BIS EDUCATION

Volume 1 2025 | DOI: 10.31603/bised.153
6th Borobudur International Symposium on Humanities and Social Science (BIS-HSS) 2024

UNIMMA PRESS
UNIVERSITAS MUHAMMADIYAH MAGELANG

Improving critical thinking skills in learning temperature and its changes with the problem-based learning with argumentation model

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Abstract

This study investigates the effectiveness of the Problem-Based Learning with Argumentation (PBLA) model in enhancing students' critical thinking skills, specifically concerning the topic of temperature and its changes. Recognizing critical thinking as a crucial 21st-century skill, this quasi-experimental research employed a pretest-posttest control group design. The study was conducted during the 2022/2023 academic year at a junior high school in Wates Kulon Progo, Yogyakarta. One class served as the experimental group, receiving instruction through the PBLA model, while the control group was taught using the Discovery Learning model. Critical thinking skills were assessed using validated tests; these tests underwent validation by experts in education and evaluation, science education, and certified science teachers, followed by empirical validation through trials. The findings indicate that the experimental class, utilizing the PBLA model, demonstrated a higher average gain score in critical thinking skills (0.62) compared to the control class (0.48).

Keywords

Critical thinking skills, Learning temperature, Problem-based learning, Argumentation model

Published:
April 15, 2025

Selection and Peer-review under the responsibility of the 6th BIS-HSS 2024 Committee

Introduction

Life in the 21st century requires everyone to have the skills to develop themselves for the development of an era of globalization full of innovation. These skills are described in four categories, namely thinking skills, skills to work, skills to use work tools, and skills to live [1]. More specifically 21St The Century Partnership Learning Framework (P21) formulates a number of skills that must be possessed in the 21st century, including critical thinking and problem-solving skills, creative thinking and innovation skills, collaboration skills, communication skills, literacy skills, and contextual learning skills [2]. These skills, especially critical thinking skills, can be learned from an early age to

students in school and become the preferred instructional learning objectives. Students must be accustomed to thinking critically from an early age. Therefore, critical thinking skills need to be practiced and habituated in learning at school to prepare for future life.

However, it is not easy to teach critical thinking skills in schools. In addition to teachers who are reluctant to invite students to think critically in the learning process and even tend to limit students' questions, a number of students are also considered to be less enthusiastic about learning; learning focuses on information transfer that only requires low-level thinking skills, namely memorization; the large number of curriculum burdens that are completed; a large number of administrative tasks; not knowing how to teach critical thinking skills; teachers are less creative in creating learning conditions with daily experiences outside the classroom; and finally teacher-centered learning. Outside of school, the community sometimes considers students' critical thinking as a form of protest.

The results of the initial ability test of thinking skills referring to the Bloom Taxonomy with the indicators of analyzing (C4), evaluating (C5), and creating (C6) on solid expansion material at one of the junior high schools in Kulon Progo, DIY, Indonesia showed low results. The acquisition of this critical thinking skills test strengthens the suspicion that more broadly the critical thinking skills of students have not been encouraging. The results of this test were then supported by the observation that the critical thinking skills of students at the school were still low. This can be seen from the symptoms that can be observed in students such as: (1) students can work on problems that are academic applicative with the help of mathematics but once faced with problems related to daily life that require analysis and evaluation, students experience confusion; (2) Some students are passive when doing work that is a group activity; and (3) some students have difficulty arguing when expressing their opinions.

This low critical thinking skill is also evidenced by several studies such as research conducted by [3] in Malang, [4] in Pontianak, and [5] in Surakarta. This low critical thinking skill is also shown by the test results conducted by the Programme for International Student Assessment (PISA). Research conducted by PISA and taken every three years to test science literacy that is closely related to higher-level thinking skills shows that Indonesia is ranked 62nd out of 69 countries in 2015, 71st out of 79 countries, and 69th out of 75 participating countries in 2021. This shows that Indonesian students have not been trained to think at a high level so that the PISA test results still put Indonesia in a low position and in general are still below the average score of the Organization for Economic, Cooperation and Development (OECD) [6].

Low critical thinking skills are a problem in education. Therefore, this low critical thinking skill must be immediately sought for a solution to be improved. This improvement in critical thinking skills is indispensable because critical thinking skills have strategic value in life [5]. Students who have critical thinking skills are able to respond to complex problems from various perspectives, are able to solve problems with specific goals, are

able to analyze ideas based on existing facts, and are able to draw conclusions and solve problems systematically based on correct arguments [7].

