Current STEAM and Education Research
Volume 2, Issue 3, December 2024

DOI: doi.org/10.58797/cser.020301

The Effect *of Blended Learning-Based Problem-Based Learning* on the Critical Thinking Ability of High School Students in Physics Subjects

Yuyun Lasmiati, Fitria Herliana[a)], Muhammad Syukri, Musdar, Nurul Wati Abdul Hamid

Department of Physics Education, Faculty of Teacher Training and Education, Universitas Syiah Kuala, Jl. Teuku Nyak Arief No.441, Aceh 23111, Indonesia

Email: [a)]fitriaherliana@usk.ac.id

Abstract

Based on the demands of 21st century ability, it is hoped that students can master critical thinking skills, especially in physics learning, considering that physics is one of the parts of science learning that cannot be separated from the ability to think critically in solving phenomena in the universe. This research is a type of quasi-experimental research that aims to see the influence of the Blended Learning-based Problem Based Learning model on students' critical thinking skills. The approach used is a quantitative approach. The research population is students of class XI MIPA SMA Negeri Unggul Subulussalam with class XI MIPA 3 as the experimental class and class XI MIPA 4 as the control class. The instruments used are test instruments, questionnaire instruments, observation instruments, and interview instruments. Based on the results of the t-test, a tcount value of 9.1493 was obtained with a ttable of 1.6735 which means that there is a significant difference between the experimental class taught using the PBL Learning model based on blended learning and the control class taught using the PBL learning model only. From the results of data analysis and discussion, it can be concluded that the blended learning based PBL learning model is one of the learning models that is able to improve the critical thinking skills of students at SMA Negeri Unggul Subulussalam

Keywords: blended learning, critical thinking skills, problem based learning

Received: 3 December 2024
Revised: 21 December 2024
Accepted: 21 December 2024
Published: 30 December 2024
Assigned: 30 December 2024

Current Steam and Education Research
e-ISSN: 3025-8529

INTRODUCTION

The development of increasingly sophisticated technology in the current era of globalization requires the world of education to always adjust technological developments to its use in the

learning process. With the sophistication of technology that has opened wider access to information and knowledge such as online learning resources, e-bookand platform Digital education allows students and gutu to access learning materials from anywhere, and anytime. In line with the opinion (Mexhuani, 2024) who said that digital technology in the context of education is an important tool in the learning process. This includes the ability to access learning resources and support learning activities, including in completing tasks.

According to Rentzou (2021) Based on the demands of 21st century ability, it is hoped that students can master the ability to communicate (Communication), collaborate (Collaborative), critical thinking (Critical Thinking) and creativity (Creativity). One of the demands of the 21st century such as the ability to think critically is very important for students to master, especially in learning physics, considering that physics is one of the parts of science learning that cannot be separated from the ability to think critically in solving phenomena in the universe.

From the results of observations and interviews with one of the teachers at SMA Negeri Unggul Subulussalam City, it shows that the learning process is still not optimal in improving students' critical thinking skills. Based on the results of the critical thinking ability test, it was found that 60% of students still have low critical thinking skills. This low critical thinking ability is caused by several factors such as some students who still tend to rely on memorization methods, as well as teaching methods that are still limited to lectures due to limited learning media and limited learning time in class. These factors can ultimately hinder students' ability to think critically. This is in accordance with the results of previous research which explained that the lack of critical thinking skills is caused by the use of technology that is not optimal in the learning process so that it only causes memorization and the learning process becomes passive because the methods used do not vary (Kabataş Memiş & Çakan Akkaş, 2020; Toker & Baturay, 2021; Sermeus et al., 2021; Lee et al., 2021). According to Supriyadi et al. (2024) almost 70% of students' critical thinking skills in Aceh are still low. This is caused by several factors, including the lack of student activity in the learning process, students also still tend to be passive and do not participate much during learning and teaching methods that do not vary.

This critical thinking ability is very important for students to have, so it needs to be developed in the learning process and one of the ways to develop it is to apply a model/approach that is in accordance with the material in the learning process. Based on the results of previous research, it is known that one of the learning models that can be used to improve students' critical thinking skills is the Problem Based Learning (PBL). In the application of the PBL model, students will work in groups to collect information and solve problems given by teachers (Andersen et al., 2022; Crespí et al., 2022; Pimdee et al., 2024;) However, according to research Kennedy and Gruber (2020) and Feng et al. (2023) stated that PBL learning is a learning model that has not been effective in improving students' critical thinking skills. Due to limited time during the learning process, students also still have difficulty accessing learning resources, and students who still rely on other friends when discussing. Likewise, online-based PBL learning is also still ineffective, this is caused by the lack of effective role of teachers during the learning process, students who are still passive during the

learning process, students do not focus on learning, and limited interaction between students and teachers. Thus, various innovative learning approaches that can be accessed to support the learning process using PBL are urgently needed. As stated by Lazarinis et al. (2024) that one of the innovations in learning approaches in the field of education that is in accordance with the demands of the current times is blended learning.

