

Project Based Learning Model Assisted by STEM Teaching Materials on Students' Critical Thinking Skills

Muhammad Ulil Absor✉, Barokah Isdaryanti, Bambang Subali

Sekolah Pascasarjana, Universitas Negeri Semarang, Indonesia

Article Info

History Articles

Received:

10 May 2024

Accepted:

15 September 2024

Published:

30 June 2024

Keywords:

Project Based Learning,
STEM Teaching
Materials, Critical
Thinking Skills

Abstract

This research aims to see the effect of the project-based learning model assisted by STEM teaching materials on students' critical thinking skills. The type of research used is experimental research with pretest and posttest group design. The population and subjects in this research were 4th grade students at MI Ma'arif NU Tamansari, totaling 42 students, with details of 21 students as the experimental class and 21 students as the control class. The data collection technique was carried out by conducting a critical thinking skills test. The activity began with a pretest in both the experimental and control classes, then continued by giving treatment to the experimental class with a project-based learning model assisted by STEM teaching materials and the control class with a discovery learning model assisted by conventional teaching materials. The activity ended by conducting a posttest in both the experimental class and the control class. The results of the pretest and posttest data are then processed by carrying out normality tests and homogeneity tests as prerequisite tests. The results of the normality and homogeneity tests show that the data is normally and homogeneously distributed. Next, data analysis was carried out by making decisions using the paired sample t test and the independent t test. The results of the paired sample t test and the independent sample t test show a significance value of $0.000 < 0.05$ so it can be interpreted that the use of the project-based learning model assisted by STEM teaching materials and the discovery learning model assisted by conventional teaching materials has an influence and difference in the average skill results. students' critical thinking. The posttest results in the experimental class averaged $86.95 > 65.71$ compared to the average posttest results in the control class so it can be concluded that the use of the project-based learning model assisted by STEM teaching materials has a more significant effect on students' critical thinking skills.

✉ Correspondence address:

E-mail: absor710@students.unnes.ac.id

INTRODUCTION

The current national development priority is to create a society with noble, moral, ethical, cultured and civilized society based on the Pancasila philosophy (Vhalery et al., 2022). One effort to make this happen is by strengthening national identity and character through education. Education in the sense that includes all the actions and efforts of the older generation to transfer their knowledge, experience, abilities and skills to the younger generation in an effort to prepare them so they can fulfill their life functions both physically and spiritually (Pratama et al., 2022). Education is a determining factor in the progress and development of society. Education is one way for humans to survive in order to adapt to the rapidly changing times (Widiyawati et al., 2021). Every individual has the right to get a decent education. To achieve these educational goals, an intermediary tool is needed, namely a curriculum. The independent curriculum is an idea in the transformation of Indonesian education to produce superior future generations (Septia & Raharjo, 2024).

The PjBL (Project Based Learning) learning model is one of the learning models recommended for use in the independent curriculum in order to strengthen the profile of Pancasila students (H. Fitri et al., 2018). According to Zubaidah, as quoted by Fitri & Dasna, (2018) stated that Project Based Learning is an ideal learning model for achieving 21st century educational goals, because it involves the principles of critical thinking, communication, collaboration and creativity (Kurniawan et al., 2023). In line with this, Hakkinen said that PjBL is an effective way to develop the skills needed in the 21st century, by emphasizing critical thinking processes as well as problem solving, interpersonal communication, information and media literacy, cooperation, leadership and working in team, innovation and creativity (Almulla, 2020). PjBL is a learning model that involves students in designing, creating and displaying products that are used to solve real world problems (Astri et al., 2022). The PjBL concept involves two or more teachers

collaborating at a certain level when planning, implementing and evaluating learning which primarily involves exchanging expertise and reflective discussions (Siboro et al., 2022). In Project-based learning (PjBL) students are free to learn by integrating various scientific fields to explore (Rahmawati et al., 2022). It is hoped that this freedom will make students more motivated to explore themselves through project activities because there are no rigid rules like conventional learning. Teachers have an important role in implementing PjBL because here the teacher will guide and guide students so that they can increase creativity and think critically about the surrounding environment (Atiaturrahmaniah et al., 2022).

