the Learning and Research Center and in industrial practice to design projects based on the STEAM.

Introduce an inquiry learning style that incorporates STEAM principles into physical learning. This method has been used in learning and research centers and in scientific practices to design and develop STEAM projects. Learning the question was chosen because it develops students' critical thinking and problem-solving skills. This style is also in line with our goal of developing a classroom through the realistic use of physics concepts presented to students.

2. EXPERIMENTAL BASE AND PARTICIPANTS IN THE EXPERIMENT

A total of 212 students from two universities (Khoja Akhmet Yassawi International Kazakh-Turkish University and M.Auezov South Kazakhstan State University) took part in the pedagogical experiment (Table 1).

Table 1. Detailed information about the student participating in the experiment.

Group	Number	Percentage	Total
Experimental	106	52%	212 (100%)
Control	106	48%	
Gender	female (125) Control 60 / Experimental 65	59%	
	male (87) Control 46 / Experimental 41	41%	

Demographic characteristics of the participants: The participants were between 18 and 25 years of age. In addition, participants in the experimental group had a study year between 1st and 3rd year. However, the participants in the control group were in the same year of the study. Besides, other important academic aspects are described as scientific and study characteristics.

Quantitative data were collected quasi-experimentally through pre- and post-experiment surveys of the two groups. In addition, the relationship between the independent and dependent variables was demonstrated. The dependent variable in the pre-experimental questionnaire was of the same nature as in the experimental and control groups. After a preliminary survey, the course "alternative energy sources" was taught in the experimental group on the basis of STEAM projects for 15 weeks. This course was traditionally taught to the control group. At the end of the course, dependent variables were used of the same nature for the experimental and control groups. The results before and after the experiment were analyzed to determine the improvement in the dependent variables (Table 2). Finally, significant variables were used equally for the experimental and control groups. An increase in the significant variable is described in the results before and after the experiment.

Table 2. General characteristic view of the experiment.

Group	Implementation		
Experimental Control	before the experiment	Intervention	after the experiment

In the quasi-experimental design, the experimental and control participants were selected and how the validation took place. In the quasi-experimental design, the experimental and control participants were selected through individual selection. Participants in the experimental and control groups were randomly selected for participation. Accuracy was evident in the participants of the experimental and control groups in using their questions in the experimental style.

To report the largest number, it can be shown according to the power analysis that it is significant to present the interpretation of the large areas; through the power analysis, we can show that the number of participants with less than 212 is more important for large areas. This analysis suggests that the participants' judgment is the first to accept members of the region and interpret the larger ones.

Regarding the experiences of the control group, we explained how they were interpreted in the same way; in the control group, the lesson alternative sources were taught in a traditional way, where the understanding of the students depended on traditional standards. On the other hand, in the experimental group, lessons in the basics of STEAM projects were taught in a modern and progressive way. These styles are individually added to the new study features of learning and enhancement of the classroom.

The content of the questionnaire consisted of 10 main questions, and this questionnaire focused on determining the indicators of student interest. The obtained data were analyzed using SPSS.

H_{01}: There is no significant difference between the results of the survey before and after the experiment to determine students' interest.

H_{02}: According to the results of the post-experimental survey of 2nd year students, there was no significant difference in the indicators of interest between the experimental and control groups.

Based on the t criterion, the effectiveness of the dependent variable between the control and experimental groups was evaluated using data from the survey results. The independent selective t-criterion was used to compare the dependent variables between the two groups after the experiment.

2.1 Selection of Participants

Evaluating the effectiveness of STEAM projects on students' interest in physics. A total of 212 students from Khoja Akhmet Yassawi International Kazakh-Turkish University and M. Auezov South Kazakhstan State University participated in the experiment. The students were divided into experimental (106) and control (106) groups. The selection of two universities and the distribution of groups in the experimental and control groups support a diverse sample and a good sample to increase the relationship. This style helps bridge the gap between the effectiveness of STEAM and traditional learning styles.

2.2 Experimental Design

The effectiveness of the STEAM projects was evaluated based on students' interest in alternative energy sources. The experimental group participated in STEAM learning for 15 weeks, whereas the control group received old learning. Pre- and post-experiment questionnaires suggested changes in the students' motivation and balance. A quasi-experimental design was chosen to allow for a controlled interaction between the two learning styles. This design helps measure the effectiveness of the STEAM intervention in student outcomes.