In line with this opinion, according to Sala et al. (2024) blended learning It is a comprehensive new breakthrough in the world of education by trying to use the advantages of face-to-face learning, distance learning and independent learning. However, as the times evolve into the digital era blended learning has improved by incorporating web-based learning, Streaming video, video communication Synchronous and Asynchronous with traditional "face-to-face" learning (Krishnan, 2021). So that PBL learning with the approach blended learning is an excellent choice to be developed in the world of education, with the existence of blended learning Therefore, the interaction between students and teachers can still be maintained through face-to-face meetings and remote meetings. This not only increases student engagement, but also encourages active participation in the learning process.

This study aims to determine the influence of Blended Learning-based Problem Based Learning on the critical thinking ability of high school students in physics subjects.

METHOD

This research is a type of quasi-experimental research and the design used is Non equivalent Control Group Design. The design involved two groups of subjects where one group received treatment, while one group acted as a control group. But both groups underwent the pretest and posttest stages as part of the data collection process. The sample in this study was taken using a purposive sampling technique with the characteristics of students having mobile phones, dominant students who are active and have a fairly high curiosity. Based on these characteristics, two classes consisting of 28 students were taken. Each class is given different treatment during learning activities in the classroom.

This research was carried out by conducting three stages of research. Each stage of the research is as follows: (1) Data collection, at this stage is carried out by giving a pretest to students before being treated and giving a posttest after being treated, then taking data based on the values that have been obtained based on the results of the test, (2) Analyzing data, at this stage the data that has been obtained is analyzed whether it is in accordance with theory or not, (3) Interpreting the data, at this stage the data that has been analyzed is then interpreted so that conclusions can be drawn. This research was carried out on the even day of the 2023/2024 school year for two weeks which coincided with the learning of the Sound Wave subject at SMA Negeri Unggul Subulussalam.

The research instruments in this study are test instruments, questionnaires, observations, and interviews. The data of this study was obtained based on the results of the pretest and posttest scores obtained by students during sound wave learning. After the data is collected, the data is

analyzed using descriptive analysis to describe the raw data (quantitative) into a form that is easier to understand (descriptive).

RESULTS AND DISCUSSION

Data were obtained from two classes, namely, class XI MIPA 3 as an experimental class using the PBL-based model blended learning and class XI MIPA 4 as a control class using the PBL model. The purpose of conducting the initial test (pretest) is to see the initial ability of students before being treated. While the purpose of conducting the final test (posttest) is to see how the PBL-based model affects blended learning on the critical thinking skills of students of SMA Negeri Unggul Subulussalam. Improving students' critical thinking skills before and after learning can be obtained by the N-gain test. The N-gain obtained by students in the experimental class and the control class as a whole can be seen in the following Table 1.

Table 1. N-gain Experimental Class and Control Class

	Class	
Category	**Experiment**	**Control**
Tall g 0,7≥	5	0
Keep 0.3 g < 0.7≤	20	13
Low g 0,3<	3	15
Total	28	28
Average N-gain	0,53	0,26

In Table 1 above, it can be seen that in the N-gain experimental class with 5 students obtained an increase in the high category, 20 students obtained an increase in the medium category, 3 students obtained an increase in the low category, and the average N-gain for the experimental class was 0.53 with the medium category. Meanwhile, in the control class, there were no students who were included in the increase in the high category, but in the medium category obtained by 13 students, the low category was obtained by 15 students and the average N-gain for the control class was 0.26 with the low category.

