Impact of Phenomenon-Based Learning on High School Physics Education in Shymkent, Kazakhstan

Bayan Ualikhanova [1], Ganiya Ormanova [1,*], Dauletbay Berdaliyev [2], Nurken Mussakhan [3], Bakdaulet Anas [4], and Ertan Güdekli [5]

[1] Department of Physics, NJSC South Kazakhstan Pedagogical University named after Ozbekali Zhanibekov, Shymkent 160012, Kazakhstan;
[2] Academic Affairs Department, NJSC South Kazakhstan Pedagogical University named after Ozbekali Zhanibekov, Shymkent 160012, Kazakhstan;
[3] Scientific Research Institute "Natural Sciences, Nanotechnologies and New Materials", Khoja Akhmet Yassawi International Kazakh-Turkish University, Turkestan 161200, Kazakhstan;
[4] Department of Physics and Technology, Higher School of IT and Natural Sciences, Sarsen Amanzholov East Kazakhstan University, Ust-Kamenogorsk 070004, Kazakhstan;
[5] Department of Physics, Istanbul University, Istanbul 34116, Turkey.
* **Corresponding Author:** g.ormanova@ro.ru.

ABSTRACT: Traditional teaching methods have become obsolete in modern society, and require people with high efficiency, cooperation, and active participation. Consequently, a new approach to education should provide necessary information and abilities for further progress on a global scale. This study aims to examine the beneficial effects of using phenomenon-based learning (PhBL) as a pedagogical approach for teaching physics to high school students in Shymkent, the Republic of Kazakhstan. The research also aims to examine the influence of PhBL on students' motivation to study physics and improve their knowledge of the subject. The fundamental approach to teaching physics was to introduce lessons through phenomena and use interdisciplinary communication as a universal approach. In addition, a survey was conducted to determine the rationale for the interaction of students with physics both in the academic environment and in practical use as well as to assess the longevity of these acquired abilities in the memory of students. The results show that the introduction of PhBL led to an enhancement in student performance, with an increase of more than 10%. This indicates the high efficiency of the proposed approach. In addition, the introduction of phenomenon-based learning contributes to an increase in retention and stable assimilation of information received over a long period. The use of PhBL to teach physics through interdisciplinary courses significantly improves students' skills and contributes to long-term preservation of their acquired abilities.

Keywords: phenomenon-oriented learning, methods of teaching physics, high school, Kazakhstan education system, student survey.

I. INTRODUCTION

Phenomenon-based learning (PhBL) involves a significant increase in students' skills, critical thinking, complex communication, game-based and collaborative work. This is because of the realistic and comprehensive study of the subject by crossing the boundaries between subjects, covering all objects that are rich in phenomena. The most important requirements of this educational process are integrity and sincerity.

Phenomenon-based learning is not based on a set of frozen rules. This is largely related to the active role of students in understanding certain phenomena [1]. Unlike classical learning, where the role of students is passive and depends on their memory of the subject, phenomenon-based learning creates conditions for students to actively participate in joint activities with the aim of solving problems and questions. In addition, it implies the idea of providing experimental learning and developing students' ability to work independently to allow for profound study. In-depth learning allows students to overcome gaps in various subjects. This fact is evidenced by a two-year study conducted by researchers from the University of Juvjaskül (Juvjaskül, Finland), which laid the foundation for learning on the basis of a dynamic problem in chemistry. Their work showed positive results in professional development, interest, and critical thinking. Phenomenon-based learning has four main advantages: holistic, interdisciplinary, group, and interdisciplinary learning [2-4]. In addition, PhBL promotes the development of critical thinking and problem-solving skills, particularly in the context of STEM education. A student with a phenomenon-based learning curriculum will not be a passive listener in the classroom but rather an active participant who contributes to the subject and learns. This approach has been widely adopted offering a model for its potential implementation worldwide, including in Kazakhstan. Their point of view was taken into account, requiring teachers to teach each student one topic per year and conduct it based on a phenomenon-based learning program. The use of the external environment of the school and innovative technologies plays an important role in mobilizing, involving, and activating students in learning.

Furthermore, this innovative educational approach not only improves learning capabilities, but also enhances understanding across different disciplines and extends the duration over which students can refine their skills. A broader evaluation of the phenomenon-based learning approach in educational institutions worldwide, is crucial to understanding its impact on learning outcomes. In Shymkent, Kazakhstan, there is a lack of research on this method, which highlights a critical gap in the educational landscape. Therefore, it is essential to investigate how PhBL can be effectively integrated into the high school curriculum in Kazakhstan, particularly in physics education. The absence of research on this method in Shymkent, Kazakhstan highlights a critical gap. Therefore, it is vital to investigate the implementation of this phenomenal learning strategy in the curriculum to improve overall student competencies and knowledge in Kazakhstan.

It is important to conduct this research, given that the process of oriented learning should be as effective as possible to achieve students' learning goals. Guided learning should be supported by digital tools that facilitate independent learning. Based on the above, the following tasks were formulated for this study:

1. How can the implementation of phenomenon-based learning in the physics curriculum enhance students' problem-solving skills in high school?
2. How can the use of workbooks based on phenomenon-based learning improve students' ability to solve complex problems?

II. LITERATURE REVIEW

To effectively deliver high school physics education, it is imperative to consider various factors supported by scholarly research. A key component is the training of educators to apply inquiry-based teaching methods, as advocated by the Physics Education Group at the University of Washington [5]. This method underscores the significance of hands-on experiments and problem-solving in deepening students' understanding of essential physics concepts.

Views on teaching methods among prospective high school physics teachers vary from traditional to constructivist [6]. Tailoring teaching strategies to these theories can enhance instructional methods and boost student involvement. Integrating local cultural knowledge into physics education, as demonstrated by Bali, can also promote moral and ethical development among students by emphasizing cultural values [7]. By incorporating culturally pertinent materials, teachers can enhance the relevance of physics to their students. Understanding the factors that influence the professional growth of physical education teachers in schools is crucial [8]. The influence of socialization and personal experience on teaching practices underscores the need for focused support and professional development programmes.

