Advanced Physical Research
Vol.5, No.3, 2023, pp.207-218

IMPLEMENTING BLOOM'S TAXONOMY-BASED STANDARDS FOR ENHANCED PHYSICS TEACHING IN LYCEUMS: A NOVEL APPROACH

G. Sharifov*

Azerbaijan State Pedagogical University, Baku, Azerbaijan

Abstract. This study aimed to examine the effectiveness of the newly developed lyceum assessment standards in seventh-grade physics education. Based on Bloom's taxonomy, the lyceum assessment standards were developed and applied to evaluate the knowledge and skills of the students. A formative assessment was created based on the established sub-standards, and a self-assessment schedule was also developed. The study included 61 Baku European Lyceum and 107 Modern Educational Complex students in experimental and control groups. The experimental group was taught using new lyceum assessment standards, while the control group was taught traditionally. Following the experiment, both groups were given 30 dynamics-related physics tasks and scored out of 100.

The experimental group, which received new assessment standards-based teaching, outperformed the control group, which received traditional teaching. The experimental group averaged 81.4, while the control group averaged 65.8. The study also found that the self-assessment schedule helped students assess their knowledge and skills.

The new Bloom's taxonomy-based lyceum assessment standards assessed students' physics knowledge and skills well. This study suggests the criteria-based evaluation system can standardize lyceum natural science teaching. Lyceum assessment standards should be improved and implemented in Azerbaijan's physics education in other grades and subjects.

Keywords: *lyceum education, assessment standards, bloom's taxonomy, formative assessment, self-assessment, physics teaching*

****Corresponding Author:*** *Galib Sharifov, Azerbaijan State Pedagogical University, Baku, Azerbaijan, Phone: (+994 55) 513-17-73, e-mail: galibsharifov@gmail.com*

Received: *30 June 2023;* ***Accepted:*** *26 August 2023;* ***Published:*** *03 October 2023.*

1. Introduction

There are educational institutions around the world that operate similarly to lyceums in Azerbaijan but under different names: "magnet school" in America, "specialist school" in England, "Gymnasium" in Germany, "selective" in Australia, and "Lyceum" in France. The main goal of physics education in these lyceums is to provide students with a fundamental foundation for problem-solving and explaining physical phenomena (Lindgren *et al.*, 2016). Lyceums, where unique, talented, and capable students studied, were transformed into educational institutions that required specialized training for lyceum students to enter lyceums. However, the primary goal of lyceum subjects is to develop scientific thinking in students, instil more profound knowledge, form a complete picture of the world around them, and instil specific knowledge and skills in problematic situations. As a result, the impact of lyceum project work (Sharifov, 2020), deepening

How to cite (APA):
Sharifov, G. (2023). Implementing bloom's taxonomy-based standards for enhanced physics teaching in lyceums: A novel approach. *Advanced Physical Research, 5*(3), 207-218.

mathematical understanding (Sharifov, 2020a), explaining some physics misconceptions (Sharifov, 2021), and virtual experiments in deep mastering of some physics subjects (Sharifov, 2020c; Sharifov & MacIsaac, 2021; Sharifov, 2022) becomes critical for their implementation. Furthermore, using the 7E model as an example, it is appropriate to provide an innovative teaching technique for basic solid-state physics features in lyceums (Sharifov, 2019). It should be noted that these institutions assess in different ways. Lyceums, on the other hand, require systematic criteria-based evaluation. Natural science education in secondary schools can be standardized by changing the content and structure of national science (Mambetakunov & Mambetakunov, 2019). It was also discovered that problem-solving abilities indicate practical knowledge (Rustaman *et al.*, 2018; Palisoa *et al.*, 2020).

