

UDC 37.016

IRSTI 14.25.09

<https://doi.org/10.48371/PEDS.2026.82.3.038>

**THE INTEGRATION OF STEM AND THE 5E INSTRUCTIONAL
MODEL IN PHYSICS EDUCATION:
AN ANALYSIS OF TEACHING PRACTICES**

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Abstract. The application of the 5E educational model through the STEM education system in the process of teaching physics is among the main tasks. In addition, the 5E educational model is full of scientific novelty integration education. Justification of the lesson plan using the 5E educational model in the integration of physics, which will become a scientific basis for university students. Therefore, the course of this lesson, which is presented in the article, is a scientific lesson in the 5E model based on science for university students. In drawing up the lesson plan, we will focus on the laboratory work «study of light refraction» in the Chapter “optics” of physics. This lesson is conducted by students of the 2nd year of Skpu named after Uzbekali Zhanibekov. Students of the group are divided into experimental and control groups. Passing the topic of laboratory work “study of refraction of light”, the experimental group is trained according to the 5E model with a lesson plan based on the STEM approach, and the control group is trained with a lesson plan of a traditional direction. According to methodological analysis, the brainstorming method is used. According to the brainstorming method, students are brainstormed how to do laboratory work using the 5E educational model. In addition, work will be carried out on a stage based on the 5E educational model. To determine the impact of integrating the STEM approach and the 5E learning model into physics lessons on students’ subject knowledge, research skills, and learning activity. In accordance with this goal, the tasks were set to systematize the theoretical foundations of integrating the STEM and 5E models, develop a methodological structure of the lesson, implement the proposed approach in experimental teaching, and conduct a comparative analysis of its results. In addition, their importance in teaching the STEM education system is characterized and methods for forming the concept of the 5E educational model are considered.

Keywords. STEM, model 5E, education system, interdisciplinary communication, integration education, experiment, physics teaching, laboratory work

Introduction

It is not superfluous to say that today is the time of technology. Along with the rapid development of time, the rapid development of modern technology is growing every day. This means that a basic system has been created that can

unite all modern technology. It is the STEM education system. Let's take a deep understanding of the concept of the first STEM in general. If we broadly reveal the concept of STEM-the main scientific direction, which is formed from four Sciences-Science, Technology, Engineering, Mathematics. The first meaning of the STEM education system is an educational program designed for general high school students and university students and focused on a specific career. And the second meaning is an extended type of research project of students [1]. That is, the direction of internship of graduate students. As we have already mentioned, the concept of STEM is the main collaboration of interdisciplinary communication. However, it does not teach as an integrative approach: biology, physics, chemistry and mathematics separately [2]. But the same applies to solving subject problems in the teaching of real physics. However, the interdisciplinary nature of the preparation for the development of cognitive interest in teaching physics contributes to the penetration of scientific ideas, concepts, values, as well as the formation of a holistic view of the environment [3]. This means a community of scientific problems that it uses as a way to solve. Having studied the importance of the STEM education system at a global level, it was found that in the field of education it is necessary for more needs [4]. The term STEM was first introduced by the United States in the 1990s as a lesson for basic high school students and university students, i.e. students studying science [5]. After the US introduced the term STEM, the STEM education system began to develop rapidly. That is, many articles and reports began to be published. There are many major discoveries of the STEM education system. For example, robotics, inverted class, all internet devices. These devices are one of the most important areas of the education system. At the same time, it is a common type of activity, practices and methods of society and the individual. With the STEM education system, we can determine the experience of reflection, Special Studies and their development [6]. At the same time, any student can be provided with innovative thinking tools and experience in using mathematics, engineering and science to solve various professional problems.

The concept of the 5e educational model. The dynamic development of the education system continues to amaze with the results of best practices. In the integration of physics, the functions of forming the worldview of students are implemented. And in this direction, it is necessary to be able to correctly apply the 5E educational model. What is the general 5E educational model? let's try to find a detailed answer to the question "what is it?" As for the scientist who studied the 5E educational model in general. The 5E educational model, a framework for leading research, is known to be one of the most effective pedagogical models commonly used in STEM-oriented science courses, commonly referred to as the 5E-based STEM (5E STEM) model. [7]. The overall 5E learning model was proposed in 1987 by the Biological Sciences Committee to be included in the curriculum. It was first proposed by Dr. R Bybee as a way to structure science classes and improve students' understanding of scientific concepts [8]. Although the 5e learning model was originally developed for scientific education, it has become a popular learning model in all subjects due to its effectiveness. [9].