Critical thinking is the ability that every person has to analyze ideas or ideas in a more specific direction to obtain relevant knowledge and involves evaluation as a reflection in decision making (Afifah et al., 2019). The purpose of critical thinking is to test an opinion or idea, including thinking based on the opinion put forward so that students are able to create an active and meaningful learning process. Low critical thinking skills have an impact on students' cognitive abilities and the subsequent learning process (I. A. Fitri et al., 2022). The higher the cognitive level of material, the more difficult it will be for students to understand the material if their critical thinking skills are low. Apart from these difficulties, it also results in learning outcomes automatically being low, because the basic skills in implementing learning have not been mastered by students (Lestari et al., 2018). For this reason, a learning model is needed that can train critical thinking skills, one of which is a project based learning model assisted by STEM teaching materials (Arrohman et al., 2022).

The STEM learning model is an acronym for science, technology, engineering and mathematics, first launched by the United States National Science Foundation in the 1990s as a technique, formation in these four disciplines to foster work techniques in STEM fields (Izzah et al., 2020). STEM learning is able to motivate students to think critically regarding solving problems in a given learning project so that there

is an increase in students' critical thinking skills (Saw et al., 2019). A contextual approach to learning can lead to the development of students' conceptual mastery, process skills, problem solving skills, scientific attitudes and critical thinking skills (Lestari et al., 2018). The application of the STEM approach to science learning can be implemented by integrating STEM subjects (Sarwi et al., 2021). The application of this learning can be done by studying the process of making a product with scientific concepts (Zunanda & Sinulingga, 2015). STEM-based teaching materials can be used as an alternative learning material for environmental conservation efforts (Pratama et al., 2022).

The results of observations and interviews conducted by researchers at Madrasah Ibtidaiyah Ma'arif NU Tamansari, Karanglewas District, Banyumas Regency, found several problems that occurred in the classroom so that learning did not run optimally. Students experience several difficulties in understanding science lesson content. This is because the learning model used by teachers is less innovative. The learning process is still teacher-centered, so students are not actively involved in the learning process. The implementation of the teaching and learning process by teachers tends to use the direct instruction (DI) model. The teacher delivers the material by explaining it directly in front of the class, then the students pay attention to the teacher's explanation. Next, the learning activities continue with assignments in the student book. Students are not fully involved in learning and have not been trained to make appropriate decisions and think critically. It can be explained that the results of these observations and interviews show several obstacles that must be overcome immediately because if this continues, it will make students only recipients of information, making students' thinking skills low or in other words, learning will feel less meaningful.

The problems that arise are related to the learning process which is still monotonous due to inappropriate and less innovative learning models. This problem requires further research to

overcome it (Zunanda & Sinulingga, 2015). Based on the explanation above, researchers took a solution by implementing a project based learning (PjBL) model assisted by STEM teaching materials to overcome the lack of critical thinking skills in science learning. The formulation of the problem in this research is to determine the effect of the project based learning model assisted by STEM teaching materials on students' critical thinking skills.

METHOD

The type of research carried out was a pretest posttest group design (Wahyudin, 2015). This type of research is used to determine the effect of the project based learning (PjBL) learning model on students' critical thinking skills. The research design used was to provide project based learning model treatment assisted by STEM teaching materials (X) in the experimental class, while the control class was treated with discovery learning assisted by conventional teaching materials (Y).

Table 1. Research design

Class	Pretest	Treatment	Posttest
Experiment	O ₁	X	O ₂
Control	O ₃	Y	O ₄

The population in this study were grade 4 students at SD/MI in Karanglewas sub-district, Banyumas district. The subjects in this research were 42 students in class 4 MI Ma'arif NU Tamansari, with details of 21 students in the experimental class and 21 students in the control class. The data collection technique used was conducting a critical thinking skills test. The pretest and posttest results of critical thinking skills in the experimental and control classes were tested prerequisites with normality and homogeneity tests. Data analysis and decision making were carried out by conducting paired sample t tests and independent sample t tests.

RESULTS AND DISCUSSION

This research was conducted at MI Ma'arif NU Tamansari on class 4A students as the experimental class and class 4B students as the control class. Learning in the experimental class uses a project based learning model assisted by STEM teaching materials and in the control class uses a discovery learning model assisted by conventional teaching materials. This research aims to see the difference in improving critical thinking skills with the project based learning model assisted by STEM teaching materials. The following are the results of the pretest and posttest in the experimental class and control class.