Criteria-based evaluation can help determine the degree of conformity between the student's goals and the results obtained. Besides, this evaluation solves problems by organizing individual and group work in class and creating a psychologically comfortable educational environment to motivate the student (Black & Wiliam, 1998; Black & Harrison, 2004; Gioka, 2006; Eber & Parker, 2007). Furthermore, criteria-based evaluation technology has been used to control, instruct, educate, diagnose, and inspire students' knowledge (Comparative Analysis of Assessment, 2019). Criteria-based assessments have proven to be effective in developed countries. Many developed countries' evaluation systems for lyceums and schools are based on IB, IGCSE and AP Physics. Magnet schools in America use IB and AP physics systems, and in the United Kingdom use the IGCSE system (Haliciolu, 2008; Visser, 2010; Mayer, 2010; MacKenzie, 2010; Stillisano *et al.*, 2011; Lee *et al.*, 2012, Syllabus, 2017; AP Physics 1, 2017; Sonny & Bill, 2020). Table 1 shows the criteria-based assessment directions for those systems.

Table 1. Criteria-based-assessment directions for IB, IGCSE and AP Physics

IGCSE	IB Physics	AP Physics
1. Knowledge and understandings	1. Knowledge and comprehension	1. Modelling
2. Handling information and problem solving	2. Inquiry and design	2. Mathematical Routines
3. Experimental skills and investigations	3. Evaluation and processing,	3. Scientific Questioning
	4. Scientific impact	4. Experimental Methods
		5. Data Analysis
		6. Argumentation
		7. Making Connections

According to curriculum standards, assessment should assess not only students' knowledge but also their practical skills. The physics content standards in Azerbaijan's assessment concept were approved in 2009. They outlined the specific knowledge and activities to be mastered. The knowledge component explains what is taught, whereas the activity component describes how this will be demonstrated. The content of physics education is presented as a standard. These standards shape the overall learning outcomes that students are expected to achieve in terms of a subject's capabilities. Each standard must contain content (knowledge) as well as activities (skills). The subject matter and nature of the skills taught are specified in these standards. Each of these standards has sub-standards. Sub-standards, which serve as the basis for determining training objectives, simplify complex ideas by reducing complexity. Different classes have different sub-standards. As an example, in 7th grade, as follows (Ismayilov, 2019):

1. Physical phenomena, rules, and regularities - content line.

1.1. Demonstrate knowledge and competence in the area of physical phenomena - the content standard.

1.1.1 Interpretation of thermal and electromagnetic (electrical) phenomena and their causes - sub-standard.

The learning outcomes for each subject in secondary school physics obtain a methodological manual. Learning outcomes were compiled from sub-standards to assess student's knowledge during the lesson. Each learning outcome grades on four different levels. The other type of assessment is self-assessment that used in various foreign countries. Panadero, a Spanish researcher, developed his typology for self-evaluation by combining five distinct taxonomies (Panadero & Romero, 2014; Panadero *et al.*, 2013; Panadero *et al.*, 2016a; Panadero *et al.*, 2016b).

Considering the education of students with talents, standards for lyceum should be improved to accurately measure their knowledge and activity based on Bloom's taxonomy through IB, IGCSE, and AP physics. As a result, this article examines the newly developed lyceum standards and the effectiveness of their implementation in the context of seventh grade.

2. Material and methods

Initially, physics teaching problems in lyceums were analysed, and as a result, factor analysis was performed using the SPSS program (Sharifov, 2022a). According to the research carried out, modern problems of physical training in lyceums were classified into four groups:

- Problems related to the content of physics;
- Problems of creating motivation from physics;
- Problems with the professional competencies of physics teachers;
- Problems with methods and methods used in physics training.

In order to solve these problem, lyceum assessment standards were developed in some directions in accordance with Bloom's taxonomy. Table 2 describes the evaluation directions available for lyceum physics teaching. Thus, L-standards cover lower intellectual level assessments, while H-standards cover higher intellectual level assessments. Both standards have joint activities, meaning they can be used at lower and upper levels. The numbers in brackets next to the instructions represent the number of sub-standards. A formative assessment was developed as an analytical rubric based on the newly established lyceum sub-standards

Table 2. Proposed assessment model for lyceums.