2.3 Data Analysis

Assessing the significance of the results and the effectiveness of the intervention. The data were analyzed using the SPSS program to evaluate the differences in students' attitudes before and after the intervention and between the experimental and control groups. The use of SPSS supports statistical analysis that helps evaluate the effectiveness of the intervention in reality and with our goal to determine the effectiveness of STEAM projects on student engagement. The chosen questions, statistical analysis, modeling, and question learning were relevant to our research questions and goals. Together, they help to analyze the data of all monitoring, evaluate the effectiveness of STEAM projects, and evaluate their characteristics in increasing students' interest in physics and alternative energy sources.

IV. RESULTS

1. CONCLUSION OF A COMPREHENSIVE ANALYSIS OF SCIENTIFIC WORKS

As a result of the search and compilation of articles on keywords, the authors found more than hundred articles related to training in physical education, focusing on the STEAM project. However, the authors selected only 36 articles were included in the review. The selection of articles was based on criteria such as the period of publication, rating of the journal, base of the study, participants of the study, and methods used in the study. The results of the analysis of the scientific literature substantiate the relevance of this research topic. However, there is a lack of research on the issues of developing and evaluating interest in research activities in the training of students studying solar energy through the integrated experience of STEAM.

The results of the 36 research articles reviewed by STEAM conclude that the project can be used as a new teaching method using science, technology, engineering, art, and mathematics, which have a positive impact on cognitive aspects, skills, and physical attitude. Quantitative methods were used in most of the articles analyzed. Researchers used tests, interviews, questionnaires, and control work to collect data. The results of the analysis showed that the problem of implementing STEAM projects in teaching physics is still at an insufficient level at the university level.

After analyzing the scientific literature, we identified the features of STEAM education in teaching physics (Figure 1).

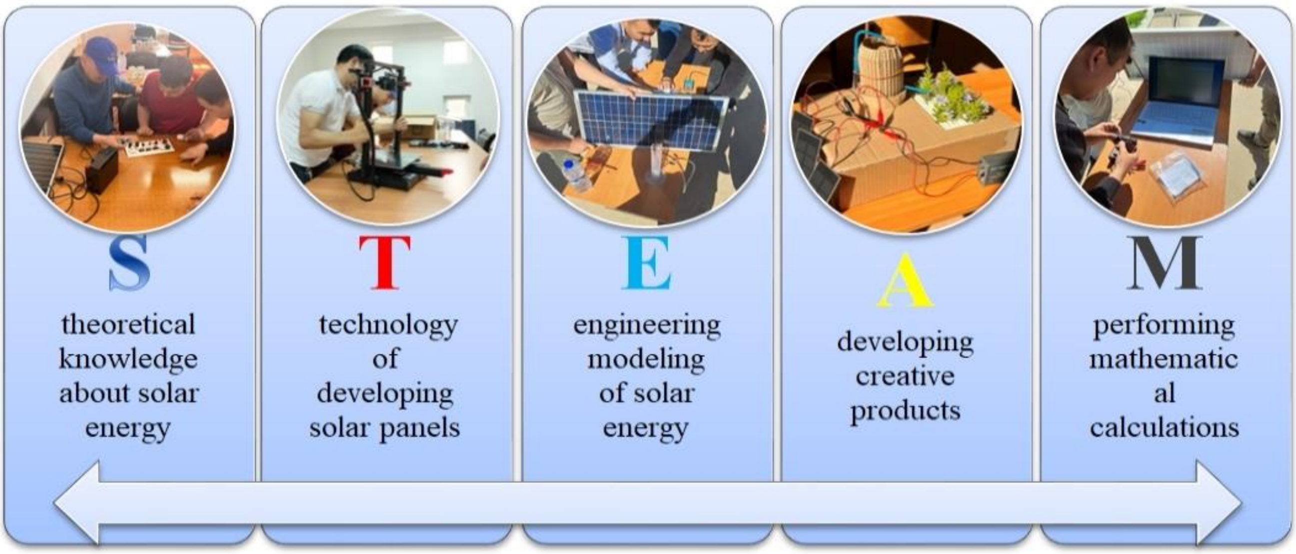

FIGURE 1. Features of STEAM education in teaching physics.