This critical thinking skill can be practiced with various learning models, one of which is the Problem Based Learning with Argumentation (PBLA) model. The PBLA model is the result of an intervention model of the Problem Based Learning (PBL) model with arguments. Argumentation is a serious attempt to convince or prove the truth of a statement, idea, attitude, belief, or action to the listener or audience concerned that a statement, idea, attitude, belief, or action is correct. Argumentation aims to influence the audience so that the audience believes in a statement, id, attitude, keyness or action taken. The PBLA syntax is arranged in five phases, namely (1) identifying problems and orienting, (2) organizing and investigating, (3) building arguments, (4) argumentation sessions, and (5) evaluating and reflecting [7]. The purpose of developing this PBLA model is to train critical thinking skills to the maximum. Therefore, this PBLA model is also useful for accelerating the training of students' critical thinking skills.

This PBLA model has gone through a feasibility test through weak experiments and has been declared feasible to improve critical thinking skills, but has not been compared to other models that have the function of improving students' critical thinking skills. Therefore, in this follow-up research, another model that is able to improve critical thinking skills is needed to be compared to the PBLA model. The focus of this study is to test whether the use of the Problem Based Learning with Argumentation (PBLA) model is effective in improving students' critical thinking skills.

Method

This study is a quasi-experiment with a pretest-posttest control group design. The research was carried out by applying the PBLA model in the experimental class while in the control class, the researcher applied the discovery learning model. Both classes are first given a pretest before being treated with a learning model, and after completing the treatment, they are given a posttest. The results of the pretest-posttest are assessed based on the assessment rubric and then analyzed statistically. The data was analyzed using SPPS 23.0 for Windows to determine the results of pretest-posttest descriptive analysis, normality test with one sample Kolmogorov-Smirnov and homogeneity test with Levene test, ANCOVA test, n-gain calculation with its interpretation [8]. Meanwhile, the effect size test was carried out by interpretation according to Hedges (1981), Cohen (1988), and Glass (1976), [5].

Population and sample

The population of this study is junior high school students in Wates Kulon Progo, Special Region of Yogyakarta. The sample used in this study is grade VII students in the even semester of the 2022/2023 academic year which totals 64 students. Sampling was carried out purposively based on the data from the results of the initial ability test of critical thinking skills. A total of 32 students were in the experimental class using the

PBLA model and 32 other students were in the control class using the discovery learning model used by the school's teachers.

Data collections and analysis

The research data was obtained using a critical thinking skills test which was compiled based on three indicators of Bloom's critical thinking skills that had been revised by Krathwohl (2002) which included analyzing (C4), evaluating (C5), and creating (C6) [9], [10]. This critical thinking skills test has been validated by science educators, media experts, and science teachers who are certified educators and through empirical validation that shows that the instrument is valid and reliable [7]. The data analysis of this study used covariate analysis (Ancova) which was preceded by a normality test and a sample homogeneity test.

Results

Descriptive analysis of pretest-posttest scores of critical thinking skills

The results of the descriptive analysis of the pretest-posttest scores of critical thinking skills are presented in Table 1.

Table 1. Results of descriptive analysis of pretest-posttest scores of critical thinking skills

Types of tests	Class	Number of students	Min score	Max score	Mean	Std
Pretest	Experiment	32	36.85	69.89	45.28	6.87
	Control	32	36.85	66.46	46.89	7.39
Posttest	Experiment	32	60.32	92.52	80.76	7.99
	Control	32	51.27	89.03	73.09	10.36

Table 1 presents the descriptive analysis results for critical thinking skills both before and after the intervention. The pretest scores for the experimental and control groups were very similar, with means of 45.28 and 46.89, respectively. This indicates that both groups possessed nearly identical baseline critical thinking abilities at the outset of the study. In contrast, a substantial difference emerged in the mean posttest scores between the two groups. The experimental group achieved a posttest score of 80.76, notably higher than the control group's score of 73.09.

This study hypothesizes a significant difference in critical thinking skills between students taught using the PBLA model and those taught via conventional methods employed by teachers at the school. To validate this hypothesis, preliminary analyses were conducted. Normality was assessed using the Kolmogorov-Smirnov test, while homogeneity of variances was evaluated using Levene's test. A summary of the results from both the normality and homogeneity tests is provided in Table 2.

