Vol 14 (1), 2025, 20-29 DOI: 10.23960/jppk.v14.i1.32403
Jurnal Pendidikan dan Pembelajaran Kimia
e-ISSN: 2714-9595| p-**ISSN 2302-1772**
http://jurnal.fkip.unila.ac.id/index.php/JPK/index

The Effect of STEM Integrated PjBL Learning on Students' HOTS and Collaboration Abilities on Biotechnology Material

Rahma Dwi Fadila, Nadya Meriza*, Berti Yolida, Rini Rita T. Marpaung

Biology Education, Faculty of Teacher Training and Education, University of Lampung,
Jl. Prof. Dr. Ir. Soemantri Brojonegoro No. 1 Bandar Lampung, Indonesia.
*Corresponding e-mail: nadya.meriza@fkip.unila.ac.id

Received: Jan 6th, 2025 Accepted: Jan 17th, 2025 Online Published: April 25th, 2025

Abstract:The Effect of STEM Integrated PjBL Learning on Students' HOTS and Collaboration Abilities on Biotechnology Material. This study aims to determine the effect of implementing integrated PjBL learning with STEM on HOTS and collaboration skills of students in biotechnology material. The type of research used is *quasi-research. experiment with pretest-posttest* research design *nonequivalent control group*. The research sample consisted of 58 students consisting of class IX.7 (control) and IX.9 (experiment) with *purposive sampling technique*. The experimental class used STEM integrated PjBL learning, while the control class used a discussion method with a scientific approach. HOTS ability data were obtained from the results of *the pretest-posttest* which was analyzed using the *Independent Sample T- test* with the help of the SPSS *Statistics program Version 27 at a significance level of 0.05, the Sig. (2-tailed)* value is 0.001 < 0.05, so H1 is accepted. The results of the effect size of 1.21 with the criteria of "High" which means that STEM integrated PjBL learning has an effect on improving HOTS abilities. Meanwhile, data on collaboration ability was obtained from the results of the calculation of student observation sheets, the results of experimental class students were higher with a percentage of 81.7% in the "Very Good" category compared to the control class with a percentage of 73.1% in the "Good" category. Thus, it can be concluded that integrated PjBL learning with STEM has an effect on improving HOTS abilities and has an effect on student collaboration on biotechnology material.

Keywords: Biotechnology; Higher Order Thinking Skills; Collaboration; Project Based Learning (PjBL)- STEM.

Abstrak: Pengaruh Pembelajaran PjBL Terintegrasi STEM Terhadap Kemampuan HOTS dan Kolaborasi Peserta Didik pada Materi Bioteknologi. *Penelitian ini bertujuan untuk mengetahui pengaruh penerapan pembelajaran PjBL terintegrasi dengan STEM terhadap kemampuan HOTS dan kolaborasi peserta didik materi bioteknologi. Jenis penelitian yang digunakan adalah quasi experiment dengan desain penelitian pretest-posttest nonequivalent control group. Sampel penelitian berjumlah 58 peserta didik terdiri dari kelas IX.7 (kontrol) dan IX.9 (eksperimen) dengan teknik pengambilan sampel purposive sampling. Kelas eksperimen menggunakan pembelajaran PjBL terintegrasi STEM, sedangkan kelas kontrol menggunakan metode diskusi dengan pendekatan saintifik. Data kemampuan HOTS didapatkan dari hasil pretest-posttest yang dianalisis menggunakan uji Independent Sample T-test dengan bantuan program SPSS Statistic Version 27 pada taraf signifikansi 0,05 didapatkan nilai Sig. (2 -tailed) 0,001 < 0,05 maka H1 diterima. Hasil uji pengaruh (effect size) sebesar 1,21 dengan kriteria "Tinggi" yang berarti pembelajaran PjBL terintegrasi STEM berpengaruh dalam meningkatkan kemampuan HOTS. Sedangkan data kemampuan kolaborasi diperoleh dari hasil perhitungan lembar observasi peserta didik, didapatkan hasil peserta didik kelas eksperimen lebih tinggi dengan persentase 81,7% kategori "Sangat Baik" dibandingkan kelas kontrol dengan persentase sebesar 73,1%*

kategori "Baik". Dengan demikian dapat disimpulkan bahwa pembelajaran PjBL terintegrasi dengan STEM berpengaruh dalam meningkatkan kemampuan HOTS dan berpengaruh terhadap kolaborasi peserta didik materi bioteknologi.