Consequently, STEM education provides an opportunity to implement integrated training on topics in the field of solar energy effectively; promotes students to apply their scientific and technical knowledge of physics in real life; develops critical thinking and problem-solving skills of specialists in the field of physics; develops interest in the technical disciplines of physics specialists. STEAM increases the ability to combine creative and innovative approaches to projects; provides professional guidance to students; prepares physics professionals for technological innovations.

2. ORGANIZATION AND CONDUCT OF THE PEDAGOGICAL EXPERIMENT

In our research, we refer to the research activity of students studying in the field of physics-individual integration knowledge, which is distinguished by the constant motivation in research activities during the training of the course "alternative energy sources". Of course, this definition is given for the effective assessment of students within the framework of only one area. Now, we take into account that each of the STEAM' approaches reflects an area based on one or more disciplines. Let us give an example of the use of STEAM projects in the above discipline and thereby implement the development of student interest. Based on the main idea of this study, the stage of effective implementation is shown in Figure 2.

In the 1st Stage, students study the basic photoelectric characteristics of the solar element, physical phenomena, and laws on which the principle of operation of solar cells is based. At the same time, a student becomes acquainted with the method of using solid-state diffusion sources based on p-n transitions, the vacuum-thermal method of developing current contacts, glow shutters, scientific and methodological works related to solar cells developed in a new way, and studies scientific content (Figure 3).

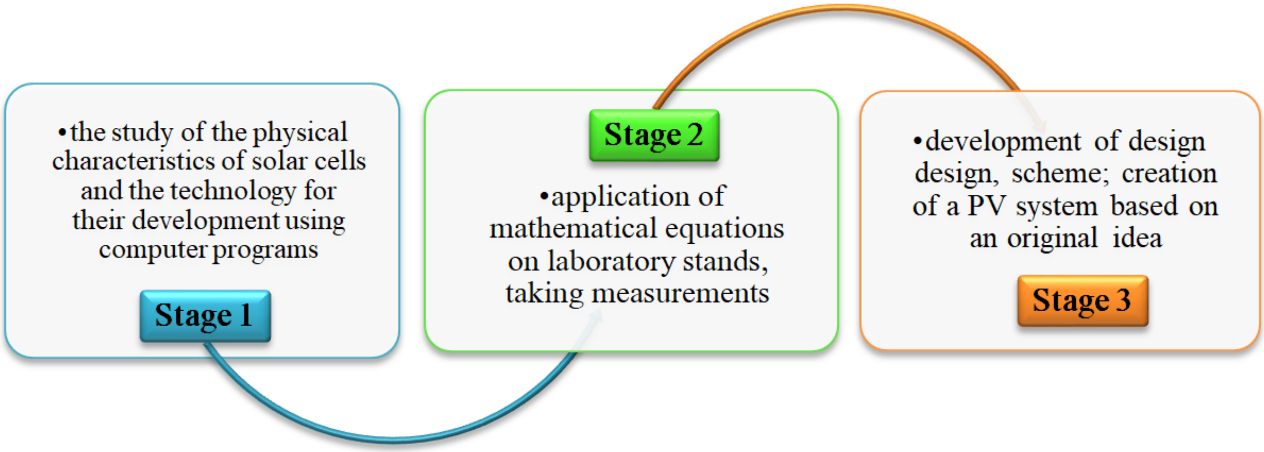

FIGURE 2. Stages of effective implementation of the STEAM project based on photovoltaic systems in the educational process.