That is, using this approach, students redefine, reorganize, refine and modify their original concepts through self-expression and interaction with peers and the environment. Science teachers and curriculum developers can combine or use the model on multiple levels. The model can be a model for organizing a sequence of daily classes, individual sections, or annual plans [10].

Recent international studies show that the STEM approach and the 5E learning model contribute to the development of students' scientific literacy, research skills, and conceptual understanding of physical phenomena. For example, in the teaching of the mechanics department, students design the structure of a bridge or vehicle model and analyze the forces acting on it based on experimental data, which demonstrates the engineering design capabilities of the STEM approach. The organization of this task according to the 5E model according to the stages of arousing interest, research, explanation, deepening knowledge, and evaluation allows for the theoretical and practical mastery of physical laws. However, the scientific literature does not sufficiently systematize the methodological mechanisms for the comprehensive integration of STEM components and the 5E model into physics teaching. Especially in the conditions of domestic education, empirical studies that determine their mutual continuity and pedagogical effectiveness are limited. Therefore, the scientific gap in research is characterized by the need to justify the use of STEM and the 5E model as a single methodological system for teaching physics.

Recent international studies show that the STEM approach and the 5E model contribute to the development of students' academic achievements, research and scientific reasoning skills. For example, in the Explore phase of the 5E model, students experimentally study the refraction of light in various transparent media, and in the Explain phase, they explain the results obtained based on Snell's law. And in the Elaborate phase, they relate the phenomenon of refraction to the principle of operation of a lens, optical device or fiber-optic system.

However, existing studies have not sufficiently considered the use of STEM components and the 5E phases as a single methodological system in physical laboratory work. The scientific novelty of this study is the systematic integration of physical experiments, mathematical calculations and engineering tasks with the 5E phases in the laboratory work "Investigating the Refraction of Light". For example, students calculate the refractive index of the medium based on experimental data, compare the measurement results and present a simple optical model for controlling the direction of light. The effectiveness of this approach was determined by comparing the test results of the experimental and control groups.

Methodology of the 5e-stem model. And if we analyze the process of teaching science using the 5E-STEM model, dividing it into five stages. First, participation in classes (focusing the attention of students only on the lesson), second-research (students study various topics through experiments), third-explanation (students get acquainted with new concepts related to the topic and can explain it), fourth-elaboration (students study with modern reading, analyze the lesson) and last-Fifth-Assessment (assessment of students' knowledge). In other words, the

5E-STEM model describes a sequence of tasks that are performed over time in the process of designing and implementing a STEM-oriented science course [11].