Based on the calculation of the data, the results were obtained that the two samples were normally distributed. The results of the calculation of the experimental class are based on the significance level of 5% ($\alpha = 0.05$), then LTabel = 0.1665. Since the L Table is< 0.0411 0.1665 and 0.0616 0.1665, both receive H<<$_0$ and it can be concluded that the sample comes from a normally distributed population. While the calculation results obtained in the control class are because the L<$_{Table}$ is 0.0256 0.1665 and 0.0688 0.1665, both receive H<<$_0$ and it can be concluded that the sample comes from a normally distributed population

After the two research samples were declared to be normally distributed, the homogeneity value was then calculated. Based on the data obtained $F_{Calculate} < F_{Table}$ which is 1.1686 1.9048, then it is accepted $H < 0$ and it is stated that there is no difference in variance between the experimental class and the control class, so that it can be concluded that the two variances are homogeneous for *the pretest* value. As for the *posttest* value $F_{, calculate} < F_{Table}$ is 1.1623 4.1959 so that it can be concluded that both homogeneous variances for <*posttest values can be* concluded. Furthermore, based on the calculation of the t-test (*independent sample t-test*), it can be seen that the *posttest* tcount value is 9.1463 with a significance level of α = 0.05, and df = 54 obtained ttable = 1.6735. Because of the calculation of the table t>, H0 is rejected and Ha is accepted, so it can be concluded that there is a significant difference between the two variables compared.

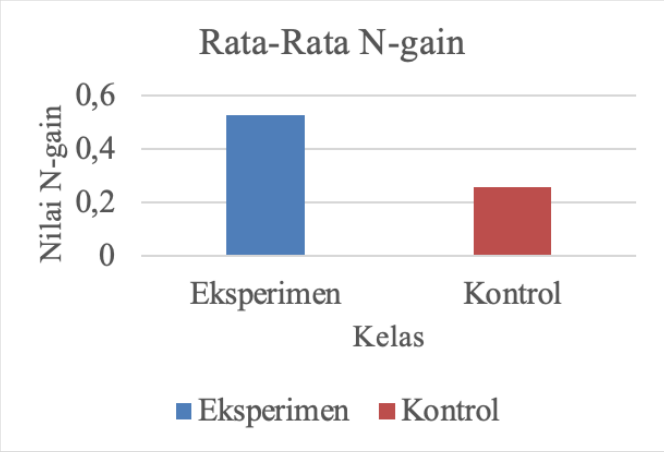

Figure 1. Average N-gain Per Class Diagram

From the results of the t-test, it can be seen that the pretest and posttest scores of the two classes have significant differences. This is also in line with the N-gain results obtained based on Figure 1 above. Where the n-gain value of the experimental class was 0.53 with the medium category and in the control class the n-gain value was 0.26 with the low category. Based on the n-gain score, it can be compared that the improvement of students' critical thinking skills with the application of PBL learning treatment based on blended learning is higher than that of students who receive treatment with the PBL learning model without blended learning. From the results of observations during the learning process, it is known that 5 students who received high grades were students who followed the PBL stage based on blended learning appropriately. Judging from the first syntax stage, the orientation of students to the problem of the teacher instructs students to formulate problems together with group friends related to the problems given, this activity is carried out by students before entering the learning hours in the classroom. The second syntax stage is the organization of students to learn, where after students formulate the problem, the teacher instructs students to answer questions available on the web related to the problem being discussed. This activity is also

carried out by students before entering the classroom learning hours. Then the third syntax stage guides individual and group investigations, the teacher instructs and guides each group to carry out practicum in accordance with the directions on the website so that students are able to obtain relevant data. This activity is carried out in the classroom during learning hours.

Furthermore, the syntax stage develops and presents the results of the work, after students carry out practicum and analyze data, each group presents the results by answering questions on the web and presenting them in class. And in the fifth syntax stage analyzes and evaluates the problem-solving process, at this stage the teacher provides input and directs students to conclude the results obtained from the learning that has been carried out. From the results of the interview, students also said that with this applied learning, students feel not bored and students also have a lot of time to practice their thinking skills. This is in accordance with the statement Carsky et al. (2022) that critical thinking skills can be improved, but not acquired instantly. The improvement of students' critical thinking skills will occur with the use of the right learning model, so learning must support the development of critical thinking skills. This is also in line with research from Olmedo-Torre et al. (2020) that the PBL model is based on blended learning Student-oriented is able to increase students' involvement in the learning process by providing opportunities for them to think critically and understand the material through group collaboration and investigation of real problems.

