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Utilize Renewable Energy Kits to Develop Students' Lower and Higher-Order Thinking Skill

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Abstract. This research aims to determine the effect of kits renewable energy projects by implementing a project-based learning (PjBL) model on students' lower order thinking skills (LOTS) and higher order thinking skills (HOTS). The research method used was quasi-experimental with a nonequivalent posttest only control group design. The population in this study was 198 students. Samples were taken randomly from a population that had passed the normality test and homogeneity test. This research uses a cognitive learning outcomes test instrument in the form of multiple choices. The research results show that there is no significant difference in cognitive learning outcomes in the LOTS category between students in classes that apply PjBL on renewable energy material and classes that apply conventional learning on renewable energy material, sig. 0.127 ≥ 0.05, using the Mann Whitney test. Meanwhile, the results of hypothesis testing for cognitive learning outcomes in the HOTS category using the independent sample t-test obtained a sig (2-tailed) value of 0.000 ≤ 0.05, which means there is a significant difference in students' cognitive learning outcomes. between classes that apply PjBL to renewable energy material and classes that apply conventional learning to renewable energy material. These results indicate that PjBL can produce student learning in the HOTS category, but has no effect on increasing students' cognitive abilities.
Keywords: PjBL, renewable energy, LOTS, HOTS

Introduction

Currently the world is in the 21st century which is marked by rapid development in all fields. This rapid development can provide opportunities if utilized properly (Redhana, 2019). The challenges and responsibilities of the world of education in the 21st century are not easy. One of these responsibilities is to produce quality workers who have at least four abilities, or what are usually called the 4Cs, namely critical thinking, communication, collaboration, and creativity (Partono et al., 2021). In the world of education, students can acquire 21st century skills through implementing innovative learning, highlighting research results that support 21st century skills, and applying technology in the learning process (Mashudi, 2021). One application of these skills is in the project-based learning (PjBL) model (Karomatunnisa et al., 2022).

PjBL is a student-centered learning model so that at the end of the learning a product will be created. It can be said that in the PjBL model students are actively involved in working in groups during the learning process to work on a project to create a product

(Fadhilah et al., 2023). Each learning model certainly has advantages and disadvantages, as does the PjBL model. The advantages of using a PjBL model are: increase learning motivation, improve problem solving abilities, train cooperation/cohesion in teams, improve 21st century skills, and make the learning process active and fun (Nurfitriyanti, 2016). Students who learn through the PjBL model typically work together to solve a specific problem, develop a product for a specific audience, and then evaluate the project and development process (Almulla, 2020). Besides that, PjBL is an effective educational tool, which helps students develop deep thinking abilities to apply knowledge, develop communication skills and also reasoning skills, and this method is more innovative, interesting compared to traditional didactic approaches. Additionally, by regularly using PjBL tools, systematic retention of project experience allows students to compare different projects more systematically and highlight the most effective problem-solving mechanisms, leading to reduced future project risks and better practical managerial skills (Vasiliene-Vasiliauskiene et al., 2020). Meanwhile, the weaknesses of using this project-based learning model are that it is expensive, takes a long time, requires skilled teachers and not all students are actively involved in working on the project (Arifianti, 2020). However, these shortcomings can be minimized by the teacher's ability to design learning strategies, project management and maximize success (Erika, 2020).