Distinguishing between the core teaching principles in school physics and the fundamental tenets of the subject itself is vital for effective education [9]. Enhanced learning outcomes can be achieved by concentrating on key concepts and addressing misconceptions from the constructivist perspective.

Teachers' proficiency is crucial for determining their teaching effectiveness, particularly in physics and chemistry. Notably, less experienced teachers often show substantial improvements in these disciplines [10]. Providing support and mentorship to new teachers can improve their physical teaching performance. Insights into the initial challenges of teaching can be gleaned by examining novice physical education teachers [11]. Assisting new teachers requires challenging their preconceptions, offering necessary support, and fostering connections between college and high school physics to ensure knowledge transfer [12, 13]. Aligning information with curriculum standards is essential for ensuring consistent student-learning experiences.

Priority should be given to curriculum design, mathematics integration, and instructional methods by high school physics teachers [14]. Enhancing problem-solving skills and the practical application of theoretical knowledge can boost students' physical proficiency. Analyzing teaching approaches in various educational systems, such as those in the United States and China, can reveal valuable alternative methods [15]. Employing a diverse array of strategies can effectively engage and immerse students into learning. The introduction of advanced technologies, such as virtual reality, in high school physics classes can significantly enrich learning experiences [16]. Virtual reality can vividly illustrate complex topics and improve understanding. Addressing the challenges faced by teachers in incorporating mathematics into physics teaching is crucial [17, 18]. The integration of concepts can be facilitated by strategies, such as making mathematics compulsory in the educational curriculum.

Expanding teaching opportunities for undergraduate physics students could alleviate the shortage of qualified physics teachers [19, 20]. Engaging in teaching and building networks within the physics education community can inspire educators in the future. Analyzing the characteristics and trends of physics teachers in American public schools may yield insights crucial for developing targeted recruitment and training initiatives [21]. A thorough understanding of the composition of teaching staff is essential to ensure the quality of physical instruction for all students. Teaching high-school physics requires a comprehensive approach that considers teacher preparation, cultural relevance, underlying principles, teaching methods, and technological integration. The quality of physics education can be significantly improved by using evidence-based methods and promoting ongoing professional growth, thereby increasing student engagement.

Phenomenon-based physics education requires students to transition from everyday experience to scientific models and experiments [22, 23]. This approach can be effectively integrated with simulation-based learning. Problem-based learning, a key component of phenomenon-based education, can be successfully applied in physical laboratory work for physics teachers, leading to a deeper understanding and application of scientific process skills [24]. However, teachers may need to enhance their qualifications to effectively implement phenomenon-based learning [25]. Despite these challenges, phenomenon-based learning has been shown to improve students' problem-solving abilities, particularly in terms of accurately understanding and applying physics concepts [26, 27].

The development of a workbook for teaching high school physics based on phenomenon-centered learning is grounded in several key features identified in academic literature. Prutko highlighted the importance of interactivity and practical skills in the use of workbooks as educational tools [28]. Cummings emphasized that the creation of well-designed examples and clear learning objectives enhances the use of workbooks by students, as it addresses the need for accessible and engaging content [29]. Resnita et al. [30] and Usman and Asrizal [31] stressed the importance of shifting toward student-centered and inquiry-based learning with a focus on hands-on activities. These features have contributed to the creation of workbooks that engage students and promote their physics studies.

This study examined the impact of phenomenon-based learning on high school students in Shymkent, Kazakhstan. The goal was to encourage students to engage in physics and to enhance their skills using these subjects. The use of PhBL to teach physics by integrating other disciplines significantly improves students' skills and helps them to retain these abilities over time. The remainder of this paper is organized as follows. Relevant articles have discussed previous aspects of studies in the field of phenomenon-based learning. The methodology outlines a plan for addressing the research question by specifying the working methods and results of the research process. In conclusion, some final comments and questions for discussion and future work are presented.

III. MATERIAL AND METHOD

This study aimed to identify the positive effects of using phenomenon-based learning as a method for teaching students' physical skills and their influence on motivating high school students in Shymkent, Kazakhstan, while improving their physical abilities. To demonstrate the effects of phenomenon-based learning, this study was conducted in three schools in Kazakhstan. The main approach is to show how phenomenon-based learning enhances physics-learning modules such as Twig Bilim and PhET Colorado. This study was conducted in three schools: School No. 50, named after A. Baitursynov; School No. 133; and School No. 40, named after Alpamys Batyr. The students were in 10th grade. They were divided into two groups: traditional and phenomenon-based methods.

The students attended classes using their respective teaching methods for two weeks. The traditional group attended individual physics classes, whereas the phenomenon-based group studied physics along with social subjects, using physical concepts and workbooks developed by the authors. The phenomenon-based learning group also had additional interdisciplinary activities to enhance their understanding of physics. Two weeks later, an examination was conducted and the results were collected, analyzed, and evaluated. Finally, the evaluation results were compared to reflect the results of this study.

1. PARTICIPANTS

The study was conducted in three high schools in Shymkent, Kazakhstan. A total of 130 students participated in the study, with 65 students each in the traditional and 65 students in the phenomenon-based learning groups. All participants were 10th grade students. The students were randomly selected and assigned to either the traditional or phenomenon-based learning groups. Gender distribution, academic history, and interest in physics were considered when forming the groups to ensure a balance between the groups.

2. PROCEDURE

The study spanned two weeks. In the first week, the traditional group received conventional physics lessons, whereas the phenomenon-based learning group was taught using integrated interdisciplinary lessons that linked physics to real-world phenomena. Students in both groups were given the same content, but their instruction methods differed. To ensure consistent delivery, teachers with experience in both approaches facilitated classes. At the end of the two-week period, an exam was administered to assess the students' understanding of the subject matter. In addition to the exam, feedback was collected from the students through surveys to assess their motivation and engagement.