Table 2. Result Pretest and Posttest

Statistics	Experiment		Control	
	Pre	Post	Pre	Post
Responden	21	21	21	21
Mean	52.10	86.95	53.52	65.71
Std. Error of Mean	1.23	1.34	1.15	1.53
Median	54.00	86.00	54.00	66.00
Mode	54	92	56	61
Std. Deviation	5.60	6.11	5.29	7.01
Variance	31.39	37.35	27.96	49.21
Range	22	24	20	24
Minimum	42	76	44	55
Maximum	64	100	64	79
Sum	1094	1826	1124	1380

Based on the table above, it can be seen that the results of descriptive statistical analysis show that the experimental class pretest has an average of 52.10, the smallest value is 42, and the largest value is 64. Meanwhile, the experimental class posttest has an average of 86.95, the value The smallest value is 76, and the largest value is 100. The results of the pretest descriptive statistical analysis in the control class have an average value of 53.52, the smallest value is 44, and the largest value is 64. Meanwhile, the results of the posttest analysis have an average value of 65.71, the smallest value is 55, and the largest value is 79.

The pretest and posttest data obtained were then carried out prerequisite tests by carrying out

normality tests and homogeneity tests. The following are the results of the normality test and homogeneity test carried out by researchers.

Table 3. Normality Test Results

Variable	Class	Shapiro-Wilk Sig.
Critical thinking	Pre Exp	0.204
	Post Exp	0.089
	Pre Con	0.710
	Post Con	0.386

Based on the table of normality test results above, it can be seen that the significance value in the experimental class, the pretest received a value of $0.204 > 0.05$ and the posttest received a value of $0.089 > 0.05$, whereas in the control class, the pretest received a value of $0.710 > 0.05$ and in the posttest gets a value of $0.386 > 0.05$, it can be concluded that the residual value is normally distributed.

Table 4. Homogeneity Test Results

Variable	Homogeneity	Sig.
Critical Thinking	Based on Mean	0.289
	Based on Median	0.291
	Based on Median and with adjusted df	0.291
	Based on trimmed mean	0.285

Based on the homogeneity test results above, it can be seen that the significance value based on mean is $0.289 > 0.05$, so it can be concluded that the data test results are homogeneous.

The results of these prerequisite tests are the basis for researchers to draw conclusions by conducting paired sample t tests and independent sample t tests. The paired sample t test was used to see the differences or influence of the project based learning model assisted by STEM teaching

materials on improving students' critical thinking skills. The following are the results of the paired sample t test that was carried out by the researcher.

Table 5. Paired Sample T Test Results

Variable	Mean	SD	T	Sig.
Critical Thinking	Pre Exs	52.10	5,60	-21.28
	Pos t	86.95	6.11	
	Pre Co	53.52	5.28	-8.37
	Pos t	65.71	7.01	

Based on the results of the paired sample t test above, it can be seen that there has been an increase in the average results of critical thinking skills in both the experimental and control classes. In the experimental class the average pretest result obtained was 52.10 then increased in the posttest to 86.95. This shows an increase in students' critical thinking skills after receiving treatment with learning using a project based learning model assisted by STEM teaching materials. In the control class the average pretest result obtained was 53.52 then increased in the posttest to 65.71. This shows an increase in students' critical thinking skills after receiving treatment with discovery learning assisted by conventional teaching materials. The significance results obtained in both the experimental and control classes showed a value of $0.000 < 0.05$, which means there was a difference in the increase in students' critical thinking skills. The existence of a greater difference in average results in the experimental class compared to the control class indicates that there is a greater difference or influence so it can be concluded that there is a significant influence of the use of the project based learning model assisted by STEM teaching materials on students' critical thinking skills.

After carrying out the paired sample t test, the independent sample t test was then carried out with the aim of finding out whether there was a difference in the average results of students' critical thinking skills from two unpaired samples. The following are the results of the independent sample t-test which was carried out by the researcher.

Table 6. Independent t test results

Variable	T	Df	Sig
Critical Thinking	Equal variances assumed	10.46	40
	Equal variances not assumed	10.46	39.26

Based on the results of the independent sample t test on students' critical thinking skills in both the experimental and control classes, the results show a sig value (2-tailed) of $0.000 < 0.05$, which means that there is a significant difference in the average results of critical thinking skills between the control and control classes. experimental class. This can be seen by the use of different treatments in the two classes, the experimental class uses the PjBL learning model assisted by STEM teaching materials while the control class uses the discovery learning model with conventional teaching materials. From the results of the explanation above, a decision can be taken that the use of the PjBL model assisted by STEM teaching materials is able to improve students' critical thinking skills.