Type of standards	Bloom taxanomy levels	Actions
L-standards	I (Knowledge), II (Comprehension)	sign (2), quantity (2), cause (2), feature (6),connecting (8)
	III (Application)	modeling (5), solving task(5), practice (4), data processing (3), reasoning (6), connecting (6), life and technology (4)
H-standards	IV (Analysis) V (Synthesis) VI (Evaluation)	

Table 3. New rubric assessment for topic of “Description of mechanical motion” for 7th lyceum students

TOPIC	Description of mechanical motion	
Standards	Bloom taxonomy	Sub-standards
L-standards	I.Knowledge	L.I.1.1. Student lists the signs of physical objects or physical phenomena on the subject
	II.Comprehension	L.II.2.2. Student distinguishes the quantities that characterize physical objects or physical phenomena on the subject
	III.Application	L.III.7.1. Student applies the knowledge and skills acquired on the topic to explain the cause of the occurrence of natural phenomena
K-standards	IV.Analysis	H.IV.2.2. Student schematically describes physics tasks on the topic
	V.Synthesis	H.V.5.2. Student makes a reasoning based on the evidence obtained during the explanation of events on the topic
	VI.Evaluation	H. VI. 6. 6. Student justifies the characteristic information on the topic

ASSESSMENT				
Learning oucomes	*I level*	*II level*	*III level*	*IV level*
The Student lists the signs of physical objects or physical phenomena on the description of mechanical motion	The Student is not able to list the signs of physical objects or physical phenomena on the description of mechanical motion	The Student partly lists the signs of physical objects or physical phenomena on the description of mechanical motion	The Student basically lists the signs of physical objects or physical phenomena on the description of mechanical motion	The Student fully lists the signs of physical objects or physical phenomena on the description of mechanical motion
The Student distinguishes quantities characterizing physical objects or physical phenomena regarding the description of mechanical motion	The Student is not able to distinguish quantities characterizing physical objects or physical phenomena regarding the description of mechanical motion	The Student partly distinguishes quantities characterizing physical objects or physical phenomena regarding the description of mechanical motion	The Student basically distinguishes quantities characterizing physical objects or physical phenomena regarding the description of mechanical motion	The Student fully distinguishes quantities characterizing physical objects or physical phenomena regarding the description of mechanical motion
Student applies the knowledge and skills acquired on the description of mechanical motion to explain the cause of the occurrence of natural phenomena	Student is not able to apply the knowledge and skills acquired on the description of mechanical motion to explain the cause of the occurrence of natural phenomena	Student basically applies the knowledge and skills acquired on the description of mechanical motion to explain the cause of the occurrence of natural phenomena	Student partly applies the knowledge and skills acquired on the description of mechanical motion to explain the cause of the occurrence of natural phenomena	Student fully applies the knowledge and skills acquired on the description of mechanical motion to explain the cause of the occurrence of natural phenomena
Student schematically describes physics tasks on the description of mechanical motion	Student is not able schematically to describe physics tasks on the description of mechanical motion	Student basically schematically describes physics tasks on the description of mechanical motion	Student partly schematically describes physics tasks on the description of mechanical motion	Student fully schematically describes physics tasks on the description of mechanical motion

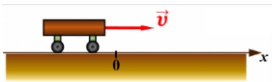
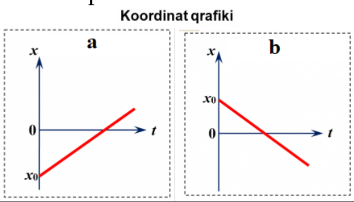
Student makes a reasoning based on the evidence obtained during the explanation of events on the description of mechanical motion	Student is not able to make a reasoning based on the evidence obtained during the explanation of events on the description of mechanical motion	Student basically makes a reasoning based on the evidence obtained during the explanation of events on the description of mechanical motion	Student partly makes a reasoning based on the evidence obtained during the explanation of events on the description of mechanical motion	Student fully makes a reasoning based on the evidence obtained during the explanation of events on the description of mechanical motion
Student justifies the characteristic information on the description of mechanical motion	Student is not able to justify the characteristic information on the description of mechanical motion	Student partly justifies the characteristic information on the description of mechanical motion	Student basically justifies the characteristic information on the description of mechanical motion	Student fully justifies the characteristic information on the description of mechanical motion mechanical motion