Table 2. The results of the normality test and the data homogeneity test of critical thinking skills

Group of data	Normality		Homogeneity	
	N	Sig.	Levene test	Sig.
Pretest	64	0.443	0.521	0.453
Posttest	64	0.306	0.743	0.236

Table 2 confirms that the prerequisites for parametric testing were satisfied, as evidenced by the normal distribution of the data and the homogeneity of variances, with all significance values for both normality and homogeneity tests found to be greater than 0.05.

The findings from the ANCOVA analysis of the critical thinking skills assessment, which investigated the influence of the learning model, are summarized in Table 3. Additionally, Table 4 presents the calculated effect sizes for these analyses.

Table 3. Summary of Ancova results

Source	Sum of Squares	Df	Mean Square	F	Sig.
Corrected model	3481.159a	2	1832.415	25.674	.000
Intercept	1798.617	1	1798.617	25.012	.000
Class	812.254	1	812.254	11.325	.001
Pretest	26872.523	1	26872.523	39.562	.000
Error	4020.873	62	64.853		.000
Total		65			
Corrected total		64			

a. R Squared = .435 (Adjusted R Squared = .412)

The covariance analysis yielded a significant result, with an F-statistic of 39.562 and a p-value of 0.001. This statistical significance ($p < 0.05$) led to the rejection of the null hypothesis and the acceptance of the research hypothesis. Consequently, it is concluded that the Problem-Based Learning Approach (PBLA) model, when implemented in the experimental class, demonstrated superior efficacy in fostering students' critical thinking skills. The observed disparity in outcomes between the two tested classes confirms the positive influence of the PBLA model on the enhancement of critical thinking abilities among junior high school students. The precise level of this effectiveness will be further determined through an effect size test.

Table 4. Summary of effect size test results

Class	Mean	Std.	Cogen's d	Hedge's g	Glass's	Interpretation
Experiment	0.532	0.112	0.678	0.682	0.562	Keep
Control	0.498	0.099				

Based on Table 4, information was obtained that the use of the PBLA model had a great effect on improving students' critical thinking skills. This is shown from the results of the size effect test according to Cohen of 0.678, Hedges of 0.682, and Glass of 0.562.

Results of score analysis gain pretest-posttest critical thinking skills

To determine the improvement in critical thinking skills concerning the topic of temperature and its changes, gain scores were calculated from the pretest and posttest results. A summary of the mean gain scores obtained from the critical thinking skills assessment is presented in Table 5.

Table 5 shows that the average gain score of the experimental class showed a result of 0.59 and the control class showed a result of 0.48. This shows that the average gain score of the experiment class is higher compared to the average gain score of the control class.

Table 5. Summary of the results of the analysis of the average gain score of the results of the critical thinking skills test

Class	Average gain score	Criterion
Experiment	0.59	Keep
Control	0.48	Keep

Discussion

The study's findings indicate that the Problem-Based Learning Approach (PBLA) exerts a positive influence on enhancing students' critical thinking skills. This effect was substantiated by both independent samples t-tests and effect size analyses. Specifically, the ANCOVA test revealed a significant impact of the PBLA model on the improvement of critical thinking skills, with an F-covariance value of 39.652 and a significance level of 0.001. Furthermore, the initial effect size assessment indicated a medium criterion. The effectiveness level of the PBLA model in fostering critical thinking, as evidenced by the effect size calculated from the n-gain score, demonstrates that the developed learning model positively influences students' critical thinking performance. This is further supported by effect size results based on Cohen's equation (0.678), Hedges' g (0.682), and Glass's delta (562). These effect size values represent the magnitude of the treatment's impact on the variables under investigation [11].

The change in the scores of students' critical thinking skills from pretest to posttest taught using PBLA was much higher than the learning usually carried out by teachers. This is suspected to be caused by PBLA's syntactic activities consisting of (1) identifying problems and orienting, (2) organizing and investigating, (3) building arguments, (4) argumentation sessions, and (5) evaluating and reflecting. The syntax of a learning model is a general guide that describes the overall sequence of flows through a sequence of steps that are generally followed by a series of learning activities [13]. The learning syntax will clearly show what activities need to be done by teachers and students, the order of these activities, and also the special tasks that need to be done by students in accordance with the instructional goals that will be achieved in learning. So, syntax in learning has the meaning of steps that must be passed in the learning process with a mandatory approach in the form of a scientific approach such as observing, questioning/gathering information/trying / experimenting, analyzing data / associating, and communicating. Therefore, the implementation of the syntax of the learning model must be sequential, and must not be randomized.