3. PHBL STRATEGY IMPLEMENTATION

Phenomenon-based learning was implemented in the experimental group. The PhBL approach involves presenting real-world phenomena and asking students to identify the physical principles behind them. Phenomenon-based lessons integrate content from subjects such as biology and chemistry to contextualize the physical concepts being studied. Each lesson aimed to allow students to discover and apply physics principles through hands-on activities, group discussions, and problem-solving.

4. WORKBOOK DESIGN

The workbook used in this study was developed by the authors and was based on the 10th grade physics curriculum. It includes sections that combine theoretical content with practical applications, and each chapter provides space for students to record observations, formulate hypotheses, and perform calculations. The workbook also includes interdisciplinary tasks designed to reinforce the connections between physics and other subjects. To support active learning, the workbook encouraged critical thinking, collaborative problem-solving, and self-assessment.

5. ASSESSMENT TOOLS

The primary assessment tool was the exam administered at the end of the two-week study period. The exam tested the students' comprehension of the key physics concepts covered in both teaching approaches. In addition to the final exam, pre- and post-surveys were conducted to measure changes in students' attitudes toward physics and their motivation to learn the subject. These surveys also included questions about students' engagement levels and perceived difficulty of the subject matter.

6. STATISTICAL ANALYSIS

Data collected from exam scores, surveys, and classroom observations were analyzed using statistical methods. Descriptive statistics were used to summarize the performance of each group, and inferential statistics (e.g., t-tests) were applied to compare the exam scores between the two groups. Statistical analysis also examined the relationship between the teaching method and students' motivation to learn physics, as indicated by their survey responses. To determine whether the observed differences were statistically significant, the significance level was set at $p < 0.05$.

Research project steps are described in Table 1.

Table 1. Research project working phases.

Step	Detailed Description
Lesson preparation	Entails the coordination of resources, the formulation of the lesson's framework, and the advance preparation of any required materials prior to the class. This stage is crucial to guarantee a seamless and efficient teaching session.
Establishing the educational setting	Classroom arrangement pertains to the organization of the physical or digital learning space in order to promote optimal learning outcomes. This includes the establishment of any required technology, organization of seats, and guaranteeing an environment that is favorable to learning.
Teaching the topic using both traditional and PhBL approaches	Engaging students in the subject matter using a combination of classical methodologies, such as conventional lecture-based approaches, and PhBL methods. It uses authentic real-world scenarios as a framework for education, hence augmenting comprehension and long-term memory.
Gathering and evaluating outcomes	Collecting data from evaluations to quantify student comprehension and advancement. This may include assessments such as quizzes, assignments, and practical projects that demonstrate their understanding of the material presented.
Examining findings	Examining the gathered data in order to detect patterns, achievements, or aspects that need improvement. This analysis facilitates comprehension of the efficacy of instructional approaches and the extent of student acquisition of knowledge.
Assessment	Conducting a comprehensive assessment of the students' achievements and the overall efficacy of the instructional design. This involves taking into account input from students and maybe modifying future teaching tactics depending on the analysis.

Based on theoretical research, the processes of experimental and phenomenon-oriented learning have a positive effect on the development of scientific literacy, and correspond to the characteristics of worldview expansion. In this way, phenomenon-based learning encourages students to relate what they are learning to a specific context and to learn by understanding what they are doing; that is, the emphasis is on student learning rather than teacher learning. PhBL allows students to relate what they have learned to the real world and to learn by understanding what they are doing. Therefore, in high school, among other things, we conducted a scientific and methodological analysis of the subject "Physics" of the 10th grade.

The scientific and methodological analysis of the educational process in physics in 10th grade is aimed at evaluating its effectiveness of the educational process. When conducting lectures on physics, the analysis also provides information on the use of teaching methods, including interactive methods and technologies, as well as differentiated approaches to consider the individual characteristics of students. An important element is the evaluation of educational materials, textbooks, and online resources as well as their relevance and quality.

The analysis examined the results of students' grades and exams, as well as their interest in and motivation to study physics. Special attention has been paid to the professional training of teachers, their qualifications, and their use of modern teaching methods.

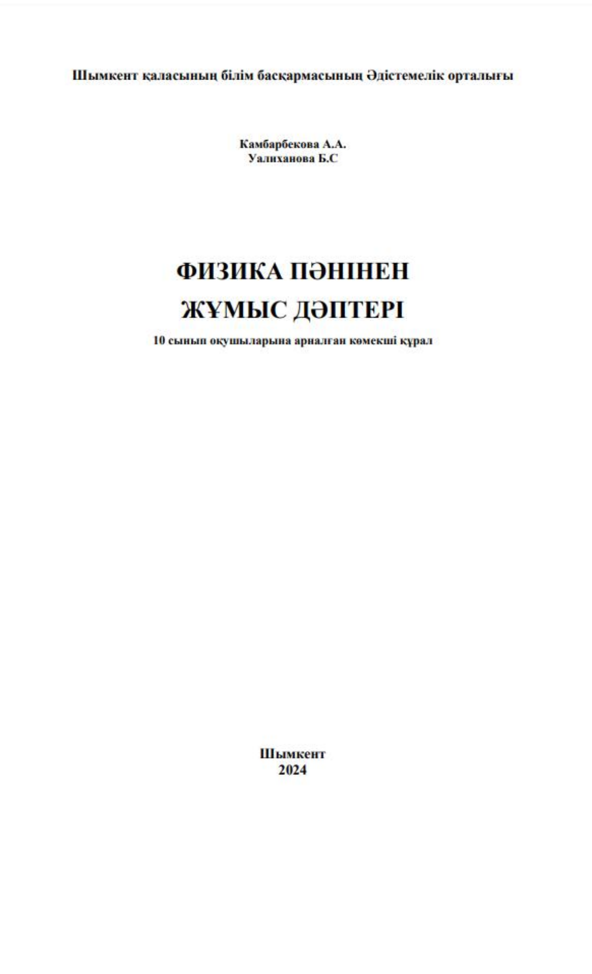
Laboratory work and practical exercises were also analyzed in terms of compliance with goals, methods, and available resources. The influence of the educational process on the formation of students' core competencies in physics and scientific thinking was also assessed. The feedback system, including consultations and discussion of grades, was also considered from the point of view of ensuring interaction with students. Scientific and methodological analysis allows us to identify successful practices and areas that require additional attention and correction in the process of teaching physics in 10th grade. Table 2 presents the 10th-grade curriculum. The analysis was also used to assess the effectiveness of phenomenon-based learning in comparison to traditional teaching methods.