Meanwhile, students who get scores in the medium and low categories are students who do not take part in the PBL-based stage blended learning precisely. For example, students must be stimulated first by the teacher to ask teachers/friends when there are things they do not understand, students are not active in group discussions, students do not participate in practicum and are not on time in collecting the assignments given in websites. This is supported by the results of the interview which said that students still like not being on time in submitting assignments due to the density of activities at school, group friends who are not agile in completing assignments and also group friends who do not participate in completing assignments/only rely on other group friends. As stated by Lopez-Gazpio (2021) that the application of the PBL-based learning model blended learning making students more directed in the group discussion process. If students follow the stages properly and correctly, then students can understand and solve every problem, and students are also easy to receive knowledge.

If critical thinking skills are calculated based on critical thinking aspects, (I) Giving basic explanations, (II) Building basic skills, (III) Conclusions, (IV) Giving further explanations, and (V) Applying strategies and tactics can be seen in the following Figure 2.

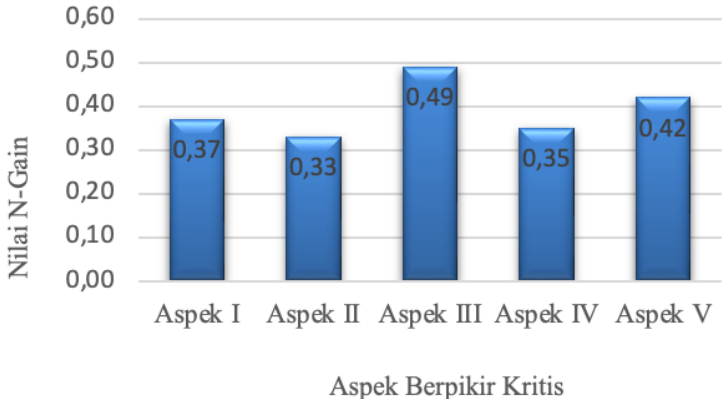

Figure 2. N-gain Value Diagram Peraspect

Based on figure 2 above, it can be seen that there is an increase in each aspect, such as in the aspect of giving a basic explanation increased by 0.37 with the medium category. The observation results show that the students' ability to increase in this aspect is because students are able to provide an appropriate question and answer related to sound propagation and students are able to mention the difference in events related to the phenomenon of the Doppler effect. This is also in accordance with the statement of Chen et al. (2024) that PBL with the approach *blended learning* proven to be effective in improving students' critical thinking skills, especially in producing strong arguments.

In the aspect of building basic skills, it increased by 0.33 with the medium category. The results of the observation show that the students' ability to increase in this aspect is because students are able to consider the credibility of the information presented related to the phenomenon of the Doppler effect, students are able to give reasons for answering a question from the information presented related to sound power and students observe and consider the results of information related to strings. In line with research Lin et al. (2021) who said that group discussions of students will help them remember the material discussed better than just receiving explanations from the teacher. In addition, through discussion, understanding, knowledge, and thinking skills of students can be further improved.

Furthermore, the aspect concluded that an increase of 0.49 was obtained with the medium category. This is supported by the results of observations that show that the increase in students' abilities in this aspect is because students are able to induce and reduce which considers the results through logical conditions related to sound frequency limits, students are also able to conclude correctly related to the rapid propagation of sound from several substances. Saha Roy et al. (2021) It also says that after identifying the relationships between the information and finding related patterns, the next step is to draw conclusions both collectively in groups and individuals.

Then the fourth aspect gave further explanation to get an increase, namely 0.35 with the medium category. This is supported by the results of observations that increase the ability of students in this aspect because students are able to identify assumptions and make assumptions related to sound rate, students can build their arguments regarding the wavelength of the string, students can determine the right arguments regarding the threshold limit of human hearing, and students are able to give their arguments appropriately regarding the loudness of sound. This is also in accordance with the research conducted by Bijsmans and Versluis (2020) states that problem-based learning models that use the *blended learning* present challenges that stimulate students' minds and logic towards the topic being studied, while encouraging them to broaden their horizons through interactions such as discussion and exchange of ideas. Thus, the use of a problem-based learning model with an approach to *blended learning* has a positive impact on students' critical thinking skills

The fifth aspect of implementing strategies and tactics has increased by 0.42 with the medium category. This is supported by the results of observations that increase the ability of students in this aspect because students have been able to determine the right action to problems related to organ pipes and have also been able to determine logical strategies to determine what to do to deal with problems related to organ pipes. As stated by Jacobs (2022) that to succeed in determining a strategy in solving a problem, a strong understanding of the concept and procedure is required.