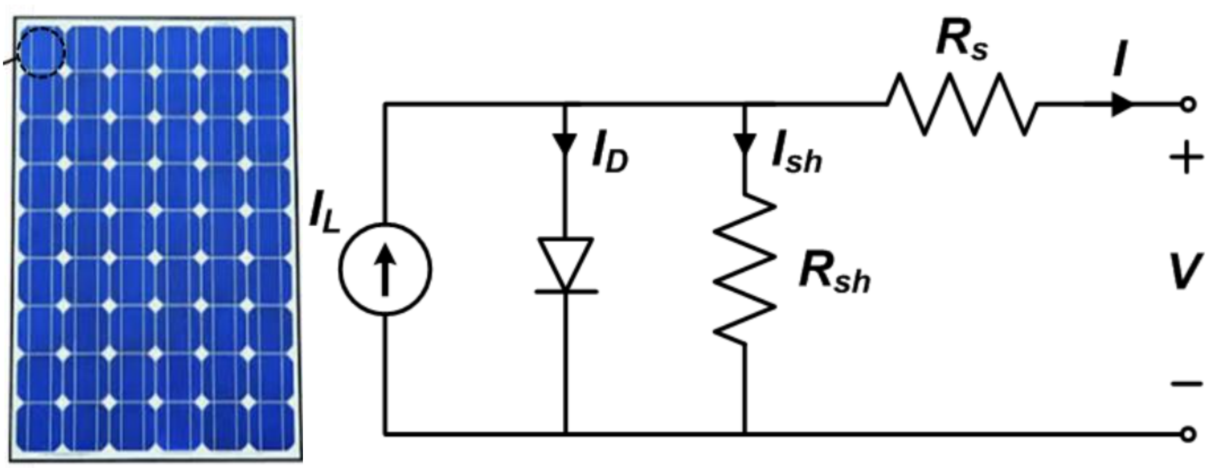

FIGURE 3. Photovoltaic panel and its equivalent circuit ($\boldsymbol{I_L}, \boldsymbol{I_D}, \boldsymbol{I_{sh}}, \boldsymbol{I}$-current strength in the corresponding parts of the circuit, $\boldsymbol{R_s}, \boldsymbol{R_{sh}}$-resistance in the corresponding parts of the circuit, $\boldsymbol{V}$-voltage).

Students conduct their research activities by analyzing advanced technology for the manufacture of silicon solar elements, methods for reducing optical problems in the technology of creating solar panels, technology for the operation of solar cells, and ways to develop cheap and efficient solar cells. The requirements for the necessary materials and technological equipment in the manufacture of solar elements are used on earth. In addition, it analyzes the modeling programs and conducts modeling in accordance with the required programs (Figure 4).

In the teaching of the discipline" alternative energy sources", through the solar cell research stands, the determination of the beneficial effect factor of the solar panel, the direct conversion of solar energy into electricity, the study of the photovoltaic energy converter, the operation of the solar cell, the relationship of the angle of inclination of the solar panel to power, etc.

In the teaching of the discipline "alternative energy sources", work is carried out on such topics as determining the efficiency of a solar panel using stands for the study of solar panels, direct conversion of solar energy into electrical energy, the study of a photovoltaic energy converter, the operation of a solar panel, the dependence of the angle of inclination of the solar panel on power, etc. (Figure 5).