Kata kunci: *Bioteknologi; Higher Order Thinking Skill; Kolaborasi; Project Based Learning (PjBL)- STEM.*

• INTRODUCTION

Education is a necessity that must be owned by every human being. Not only knowledge, through education a person can know and realize behavior and behavior that should be changed for the better. With this education, humans can achieve better life goals because education is a provision to face the challenges of life in the future that are increasingly developing. Education is currently entering 21st century education, of course it is increasingly important to ensure that students develop learning and innovation skills, the ability to utilize technology and information media, and life skills that allow them to work and survive in various situations (Wijaya, Sudjimat, & Nyoto, 2016).

The main factor driving the progress of the Indonesian nation is education. However, educational programs do not only focus on the knowledge or cognitive aspects alone, but also on the formation of attitudes and development of student skills (Triowathi & Wijayanti, 2018). The meaning of the skills developed here are skills that are in accordance with the demands of the 21st century, namely 6C *character, citizenship*, *critical thinking*, *communication*, *creativity*, and *collaboration*. With the existence of these 6C skills, students are required to have and develop *hard skills* or *soft skills* in learning in order to prepare themselves to compete in the 21st century (Armando, 2019). Therefore, students must be able to carry out the process of analyzing and evaluating a problem so that they can create a solution. This can be done by students with HOTS (*Higher Order Thinking Skills*) (Ainurrahman, et al., 2021).

HOTS is an educational concept based on Bloom's Taxonomy, which was formulated by Benjamin S. Bloom in 1956. This taxonomy has a cognitive domain with a low level of thinking ability or LOTS (*Lower Order Thinking Skills*) include C1, C2, and C3 up to a high level or HOTS (*Higher Order Thinking Skills*) include C4, C5, and C6. HOTS skills can be one of the main assets for students in learning science. Students need these thinking skills to solve problems/phenomena in issues that can be found in science subjects (Ainurrahman, et al., 2021).

Another skill needed in the 21st century is *Collaboration* or collaboration or cooperation is one of the skills that must be possessed and is very useful for the success of students in the future, so it needs to be developed and integrated in learning. Collaboration skills are the process of involving a number of individuals, groups, or organizations working together to achieve the desired results (Mariamah, Bachtiar, & Indrawati, 2021). This means that in classroom learning, students work together in groups to solve a problem, generate ideas and solutions to the problem and lead to common goals. Facts on the ground based on programs carried out by *the Organization for Economic Cooperation and Development* (OECD) namely *the Programme for International Students Assessment* (PISA) which aims to evaluate the education system globally, Indonesia has increased its ranking but experienced a decrease in its average score. Indonesia's achievement in 2022 was ranked 63 out of 73 countries with an average score of 372 in numeracy, reading, and science. However, Indonesia experienced a decrease of 10 scores from 382 to 372 from 2018 with *the assessment The framework* in the PISA study prioritizes the ability to reason, solve problems, argue, and communicate (OECD, 2023). The score results show that students in Indonesia are still weak in scientific reasoning, problem solving, arguing, and communication skills which refer to students' HOTS abilities.

In addition to HOTS capabilities, student collaboration in Indonesia is still relatively low. Based on *the Survey of Adult Skills* by OECD held in Jakarta in 2015 with adult respondents aged 16-65 years old as the research subjects revealed that residents in Jakarta scored between 326-327 out of a maximum score of 500 on the ability that highlights the respondent's activities in the form of collaboration and communication skills needed in the world of work. This score shows a level that is still low when compared to the adult population of other countries who participated in the survey (OECD, 2016 in Ayu et al., 2018).

Researchers have conducted observations at SMPN 1 Trimurjo. Based on the results of interviews with grade IX science teachers, it is known that learning uses an independent curriculum, but educators have not implemented differentiated learning that should be carried out in the independent curriculum. In the learning process, students are less active and do not try hard to find information independently so that learning is still centered on the teacher and there is no habit of practicing HOTS-oriented questions, so that students' HOTS abilities are less trained. As a result, learning does not run optimally and after an assessment, 50% have not reached the Learning Objective Achievement Criteria (KKTP), which is 70.