As an example, "L.III.3.1. In the sub-standard" using devices or equipment on the subject "L - the upper level of intelligence, III - the third stage of the Blum taxonomy" implementation "stage, 3 - the direction of activity" conducting experiments", 1 - the first sub-standard of the direction" conducting experiments" can be demonstrated. Instead of the word "on the subject" from the same standard, the subject of the lesson is written. The negation sentence for the first level is added to the adverbs "partially", "mainly", and "whole" in accordance with the verbs from the other three levels.

According to the Table 2, rubric assessment for topic of “Description of mechanical motion” for 7th lyceum students was prepared (Table 3).

In addition, a four-level self-assessment schedule for this topic was created (Table 4).

Table 4. Self-evaluation rubric for the topic of "1.1. A description of the mechanical motion" for 7th grade in lyceum.

№	Questions	I know			
		Very weak	Weak	Good	Best
1	Can I analyze the sign of a mechanical motion on a graph?				
2	The movement of the trolley is shown in the picture.  Can I represent mechanical motion with graphs? 				

This study included 61 seventh-grade (experimental – 30, control - 31) students from the Baku European Lyceum and 107 seventh-grade (experimental – 54, control - 53) students from the Modern Educational Complex. These students were divided into experimental (84 students) and control groups (84 students). Firstly, the experimental and control groups were evaluated using pre-tests, and it was determined that there were no substantial differences between them.

Previously, during teaching dynamics topics, students' knowledge and skills were evaluated in these groups using Tables 2, and 3. Representatives from both groups were given 30 physics tasks related to Dynamics at the end of the experiments. All of the tasks were scored up to 100.

The study was conducted with the approval of the principals of the Baku European Lyceum and the Modern Educational Complex. Informed consent was obtained from the students and their parents or guardians before their participation in the study. The students were informed about the purpose of the study, the procedures involved, and the voluntary nature of their participation. They were also assured of the confidentiality and anonymity of their responses.

Additionally, the study followed ethical guidelines in data collection, analysis, and reporting. The data collected was kept confidential and anonymous, and the participants' identities were not revealed in any of the reports. The results were presented objectively and without bias, and any potential conflicts of interest were disclosed.

Moreover, the study ensured that the experimental group and control group were given equal opportunities for learning and assessment. The new lyceum assessment standards were only applied to the experimental group, while the control group received traditional teaching methods. The study aims to improve teaching practices and not disadvantaged any students.

3. Results

As a result, the indicators of 84 students in the experimental group improved (M=60.1, SD=7.9) in seventh grade when compared to the indicators of 84 students in the control group (M=50.4, SD=7.95) (p=0.00) (Table 5 and 6).

Table 5. Groups statistics for 7th grades.

Groups	N	Mean	Std. Deviation	Std. Error Mean
Control	84	50,3631	7.95785	0.86827
Experimental	84	60,1369	7.92105	0.86426

Figure 2 depicts boxplots that show the overall performance of students. In the seventh grade, an examination of the experimental and control groups' results revealed that the experimental group's minimum value for a correct test answer increased. Furthermore, 50% of the points scored by students in the experimental group were distributed more densely and at a greater interval in the control group than in the experimental group in seventh grade.