Table 2. Curriculum of the discipline "Physics" in the 10th grade.

No.	Theme	Number of hours
1	Basic equations and concepts of kinematics of equal motion	1
2	Kinematics of curvilinear motion	1
3	Movement of a body thrown at an angle to the horizon	1
4	Forces. Adding forces. Newton's laws	1
5	Law of universal gravitation	1
6	Moment of inertia of an absolute solid	1
7	Momentum moment. The law of conservation of momentum. Basic equation of rotational motion dynamics	1
8	Laws of conservation of momentum in mechanics	1
9	Law of conservation and rotation of energy	1
10	Hydrodynamics. Laminar and turbulent flows of liquids and gases	1
11	Continuity equation. Bernoulli equation. Lifting force	1
12	Basic principles of the molecular kinetic theory of gases and its experimental evidence. Thermodynamic systems and parameters	1
13	Ideal gas. The basic equation of MCT. Ideal gas equation	1
14	Isoprocesses. Isoprocess graphs	1
15	Internal energy of an ideal gas. Thermodynamic work. Amount of heat, heat capacity	1
16	The first law of thermodynamics. Application of the first law of thermodynamics to isoprocesses. Adiabatic process. The rotational process and its coefficient of beneficial effect. Carnot cycle	1
17	Liquids. Saturated and unsaturated steam. Air humidity. Properties of the surface layer of the liquid. Transmission, flu-like phenomena	1
18	Electric charge. The law of conservation. Coulomb's law	1
19	Electric field. Electric field strength. Electric field superposition principle	1
20	Electric field strength vector flow	1
21	The operation of the electric field during the displacement of the charge. Potential. Potential difference of electric field	1
22	Equipotential surfaces. The relationship between Voltage and potential difference for a homogeneous electric field	1
23	Conductors and dielectrics in an electric field	1
24	Electrical capacity. Capacitors. Connecting capacitors	1
25	Electric field energy	1
26	Electric current. Ohm's law for a part of a chain. Combined connection of conductors	1
27	Electromotive force and internal resistance of the current source. Ohm's law for a complete circuit	1
28	Operation and power of electric current. Joule-Lenz law. Useful effect factor of the current	1

	source	
29	Electric current in different environments	1
30	Magnetic field. Interaction of a conductor with a current. Magnetic induction vector. Induction of conductors with circular and infinite current	1
31	Ampere Force, left hand rule	1
32	Lorentz's strength. Movement of charged particles in a magnetic field	1
33	Magnetic properties of matter. Curie temperature	1
34	Magnetic flux. The phenomenon of electromagnetic induction. Lenz rule	1
35	Self-induction. Inductance. Magnetic field energy	1
36	Electric motor and DC electric generator	1
All		**36 hours**

Our study included special didactic materials and calendar topics that contributed to the students' independent work in mastering the subject (Figure 1 and 2).



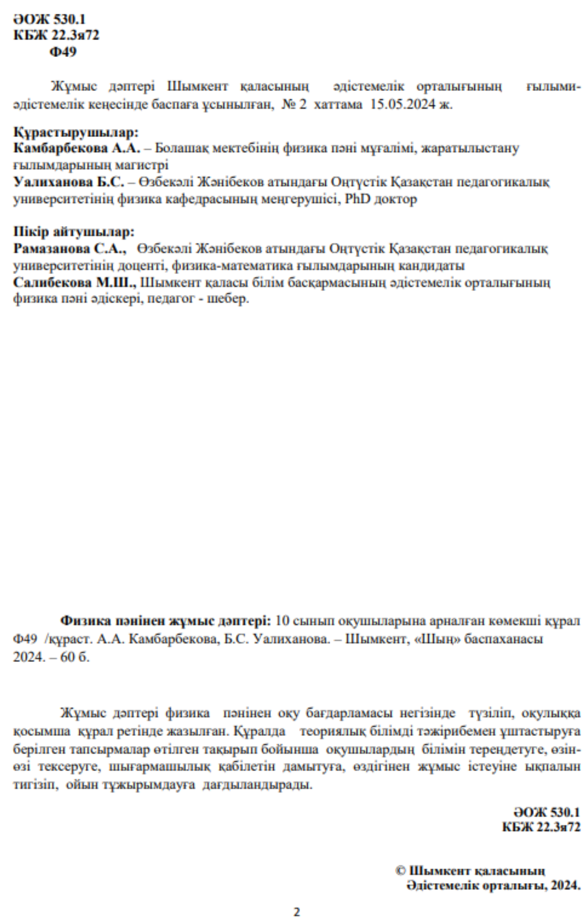
Шымкент қаласының білім басқармасының Әдістемелік орталығы

Камбарбекова А.А.
Уалиханова Б.С

ФИЗИКА ПӘНІНЕН
ЖҰМЫС ДӘПТЕРІ
10 сынып оқушыларына арналған көмекші құрал

Шымкент
2024

(a)



ӘОЖ 530.1
КБЖ 22.3я72
Ф49

Жұмыс дәптері Шымкент қаласының әдістемелік орталығының ғылыми-әдістемелік кеңесінде баспаға ұсынылған, № 2 хаттама 15.05.2024 ж.