The increase that occurred was due to the difference in the treatment given to the experimental class and the control class. In the experimental class, it is treated with a blended learning-based PBL learning model so that it is able to provide a lot of time and opportunity to find information from anywhere and anytime, students are also able to practice their critical thinking skills, because they can complete tasks outside of classroom learning hours. Meanwhile, in the control class, the treatment is provided with a PBL learning model without *blended learning*. So it takes a lot of time because all learning activities are carried out in the classroom, and students also still tend to be passive even though teachers have often provided stimuli during learning hours. This can be seen in the results of the questionnaire of students' responses to the use of *the blended learning-based PBL model* which is in the good category, which is 76.3%. The results of this questionnaire show that the use of blended learning-based PBL model is able to attract students' attention and focus on learning, making it easier for students to understand sound wave material, especially in reminding students of critical thinking.

Thus showing that the PBL-based model *blended learning* can improve students' critical thinking skills. Learning models such as PBL-based *blended learning* This is what can help students in practicing critical thinking. These results are in line with research from Niu et al. (2023) which states that after applying *blended*-PBL students can improve their critical thinking skills to provide simple explanations, build basic skills, provide further explanations, design action solutions and make conclusions correctly. These results are also strengthened by the results of the research Aba-Oli et al. (2024) which states that based on the inclusion criteria that have been set, the effect of the application of problem-based e-learning on critical thinking skills has an impact measure (*effect size*) overall reached 49% in articles covering various levels of education in various fields of study. These

results show that problem-based e-learning provides opportunities for students to learn independently. They are actively involved in cooperative and collaborative problem-solving activities by asking real questions or problems. In addition, they develop higher-level knowledge and thinking skills, including critical thinking skills through a variety of web resources such as text, simulations, videos, and presentations and use facilities such as chat rooms, message boards and dedicated environments.

CONCLUSION

Based on data analysis and discussion of the research results, the average score of the pretest was 57.47 and the posttest was 79.79 and the n-gain value was 0.53 which was classified as a medium category, supported by the results of the student response of 88.61 classified as very good so that it can be concluded that the Problem Based Learning model is based on blended learning able to improve the critical thinking skills of students of SMA Negeri Unggul Subulussalam, especially in physics subjects.

REFERENCES

Aba-Oli, Z., Koyas, K., & Husen, A. (2024). Higher-order thinking skills-oriented problem-based learning interventions in mathematics: A systematic literature review. *School Science and Mathematics*. https://doi.org/10.1111/ssm.12676

Andersen, R., Mørch, A. I., & Litherland, K. T. (2022). Collaborative learning with block-based programming: investigating human-centered artificial intelligence in education. *Behaviour & Information Technology*, *41*(9), 1830–1847. https://doi.org/10.1080/0144929x.2022.2083981

Bijsmans, P., & Versluis, E. (2020). Problem-based learning and the relevance of teaching and learning European Studies in times of crises. *European Political Science*, *19*(4), 668–686. https://doi.org/10.1057/s41304-020-00263-0

Carsky, K., Ansari, P., Patel, V. M., Dechario, S. P., Giangola, G., Coppa, G. F., & Antonacci, A. C. (2022). Using Concurrent Complication Reporting to Evaluate Resident Critical Thinking and Case Analysis. *Journal of the American College of Surgeons*, *235*(5), S237–S237. https://doi.org/10.1097/01.xcs.0000894864.83591.ed

Chen, W., Hu, H., Lyu, Q., & Zheng, L. (2024). Using peer feedback to improve critical thinking in computer-supported collaborative argumentation: An exploratory study. *Journal of Computer Assisted Learning*, *40*(6). https://doi.org/10.1111/jcal.13078

Crespí, P., García-Ramos, J. M., & Queiruga-Dios, M. (2022). Project-Based Learning (PBL) and Its Impact on the Development of Interpersonal Competences in Higher Education. *Journal of New Approaches in Educational Research*, *11*(2), 259. https://doi.org/10.7821/naer.2022.7.993

Feng, Z., Sang, A., Zhou, Q., Wang, Q. Q., Yang, F., & Ma, S. (2023). The impact of an integrated PBL curriculum on clinical thinking in undergraduate medical students prior to clinical practice. *BMC Medical Education*, *23*(1). https://doi.org/10.1186/s12909-023-04450-7

Jacobs, L. (2022). A reproducible strategy to solve problems. *Journal of Trauma and Acute Care Surgery*, *93*(1), e5–e11. https://doi.org/10.1097/ta.0000000000003568