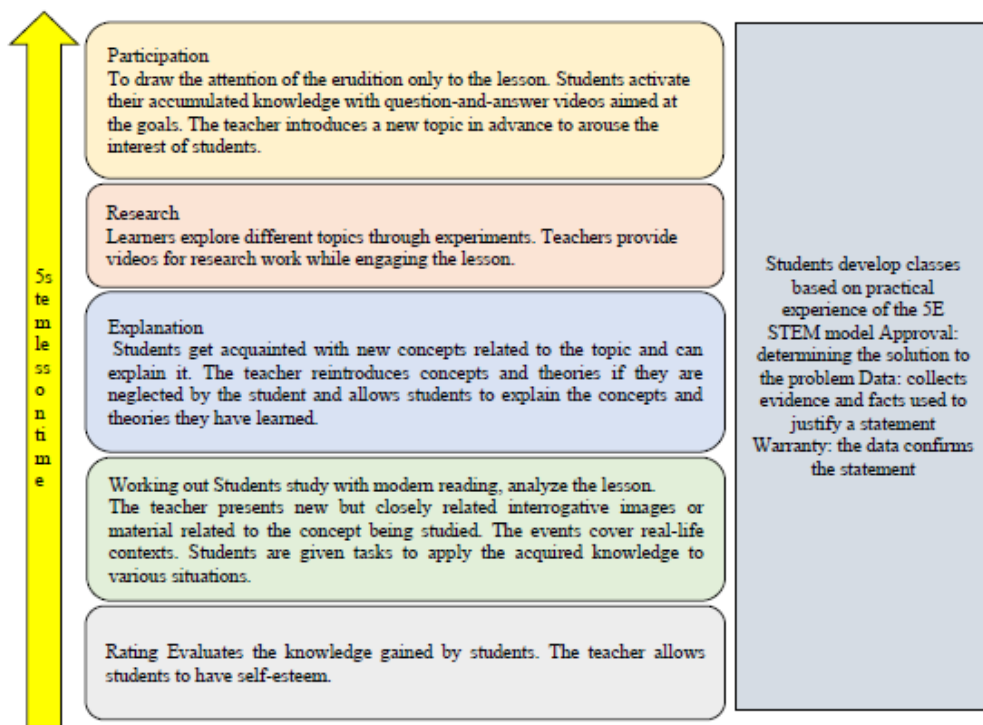


Figure 1 - 5E STEM model combination

Focusing on university students, some authors [12] identified teaching/learning difficulties and conceptual errors in the optics presented by trainee teachers. The results of some studies show that future physics teachers have great difficulty in consistently interpreting the main ideas about the concept of light in their training [13]. For example, it can be concluded that university students present various difficulties in understanding the content of images created by flat mirrors and convergent lenses and concave mirrors.

Materials and Methods

Method for analyzing a lesson using the 5E STEM education model In the correct formation of some concepts in teaching the discipline" optics", we rely on the 5E STEM education system. If we consider drawing up a lesson plan based on the 5E STEM education system in teaching the discipline" optics". The course of classes is conducted by students of the 2nd year of Skpu named after Uzbekali Zhanibekov. There are 21 students in the group. We divide the group into an experimental and control group. There were 10 students in the experimental group and 11 in the control group. We will conduct a lesson in Model 5e with an experimental group, that is, we will conduct laboratory work based on a lesson plan based on STEM education. And we go to the control group with a lesson plan in the traditional direction. Laboratory work name "Study of

refraction of light". The purpose of the work: to prove the law of reflection and refraction of light, to calculate the critical angle, to determine the speed of light for each medium.

And the equipment he needs: a computer model. 1. subject: study of light refraction The prepared concept map on the topic is presented in Figure 2.

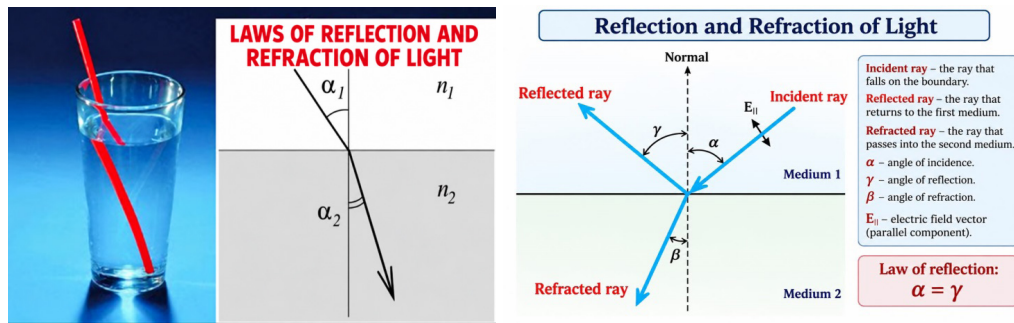


Figure 2 - Conceptual map of the subject of the study of refraction of light

Get acquainted with concepts related to the topic. Basic concepts: refraction of light, reflection of Light, 1 medium and 2 centers of incidence of light, angles of refractive media of light Stage 1.

Before starting the lesson, we provide students with information about the concept of "light". For example, what is light? How does it come about? How can he wedge in the middle? "I don't know," he said. We can show their answers in Figure 3.



	light reflected from a mirror surface travels in one direction, which is why we see our image. However, light is scattered in different directions when it is reflected from a rough surface
	bodies that emit light are called light sources. light sources are divided into two types: natural and artificial light sources. The Sun, the Moon, stars, lightning, and glowing bodies occurring in nature are classified as natural light sources.
	The famous French physicist A. Fresnel (1815) combined Huygens' principle with the principle of interference of elementary waves. Thus, the Huygens-Fresnel principle emerged. Using this principle, Fresnel provided a satisfactory explanation of the rectilinear propagation of light. He also correctly explained the phenomenon of light diffraction on the basis of the Huygens-Fresnel principle.
	E. Malus (1809) discovered the phenomenon of optical polarization, while Young (1817) established that the oscillations of light waves are transverse. Thus, at the beginning of the nineteenth century, the results of Young's and Fresnel's research led to the decisive triumph of the wave theory of light over the corpuscular theory.

Figure 3 - Samples from students ' scientific concepts

Stage 2: before the start of the lesson, tasks were given about the general light and answers were received from them. Further, in order to make the lesson very interesting and increase students ' interest in the subject, we remind them that there are several works "on the refraction of light". We also offer them 3 laboratory works similar to the same topic. They are as follows:

1. Head focus of collecting and scattering lenses determination of distances
2. Study of the polarization of light
3. Study of reflection and refraction of light waves. Huygens explanation).
4. Determination of the refractive index of glass. Samples of such laboratory work are shown in Figure 4.