Table 6. Independent t-test results for VII grade

	Levene's Test for Equality of Variances		t-test for Equality of Means						
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
Equal variances assumed	,137	,712	-7,978	166	,000	-9,77	1,23	-12,19	-7,36
Equal variances not assumed			-7,978	166	,000	-9,77	1,23	-12,19	-7,36

Students points are assigned based on five criteria: 1. Fail 30-40 points; 2. Poor 40-50 points; 3. Average 50-60 points; 4. Good 60-70 points; 5. Excellent above 70 points. As seen in Table 7, 84 people participated in the 7th-grade control group, with the majority (40.5%) having "average" points. When other criteria are considered, 13.1% of those in the 7th-grade control group showed "fail" results, 35.7% showed "poor" results, and 10.7% showed "good" results. There were no "excellent" results in this group. However, most "good" effects (39.3%) are observed in the experimental group. According to Table 7, "poor" results account for 14.3%, "average" outcomes account for 35.7%, and "excellent" effects account for 10.7%. In this group, there were no failures.

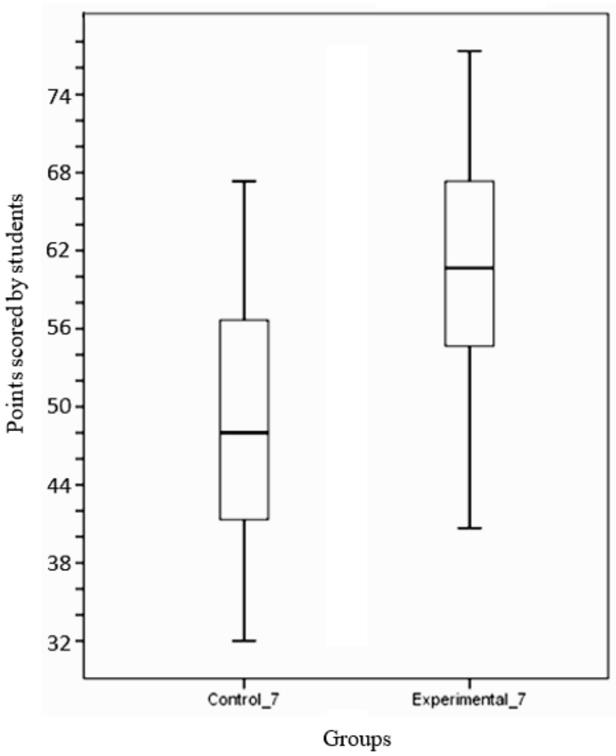


Fig. 2. Boxplot for the results of Control and Experimental groups

Table 7. Results of the 7th grade

	7th grade control group		7th grade experimental group	
	Frequency	Percent	Frequency	Percent
Fail (30-40 points)	11	13,1	12	14,3
Poor (40-50 points)	30	35,7	30	35,7
Average (50-60 points)	34	40,5	33	39,3
Good (60-70 points)	9	10,7	9	10,7
Total	84	100,0	84	100,0

Table 8. Kolmogorov-Smirnov test results

		Percentage of acquisition based on points (VII grade)	Self-assessment point (VII grade)
N		84	84
Normal Parameters	Mean	60,14	6,24
	Std. Deviation	7,92	2,42
Most Extreme Differences	Absolute	0,077	0,065
	Positive	0,072	0,062
	Negative	-0,077	-0,065
Test Statistic		0,077	0,065
Asymp. Sig. (2-tailed)		0,200	0,200

Following these experiments, the correlation between the self-assessment test results and the acquisition percentage based on the points of seventh-grade experimental group participants was examined. The results were analyzed using SPSS. The normal distribution of the numbers in these two columns of variables was first discussed. When the distribution is normal, we use the Pearson correlation; otherwise, are using the Spearman correlation (Gogtay & Thatte, 2017). The Kolmogorov-Smirnov test was used to confirm the normal distribution (Table 8). The p-value for each of the two variables was 0.200, according to the test statistics. Because it exceeds 0.05, the null hypothesis cannot be rejected, indicating that the database has a normal distribution. The Pearson correlation between these two variables was then calculated.