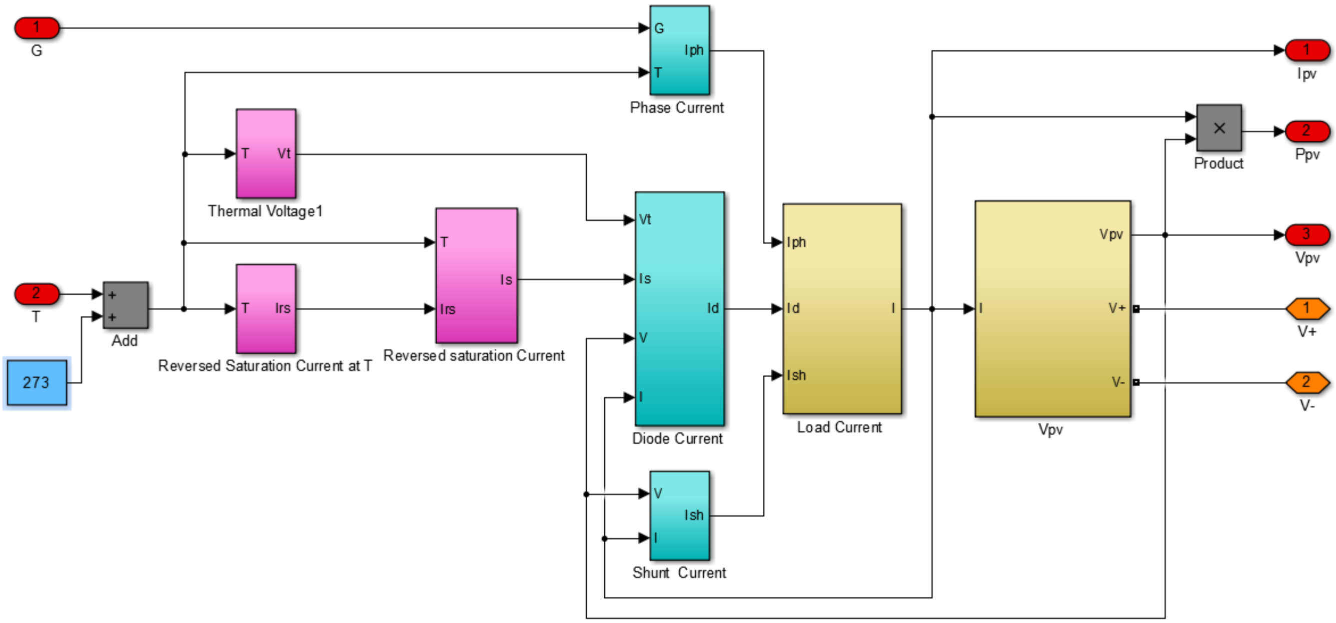

FIGURE 4. Model of the photovoltaic panel in the Matlab program.

FIGURE 5. Author’s stands: Reading and research refer to the physical characteristics of the photovoltaic panel.

In the course of alternative energy sources, students also used educational and research stands for lectures, practice, and laboratory classes. After mastering theoretical scientific knowledge, he was convinced of the technology for developing solar elements through a stand. Theoretical and experimental knowledge in the field of solar energy is simulated using the modeling method in the software system Matlab, Blender, and students are taught to create their own products on solar panels. Further, students carry out the final task with mathematical calculations.

3. RESULTS OF THE IMPLEMENTATION OF STEAM PROJECTS BY STUDENTS IN THE FIELD OF SOLAR ENERGY

During the course "Alternative energy sources", an annual lesson was organized for students of the control group in accordance with the traditional training complex. In the experimental group, the lesson was conducted with students by implementing several STEAM projects related to solar energy. Students in the experimental group developed STEAM products and presented them in the form of a project using theoretical knowledge gained within the framework of their discipline through group work. He defended his project work as a team in front of the teacher.

Then, according to the characteristics of the knowledge, to open the development of students on STEAM proposals and their teaching, important understandings of the place of the organization, their participation in the development of projects, and scientific and educational results were presented.

For example, students who worked in groups on the topic "Obtaining energy through solar panels focused on the sun" successfully completed their work, relying on their STEAM abilities. The goal of this project was to create a layout for obtaining energy through sun-oriented solar panels and evaluate its effectiveness. Students have accumulated the necessary equipment to achieve this goal: Arduino Nano, Servo motor, solar panels, printing the necessary equipment on a 3D printer, LDR, and resistors. The main feature of this research project is that photoresistors fluctuate significantly depending on the amount of light they receive. Therefore, the students considered separating resistors into four parts (Figure 6). For example, if the left part is dark, then the engine moves clockwise. The lower part was connected to the solar panel and was directed upward. In this way, the device changes its direction of movement towards the area where the light falls the most. To do this, the students modeled and printed the necessary equipment using a 3D printer.

In this project, students developed a demonstration model of a solar tracker to track the point of maximum intensity of the light source such that the voltage of the solar panel is at its maximum. The tracking system was designed such that it could receive solar energy in all possible directions. It can be used for small- and medium-scale power generation for power supply in remote areas where there are no power grids for domestic or industrial backup power systems.

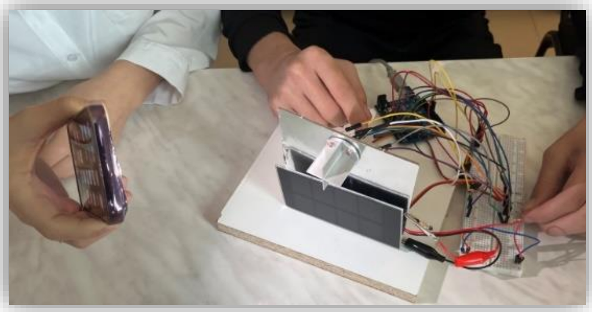

FIGURE 6. The progress of the STEAM project on the topic "Obtaining energy through solar panels focused on the sun".

Another example is the implementation of a STEAM project on the topic "Managing an irrigation system through energy from the sun'. The students associated the purpose of the implementation of this research project with the demonstration of the efficiency and reliability of the manual irrigation system and the development of a model of water extraction from a well, which proved the effectiveness of using an irrigation system that receives energy from the sun. Students obtain energy from the sun using a solar panel as an energy source to run an irrigation system (Figure 7).