Құрастырушылар:
Камбарбекова А.А. – Болашақ мектебінің физика пәні мұғалімі, жаратылыстану ғылымдарының магистрі
Уалиханова Б.С. – Өзбекәлі Жәнібеков атындағы Оңтүстік Қазақстан педагогикалық университетінің физика кафедрасының меңгерушісі, PhD доктор

Пікір айтушылар:
Рамазанова С.А., Өзбекәлі Жәнібеков атындағы Оңтүстік Қазақстан педагогикалық университетінің доценті, физика-математика ғылымдарының кандидаты
Салибекова М.Ш., Шымкент қаласы білім басқармасының әдістемелік орталығының физика пәні әдіскері, педагог - шебер.

Физика пәнінен жұмыс дәптері: 10 сынып оқушыларына арналған көмекші құрал Ф49 /құраст. А.А. Камбарбекова, Б.С. Уалиханова. – Шымкент, «Шың» баспаханасы 2024. – 60 б.

Жұмыс дәптері физика пәнінен оқу бағдарламасы негізінде түзіліп, оқулыққа қосымша құрал ретінде жазылған. Құралда теориялық білімді тәжірибемен ұштастыруға берілген тапсырмалар өтілген тақырып бойынша оқушылардың білімін тереңдетуге, өзін-өзі тексеруге, шығармашылық қабілетін дамытуға, өздігінен жұмыс істеуіне ықпалын тигізіп, ойын тұжырымдауға дағдыландырады.

ӘОЖ 530.1
КБЖ 22.3я72

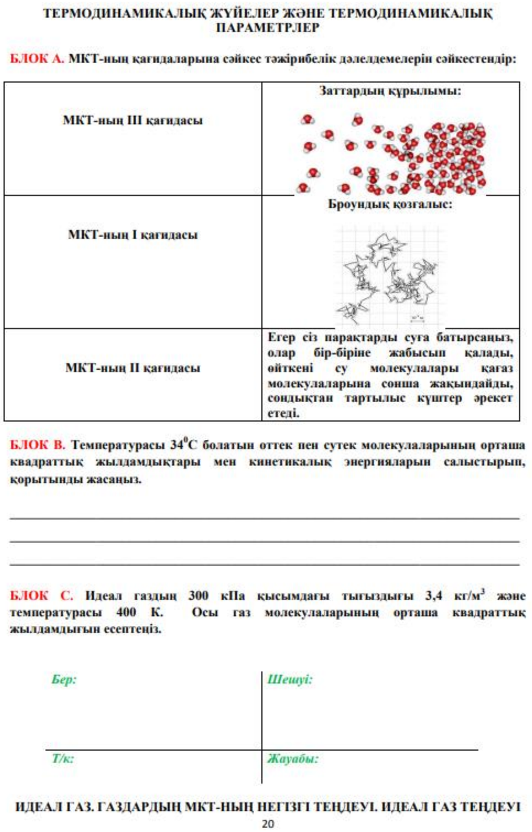
© Шымкент қаласының Әдістемелік орталығы, 2024.

2

(b)

FIGURE 1. Workbook home page (a, b).

https://doi.org/10.48161/qaj.v4n4a1203



ТЕРМОДИНАМИКАЛЫҚ ЖҮЙЕЛЕР ЖӘНЕ ТЕРМОДИНАМИКАЛЫҚ ПАРАМЕТРЛЕР

БЛОК А. МКТ-ның қағидаларына сәйкес тәжірибелік дәлелдемелерін сәйкестендір:

МКТ-ның III қағидасы	Заттардың құрылымы:
МКТ-ның I қағидасы	Броундық қозғалыс:
МКТ-ның II қағидасы	Егер сіз парақтарды суға батырсаңыз, олар бір-біріне жабысып қалады, өйткені су молекулалары қағаз молекулаларына сонша жақындайды, сондықтан тартылыс күштер әрекет етеді.

БЛОК В. Температурасы 34⁰С болатын оттек пен сутек молекулаларының орташа квадраттық жылдамдықтары мен кинетикалық энергияларын салыстырып, қорытынды жасаңыз.

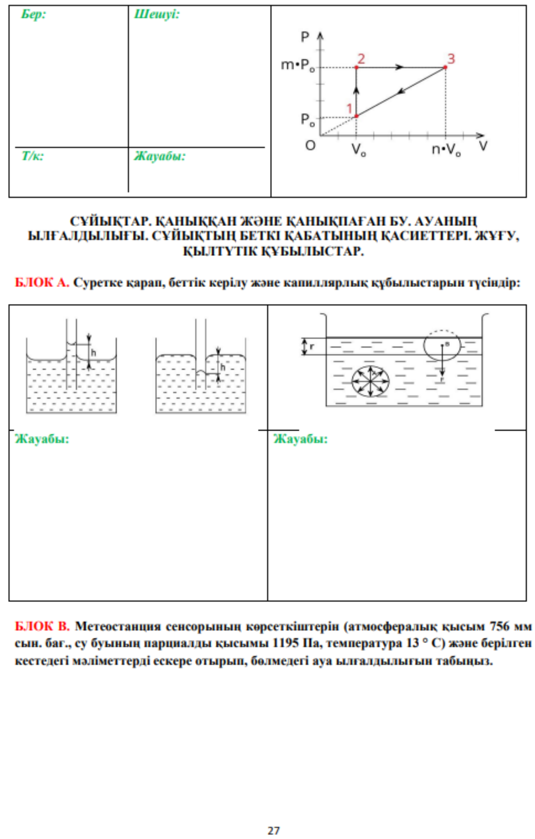
БЛОК С. Идеал газдың 300 кПа қысымдағы тығыздығы 3,4 кг/м³ және температурасы 400 К. Осы газ молекулаларының орташа квадраттық жылдамдығын есептеңіз.