The PBLA model syntax is designed to improve students' critical thinking skills to the maximum by supporting a number of learning theories to train critical thinking skills. Because learning theory is an important aspect in the development of learning models. Like a house building, learning theory plays a role as the foundation that underlies the learning process. Learning theories that support the preparation of PBLA syntax include cognitive learning theory, constructivist learning theory, behavioral learning theory, and motivation theory.

Cognitive learning theory states that each different individual will build a different understanding. Teachers must look at individual differences and get different results. Therefore, a teacher plays a role in helping students learn new information by connecting it with previously known concepts [12]. Cognitive constructivist theory explains that individuals have a natural tendency to seek understanding when interacting with the environment. When there is interaction between students and teachers or other students, there will be cognitive conflicts so that according to Piaget, the students will find solutions by reconstructing their knowledge structure [13]. Behavioral learning theory emphasizes behavior change from students as an acquisition from experience due to the interaction between stimulus and response. Certain responses or behaviors can arise due to the existence of a learning model that is a stimulus [14].

Motivation theory emphasizes attention, relevance, confidence, and satisfaction (ARCS) to arouse curiosity and interest in learning. In learning, attention aims to increase attention to learning materials and also to create an interesting learning process. This is usually done by introducing the initial objective, showing concrete and visually appealing examples, and using various elements of the learning medium. Relevance aims to connect the subject matter with students' daily experiences so that students' motivation will be maintained if they consider what they are learning to be a necessity. This can be done such as conveying the learning object explicitly as expected, and providing an alternative solution to a problem. Attention and relevance are evident in the first phase of identifying and orienting the problem, and the second phase of organizing and investigating [15].

Confidence aims to increase students' confidence in the material studied. Things that teachers can do such as arranging learning materials in order from easy to difficult, giving statements about the appreciation that will be given if students can answer questions that cause other students to dare to answer the next questions, and this is done in the first phase of the PBLA model, namely identifying problems and orienting [16]. Satisfaction aims to provide satisfaction to students with the material that has been learned. This can be done by teachers such as giving attractive gifts and also verbal praise, providing explanations if there is learning material that is poorly understood or students are not right in understanding it, and repeating the lessons that have been carried out, especially related to new concepts. This satisfaction is carried out in the fifth phase of the PBLA model, namely evaluating and reflecting.

PBLA has the advantage of training critical thinking skills to the maximum for students. This advantage lies in the phase of building arguments. Argumentation is a verbal, rational and social activity to convince a criticism that is sometimes followed by questions and closely related to critical thinking because it refers to a series of decision-making (claims) accompanied by data, evidence, support, qualifications, and rebuttals [18], An argumentative impulse to anticipate dissent, given the inherently selfish human tendency [19]. The function of building an argument is to draw a claim or conclusion

after the students carry out the stages of organizing and investigating by conducting experiments to obtain data. To claim or conclude in addition to obtaining data, it must be through warrant with support, qualification, and rebuttal [7].

The claims that have been prepared by students must be validated and evaluated through discussion activities in the argumentation session. In this phase, one group conveys the results of experiments and conclusions made through agreement, then is responded to by other groups. From the results of these observations, the discussion develops and is discussed to find answers together by giving each other's opinions with their respective arguments, then filtered to get a common understanding and become a common conclusion of the theme discussed. The teacher's task in this argumentation session phase is to keep the discussion focused and flowing and try to provide experience to students who are able to encourage critical thinking and social development. In detail, the tasks are, first, becoming an expert. When students argue that the goal is to solve problems in a lesson, then the teacher can play the role of an expert who knows more than students. Second, leading the argument session, even though it can actually be handed over to students who are able. However, it should be noted that the role of this leader is very important because it greatly determines the success or failure of argumentation in the learning area [20][21]. Therefore, the person who leads the argumentation session should be a teacher.