One of the learning processes in SMA/MA that can be applied to the PjBL model is through physics learning. So far, students consider physics to be a difficult subject because the learning carried out is still conventional, where students are required to memorize formulas. Apart from that, in the physics learning process, the use of learning media is still lacking, which causes students' low interest and motivation to learn because they feel bored with simple and less varied media (Sevtia et al., 2022). Considering that media is a tool that has quite a positive impact in minimizing educational problems, the researchers created a STEM project media kit which is arranged in 1 kit box which is portable and easy to carry anywhere. This equipment can be disassembled and assembled, like a puzzle toy for learning about renewable energy (wind energy, solar energy, and water energy). Where in the kits box 3 types of renewable energy projects can be created. Media has an important role as a means of developing thinking about the teaching materials contained therein (Andriyani & Suniasih, 2021). The results of research conducted by Subarkah et al. (2020) shows that the learning media used in the learning process has an impact on high-level thinking abilities and activities. Low interest in studying physics will affect the learning process causing learning objectives not to be achieved, resulting in low student learning outcomes (Astalini et al., 2018). Learning outcomes are the result of students' thinking abilities which according to Bloom's taxonomy are divided into 2 levels, namely LOTS and HOTS. LOTS are low/basic level thinking skills consisting of the ability to remember, understand and apply (C1-C3). Meanwhile, HOTS is high level thinking which requires the ability to analyze, evaluate and create (C4-C6) with one's own thoughts, not just memorizing facts or re-explaining a concept or phenomenon (Winarti & Istiyono, 2020).

Much research has been carried out in order to improve HOTS capabilities (Akbar Asfar et al., 2021; PH et al., 2020; Qamariyah et al., 2021). This research reveals that improving HOTS can be done with models, methods and approaches such as ethnoscience-based STEM, elaboration of the active knowledge sharing learning model, inquiry with SSI (socio scientific issues). However, this research only measured students' HOTS abilities. Research in improving HOTS and LOTS abilities as well as in physics learning is still very limited.Based on the description above, researchers conducted research that focused on implementing the KIT-assisted project based learning model for renewable energy projects in increasing LOTS and HOTS. The ability to increase LOTS and HOTS is applied based on what problems exist in the environment and require solutions to solve them. For this reason, researchers conducted research with the title "effectiveness of renewable energy project kits as physics learning media in improving LOTS and HOTS".

Methods

This type of research design is quasi-experimental using a non-equivalent posttest only control group design. This research used two sample groups, namely the experimental group and the control group. The experimental group was given treatment by being given a renewable energy project kit. Meanwhile, the control group was not given treatment by carrying out conventional learning.

This research was carried out at SMA Negeri 1 Perhentian Raja, Kampar Regency, Riau Province in the odd semester of the 2023/2024 academic year. The population of this study was class X students of SMA Negeri 1 Perhentian Raja, totaling 6 classes, namely 198 students. The samples from this research were classes X1 and X2 as experimental classes, totaling 34 students and 33 students respectively. Meanwhile, the control classes are classes X4 and X5, with 33 students and 32 students respectively.

Data was obtained from students' initial test scores to determine the sample in the research and as a reference in determining the experimental group and control group. Primary data was obtained through posttest scores. The research instrument used in this study was a cognitive learning outcomes test in the form of multiple choice questions totaling 25 questions.

The data analysis technique in this research uses descriptive analysis consisting of averages, percentages and bar charts, while inferential analysis uses the SPSS version 22 program which consists of normality tests, homogeneity tests and t tests. Descriptive analysis in this study aims to describe student learning outcomes, while inferential analysis results are a technique used to analyze sample data to generalize to the population (Sugiyono, 2019).

Results and Discussion

Analysis of Lower Order Thinking Skills Learning Outcomes

The learning outcome data used in this research came from students' daily test scores in the experimental and control classes. This data is the result of student learning LOTS category, especially in the cognitive domains of remembering (C1), understanding (C2), and applying (C3). Researchers used descriptive analysis in this study to get a general picture of how much students' cognitive learning outcomes with the LOTS question category on alternative energy material in the experimental class which used project-based learning and the control class which used conventional learning were influenced by the project-based learning. The experimental and control groups provided posttest results in the LOTS category. Figure 1 displays the students' posttest results in the LOTS category.