Furthermore, in terms of student collaboration, educators have made it a habit in each class to discuss forming groups that aim for students to collaborate with each other. However, there is a problem, namely in terms of student communication, in the interaction of learning discussions, students do not discuss or discuss learning materials but discuss things outside the context of learning. Then, when discussing in groups, there are students who play alone, making the learning situation not conducive and effective, which shows that students do not have a sense of responsibility for their work and are less flexible because they do not respect the opinions of others. As well as the lack of ability to compromise and deliberate in solving problems. The low ability of student collaboration makes it difficult for educators and students to achieve learning goals.

The solution that is considered to be able to overcome the above problems is by using integrated PjBL learning with STEM in science subjects. The PjBL model is a learning model that is centered on students who work together in groups to create projects and produce products. According to Muis & Dewi (2021), it explains that the implementation of PjBL can train students to construct an opinion and criticism because students are expected to be more open to receiving input from others. Activities in this PjBL learning will also develop students' collaboration skills to work together in teams. After that, students will also practice presenting the results of their work with their groups as well as possible. So that the cognitive learning outcomes obtained based on HOTS ability indicators will be maximized.

With the use of integrated PjBL learning with STEM, students can gain knowledge with assignments in the form of projects as the core of learning, students also gain learning experience or understand concepts that are built based on the final products produced in learning. According to Fitriyani, Toto, & Erlin (2020), explained that PjBL integrated with STEM has the ability to invite students in meaningful learning, where they can understand concepts and explore through projects. In this way, students can be actively involved in the learning process, which provides a more meaningful learning experience.

STEM-based education forms human resources (HR) who are able to think critically, logically, and systematically, so that they are ready to face the challenges of the 21st century. to participate in decision-making that affects them. Mastery of technology is useful for analyzing the impact of new technology on individuals, communities, nations, and the world. engineering/design processes by integrating various lessons, while mathematics is expected to be able to analyze reasons, communicate ideas effectively, and find solutions to various problems in various situations (Cahyono, Ibrahim, & Suprapto., 2022).

Research on PjBL learning, STEM, HOTS skills, and collaboration has been conducted by previous researchers. Walihah, et al., (2023), has conducted research on the effect of PjBL on students' HOTS skills. However, this study has not integrated STEM and measured collaboration skills. Then Fitriyani, Toto, & Erlin (2020), conducted research on PjBL and STEM learning on students' HOTS skills. However, this study has not measured its effect on collaboration skills. Rizka, (2023); has also conducted research on the effect of PjBL on students' cognitive and collaborative learning outcomes. However, this study has not measured HOTS skills and has not been integrated with STEM. Pasaribu & Suyanti (2024); have also conducted research on HOTS, but did not use PjBL learning integrated with STEM.

- **METHOD**

This study uses *quasi experiment with pretest-posttest* research design *nonequivalent control group.* The researcher gave *a pretest* to two classes (experimental and control) to find out and control the initial conditions. Then the researcher gave treatment to the experimental class, namely the use of integrated PjBL learning with STEM and then gave *a posttest*. While in the control group, the researcher left it without treatment but still gave a posttest. After that, the posttest results in the two groups were compared to test the differences. The population of the study was 262 students of grade IX divided into 9 classes at SMPN 1 Trimurjo. The sample of the study was 58 students of grade IX.7 as the control class and grade IX.9 as the experimental class. The sampling technique of the study used *purposive sampling* technique, which is a sampling technique with certain considerations (Sugiyono, 2013).

The research instruments used were tests and student assessment sheets. The test was used to measure students' HOTS abilities in biotechnology material totaling 20 questions (Table 1). The validity test of the instrument used the assistance of the SPSS program with the *Pearson Product test. Moment Correlation-Bivariate* and tested for reliability using the *Cronbach's test Alpha.* Of the 20 questions prepared, there are 13 valid questions. Then the student observation assessment sheet is used to measure the students' collaboration skills, which consist of 5 indicators according to Triling & Fadel (2009), namely cooperation, responsibility, compromise, communication, and flexibility.

Table 1. HOTS Ability Question Grid

HOTS Indicator	Distribution of Questions	Number of Questions
C4 (Analyze)	1,2,6,8,11,12,16	7
C5 (Evaluate)	4,5,7,9,14,17,19	7
C6 (Create)	3,10,13,15,18,20	6
	Total	20

Table 2. Student Collaboration Observation Sheet

No	Name	Aspect Score Collaboration					Total Score	Presentasi Criteria On
		A	**B**	**C**	**D**	**E**		
1.								
2.								
3.								
Etc.								