For example, a group of students conducts an expansion experiment on a liquid substance obtained. To obtain data as shown in Table 6, students conducted an experiment "Effect of Substance Type on Changes in Liquid Volume".

Table 6. The results of the observation experiment of the influence of substance type on changes in liquid volume.

N	Time (Minutes)	Boiling flask	
		A	B
		Water level in capillary pipes (cm)	Cooking oil surface on capillary pipe (cm)
1	0	5.0	5.0
2	2	5.0	5.5
3	4	5.1	6.1
4	6	5.3	7.3
5	8	5.5	9.3
5	10	5.8	10.5

By looking at the data in Table 6, we can actually draw a conclusion, namely that there is a difference in volume of the two heated liquids which is characterized by an increase in the liquid substance in the capillaries. This means that there is an influence of liquid substances on volume changes in the expansion process. However, in drawing these conclusions, critical thinking skills have not been used to the maximum, because they do not include the cause of the change in volume when the liquid is heated.

With the PBLA model, Table 6 can be explained in more detail, namely through the phase of building arguments as shown in Figure 1 [7].

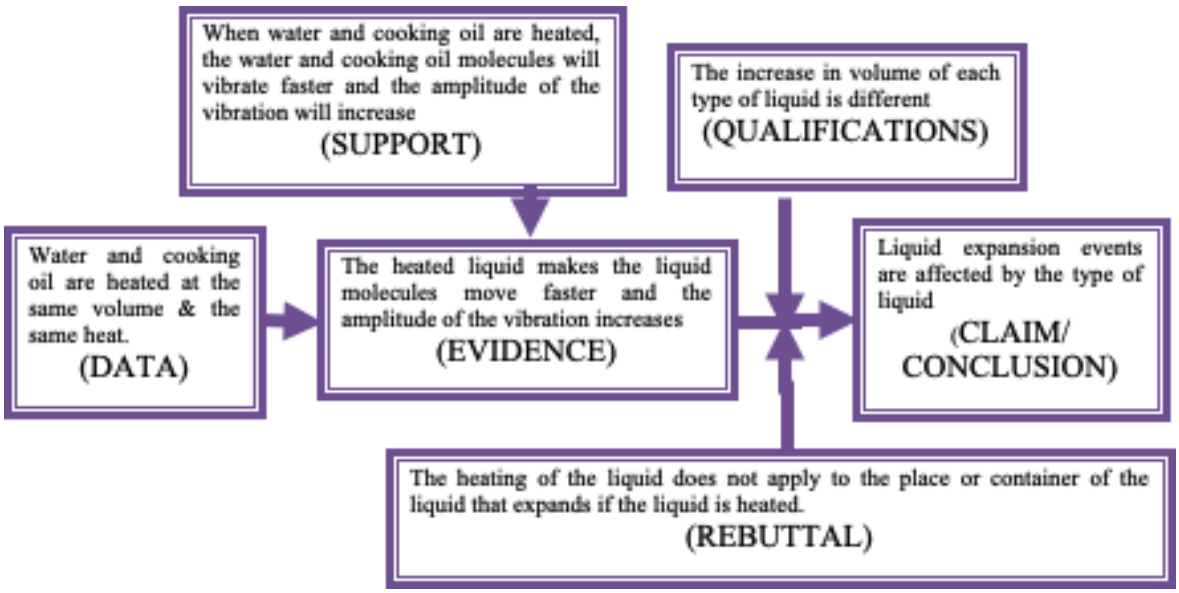

Figure 1. Building arguments on liquid expansion events.

First, there is data that a glass filled with water and cooking oil with the same volume if heated with the same heat and the same time, the volume becomes different. Second, this is evidenced by the data obtained as shown in Table 6. Third, the data and evidence need to be supported by the concept of heating liquids, namely the heated liquid, the molecules of the liquid move faster and the amplitude of the vibration increases. Fourth, the qualification that arises is the magnitude of the increase in the volume of the liquid substance depending on the type of liquid. Fifth, the rebuttal that occurs is that the heating of the liquid does not apply to the place or container of the liquid that expands if the liquid is heated. Therefore, the place of the liquid substance must be in a condition where the volume does not change when the liquid substance is heated. Sixth, claiming or inferring, the event of a change in the volume of a liquid substance is influenced by the type of liquid substance itself.