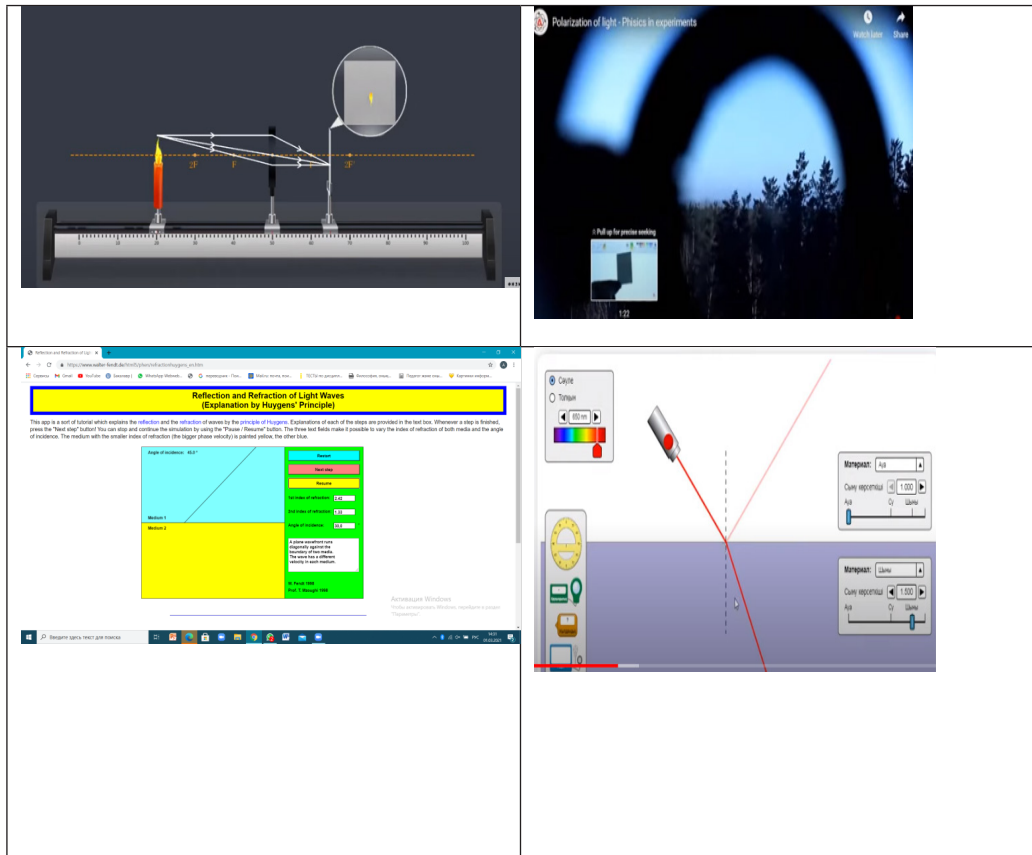


Figure 4 - Samples about the list of laboratory works similar to the refractive index of light

Stage 3. In the process of completing the lesson, the brainstorming method is used. Brainstorming: after receiving students' feedback on other laboratory work, they brainstorm how to do laboratory work. Brainstorming is carried out with a prepared presentation. We can see it in Figure 5.

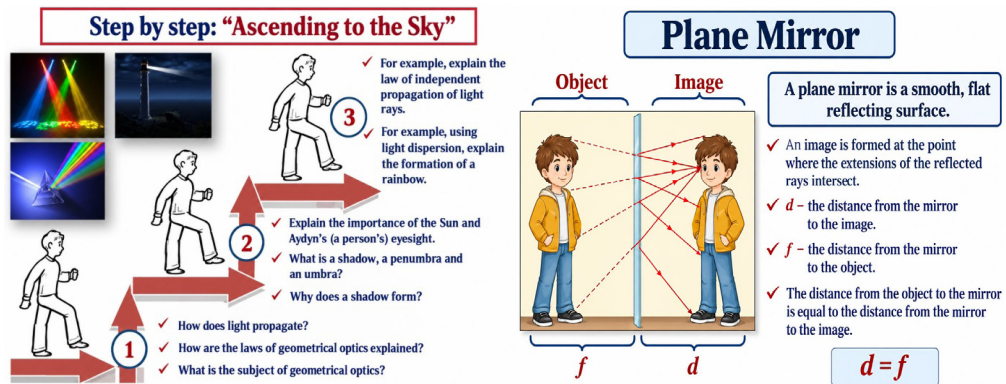


Figure 5 - The refraction of light brainstorming patterns about laboratory work

There are 18 different answers depending on the topic. The answers and frequency values given to the task are presented in Table 1.