Table 9. Pearson correlation

		Percentage of acquisition based on points (VII grade)	Self-assessment point (VII grade)
Percentage of acquisition based on points (VII grade)	Pearson Correlation	1	0,863
	Sig. (2-tailed)		0,000
	N	84	84
Self-assessment point (VII grade)	Pearson Correlation	0,863	1
	Sig. (2-tailed)	0,000	
	N	84	84

Table 9 demonstrates a strong positive correlation between the seventh and eighth grades (r(84) = 0.863). This correlation was found to be valid (p =.000). It also demonstrates how proper implementation of newly developed standards for lyceums students' self-confidence.

4. Discussion

Effective teaching of physics requires a comprehensive approach that takes into account the different learning styles and abilities of students. Various question types, such as multiple-choice, short-answer, true-false, matching, and essays, can help students improve their critical thinking skills. However, open-ended qualitative and quantitative physics tasks are crucial in developing essential physics thinking abilities. These types of tasks require students to make inferences and draw conclusions about their surroundings (Pradana & Suyatna, 2017).

The established standards of the model are based on Bloom's taxonomy through IB, IGCSE, and AP physics, which is an integral part of the systematic system of teaching physics in lyceums. These standards have contributed to the growth of lyceum students' in-depth knowledge and skills in physics and their ability to think logically, critically, and creatively about a specific physics problem. Unlike Azerbaijan's current curriculum standards, this model provides a transparent assessment of the student's knowledge and practical skills in modelling, problem-solving, experimenting, data processing, reasoning, and technology integration.

The findings of educational experiments support previous results (Kearney, 2013). It was determined that the selected didactic material for lyceums is accessible to all students and allows them to develop their knowledge and abilities that meet the regulatory document's requirements. Research studies have shown that students who are aware of this fact can better evaluate information, identify relevant information, and interpret data to solve problems.

The use of Bloom's taxonomy in the model for teaching physics in lyceums is critical in promoting a deep understanding of physics concepts. This approach involves six levels of thinking, which include remembering, understanding, applying, analyzing, evaluating, and creating. The first three levels focus on the acquisition and understanding of information, while the last three levels focus on the application and synthesis of information.

The first level, remembering, involves recalling information that has been previously learned. This level can be assessed using multiple-choice questions, which require students to recall facts and concepts. The second level, understanding, involves interpreting and explaining the meaning of information. This level can be assessed using short-answer questions, which require students to explain the meaning of a concept or idea.

The third level, applying, involves using information in a new context. This level can be assessed using true-false questions, which require students to apply concepts to new situations. The fourth level, analyzing, involves breaking down information into its component parts and understanding how they relate to each other. This level can be assessed using matching questions, which require students to match concepts with their definitions.

The fifth level, evaluating, involves making judgments about the quality of information. This level can be assessed using essay questions, which require students to evaluate a concept or idea based on evidence. The sixth level, creating, involves synthesizing information to create something new. This level can be assessed using open-ended tasks, which require students to apply their knowledge and skills to solve a complex problem. According to a few research studies, students aware of this fact can better evaluate information, identify relevant information, and interpret data to solve problems (Loes *et al*., 2015; Wylie & Neeley, 2016; Romli *et al.*, 2018).

The qualitative element in this research is evident in the detailed description of the experimental and control groups' performance, as well as the interpretation of the results.

The study reports the improvement in the experimental group's indicators, which is supported by statistical analysis. The use of boxplots to show the overall performance of students and the comparison of the experimental and control group's minimum values for correct test answers provides a visual representation of the data, enhancing the interpretation of the results.

Furthermore, the study provides a detailed description of the distribution of points scored by students in both the experimental and control groups, based on the criteria for assigning points. The description of the percentage of students in each category provides an understanding of the distribution of results in both groups.

Finally, the study reports the correlation between the self-assessment test results and the acquisition percentage based on the points of seventh-grade experimental group participants, and the interpretation of the results suggests a strong positive correlation between the seventh and eighth grades, which validates the newly developed standards for lyceum students' self-confidence.