Бер: Шешуі:
Т/к: Жауабы:

ИДЕАЛ ГАЗ. ГАЗДАРДЫҢ МКТ-НЫҢ НЕГІЗГІ ТЕҢДЕУІ. ИДЕАЛ ГАЗ ТЕҢДЕУІ

20

(a)



Бер: Шешуі:
Т/к: Жауабы:

СҰЙЫҚТАР. ҚАНЫҚҚАН ЖӘНЕ ҚАНЫҚПАҒАН БУ. АУАНЫҢ ЫЛҒАЛДЫЛЫҒЫ. СҰЙЫҚТЫҢ БЕТКІ ҚАБАТЫНЫҢ ҚАСИЕТТЕРІ. ЖҰҒУ, ҚЫЛТҮТІК ҚҰБЫЛЫСТАР.

БЛОК А. Суретке қарап, беттік керілу және капиллярлық құбылыстарын түсіндір:

Жауабы: Жауабы:

БЛОК В. Метеостанция сенсорының көрсеткіштерін (атмосфералық қысым 756 мм сын. бағ., су буының парциалды қысымы 1195 Па, температура 13 ° С) және берілген кестедегі мәліметтерді ескере отырып, бөлмедегі ауа ылғалдылығын табыңыз.

27

(b)

FIGURE 2. Sample workbook assignments (a, b).

The workbook is compiled based on the physics curriculum and written as an additional tool in the textbook. The tasks assigned in the tool to combine theoretical knowledge with practice contribute to deepening students' knowledge of the topic covered, self-testing, development of creative abilities, self-functioning, and developing the ability to formulate a game [32]. The workbook is designed to support students in the learning process after mastering the planned topic, as it contains materials for monitoring the development of students' knowledge and skills (control tasks or questions, test tasks, assignments, etc.). Using workbook pages, teachers can identify where students make mistakes in their studies and work to correct them.

IV. DATA ANALYSIS

As a result of this research, the influence of phenomenon-based learning on physics was demonstrated. The study was conducted in three different high schools, and 130 10th grade students were selected. As shown in Table 3, each class was divided into two groups based on PhBL and classical education (TEM), within the framework of the content of Kazakhstan's updated education. In the study groups, students engaged in interdisciplinary learning, where subjects were taught in combination with physics. This approach allowed students to better grasp physics concepts by applying them in real-world scenarios.

Table 3. Separation of pupils during research.

Grades	Number of Students (PhBL)	Number of Students (TEM)
10 Ath Grade	18	17
10 B th Grade	12	16
10 C th Grade	35	32
Total	65	65

Accordingly, the classical group studied disciplines in accordance with traditional teaching methods. After completing the educational process, students were evaluated using special test papers. The assessment consisted of physics-related questions. Student grades were tested, and it was found that phenomenon-based learning helped students to better understand subjects and improve their grades. Table 4 presents the exam results for all three classes in the two groups. The results showed that phenomenological learning can improve students' understanding of the subject being studied, expand their participation in it, and improve their learning opportunities and skills.

Table 4. Scores for every student included in the research.

Grades	Average Score (PhBL)	Average Score (TEM)
10 A th Grade	74.06%	58.62%
10 B th Grade	68.42%	61.63%
10 C th Grade	63.12%	56.48%
Overall	68.53%	58.91%

This was also confirmed by previous studies conducted in this area. A t-test was conducted to analyze the statistical significance of the differences in exam scores between the two groups, and the results revealed a statistically significant difference in scores, with a p-value of 0.01. This indicates that the higher scores in the PpBL group were not due to random chance, but rather due to the implementation of PhBL.

In a survey of students who participated in it after the test, students were asked, 'Can they apply the knowledge of physics acquired during their studies even in life?' The question revealed that 64% of the students in the PpBL group believed they could apply their knowledge to real-world situations. As shown in the results in Figure 3, 64% of the students could still practice the skills they had learned during the lesson. This is a clear sign that applying learning based on this phenomenon helps students apply their skills over a longer period of time. From the results collected and analyzed, it can be noted that teaching any subject using the holistic method, as in teaching based on a phenomenon, significantly increases the activity and learning ability of students. In addition, phenomenon-based learning can significantly improve students' skills and learning outcomes. The introduction of PhBL led to a significant improvement in student performance, with an increase of more than 10%. This indicates the high efficiency of the proposed learning approach. Furthermore, the knowledge gained by students from teaching based on the phenomenon remained in their minds for a long time and could be used when necessary.

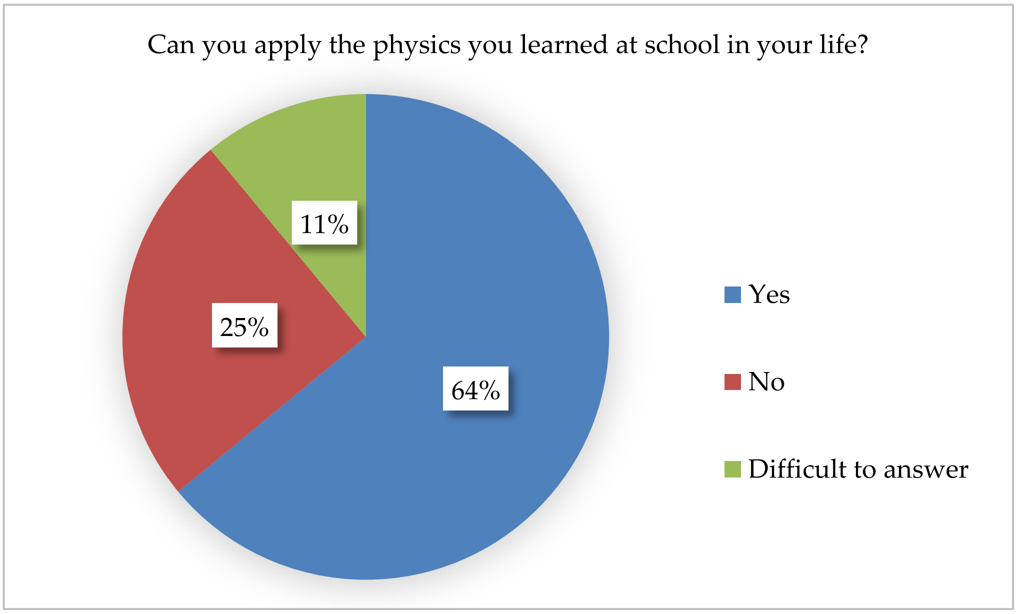


FIGURE 3. Students' survey results.