Table 1. An attempt to brainstorm responses to light refraction research topics and frequency values

Answers	f
1 On Water	10
2 in the shade	8
3 In Figure	5
4 on the machine	6
5 at home	7
6 on the ground	12
7 on the phone	6
8 on the computer	1
9 on a laptop	1
10 in the dress	1
11 in the pool	4
12 on television	4
13 at traffic lights	1
14 in the chamber	1
15 On aircraft	1
16 in refrigerators	1
17 on ships	1
18 in the environment	9

Plus-minus: the cortege activities were conducted after the brainstorming phase. The first of the events on the court was a plus-minus-an interesting event. To this end, students were asked to list interesting features of the interpretation of “refraction of Light”; 3 positive, 3 negative, 3 problems. The opinions of students on the solution of this problem are presented in Table 2.

Table 2. “Refraction of light” on the topic of the laboratory work plus – Minis neutral responses and frequency values.

Right		Negative		Neutral	
Answer	f	Answer	f	Answer	f
When passing through the boundary separating the two environments, the light refracts	8	Breaks when passing through a boundary separating one medium	4	Light refracts itself	1
The angle of refraction, constructed from the point at which the beam falls on the boundary separating the refracted beam and the two media, is the angle of refraction	6	The angle at which the refracted beam is erected to the point is the perpendicular angle	3	The beam incident on the boundary separating the two media is the angle of light	2

The refractive index does not depend on the angle of incidence	11	The angle of refraction depends on the angle of incidence	2	The angle of refraction can be both dependent and independent of the angle of incidence	1
When a beam of light hits some surface, it is partially or completely reflected from it	10	A ray of light does not come out when it hits any surface	5	The beam of light is not reflected at all	1
The mirror surface reflects most of the incident light energy	8	A flat surface reflects light energy	2	Neither the mirror surface nor the flat surface reflects the light energy	1

In the course of the lesson, you will make a package for “fruits resistant to the rays of light”, depending on the activity of plus – minus – neutral activity. To do this, you need to have your own special design, write about the cost of its thinness, thickness. Students’ responses and frequency values are shown in Table 3.

Table 3. thoughts on factors that are effective for the light beam

Package	Answer	f	Answer	f
Exterior	I make a white package	9	I choose a color that reflects light	1
	It will be a thin gelatin and the sun will not shine from it	4	I cover the top with aluminum foil	1
	It will be perfect	1	I make the package container green	2
	I make a surprise package	1	I wrap a white cloth around it	1
Inside	Covered with aluminum foil	7	I make the inside like a thermos	1
	I choose white	9		
Size	Mid-level	8	If it is narrow, then the ice cream will have little place to Melt	1
	Long	8	Short	2
Thickness	Will be thin	10	Will be average	1
	The thickness will be 15 mm	1	Will be thick	1
			The thickness will be 25 mm	1
Cost	I don't spend a lot of money on an external container	1	Cost 2 lira	1
	Cost in average price	1		
Price	I get cheap fruits	1	Must be 0.5 lira	1
	I make discounts for cheap sales	1	battery-powered refrigerator 1 time for 2 lira	1
Fruits and berries	Available in different, different colors		Types of work	1

Stage 4: students carry out laboratory work at the stage of wk1.

The purpose of the work: to prove the law of reflection and refraction of light, to calculate the critical angle, to determine the speed of light for each medium. And the equipment he needs: a computer model.

- 1.Can choose between two different environments
- 2.The angles of reflection and refraction are determined.
- 3.Select 10 points in coordinates and place them in the table.
4. The speed of each medium is determined by n_1 and n_2
- 5.At the end, put it in a colander and take out the graph.

In this experiment, students select the coordinates of two environments, as can be seen in the figure. By the same coordinates, 10 points are taken and

entered into the table. In the course of work, it determines the angle of fall and the angle of reflection and the angle of refraction. It also calculates the velocities of these angles, draws graphs and draws the conclusions of the laboratory.