Description: A: Cooperation, B: Responsibility, C: Compromise, D: Communication, E: Flexibility.

The research procedure was carried out in 3 stages, namely the initial stage, the research implementation stage, and the final stage. The initial stage ; (1) conducting observations of problems in schools, (2) determining the population and research sample, (3) compiling learning device instruments to measure HOTS abilities and student collaboration, (4) conducting instrument trial analysis including validity, reliability, discrimination, and difficulty level tests. Implementation stage; (5) conducting *a pretest* , (6) conducting research using STEM integrated PjBL learning in the experimental class, (7) conducting *a posttest* . *The final stage; (8) processing data and analyzing pretest-posttest* results . and observation sheets, (9) Providing conclusions.

HOTS ability data of students was obtained from *pretest-posttest scores.* Then the value was tested for *Normalized-gain (N-gain)* using *Microsoft Excel application. Furthermore,* normality test was performed assisted SPSS *Statistics Version* 27 using the *Kolmogorov test Smirnov* and homogeneity test using *Lavene Test.* Data that is normally distributed and homogeneous is tested for its hypothesis using the *Independent Sample T-Test.* Then the *effect test is carried out. size* to find out how much influence the use of integrated PjBL learning with STEM has on students' HOTS abilities. Then for student collaboration data obtained from the results of the calculation of student observation sheets.

• RESULT AND DISCUSSION

Student HOTS ability data was obtained from *pretest scores.* and *posttest* then the *N-gain calculation is carried out* which can be seen in the following table**.**

Table 3. Results of HOTS Ability Statistical Test Based on *Pretest*, *Posttest*, and *N-Gain*

Mark	Class	$\bar{X} \pm$ Sd	Normality Test	Homogeneity Test	Sample t-Test
Pretest	E	37.14± 14.36	*Sig.* 0.10 > 0.05	Sig. 0.34 > 0.05	
	K	28.33± 12.34	*Sig.* 0.06 > 0.05		
Posttest	E	72.14± 12.57	*Sig.* 0.56 > 0.05	Sig. 0.79 > 0.05	
	K	56± 13.02	*Sig.* 0.57 > 0.05		
N-Gain	E	0.56±	*Sig.* 0.075 >	Sig. 0.221 >	*Sig. (2-tailed)*

		0.15	0.05	0.05	*0.001<0.05*
	K	0.39± 0.13	*Sig.* 0.195 > 0.05		

Based on table 3, it shows that the data is normally distributed and homogeneous. For this reason, the *Independent Sample T- Test was then carried out*. by using the *N-gain value* . The average N-gain value in the experimental class is 0.56 while in the control class the average N-gain value is 0.39. This shows that the increase in HOTS abilities of students in the experimental class is higher than in the control class. The results of the normality test obtained *Sig.* 0.075 > 0.05 in the experimental class and *Sig.* 0.195 > 0.05 in the control class, which means that H_0 is accepted and H_1 is rejected, which means that the data is obtained from normally distributed samples. The results of the homogeneity test of *Sig.* 0.221 > 0.05 indicate that the results of the variance of the experimental class and control class values are homogeneous. Then in the *Independent Sample t- test* shows the *Sig.* (2-*tailed*) 0.001 < 0.05 which means that there is an influence of the use of STEM integrated PjBL learning on students' HOTS abilities.

Pretest scores and *posttest* in the experimental class, it can be proven that integrated PjBL learning with STEM has an effect on improving students' HOTS abilities. The results of students' HOTS abilities on each indicator are presented in the graph below :

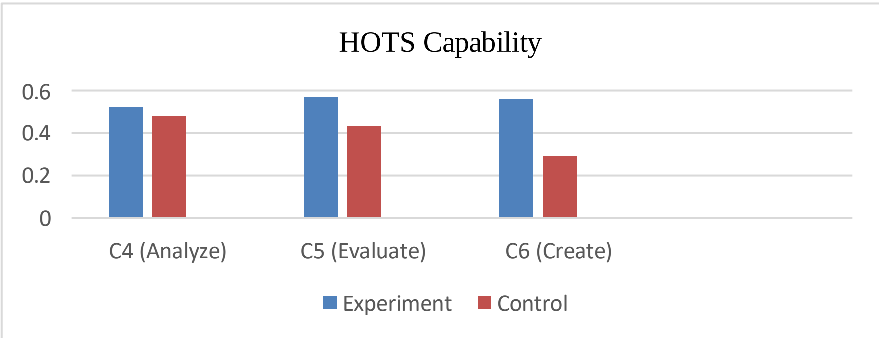

Figure 1. Graph of Student HOTS Ability Indicators

Based on Figure 1, it shows that the HOTS abilities of students in each indicator in the experimental class are higher compared to the control class, both in indicators C4 (analyzing), C5 (evaluating), and C6 (creating).