The results of the presentation of the paired sample t test and independent t test show significant results of critical thinking skills regarding the use of the PjBL model assisted by STEM teaching materials, the use of this model is able to achieve planned targets and build their own knowledge because learning becomes focused on independent learning activities with empirical projects through practical activities, interactive discussions, independent operations or teamwork. The use of a project-based model can focus on student activities in the form of

collecting information and using it to produce a product that is useful for students' lives (Agussuryani et al., 2022). The learning applied in the experimental class makes students able to make decisions about the learning framework, after that students discuss solutions to the problems that have been obtained, after discussion students divide parts of the task to group members to complete the project that has been designed, after The students evaluate the products that have been made. The learning process makes students more enthusiastic about learning because students enjoy experiencing learning and getting aspirations from their curiosity (Mohd Najib et al., 2020). The PjBL model assisted by STEM teaching materials is a learning method that uses problems as the first step in collecting and integrating new knowledge based on experience in real activities (Benjamin et al., 2017). In STEM integration, students are trained to learn to connect the learning process between science learning integrated with technology and then creating projects and connecting them with mathematics learning (Sarwi et al., 2020).

Research on the influence of learning models has been carried out by several previous researchers. This is based on research conducted by Afifah et al., (2019) which explored a STEM-based project based learning model to improve students' mastery of concepts and critical thinking skills. The research results concluded that the STEM-based PjBL model can increase mastery of concepts and improve critical thinking skills. Another research conducted by Atiaturrehmaniah et al., (2022) analyzed the role of the STEAM (science, technology, engineering, arts, and math) model in elementary school learning so that students are able to think critically and increase scientific literacy. STEAM learning is useful for improving students' abilities in critical thinking and scientific literacy so that students are better able to develop their own competencies (Suryandari et al., 2018). Furthermore, there was research conducted by Rahmawati et al., (2022) which explored the implementation of STEM in improving mathematical critical and creative thinking

abilities with the research results providing information that the STEM approach had a positive influence on increasing students' mathematical creative thinking and critical thinking abilities. Likewise, research conducted by Khairani et al., (2022) explored the influence of the project based learning model on students' critical thinking and communication skills. The results of the research show that the average value of critical thinking and communication skills for students who carry out learning using the project based learning model is higher than conventional learning. Another research conducted by Siboro (2022) explored the influence of the project based learning model assisted by quiziz media on students' critical thinking abilities. The results of his research show that there is a significant influence using the PjBL model assisted by quiziz media on students' critical thinking abilities (Kusumaningrum & Djukri, 2016).

The PjBL learning model is a learning process that uses projects or activities as its goal. Project-based learning takes the form of activities to collect information and use it to produce something that is useful for the students' own lives and for others (Arfianawai et al., 2016). The advantage of the PjBL model is that it provides special experiences for students because it involves students, this will give a special impression to students so that it will be easier to remember when studying. Based on the explanation above, it can be concluded that there is a difference in increasing the critical thinking skills of experimental class students in cognitive knowledge who apply the PjBL learning model assisted by STEM teaching materials compared to the control class taught by discovery learning and conventional teaching materials. The PjBL model is an innovative learning model that plans contextual learning through complex activities such as giving students freedom to explore, plan learning activities, carry out projects collaboratively, and ultimately produce products, meaning that there needs to be encouragement to stimulate children to create learning products. so that students can more easily accept lessons.

CONCLUSION

The results of the pretest and posttest carried out in the experimental class and control class showed that there was an increase in the average results of students' critical thinking skills. In the experimental class, which was initially 52.10, it increased to 86.95 after being treated with a project based learning model assisted by STEM teaching materials. In the control class, which was initially 53.52, it increased to 65.71 after being treated with the discovery learning model assisted by conventional teaching materials. The results of the analysis of the paired sample t test and the independent t test show a significance value of $0.000 < 0.05$ which can be interpreted that there is a difference or influence and difference in the average results of students' critical thinking skills so that it can be interpreted that the use of the project based learning model is assisted by teaching materials. STEM and discovery learning models assisted by conventional teaching materials influence students' critical thinking skills. The larger difference between the posttest results in the experimental class and the control class shows that the use of the project based learning model has a significant effect on students' critical thinking skills.