*64% of students in the PhBL group believed they could apply the physics knowledge they had learned to real-world situations.
*In contrast, 32% of students in the traditional group expressed similar confidence.

V. DISCUSSION

The effectiveness of textbooks in controlling students' knowledge remains central to modern educational frameworks. In this context, workbooks have proven to be valuable tools, facilitating not only student learning, but also enabling teachers to track individual progress and identify areas for improvement. Workbooks promote active student engagement, encouraging deeper understanding and fostering autonomy in the learning process. This active participation is crucial in ensuring that students can internalize knowledge rather than passively receiving it.

However, potential disadvantages must be acknowledged. Some students might perceive workbooks as mere assignments, focusing on completion rather than engaging with content. Moreover, the workbook format may not be suitable for every learning style, and certain students may face difficulties in adapting to this approach, especially in cases where the format is unfamiliar.

As highlighted by this study, the application of phenomenon-based learning can enhance the development of both cognitive and social learning processes, in line with theories of constructivism and experiential learning. These theories emphasize the importance of active learning and real-world applications, both of which are central to the PhBL methodology. However, the geographic limitations of the study, with its focus on a specific region and a relatively small sample size, mean that the findings may not be generalizable to other contexts. Future studies should consider incorporating a larger, more diverse sample, including both urban and rural schools, to expand our understanding of PhBL's broader applicability.

A critical area for future research involves assessing the long-term effects of PhBL. While this study demonstrated positive short-term outcomes, further longitudinal research is necessary to determine the sustained impact of PhBL on knowledge retention and student motivation over time. We also recognize that teacher training plays a crucial role in PhBL's success, and further exploration of the challenges teachers face, such as lack of preparation or resistance to new methods, is vital.

VI. CONCLUSION

Classical teaching methods are becoming increasingly outdated and less effective in the context of rapid growth of knowledge in the modern world. Therefore, it is imperative to adopt innovative teaching approaches to help students maintain a high pace of learning and development within the modern educational landscape. In this study, based on phenomenon-based learning, the positive effects of this approach on students' overall educational outcomes were demonstrated. The study was conducted in several high schools, with one group studying physics using traditional teaching methods, while another group was taught using phenomenon-based methods. The results from both groups were analyzed and yielded statistically reliable findings. The analysis showed that PhBL significantly enhanced students' understanding of physics and helped them retain these concepts in the long term. Additionally, PhBL-based instruction contributed to better student performance on exams such as the NUYET (Nazarbayev University Entrance Test, Nazarbayev University Foundation Program) and UNT (Unified National Testing), demonstrating the sustained retention of knowledge gained through this method. The positive impact on students' long-term learning and retention underscores the effectiveness of phenomenon-based learning.

Consequently, the development of a workbook specifically designed for phenomenon-oriented physics teaching has proven to be an essential tool for educators. It not only facilitates the formation of stable, foundational knowledge but also nurtures critical and analytical thinking skills key aspects of effective physics education at the high school level. This workbook helps teachers systematize their instruction and monitor the progress of their students more effectively. Proper use of such resources enables teachers to offer valuable feedback, engage students more fully in the learning process, and foster both their personal and academic growth. However, despite the many advantages of PhBL, it is crucial to consider the individual learning styles of students and adapt teaching and assessment methods accordingly to ensure that the approach is suitable for all learners.

Funding statement

This work was supported by the Ministry of Science and Higher Education of the Republic of Kazakhstan [Grant No. AP15473436].

Author contribution

All authors contributed equally to this paper. All authors have read and agreed to the published version of the manuscript. All authors confirm that their authorship complies with commonly acknowledged international criteria (every author had made a significant contribution to the development of the concept, conducting the research and preparing the article, read and approved the final version before publication).

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

Data are available from the authors upon request.

REFERENCES

1. Adaktylou, N. (**2020**). Remote sensing as a tool for phenomenon-based teaching and learning at the elementary school level: A case study for the urban heat island effect. *International Journal of Educational Methodology*, *6*(3), 517–532.
2. Zimmerman, B. J. (**1989**). A social cognitive view of self-regulated academic learning. *Journal of Educational Psychology*, *81*(3), 329–339.
3. Alsibani, A. A., & Eladl, A. A. (**2024**). New ranking system for higher education institutions in Oman as a tool for achieving SDGs. *Istanbul Journal of Social Sciences and Humanities*, *2*(2), 54–61.
4. Sahlberg, P. (**2015**). *Finnish lessons: The success story of school education reforms in Finland* (P. Petrov, Trans.). Classic-XXI: Moscow, Russia. (In Russian)
5. McDermott, L. C., Shaffer, P. S., & Constantinou, C. P. (**2000**). Preparing teachers to teach physics and physical science by inquiry. *Physics Education*, *35*(6), 411–416.
6. Demirci, N. (**2015**). Prospective high school physics teachers' beliefs about teaching practices: From traditionalist to constructivist. *Eurasia Journal of Mathematics, Science and Technology Education*, *11*, Article 1332.