After conducting the hypothesis test, it is continued with the *effect test. size* to determine the magnitude of the influence of integrated PjBL learning with STEM on students' HOTS abilities. The results of the *effect calculation size* can be seen in the following table:

Table 4. *Effect* Calculation Results *Size*

Class	Average N-Gain	Standard Deviation	*Effect Size*	Information
Experiment	0.56	0.15	1.21	Tall
Control	0.39	0.13		

The results of calculating the value of the *effect test size* of 1.21 (Table 4). This shows that the use of integrated PjBL learning with STEM has a high influence on students' HOTS abilities in biotechnology material for class IX of SMPN 1 Trimurjo.

Then the data on the students' collaboration skills. Based on the results of the research that has been conducted on the experimental class and the control class, the percentage of the average score of the student collaboration indicator was obtained using the observation sheet which can be seen in the following table:

Table 5. Ability Collaboration Every Student Indicator

Indicator	Experiment Class		Control Class	
	Percentage (%)	Criteria	Percentage (%)	Criteria
Cooperation	87.7%	Very good	76.6%	Good
Responsibility	85.5%	Very good	77.7%	Good
Compromise	73.3%	Good	67.7%	Good
Communication	77.7%	Good	68.8%	Good
Flexibility	84.4%	Very good	74.4%	Good
$\bar{X}$	81.7%	Very good	73.1%	Good

Researchers used 5 indicators of collaboration ability (Table 5). In the experimental class there were 3 indicators with the criteria "Very Good" and 2 indicators with the criteria "Good". While in the control class all or all 5 collaboration indicators received the criteria "Good". Overall, the collaboration ability of the experimental class had an average percentage of 81.7% with the criteria "Very Good". While in the control class had an average percentage of 73.1% with the criteria "Good". This shows that the use of integrated PjBL learning with STEM has an effect on the collaboration ability of students in biotechnology material for class IX SMPN 1 Trimurjo.

The results obtained from this study indicate that the implementation of STEM integrated PjBL learning has an effect on students' HOTS and collaboration abilities. The results of data analysis that have been carried out on grade IX students of SMPN 1 Trimurjo show that the experimental class obtained a significant increase compared to the control class. This is proven through the results of the *independent test sample t- test* get *Sig.* (2-*tailed*) 0.001 < 0.05 so that H_1 is accepted (Table 4). The use of STEM-integrated PjBL learning has the potential as an effective learning alternative to encourage and hone students' HOTS abilities. The increase in HOTS abilities of experimental class students occurred because of the learning process that involved students carrying out STEM-integrated projects that could provide meaningful learning and experience to students. The application of PjBL integrated with STEM provides students with the opportunity to practice collaboration skills between students, problem solving, critical thinking, creative thinking, and scientific thinking which can improve students' high-level thinking skills (Baharin, Kamarudin, & Manaf, 2018). Syntax The learning consists of: 1) *Reflection*; 2) *Research*; 3) *Discovery*; 4) *Applications;* and 5) *Communication* (Laboy-Rush, 2011).

The improvement of HOTS ability of students in the experimental class is strengthened by the n-gain results of each indicator (Figure 1). The HOTS ability indicator that developed the most in the experimental class was indicator C6, seen from the difference in N-gain in the experimental class and the control class in indicator C6 which was higher than the other two indicators. This is because students can answer *posttest questions* correctly. In the question, students can formulate a hypothesis based on the data that has been presented in the form of tempeh with deliberate treatment using different packaging or wrappers, namely banana leaves, perforated plastic, and unperforated plastic along with their respective results. Students are able to provide correct answers along with their reasons because learning by integrating STEM requires students to think critically in analyzing problems and actively play a role in designing more real projects starting from finding solutions, deciding on ideas, designing projects, and implementing projects, so that students can evaluate and create products well.