REFERENCES

- Almulla, M. A. (2020). The Effectiveness of the Project-Based Learning (PBL) Approach as a Way to Engage Students in Learning. *SAGE Open*, 1–15. <https://doi.org/10.1177/2158244020938702>
- Arfianawai, S., Sudarmin, S., & Sumarni, W. (2016). Model Pembelajaran Kimia Berbasis Etnosains Untuk Meningkatkan Kemampuan Berpikir Kritis Siswa. *Jurnal Pengajaran MIPA*, 21, 46–51.
- Arrohman, D. A., Wahyuni, A. L. E., Wilujeng, I., & Suyanta, S. (2022). Implementasi Penggunaan LKPD Pencemaran Air Berbasis STEM dan Model Learning Cycle 6E Terhadap Kemampuan Literasi Sains. *Jurnal Pendidikan Sains Indonesia*, 10(2), 279–293. <https://doi.org/10.24815/jpsi.v10i2.23584>
- Astri, E. K., Siburian, J., & Hariyadi, B. (2022). Pengaruh Model Project Based Learning terhadap Keterampilan Berpikir Kritis dan Berkomunikasi Peserta Didik. *BIODIK: Jurnal Ilmiah Pendidikan Biologi*, 08, 51–59.
- Atiaturrahmaniah, A., Bagus, I., Aryana, P., & Suastra, I. W. (2022). Peran model science, technology, engineering, arts, and math (STEAM) dalam meningkatkan berpikir kritis dan literasi sains siswa sekolah dasar. *Jurnal Penelitian Guru Indonesia*, 7(2), 368–375.
- Benjamin, T. E., Marks, B., Demetrikopoulos, M. K., Rose, J., Pollard, E., Thomas, A., & Muldrow, L. L. (2017). Development and Validation of Scientific Literacy Scale for College Preparedness in STEM with Freshmen from Diverse Institutions. *International Journal of Science and Mathematics Education*, 15(4), 607–623. <https://doi.org/10.1007/s10763-015-9710-x>
- Fitri, H., Dasna, W. I., & Suharjo, S. (2018). Pengaruh Model Project Based Learning (PjBL) Terhadap Kemampuan Berpikir Tingkat Tinggi Ditinjau dari Motivasi Berprestasi Siswa Kelas IV Sekolah Dasar.
- Affifah, N. A., Ilmiyati, N., & Toto, T. (2019). Model Project Based Learning (PjBL) Berbasis STEM Untuk Meningkatkan Penguasaan Konsep dan Keterampilan Berpikir Kritis Siswa. *Quagga: Jurnal Pendidikan Dan Biologi*, 11, 73–78. <https://doi.org/10.25134/quagga.v11i2.1910>.Received
- Agussuryani, Q., Sudarmin, S., Sumarni, W., Cahyono, E., & Ellianawati, E. (2022). STEM literacy in growing vocational school student HOTS in science learning: A meta-analysis. *International Journal of Evaluation and Research in Education*, 11(1), 51–60. <https://doi.org/10.11591/ijere.v11i1.21647>