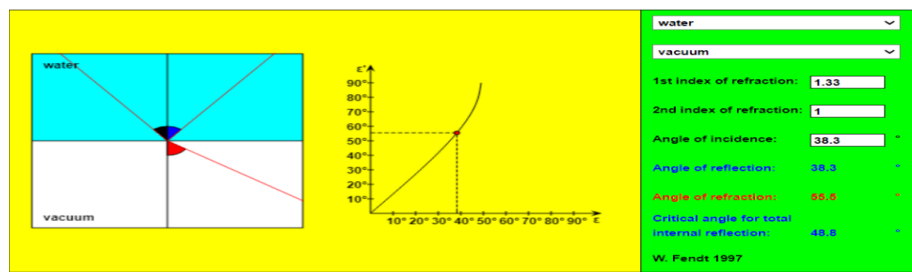


Figure 6 - Reflection and refractive angle

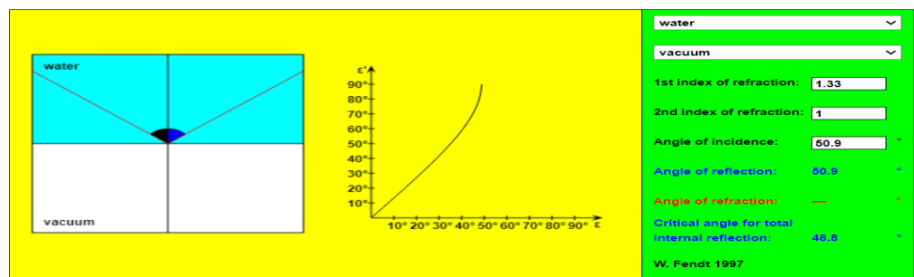


Figure 7 - Medium speed

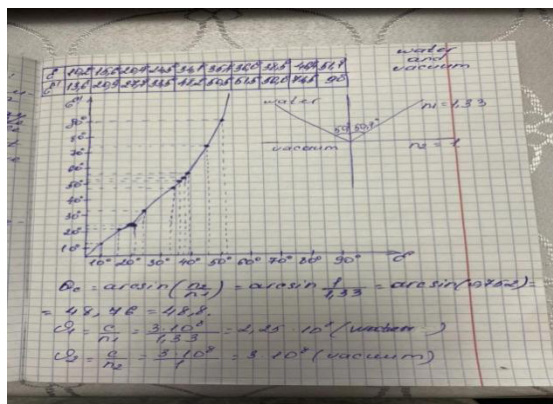


Figure 8 - Result summary

Students will be able to ask their questions by doing laboratory work. We can see it in Table 4.

Table 4. Problems of solving emerging questions about refraction of light

№	Questions	№	Questions
1	Refractive indices of light?	3	The concept of light dispersion?
2	Reflection of a light beam?	4	Features of the nature of light

5.stage: at this stage, students learn to share their experiences and explain the concepts in their own words. The researcher made comments, shared information about the topic and concepts and by completing the lesson, they will be able to establish a connection with a large number of courses that include the achievements of the subject, using systematic creative actions to solve previously learned problems.

Results and Discussion

According to the plan-based model 5E, the results were summed up by the test system of our lesson aimed at Stem. Therefore, according to the qualitative criterion of the study, a test is carried out for students of the experimental group in order to determine their views on STEM applications in teaching the topic “study of light refraction”.

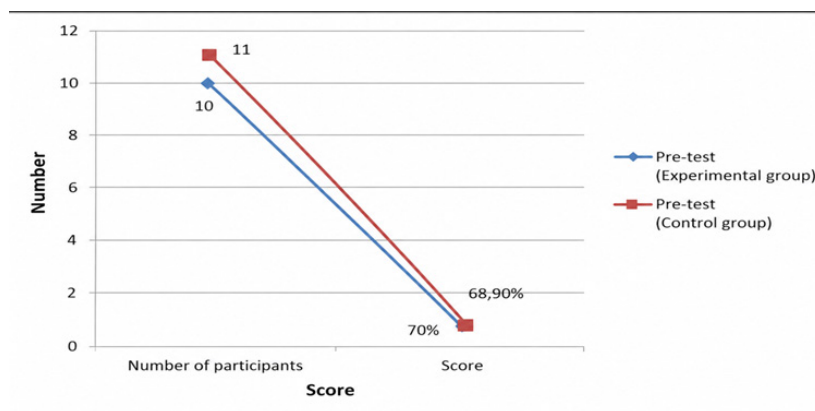
Table 5. The experimental model is shown

Group	Pre-test	Direction	Post-test
Experimental group	Test progress Get used to the scientific process	STEM based on Model 5E	Success Test Testing scientific skills What is STEM GE, exchange of views
Control group	Test progress Get used to the scientific process	Lesson in the traditional direction	Success Test Testing scientific skills

Since the test scores show a normal distribution, the test of the groups is used to compare the highest academic performance scores of the students of the experimental and control groups. To determine if there is a difference in pre-test scores, the test results of independent groups are shown in Table 6.