Kabataş Memiş, E., & Çakan Akkaş, B. N. (2020). Developing critical thinking skills in the thinking-discussion-writing cycle: the argumentation-based inquiry approach. *Asia Pacific Education Review*, *21*(3), 441–453. https://doi.org/10.1007/s12564-020-09635-z

Kennedy, H., & Gruber, A. (2020). Critical Thinking in a Service-Learning Course: Impacts of Information Literacy Instruction. *Communications in Information Literacy*, *14*(2).

https://doi.org/10.15760/comminfolit.2020.14.2.3
Krishnan, N. (2021). A hemodialysis curriculum for nephrology fellows using a blended learning approach: best of both worlds? *Journal of Nephrology*, *34*(5). https://doi.org/10.1007/s40620-020-00945-4
Lazarinis, F., Panagiotakopoulos, T., Armakolas, S., Vonitsanos, G., Iatrellis, O., & Kameas, A. (2024). A Blended Learning Course to Support Innovative Online Teaching in Higher Education. *European Journal of Education*, *60*(1). https://doi.org/10.1111/ejed.12820
Lee, N. Y., Wang, Z., & Lim, B. (2021). The Development of Critical thinking: What University Students Have to Say. *Teaching in Higher Education*, *29*(1), 1–14. https://doi.org/10.1080/13562517.2021.1973412
Lin, T., Kraatz, E., Ha, S. Y., Hsieh, M., Glassman, M., Nagpal, M., Sallade, R., & Shin, S. (2021). Shaping classroom social experiences through collaborative small-group discussions. *British Journal of Educational Psychology*, *92*(1). https://doi.org/10.1111/bjep.12442
Lopez-Gazpio, I. (2021). Gaining Student Engagement Through Project-Based Learning: A Competitive 2D Game Construction Case Study. *IEEE Access*, *10*, 1–1. https://doi.org/10.1109/access.2021.3139764
Mexhuani, B. (2024). Adopting Digital Tools in Higher Education: Opportunities, Challenges and Theoretical Insights. *European Journal of Education*, *60*(1). https://doi.org/10.1111/ejed.12819
Niu, Y., Xi, H., Liu, J., Sui, X., Li, F., Xu, H., Zhao, L., Li, Y., Zhang, S., & Guo, L. (2023). Effects of blended learning on undergraduate nursing students' knowledge, skill, critical thinking ability and mental health: a systematic review and meta-analysis. *Nurse Education in Practice*, *72*, 103786–103786. https://doi.org/10.1016/j.nepr.2023.103786
Olmedo-Torre, N., Martínez, M. M., & Peña, M. (2020). Effectiveness of blended instructional design based on active learning in a graphic engineering course. *Computer Applications in Engineering Education*, *29*(4). https://doi.org/10.1002/cae.22338
Rentzou, K. (2021). Twenty-first-century skills and learning capacities and the physical environment of Cypriot preschool settings. *Early Child Development and Care*, *191*(2), 1–13. https://doi.org/10.1080/03004430.2019.1614569
Saha Roy, T., Mazumder, S., & Das, K. (2021). Wisdom of crowds benefits perceptual decision making across difficulty levels. *Scientific Reports*, *11*(1). https://doi.org/10.1038/s41598-020-80500-0
Sala, R., Maffei, A., Pirola, F., Enoksson, F., Ljubić, S., Skoki, A., Zammit, J. P., Bonello, A., Podržaj, P., Žužek, T., Priarone, P. C., Antonelli, D., & Pezzotta, G. (2024). Blended learning in the engineering field: A systematic literature review. *Computer Applications in Engineering Education*, *32*(3). https://doi.org/10.1002/cae.22712
Sermeus, J., De Cock, M., & Elen, J. (2021). Critical thinking in electricity and magnetism: assessing and stimulating secondary school students. *International Journal of Science Education*, *43*(16), 2597–2617. https://doi.org/10.1080/09500693.2021.1979682
Supriyadi, S., Djou, D. N., & Muslimin, M. (2024). Flipped Classroom Method to Build Students' Critical Thinking Skills: A Study on the Indonesia Language and Literature Research Methodology Course. *Evolutionary Studies in Imaginative Culture*, 1323–1337. https://doi.org/10.70082/esiculture.vi.1380
Toker, S., & Baturay, M. H. (2021). Developing disposition to critical thinking and problem-solving perception in instructional design projects for producing digital materials. *International Journal of Technology and Design Education*, *32*(2). https://doi.org/10.1007/s10798-020-09646-2