7. Suastra, I. W., Jatmiko, B., Ristiati, N. P., & Yasmini, L. P. B. (**2017**). Developing characters based on local wisdom of Bali in teaching physics in senior high school. *Jurnal Pendidikan IPA Indonesia, 6*(2), 306.
8. Capel, S., Hayes, S., Katene, W., & Velija, P. (**2011**). The interaction of factors which influence secondary student physical education teachers' knowledge and development as teachers. *European Physical Education Review, 17*(2), 183–201.
9. Deng, Z. (**2001**). The distinction between key ideas in teaching school physics and key ideas in the discipline of physics. *Science Education, 85*(3), 263–278.
10. Henry, G. T., Fortner, C. K., & Bastian, K. C. (**2012**). The effects of experience and attrition for novice high-school science and mathematics teachers. *Science, 335*(6072), 1118–1121.
11. Smyth, D. M. (**1995**). First-year physical education teachers' perceptions of their workplace. *Journal of Teaching in Physical Education, 14*(2), 198–214.
12. Ma, C. (**2019**). Teaching strategies for effective connection between college physics and high school physics. *International Journal of Engineering Applications and Sciences Technology, 4*(3), 62–67.
13. Mukataeva, Z., Dinmukhamedova, A., Kabieva, S., Baidalinova, B., Khamzina, S., Zekenova, L., & Aizman, R. (**2022**). Comparative characteristics of developing morphofunctional features of schoolchildren from different climatic and geographical regions. *Journal of Pediatric Endocrinology and Metabolism, 36*(2), 158–166.
14. Hansson, L., Hansson, Ö., Juter, K., & Redfors, A. (**2020**). Curriculum emphases, mathematics, and teaching practices: Swedish upper-secondary physics teachers' views. *International Journal of Science and Mathematics Education, 19*(3), 499–515.
15. Tosa, S., & Qian, L. (**2014**). Comparison of U.S. and Chinese high-school physics teaching and the need for active learning at the college level. *Proceedings of the 12th Asia Pacific Physics Conference (APPC12)*, 1, 017002.
16. Guan, S., Li, G., & Fang, J. (**2022**). Optimization of 3D virtual reality technology in high school physics direct-type teaching. *Wireless Communications and Mobile Computing, 2022*, Article 8475594.
17. Retnawati, H., Arlinwibowo, J., Wulandari, N. F., & Pradani, R. G. (**2018**). Teachers' difficulties and strategies in physics teaching and learning that applying mathematics. *Journal of Baltic Science Education, 17*(2), 120–135.
18. Berdi, D., Niyazova, G., Bayterekova, N., Koshanova, G., & Usembayeva, I. (**2024**). Digital hygiene skills and cyberbullying reduction: A study among teenagers in Kazakhstan. *International Journal of Evaluation and Research in Education, 13*(6), 4170–4188.
19. Cottle, D. (**2024**). Exploring the experiences of undergraduate physics students taking a "Teaching Physics in School" module and the effects on their intentions to become a secondary physics teacher. *Journal of Physics: Conference Series, 2750*(1), 012038.
20. Yedilbayev, Y., Sarybayeva, A., Zharylgapova, D., Shektibayev, N., Usembayeva, I., & Kurbanbekov, B. (**2023**). Factors influencing future physics teachers' acceptance of information and communicative competence technologies: A survey study. *Cogent Education, 10*(1), Article 2212119.
21. Rushton, G. T., Rosengrant, D., Dewar, A., Shah, L., Ray, H. E., Sheppard, K., & Watanabe, L. (**2017**). Towards a high-quality high school workforce: A longitudinal, demographic analysis of U.S. public school physics teachers. *Physical Review Physics Education Research, 13*(2), Article 020122.
22. Trang, N. T., Khanh, L. Q., & Hong, D. T. (**2024**). How extra tuition affects students' learning? *Istanbul Journal of Social Sciences and Humanities, 2*(1), 51–64.
23. Dosymov, Y., Usembayeva, I., Polatuly, S., Ramankulov, S., Kurbanbekov, B., Mintassova, A., & Mussakhan, N. (**2023**). Effectiveness of computer modeling in the study of electrical circuits: Application and evaluation. *International Journal of Engineering Pedagogy, 13*(4), 93–112.
24. Ünal, C., & Özdemir, Ö. F. (**2013**). A physics laboratory course designed using problem-based learning for prospective physics teachers. *European Journal of Science and Mathematics Education, 1*(1), 29–33.
25. Hongyim, K., & Brunsell, E. (**2021**). Identifying teacher understanding of phenomena-based learning after professional development. *Journal of Physics: Conference Series, 1957*(1), 012039.
26. Yuliati, L. (**2018**). Exploration of physics problem-solving skills within phenomenon-based learning in senior high school students. *International Conference on Education, 4*, 97–103.
27. Jorgji, S., Davletova, A., Assylbekova, S., Susimenko, E., Kulikova, E., Kosov, M., Vlasova, E., Shcherbatykh, L., Saddhono, K., & Dudnik, O. (**2024**). A cross-cultural study of university students' e-learning adoption. *Emerging Science Journal, 8*(3), 1060–1074.
28. Prutko, A. S., Kudussov, A. S., Mussenova, E. K., & Kambarova, Zh. T. (**2020**). Development of the electronic physics textbook for students of secondary school. *Bulletin of Karaganda University, Physics Series, 100*(4), 87–94.
29. Cummings, K., French, T. A., & Cooney, P. (**2002**). Student textbook use in introductory physics. *Journal of Physics: Conference Series, 132–155*.
30. Resnita, L., Yulkifli, N., Abdullah, R., & Faradillah, N. (**2019**). Preliminary analysis of students' worksheet development using inquiry-based learning models with scientific approach for physics learning of senior high school class X. *Journal of Physics: Conference Series, 1317*(1), 012162.
31. Usman, E. A., & Asrizal, A. (**2020**). Results of validity and practicality test of ICT-science learning material with learning cycle model for improving digital literacy of students. *International Journal of Progressive Sciences and Technologies, 23*(2), 580–588.
32. Kambarbekova, A. A., & Ualikhanova, B. S. (**2024**). *Physics workbook: A tool for students of 10th grade*. Tszin Publishing House: Shymkent, Kazakhstan.