Table 6. Preliminary test results

Preliminary testing	Group	Number	points
	Experimental	10	70 %
	Control	11	68,9%

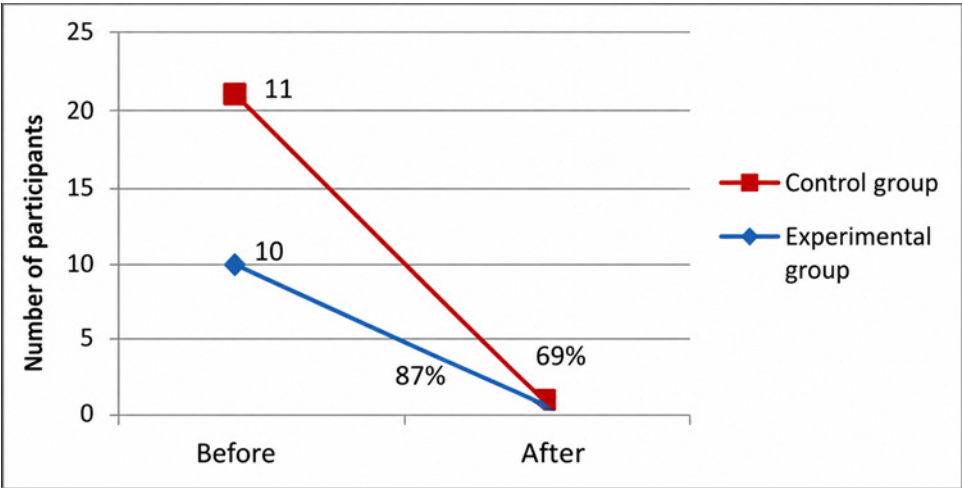


When analyzing Table 2, it can be seen that there is no significant difference between the experimental and control group.

According to these results, since there was no difference between the experimental and control groups, the students, that is, the experimental group, were taught a lesson based on STEM in the 5e educational model.

The experiment was carried out in the 1st semester, from 1.09.24 to 15.11.2024. At the end of the experiment, the final Test was obtained as a result of testing students ‘ knowledge about how much they mastered the subject, formed their interest in the subject and scientific worldview. We see its result in Table 3.

Testing	Group	Number	points
	Experimental	10	87%
	Control	11	69%



According to the students ‘ response to the test result, the experimental group showed 87%, and the control group showed 69%. In addition, students were able to show the effectiveness of using a system of knowledge based on STEM in teaching the discipline in the 5E model.

Conclusion

In the study, students’ academic achievements were assessed through the results of the initial and final tests conducted on the topic «Research on the Refraction of Light». The test tasks included understanding the law of refraction of light, determining the relationship between the angles of incidence and refraction, calculating the refractive index, analyzing experimental data, and scientifically interpreting the results. For example, students were presented with the values of the angles of refraction measured at different angles of incidence, and were asked to determine the refractive index of the medium based on the data, explain the reasons for the deviations in the measurement results, and relate the experimental conclusion to Snell’s law. The answers were evaluated for the correctness of the

physical understanding, the use of experimental evidence, the determination of the cause-and-effect relationship, and the validity of the conclusion.

The results of the study showed that the final test scores of students in the experimental group who used the STEM teaching method based on the 5E model were higher than those of the control group who received education according to the traditional curriculum. This result indicates that this method contributed to the development of students' academic achievements, the interpretation of experimental data, and the skills of making substantiated scientific conclusions. However, since scientific worldview was not measured using a specifically validated questionnaire or self-reported diagnostic tool, it is not possible to conclude that it significantly improved. Therefore, the study's findings were limited to the impact of STEM education based on the 5E model on academic achievement and scientific reasoning skills.

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ФИЗИКАЛЫҚ БІЛІМ БЕРУДЕ STEM ТӘСІЛІ МЕН 5Е ОҚЫТУ МОДЕЛІН ИНТЕГРАЦИЯЛАУ: ОҚЫТУ ТӘЖІРИБЕЛЕРІН ТАЛДАУ