The effectiveness of the PBLA model on temperature materials and its changes in activities to improve critical thinking skills is also supported by the results of observation of teacher and student activities during the learning process. The observation results of the application of the PBLA model syntax went well. This shows that the PBLA model is proven to be effective for improving critical thinking skills on temperature matter and its changes. However, the improvement of critical thinking skills in students also involves such as psychological character, intelligence, and the learning environment. Therefore, to improve critical thinking skills, teachers need to design and develop appropriate learning media. Teachers are also required to have good classroom management skills in order to achieve effectiveness and flexibility in learning, and must also inform the next subject matter and follow the order of lessons from easy to difficult [23][24]. Flexibility in classroom management provides opportunities for students to think outside the box and try different approaches and feel in the learning process [25]. Thus, in accordance with the purpose of developing the learning model, the PBLA model has the advantage of training critical thinking skills to the maximum.

Conclusion

This study concludes that the Problem-Based Learning Approach (PBLA) model, when applied to the topic of temperature and its changes, effectively enhances students' critical thinking skills. This effectiveness is supported by the ANCOVA test, which showed a significant influence of the PBLA model on critical thinking improvement ($F = 39.562$, $p = 0.001$). The effect size was categorized as medium. Furthermore, the PBLA group exhibited a higher average gain score (0.59) compared to the control class (0.48), with this gain falling within the medium criteria for critical thinking skills. Consequently, all facets of critical thinking, including analyzing, evaluating, and creating, can be improved through PBLA-based learning activities.

The scope of this research was confined to the topic of temperature and its changes, delivered to 9th-grade junior high school students. Future investigations could extend this research by applying the PBLA model to diverse subject matter, different educational levels, or even other academic disciplines beyond science. Additionally, this study primarily focused on PBLA's effectiveness in developing critical thinking. Subsequent research should explore how the PBLA model can be integrated with other learning activities to foster broader 4C skills (critical thinking and problem-solving, creative thinking and innovation, collaboration, and communication) and 21st-century life skills.

Acknowledgments

The author would like to thank Muhammadiyah University of Purworejo and SMP Negeri 5 Wates for providing the author with the opportunity to conduct research as stated in the Joint Memorandum of Understanding NOMOR: 128/FKIP/KER/II.3.AU/F/2020; NOMOR: 420/67/2020.

References

[1] T. Blyznyuk, "Formation of Teachers' Digital Competence: Domestic Challenges and Foreign Experience," J. Vasyl Stefanyk Precarpathian Natl. Univ., vol. 5, no. 1, pp. 40–46, 2019, doi: 10.15330/jpnu.5.1.40-46.

[2] B. Thornhill-Miller et al., "Creativity, Critical Thinking, Communication, and Collaboration: Assessment, Certification, and Promotion of 21st Century Skills for the Future of Work and Education," J. Intell., vol. 11, no. 3, 2023, doi: 10.3390/jintelligence11030054.

[3] S. Mahanal, S. Zubaidah, A. Bahri, and M. S. Dinnurriya, "Improving students' critical thinking skills through Remap NHT in biology classroom," Asia-Pacific Forum Sci. Learn. Teach., vol. 17, no. 2, pp. 1–19, 2016.

[4] H. Hairida, "The effectiveness using inquiry based natural science module with authentic assessment to improve the critical thinking and inquiry skills of junior high school students," J. Pendidik. IPA Indones., vol. 5, no. 2, pp. 209–215, 2016, doi: 10.15294/jpii.v5i2.7681.

[5] A. C. Saputri, Sajidan, Y. Rinanto, Afandi, and N. M. Prasetyanti, "Improving students' critical thinking skills in cell-metabolism learning using Stimulating Higher Order Thinking Skills model," Int. J. Instr., vol. 12, no. 1, pp. 327–342, 2019, doi: 10.29333/iji.2019.12122a.