Furthermore, the HOTS ability indicator, namely C4 in the experimental class and control class, has the lowest difference, because students in the experimental class and control class have been able to answer questions and their reasons correctly on average. However, the n-gain of the experimental class on the C4 indicator of the experimental class remains higher than that of the control class (Figure 1). This means that students have analytical skills, are able to separate ideas into parts or elements and show an understanding of the relationship between the parts as a whole (Sulistyorini, 2012)

PjBL learning with STEM on students HOTS abilities can be seen from the results of the *effect test. size* which obtained a value of 1.21 (Table 5) with the criteria of "High". Integrated PjBL learning with STEM has a major influence on HOTS abilities, this is because this learning involves students in a complex environmental problem, so that students are motivated to think critically in solving a given problem by making a product creatively. This is reinforced by research by Fitriyani, Toto, & Erlin (2020) which states that the application of the STEM integrated PjBL model has a significant influence on students' high-level thinking skills in biotechnology material.

In addition to influencing HOTS skills, the use of integrated PjBL learning with STEM also influences the collaboration of grade IX students at SMPN 1 Trimurjo. Student collaboration in science learning on biotechnology material can be seen based on observations assessed from the results of the collaboration observation sheet by researchers. An assessment was carried out on each collaboration indicator, to determine the effect of integrated PjBL learning with STEM that was applied. The collaboration indicators assessed were cooperation, responsibility, compromise, communication, and flexibility.

PjBL learning with STEM has the potential to improve students' collaboration skills and also as an effective learning alternative in the classroom because it can train good cooperation in a team to discuss determining the project, in the discussion it is expected that students are active in expressing opinions and respecting each other's opinions. In addition, students have their own responsibilities and communicate the results of the project. The increase in collaboration of experimental class students occurs because of the learning process that involves students to carry out STEM integrated projects that can provide meaningful learning and experience to students. The application of integrated PjBL with STEM provides students with the opportunity to practice collaborating between students, solving problems, thinking critically, thinking creatively, and thinking scientifically which can improve students' high-level thinking skills (Baharin, Kamarudin, & Manaf, 2018).

The most developed collaboration capability indicator is the cooperation indicator with a percentage of 87.7% with the criteria of "Very Good" (Table 6). The results of this study are in accordance with the results of research conducted by Ilmiyatni (2019), which showed that the average collaboration score of the experimental class was higher than the control class and the highest indicator was the cooperation indicator . This can be seen from the group discussion activities and each group member actively works together in solving problems or tasks given effectively and asks if there are obstacles. Furthermore, the lowest collaboration capability indicator is the compromise indicator with a percentage of 67.7% with the criteria of "Good". These results are also in accordance with the results of research conducted by Nur & Taim (2023), which states that the lowest collaboration indicator is compromise. The low compromise indicator in students is because almost all students in the group do not dare to express their opinions in making decisions during group discussions and only follow the flow and rules that have been determined.

Based on the above explanation, it can be concluded that the use of integrated PjBL learning with STEM has a positive impact on increasing collaboration of class IX students at SMPN 1 Trimurjo .

- **CONCLUSION**

Based on the results of the study and discussion, it can be concluded that there is an influence of the use of integrated PjBL learning with STEM on HOTS abilities and student collaboration in biotechnology material for grade IX of SMPN 1 Trimurjo . Then the researcher suggests that in this study the increase in students' HOTS abilities is still low on indicator C4 (analyzing). So that further research is expected to provide more familiarization with questions in analyzing a problem in order to get maximum results.

- **REFERENCES**

Ainurrahman, Rusdiono, Sulistyarini, Maryuni, S., Sutarman, Bistari, Herawati, H., Hilda, & Nurdini, A. (2021). Guide to Developing Teaching Materials Oriented to *Higher Order Thinking Skills* (HOTS). Tanjungpura University

Ayu, P.S., Marhaeni, & Budiadnyana, P. (2018). Development of Learning Skills and Innovation Assessment Instruments in Elementary School Science Subjects. *PENDASI: Indonesian Elementary Education Journal*, *2*(2), 90-100. https://doi.org/10.23887/jpdi.v2i2.2696

Baharin, N., Kamarudin, N., & Manaf., (2018). *Integrating STEM Education Approach in Enhancing Higher Order Thinking Skills. International Journal of Academic Research in Business, and Social Sciences. 8* (7): 810-822. http://dx.doi.org/10.6007/IJARBSS/v8-i7/4421

Cahyono, A. H., Ibrahim, M., & Suprapto, N. (2022). Development of Science, Technology, Engineering and Mathematics (STEM)-Based Science Learning Devices to Improve Critical Thinking and Problem-Solving Skills in Elementary School Students. *Jurnal Pendidikan dan Pembelajaran Kimia*, *11*(3), 104-115.