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Аңдатпа. Физиканы оқыту процесінде STEM білім беру жүйесі арқылы 5Е білім беру моделін қолдану негізгі міндеттердің бірі болып табылады. Сонымен қатар, 5Е білім беру моделі ғылыми жаңалыққа толы интеграциялық білім беру. Университет студенттері үшін ғылыми негіз болатын физиканы интеграциялауда 5Е білім беру моделін қолдана отырып, сабақ жоспарын негіздеу. Сондықтан, мақалада ұсынылған бұл сабақтың барысы университет студенттеріне арналған ғылымға негізделген 5Е моделіндегі ғылыми сабақ болып табылады. Сабақ жоспарын құру кезінде біз физиканың «оптика» тарауындағы «жарық сынуын зерттеу» зертханалық жұмысына назар аударамыз. Бұл сабақты Өзбекәлі Жәнібеков атындағы ОҚПУ-дың 2-курс студенттері өткізеді. Топ студенттері эксперименттік және бақылау топтарына бөлінеді. «Жарық сынуын зерттеу» зертханалық жұмысы тақырыбын өткеннен кейін, эксперименттік топ STEM тәсіліне негізделген сабақ жоспарымен 5Е моделі бойынша, ал бақылау тобы дәстүрлі бағыттағы сабақ жоспарымен оқытылады. Әдістемелік талдауға сәйкес, ми шабуылы әдісі қолданылады. Ми шабуылы әдісі бойынша студенттерге 5Е білім беру моделін қолдана отырып зертханалық жұмыстарды қалай орындау керектігі туралы ми шабуылы жасалады. Сонымен қатар, жұмыс 5Е білім беру моделіне негізделген сахнада жүргізіледі. Мақаланың мақсаты - STEM тәсілі мен 5Е оқыту моделін физика сабақтарына интеграциялаудың оқушылардың пәндік біліміне, зерттеу дағдыларына және оқу белсенділігіне әсерін анықтау. Осы мақсатқа сәйкес STEM және

5Е модельдерін интеграциялаудың теориялық негіздерін жүйелеу, сабақтың әдіснамалық құрылымын әзірлеу, ұсынылған тәсілді эксперименттік оқытуда енгізу және оның нәтижелеріне салыстырмалы талдау жүргізу міндеттері қойылды. Сонымен қатар, олардың STEM білім беру жүйесін оқытудағы маңыздылығы сипатталады және 5Е білім беру моделі тұжырымдамасын қалыптастыру әдістері қарастырылады.

Тірек сөздер. STEM, 5Е моделі, білім беру жүйесі, пәнаралық байланыс, интеграциялық білім беру, эксперимент, физиканы оқыту, зертханалық жұмыс

ИНТЕГРАЦИЯ STEM-ПОДХОДА И УЧЕБНОЙ МОДЕЛИ 5Е В ФИЗИЧЕСКОМ ОБРАЗОВАНИИ: АНАЛИЗ ПЕДАГОГИЧЕСКИХ ПРАКТИК

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Аннотация. Применение образовательной модели 5Е через систему STEM education в процессе преподавания физики входит в число основных задач. Кроме того, образовательная модель 5Е полна научной новизны интеграционного обучения. Обоснование плана урока с использованием образовательной модели 5Е по интеграции физики, которая станет научной основой для студентов университетов. Таким образом, курс этого урока, который представлен в статье, является научным уроком в рамках модели 5Е, основанной на естественных науках, для студентов университетов. При составлении плана урока мы сосредоточимся на лабораторной работе «Изучение преломления света» в главе «оптика» курса физики. Данное занятие проводят студенты 2 курса ЮКПУ им. Узбекали Жанибекова. Студенты группы делятся на экспериментальную и контрольную группы. Проходя тему лабораторной работы «изучение преломления света», экспериментальная группа обучается по модели 5Е с планом урока, основанным на STEM-подходе, а контрольная группа обучается по плану урока традиционной направленности. Согласно методологическому анализу, используется метод мозгового штурма. Согласно методу мозгового штурма, студентам предлагается провести мозговой штурм, как выполнять лабораторную работу, используя образовательную модель 5Е. Кроме того, работа будет проводиться на этапе, основанном на образовательной модели 5Е. Цель статьи определить влияние интеграции подхода STEM и модели обучения 5Е в уроки физики на предметные знания, исследовательские навыки и учебную активность учащихся. В соответствии с этой целью были поставлены задачи систематизировать теоретические основы интеграции моделей STEM и 5Е, разработать методическую структуру урока, внедрить предложенный подход в экспериментальное обучение и провести сравнительный анализ его результатов. Кроме того, охарактеризована их важность в преподавании системы STEM-образования и рассмотрены методы формирования концепции образовательной модели 5Е.

Ключевые слова. STEM, модель 5Е, система образования, междисциплинарная коммуникация, интегративное образование, эксперимент, преподавание физики, лабораторные работы

Received / Мақала түсті / Стаття поступила: 11.02.2026

Accepted: / Жариялауға қабылданды / Принята к публикации: 25.09.2026

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