[6] OECD, Education at a glance 2023 - Slovenia. 2023. [Online]. Available: https://gpseducation.oecd.org/Content/EAGCountryNotes/EAG2023_CN_SVN_pdf.pdf

[7] R. W. Akhdinirwanto, R. Agustini, and B. Jatmiko, "Problem-based learning with argumentation as a hypothetical model to increase the critical thinking skills for junior high school students," J. Pendidik. IPA Indones., vol. 9, no. 3, pp. 340–350, 2020, doi: 10.15294/jpii.v9i3.19282.
[8] R. R. Hake, "Analyzing change/gain scores," Unpubl. URL http//www. physics. indiana. edu/\~ sdi/AnalyzingChange-Gain. pdf, vol. 16, no. 7, pp. 1073–80, 1999, [Online]. Available: http://www.ncbi.nlm.nih.gov/pubmed/22025883%5Cnhttp://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:ANALYZING+CHANGE/GAIN+SCORES#0%5Cnhttp://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:Analyzing+change/gain+scores#0
[9] T. Practice and R. Bloom, "A Revision of Bloom ' s Taxonomy : An Overview David R . Krathwohl," ReVision, vol. 41, no. 4, pp. 212–218, 2008.
[10] S. Nurmatova and M. Altun, "A Comprehensive Review of Bloom's Taxonomy Integration to Enhancing Novice EFL Educators' Pedagogical Impact," Arab World English J., vol. 14, no. 3, pp. 380–388, 2023, doi: 10.24093/awej/vol14no3.24.
[11] G. M. Sullivan and R. Feinn, "Using Effect Size—or Why the P Value Is Not Enough ," J. Grad. Med. Educ., vol. 4, no. 3, pp. 279–282, 2012, doi: 10.4300/jgme-d-12-00156.1.
[12] W. M. Reynolds and G. E. Miller, "Educational Psychology: Contemporary Perspectives," Handb. Psychol. Second Ed., no. November, 2012, doi: 10.1002/9781118133880.hop207001.
[13] R. I. Arends, Learning to Teach. 9th ed. 2012. [Online]. Available: http://onlinelibrary.wiley.com/doi/10.1002/cbdv.200490137/abstract
[14] P. C. Holland, "Cognitive versus stimulus-response theories of learning," Learn. Behav., vol. 36, no. 3, pp. 227–241, 2008, doi: 10.3758/LB.36.3.227.
[15] P. Peciuliauskiene, "School Students' Motivation for Learning Physics: How Does Instructional Clarity in Physics Lessons Engage?," Soc. Integr. Educ. Proc. Int. Sci. Conf., vol. 1, pp. 486–496, 2022, doi: 10.17770/sie2022vol1.6815.
[16] R. M. D. Guido, "Attitude and Motivation towards Learning Physics," vol. 2, no. 11, pp. 2087–2094, 2018, [Online]. Available: http://arxiv.org/abs/1805.02293
[17] F. H. van E. & R. Grootendorst, "A Systematic Theory of Argumentation. The Pragma-Dialectical Approach," J. Pragmat., vol. 37, no. 4, pp. 577–583, 2005, doi: 10.1016/j.pragma.2004.07.003.
[18] M. O. Samuel Kwofie, "Proceedings of the 19," no. January, pp. 387–397, 2011.
[19] R. P. Ferretti and S. Graham, "Argumentative writing: theory, assessment, and instruction," Read. Writ., vol. 32, no. 6, pp. 1345–1357, 2019, doi: 10.1007/s11145-019-09950-x.
[20] W. E. Cashin, "IDEA PAPER # 49 -- techniques for discussion," no. 15, pp. 1–5, 2011.
[21] I. A. G. Wilkinson, "Discussion methods," no. April, 2016.
[22] K. H. D. Tang, "Student-centered Approach in Teaching and Learning: What Does It Really Mean?," Acta Pedagog. Asiana, vol. 2, no. 2, pp. 72–83, 2023, doi: 10.53623/apga.v2i2.218.
[23] E. Thanheiser and K. Melhuish, "Teaching routines and student-centered mathematics instruction: The essential role of conferring to understand student thinking and reasoning," J. Math. Behav., vol. 70, no. January, p. 101032, 2023, doi: 10.1016/j.jmathb.2023.101032.
[24] N. İ. Azizoğlu and A. Okur, "The impact of education tailored for critical listening on the critical listening skills of seventh-grade students," South African J. Educ., vol. 43, no. 4, pp. 1–11, 2023, doi: 10.15700/saje.v43n4a2158.
[25] K. D. Vattøy and K. Smith, "Students' perceptions of teachers' feedback practice in teaching English as a foreign language," Teach. Teach. Educ., vol. 85, no. July 2019, pp. 260–268, 2019, doi: 10.1016/j.tate.2019.06.024.