An alternative explanation worth noting is that the study's findings carry significant implications for enhancing both the teaching and assessment practices in physics education across Azerbaijan. By utilizing the newly developed lyceum assessment standards, which are grounded in Bloom's taxonomy, the teaching of natural sciences in lyceums can be standardized while also promoting a comfortable learning environment for students. Therefore, it is highly recommended that these assessment standards be further refined and integrated into physics education for other grades and subjects in Azerbaijan.

4. Conclusion

In conclusion, the model for teaching physics in lyceums, which is based on Bloom's taxonomy through IB, IGCSE, and AP physics, is an effective approach to promote deep understanding and critical thinking skills in students. This approach involves different question types that assess various levels of thinking. Open-ended qualitative and quantitative physics tasks are crucial in developing essential physics thinking abilities. The use of this model can provide a transparent assessment of the student's knowledge and practical skills in physics and prepare them for future academic and professional pursuits.

Acknowledgement

The author wishes to express his gratitude to the principals of the Baku European Lyceum and the Modern Educational Complex, where he taught physics for many years, for allowing him to conduct experiments. He would also like to thank his master's student, Gulhane Abdulkerimova, for organizing the survey and questionnaire at the Baku European Lyceum.

References

AP Physics 1: Algebra-Based Course and Exam Description. College Board 2017, 130

Black, P., Harrison, C. (2004). *Science Inside the Black Box: Assessment for learning in the science classroom*. London: NFER Nelson.

Blackş, P., Wiliam, D. (1998). Assessment and classroom learning. *Assess Education,* 5, 7-75.

Comparative Analysis of Assessment in the IB Middle Years Programme and the UK GCSE UK NARIC, *The National Recognition Information Centre for the United Kingdom, May 2019*.

Eber, P.A., Parker, T.S. (2007). Assessing student learning: applying bloom's taxonomy. *Human Service Education*, 27, 26-35.

Gioka, O. (2006). Assessment for learning in physics investigations: Assessment criteria, questions and feedback in marking. *Physics Education*, 41, 342.

Gogtay, N.J., Thatte, U.M. (2017). Principles of correlation analysis. *Journal of the Association of Physicians of India*, 65, 78-81.

Haliciolu, M. (2008). The IB diploma programme in national schools: the case of Turkey. *International Journal* of *Educational Research*, *7,* 164-183.

Ismayilov, I.N. (2019). *Modern problems of physics teaching methodology*. ADPU-publishing house. Baku, 378.

Kearney, S. (2013). Improving engagement: the use of 'Authentic self-and peer-assessment for learning' to enhance the student learning experience. *Assessment & Evaluation in Higher Education*, 38, 875-891.

Lee, M., Hallinger, P. & Walker, A. (2012). Leadership challenges in international schools in the Asia Pacific Region: evidence from programme implementation of the international baccalaureate. *International Journal* of *Leadership* in *Education,* 15, 289-310.

Lindgren, R., Tscholl, M., Wang, S. & Johnson, E. (2016). Enhancing learning and engagement through embodied interaction within a mixed reality simulation. *Computers and Education,* 95, 174–87.

Loes, C.N., Salisbury, M.H. & Pascarella, E.T. (2015). Student perceptions of effective instruction and the development of critical thinking: A replication and extension. *Higher Education,* 69, 823-838.

MacKenzie, P. (2010). School choice in an international context. *International Journal of Educational Research,* 9, 107-123.

Mambetakunov, E., Mambetakunov, U. (2019). Standardization of natural and scientific education in secondary school. *Advanced Physical Research*, 1, 105-110.

Mayer, A.P. (2010). Factors influencing the implementation of an international baccalaureate diploma program in a diverse urban high school. *Journal* of *Advanced Academics*, 22, 78-105.