- BRILLIANT: Jurnal Riset Dan Konseptual*, 3(1), 201–212.
- Fitri, I. A., Sumarti, S. S., Mulyono, S. E., & Sudarmin, S. (2022). Tren Riset Sains di Tingkat Sekolah Dasar berbasis Database Scopus (2018-2022) dan Implikasinya pada Penguatan Literasi Sains bagi Siswa SD. *Proceeding Seminar Nasional IPA*, 193–203.
<https://proceeding.unnes.ac.id/index.php/snipa/article/view/1353>
- Izzah, S. N., Sudarmin, S., Wiyanto, & Prasetyo, A. P. B. (2020). Identification of the indigenous science concepts in the batik-manufacturing process to develop STEM integrated ethnoscience learning. *Journal of Physics: Conference Series*, 1567(4).
<https://doi.org/10.1088/1742-6596/1567/4/042032>
- Kurniawan, I., Sarwi, S., & Sukasih, S. (2023). Application of the Lok-R Learning Strategy to Science Literacy. *Ta'dib*, 26(2), 237–243.
- Kusumaningrum, S., & Djukri, D. (2016). Pengembangan Perangkat Pembelajaran Model Project Based Learning (PjBL) untuk Meningkatkan Keterampilan Proses Sains dan Kreativitas Developing a Learning Kit with Project Based Learning Model (PjBL) to Improve Scientific Process Skills and Creativity. *Jurnal Inovasi Pendidikan IPA*, 2(2), 241–251.
<http://journal.uny.ac.id/index.php/jipi>
- Lestari, T. P., Sarwi, S., & Sumarti, S. S. (2018). STEM-Based Project Based Learning Model to Increase Science Process and Creative Thinking Skills of 5th Grade. *Journal of Primary Education*, 7(1), 18–24.
- Mohd Najib, S. A., Mahat, H., & Baharudin, N. H. (2020). The level of STEM knowledge, skills, and values among the students of bachelor's degree of education in geography. *International Journal of Evaluation and Research in Education*, 9(1), 69–76.
<https://doi.org/10.11591/ijere.v9i1.2041>
- Pratama, R. A., Pratiwi, I. M., Saputra, M. A., & Sumargono. (2022). Integration of STEM education in history learning. *International Journal of Evaluation and Research in Education*, 11(1), 313–320.
<https://doi.org/10.11591/ijere.v11i1.22064>
- Rahmawati, L., Juandi, D., & Nurlaelah, E. (2022). Implementasi STEM Dalam Meningkatkan Kemampuan Berpikir Kritis dan Kreatif Matematis. *AKSIOMA: Jurnal Program Studi Pendidikan Matematika*, 11(3), 2002–2014.
- Sarwi, S., Baihaqi, M. A., & Ellianawati, E. (2021). Implementation of Project Based Learning Based on STEM Approach to Improve Students' Problems Solving Abilities. *Journal of Physics: Conference Series*, 1918(5), 1–5.
<https://doi.org/10.1088/1742-6596/1918/5/052049>
- Sarwi, S., Nisa, G., & Subali, B. (2020). An analysis of critical thinking skill and interpersonal intelligence in the development of ethnoscience-based teaching material salt production An analysis of critical thinking skill and interpersonal intelligence in the development of ethnoscience-based. *Journal of Physics: Conference Series*, 1918, 1–6.
<https://doi.org/10.1088/1742-6596/1918/5/052060>
- Saw, G. K., Swagerty, B., Brewington, S., Chang, C. N., & Culbertson, R. (2019). Out-of-school time STEM program: Students' attitudes toward and career interests in mathematics and science. *International Journal of Evaluation and Research in Education*, 8(2), 356–362.
<https://doi.org/10.11591/ijere.v8i2.18702>
- Septia, R. N., & Raharjo, T. J. (2024). Problem Solving Skills in Child Friendly Learning Through the Discovery Learning based on Applet Geogebra in Terms of Learning Style. *International Journal of Research and Review*, 11(January), 501–511.

- Siboro, A., Debataraja, E., & Tafonao, D. (2022). Pengaruh Model Project Based Learning (PjBL) Berbantuan Media Quizizz Terhadap Kemampuan Berpikir Kritis Peserta Didik. *Jurnal Kewarganegaraan*, 6(3), 5182–5188.
- Suryandari, C. K., Sajidan, S., Rahardjo, B. Prasetyo, K. Z., & Fatimah, S. (2018). Project-based science learning and pre-service teachers' science literacy skill and creative thinking. *Cakrawala Pendidikan*, 37(3), 345–355. <https://doi.org/10.21831/cp.v38i3.17229>
- Vhalery, R., Setyastanto, A. M., & Leksono, A. W. (2022). Kurikulum Merdeka Belajar Kampus Merdeka: Sebuah Kajian Literatur. *Research and Development Journal of Education*, 8(1), 185. <https://doi.org/10.30998/rdje.v8i1.11718>
- Wahyudin, A. (2015). *Metodologi Penelitian*. UNNES Press.
- Widiyawati, Y., Nurwahidah, I., Sari, D. S., Masykuri, M., & Budiyanto, C. W. (2021). The 21 st century science learning: HOTS and digital literacy among junior high school students in Semarang, Indonesia. *Journal of Physics: Conference Series*, 1842(1), 1–13. <https://doi.org/10.1088/1742-6596/1842/1/012081>
- Zunanda, M., & Sinulingga, K. (2015). Pengaruh Model Pembelajaran Berbasis Masalah dan Kemampuan Berpikir Kritis Terhadap Keterampilan Pemecahan Masalah Fisika Siswa SMK. *Jurnal Pendidikan Fisika*, 4(1), 63–70.