Fitriyani, A., Toto, T., & Erlin, E. (2020). Implementation of PjBL -STEM Model to Improve Higher Order Thinking Skills. *Bioed: Journal of Biology Education*, *8* (2), 1-6. http://dx.doi.org/10.25157/jpb.v8i2.4375

Ilmiyatni, F., Jalmo, T., & Yolida, B. (2019). *Problem Based* Influence *Learning* towards Collaboration Skills and High-Order Thinking. *Bioterdidik Journal: Scientific Expression Vehicle*, *7* (2), 35-45.

Laboy-Rush, D. (2011). *Integrated STEM Education Through Project-Based Learning. Learning.com*, *12* (4).

Lutfi, L., Ismail, I., & Azis, A.A. (2018). The Influence of *Project Based* STEM Integrated *Learning on Science* Literacy , Creativity, and Student Learning Outcomes. *National Seminar on Biology and Its Learning Innovation in*

Biology Learning and Research Based on Natural Potential.

Mariamah, S., Bachtiar, M.Y., & Indrawati, I. (2021). Implementation of *Project Based Learning* to Improve Collaboration Skills of Early Childhood. *Journal of Educational Professions*, *2* (1), 125-130.

Muis, A., & Dewi, L. (2021). *Day Care Management Course Design Based on OBE and PjBL for Teacher Education of Early Childhood Education Program. Curriculum Innovation*, *18* (2), 128-140.
https://doi.org/10.17509/jik.v18i2.35713

Nur, S., & Taim, M.A.S. (2023). Analysis of High School Students' Collaboration Skills in Biology Learning. *Diklabio: Journal of Biology Education and Learning*, *7* (1), 82–89. https://doi.org/10.33369/diklabio.7.1.82-89

Pademi, B. S. (2023). Pengaruh Model Pembelajaran *Project Based Learning* Terintegrasi STEM Terhadap Hasil Belajar Siswa. *Jurnal Ilmiah IKIP Mataram*, *10*(1), 50-56.

Pasaribu, P. C., & Suyanti, R. D. (2024). Application of Kvisoft Maker-Based Flipbook Problem Based Learning (PBL) Model Based on Kinemaster to Improve Capabilities Hots Literacy for Grade XI Students of SMA Negeri 1 Percut Sei
Master Matter Reaction Rate. *Jurnal Pendidikan dan Pembelajaran Kimia*, *13*(1), 133-141.

Rizka Fathi, A. (2023). Pengaruh Model Project Based Learning Terhadap Kemampuan Kolaborasi Dan Hasil Belajar Kognitif Peserta Didik pada Materi Bioteknologi.

Sugiyono, P. D. (2013). Statistika Untuk Penelitian. Bandung: Alfabeta.

Sulistyorini, (2012). Analysis of Cognitive Competence Achievement at Application Level (C3) and Analysis (C4) in Physics Learning for Grade XI Students of Senior High School in the Rsbi Program .

Trilling, B., & Fadel, C. (2009). *21st century skills: Learning for life in our times*. John Wiley & Sons.

Triowathi, N., & Wijayanti, A. (2018). Implementation of *Team Games Tournament* (TGT) in Improving Science Cooperation and Learning Outcomes. *Jurnal Pijar MIPA*, *13* (2), 110-118. http://dx.doi. org/10.29303/jpm.v13i2.752

Walihah, Z., Gunada, IW, Sutrio, S., & Ayub, S. (2023). The Influence of *Project Based Model Learning* On Students' *Higher Order Thinking Ability*. *Empiricism Journa*, *4* (2), 348–355. https://doi.org/10.36312/ej.v4i2.1389

Wijaya, E.Y., Sudjimat, D.A., & Nyoto, A. (2016). Transformation of 21st Century Education as a Demand for Human Resource Development in the Global Era. *In Proceedings of the National Seminar on Mathematics Education*, *1* (26), 263-278.