The results of inferential analysis are in the form of normality tests, homogeneity tests, and hypothesis tests. Based on the normality test, it shows a significance value ≤ 0.05, which means the data is not normally distributed. Based on the homogeneity test, a significance value of ≥ 0.05 was obtained, which means the data is homogeneous. The data on learning results for LOTS questions is not normal and homogeneous, therefore hypothesis testing using the Mann Whitney U test is used. Based on the Mann Whitney U test, a significance value of 0.127 ≥ 0.05 is obtained, so H_0 is accepted, which means there is no significant difference in student cognitive learning outcomes between classes that apply project-based learning on renewable energy material and classes that apply conventional learning to renewable energy material. Based on the results of the hypothesis test, it can be concluded that the KIT renewable energy project cannot improve students' cognitive learning outcomes in the LOTS question category.

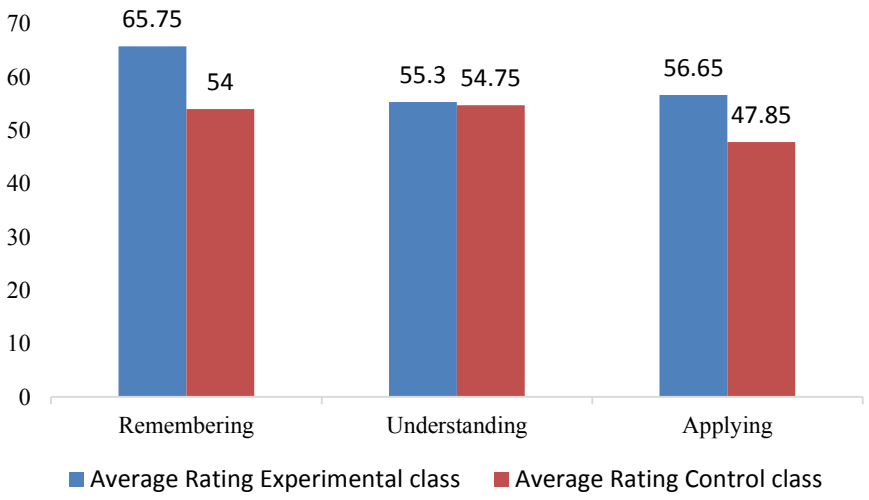


Figure 1. Graph of Average Cognitive Learning Results for groups of questions involving low-level thinking skills

The results is not surprising. It is because LOTS question do not require students to think critically (Mustika et al., 2020). Apart from that, students are already used to working on LOTS questions because most teachers also create questions to measure lower level in Bloom's taxonomy (Abosalem, 2015). This result shows that there is no need to apply a specific learning model to increase students' LOTS.

LOTS are knowledge questions that require simple recall of information or simple application of information, theory, or knowledge that does not require complex solutions (Tsaparlis, 2020). LOTS type questions are questions that apply low level thinking skills which only test the 3 lowest abilities, namely the ability to remember, understand and create (Nurjanah, 2021). Based on Anderson et al. (2001), the cognitive domain of the LOTS level is as follows.

Remembering

Remembering is an attempt to retrieve knowledge from long-term memory and recall it. Remembering is related to recognizing and remembering. Recognizing is concerned with taking long-term knowledge and comparing it with newly acquired knowledge. Students look for similar information in the light period with their newly received knowledge. Meanwhile, recalling is the process of recalling long-term information that has been learned. Students look for information in the past and bring it to memory for processing. The operational verbs of recall are mentioning, identifying, showing, labeling, defining, listing, matching, etc.

Understanding

Understanding is constructing meaning from learning messages, whether verbal, written or visual, as outlined in teaching, books or computers. Understanding is related to classifying and comparing activities. Classification is related to the process of finding characteristics that are in accordance with principles. Comparing relates to the process of finding similarities and differences between two or more objects, events, ideas, problems or situations. The operational verbs of understanding are explaining, comparing, exemplifying, differentiating, interpreting, etc.