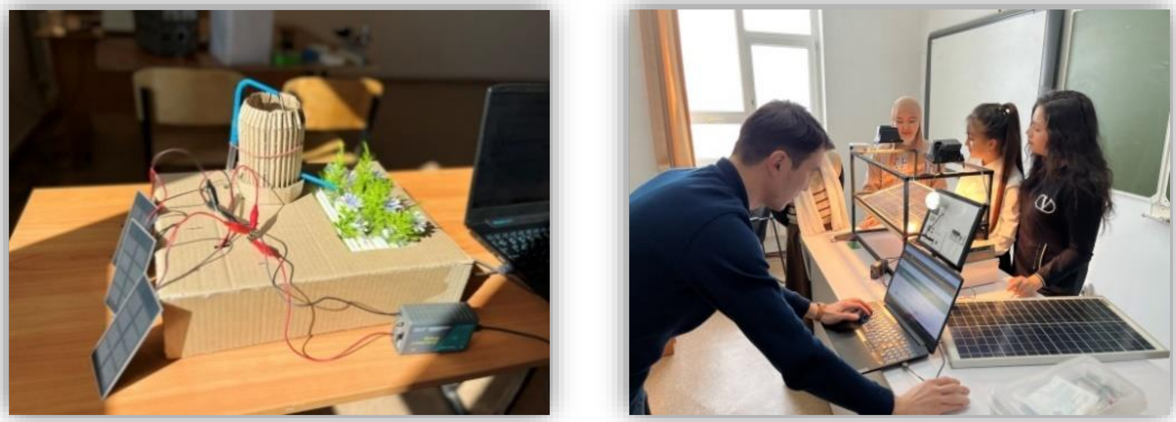

FIGURE 7. The progress of the STEAM project on the topic "Managing an irrigation system through energy from the sun".

Energy from the sun started the pump and consumed the correct amount of water. List of equipment used in the project: plastic container, cardboard, scissors, clay, water bottle, 9V small DC Water Pump, 12V solar panel, and connectors.

Through the implementation of the STEAM project, the students explained that the photons that hit the solar cell were absorbed along with the material, and the photons that collided with the atoms of the substance expelled the electrons of that substance. As a result of this process, a potential difference comes and goes. The free electrons begin to move inside the substance to eliminate any potential differences. This occurs' when an electric current is generated. This is because the solar cell is a semiconductor and electrons only move in one direction. The current received from the solar cell is converted into direct current and sends the current to the device that needs it. As a result, field irrigation was performed.

Working in groups, students implemented several other STEAM projects in the field of solar energy.

S: in the implementation of the project, students acquire scientific theoretical knowledge.

T: master the technology of manufacturing the product to be developed.

E: develops engineering activities in product development.

A: shows exceptional abilities in creative product development.

M: uses mathematical knowledge in explaining a physical law through a product.

4. RESULTS OF AN EXPERIMENTAL STUDY

To evaluate the effectiveness of the educational process based on STEAM projects in the field of solar energy using a questionnaire to determine the interests of students, the results of a paired selective t-test are presented in the table below (Table 3).

Table 3. The results of a paired selective t-test based on the interests of students.

Category	Group	Survey	Mean M	Standard Deviation SD	t	Degree of Freedom DF	MD
Interest	EG	before the experiment	3.5	0.5	-10	105	-0.90
		after the experiment	4.4	0.4			

CG	before the experiment	3.3	0.4	-1.7	105	-0.1
	after the experiment	3.4	0.41			

Let us make a descriptive analysis based on the results of a pre-and post-training survey of students in the 2nd year of teaching the course "alternative energy sources". The results of the survey showed that in the experimental group, before the introduction of the course into the educational process and after 15 weeks, students showed a statistically significant increase in interest from the survey. Before the experiment (M = 3.5, SD = 0.5), these indicators were (M = 4.4, SD = 0.4). The average increase was 0.9 at a confidence interval of 95%. However, in the control group, there was no statistically significant increase in interest. The average increase was 0.1 at a confidence interval of 95%.

During this time, in the 2nd year of the "alternative resources" course, student members were presented with STEAM activities. At the end of the follow-up period, students were included in the help after 15 weeks.