Palisoa, N., Tahya, D. & Kayadoe, V. (2020). Students misconception identification of chemical candidates teachers using three tier test method in the basic concept of chemical bond. *Journal of Science Education*, 1, 37–43.

Panadero, E., Alonso-Tapia, J. & Reche, E. (2013). Rubrics vs. self-assessment scripts effect on self-regulation, performance and self-efficacy in pre-service teachers. *Studies in Education Evaluation,* 39, 125-132.

Panadero, E., Brown, G.L., Strijbos, J.W. (2016a). The future of student self-assessment: a review of known unknowns and potential directions. *Educational Psychology Review*, 28, 803-830.

Panadero, E., Jonsson, A. & Strijbos, J. (2016b). Scaffolding self-regulated learning through self-assessment and peer assessment: guidelines for classroom implementation, in assessment for learning: meeting the challenge of implementation, eds D. Laveault and L. Allal (New York, NY: Springer), 311-326.

Panadero, E., Romero, M. (2014). To rubric or not to rubric? The effects of self-assessment on self-regulation, performance and self-efficacy. *Assessment in Education*, 21, 133-148.

Pradana, F.A., Suyatna, A. (2017). The needs of interactive electronic school books to enhance the critical thinking skills of the students. *Advances in Social Science, Education and Humanities Research*, 158, 446-454.

Romli, S., Abdurrahman, A. & Riyadi, B. (2018). Designing students' worksheet based on open-ended approach to foster students' creative thinking skills. *Journal of Physics: Conference Series,* 948, 1-6.

Rustaman, N.Y., Afianti, E. & Maryati, S. (2018). STEM based learning to facilitate middle school students' conceptual change, creativity and collaboration in organization of living system topic. *Journal of Physics: Conference Series*, 1013, 012021.

Sharifov, G. (2022). The effect of virtual laboratory use on VII grade students' understanding of physics concepts in the lyceum. *International Journal on Technical and Physical Problems of Engineering*, 1, 190-195.

Sharifov, G., MacIsaac, D. (2021). Effectiveness of a simulated thermodynamics lab in a grade eight lyceum class. *Jurnal Pendidikan Fisika Indonesia,* 17, 133-140.

Sharifov, G. (2022a). The peculiarities of the concept and methodological system of physics training in lyceums. *Azerbaijan Journal of Educational Studies,* 701, 35–50.

Sharifov, G.M. (2020). The double superior mirage in a specialized school. *Physics Education,* 55, 035003.

Sharifov, G.M. (2020a). The effectiveness of Head-to-tail method in solving challenging physics tasks. *Jurnal Pendidikan Fisika Indonesia*, 16, 132-139.

Sharifov, G.M. (2020c). The effectiveness of using a virtual laboratory in the teaching of electromagnetic in the lyceum. *Physics Education*, 55, 065011.

Sharifov, G.M. (2021). The misconceptions about the interpretation of light bulb resistance in specialized school. *Revista Mexicana de Física E*, 18, 90-96.

Sharifov, G.M. (2019). Interactive teaching method of solid – state physics in lyceums. *Advanced Physical Reseach*, 1, 52–60

Sonny, M., Bill, T. AP Physics 2. Course and Exam Description. College Board, 2020, 246.

Stillisano, J.R., Waxman, H.C., Hostrup J and Rollins KB (2011). Case studies of eight Texas schools implementing International Baccalaureate programs. *Journal of Ethnographic & Qualitative Research,* 5, 171-185.

Syllabus Cambridge IGCSE™ Physics 0625, 2017.

Visser, W. (2010). CSR 2.0: *From the Age of Greed to the Age of Responsibility. In Reframing Corporate Social Responsibility*: Lessons from the Global Financial Crisis, Sun, W. et al. (eds.). Bingley: Emerald.

Wylie, C., Neeley, K. (2016). Learning Out Loud (LOL): How Comics Can Develop the Communication and Critical Thinking Abilities of Engineering Students. In *Proceedings of the 2016 ASEE Annual Conference.*