This result refuted **H_{01}** hypothesis. That is, there was a difference between the results of the survey before and after the experiment to determine students' interest. In other words, STEAM projects had a positive impact on the development of students ' interests.

Table 4 shows the results of an independent selective t-test to evaluate the effectiveness of the educational process based on STEAM projects in the field of solar energy through a survey of student interest determination between experimental and control groups (Table 4).

Table 4. Results of an independent selective t-test to evaluate the effectiveness of the educational process.

Category	Group	M	SD	Levene's Test		t-test			
				F	p	T	df	p (2-tailed)	MD
Interest	EG	4.4	0.4	0.4	0.5	9.1	104	< .001*	1
	CG	3.4	0.41						

* p ≤ 0.05; (SD: Standard Deviation); (DF: Degree of Freedom).

From the point of view of students, there was a significant statistical difference between the pedagogical experiment, that is, the experimental one after completing the course (M = 4.4, SD = 0.4), and the control groups (M=3.4, SD=0.41): t (104)=9.1, p<.001. The difference in the average values was 1.

Based on the results obtained, the **H_{02}** hypothesis was refuted. That is, according to the results of a post-experimental survey of 2nd year students, there was significant development in the indicators of interest between the experimental and control groups.

In conclusion, it should be noted that the implementation of STEAM projects in teaching physics had a beneficial effect on the development of students' interests.

V. DISCUSSION

The results of this study will allow the introduction of STEAM knowledge into physics and thereby the interdisciplinary use of students ' knowledge in the field of solar energy, designing and developing STEAM products, and improving the methodology for their application in the educational process. Promotes the development of students ' positive attitudes towards solar and renewable energy. According to other recommendations on school trends and special works on solar energy students, our results from other scientific publications have great similarities of opinion with other works here and against silver.

This development can renew the characteristics of the students on STEAM projects on solar energy and increase the hidden method of the students' projects with special scientific follow-ups.

Subsequently, this development can develop the learning features and relevance to the overall STEAM standard. These projects can work and provide knowledge through their management in STEAM within the framework of general learning criteria.

These results can be compared with those of other scientists that have taken place in the scientific literature. Problem-oriented learning (PBL) is considered an innovative pedagogical method based on the critical use of knowledge, and it is concluded to be the correct method of knowledge generation in the development of alternative energy teaching methods [30]. It is argued that the introduction of alternative energy sources into the educational process enriches students ʼ scientific knowledge and prepares them to solve life problems [31]. As an advanced technology for teaching solar energy, STEM modules have been studied to fully implement practical activities using smartphones, QR codes, images, and videos [27]. If Hiğde [32] identified the positive impact of STEM-based alternative energy activities on the attitude of STEM Integrative Learning and science teachers toward STEM, Mayasari et al. [33] proved with quantitative and qualitative research methods that the solar energy project can be useful for enhancing students' STEM knowledge and providing meaningful learning.

Our research uses a limited budget and design criteria for teaching solar energy, and as a result, STEAM solar energy projects improve student success and provide a huge breakthrough in the relevant areas of socio-economic, scientific-technical, and public relations in the world.

VI. CONCLUSION

Solutions to most global problems related to the social and economic conditions of a country, such as energy, the environment, and employment, require an interdisciplinary perspective that includes natural sciences and technologies, such as physics and mathematics. The latest reforms purposefully combined teaching and curricula by ensuring strong links between STEAM disciplines. We need to use materials that arouse students' interest in STEAM industries and allow them to create solutions to specific problems, the latest models of 3D printers, and robotic coding materials that help create STEM products and laser cutting machines in the current study. It is also a matter of the future to create a centralized STEAM park dedicated to the relationship between STEAM occupation and STEAM education. This is one of the necessary conditions for achieving the expected results, and will require additional research for future researchers to better understand the impact of STEAM education on unemployment and new professions.

The results of this study contribute to solving the problems of reforming the higher education system in the world in accordance with the Sustainable Development Goals, modernizing the material and technical base, and improving the content of the Natural Science and engineering educational process, in particular, improving the interests of students in the field of solar energy.

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Author contribution

All authors made an equal contribution to the development and planning of the study.

Conflict of Interest

The authors declare no conflicts of interest.

Data Availability Statement

Data are available from the authors upon request.

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