Applying

Applying is using a procedure to carry out an experiment or solve a problem. Implementation includes activities to carry out procedures and implementation. Carrying out procedures means the process of solving problems related to knowledge of information, so that students are confident in determining the steps that need to be taken to solve the problem. Implementing occurs when students choose and use procedures for things they don't know or are still unfamiliar with. Because students still feel unfamiliar with this problem, students need to first recognize and understand the problem, then decide on the appropriate procedure to solve the problem. The operational verbs for implementation are apply, calculate, carry out, modify and so on.

Analysis of HOTS

The learning result data used in this research is the HOTS category learning result data, namely the cognitive domains of analyzing (C4), evaluating (C5) and creating (C6) obtained from student test results in the experimental and control classes. Results of descriptive analysis of HOTS category learning outcomes in the experimental class using PjBL and the control class using conventional learning. The HOTS category student learning outcome scores can be seen in Figure 2.

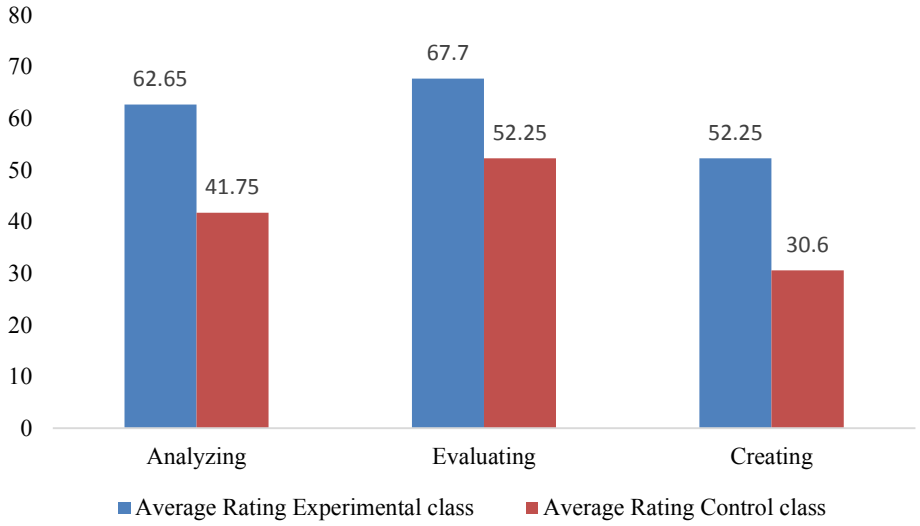


Figure 2. Graph of average cognitive learning results for groups of questions involving low-level thinking skills

Figure 2 shows that the average score of students' cognitive learning outcomes is different for each indicator. The experimental class outperformed the control class in the HOTS category cognitive learning outcomes. The control class got an average score of 41.5 in the poor category, while the experimental class got an average score of 60.8 in the quite good category. Normality, homogeneity and hypothesis tests are examples of inferential analysis. Based on the normality test, a significance value of ≥ 0.05 was obtained, which indicates that the data is normally distributed. The homogeneity test produces a significance value ≥ 0.05 which indicates the homogeneity of the data. The learning results for HOTS questions are homogeneous and normally distributed, so the independent sample T-Test is used to test the hypothesis. If the significance value is 0.000 ≤ 0.05 then Ho is rejected, which means there is a significant difference in the cognitive learning outcomes of students in classes that use PjBL based on alternative energy

materials compared to classes that use conventional learning. Hypothesis testing resulted in the conclusion that students' cognitive learning outcomes in the HOTS question category could be improved with the renewable energy KIT project. The following is an examination of each question indicator in the HOTS category.

Analysis of Analytical Skill (C4)

Based on the average score on HOTS questions obtained between the experimental class and the control class, the average score for the experimental class was higher than the control class. This is because the experimental class is used to solving problems through LKPD which is located in the data analysis section. Problem solving is included in the realm of cognitive analysis (C4). In line with what was said by Chistyakov et al. (2023) that PjBL is a cognitive analyzing domain.

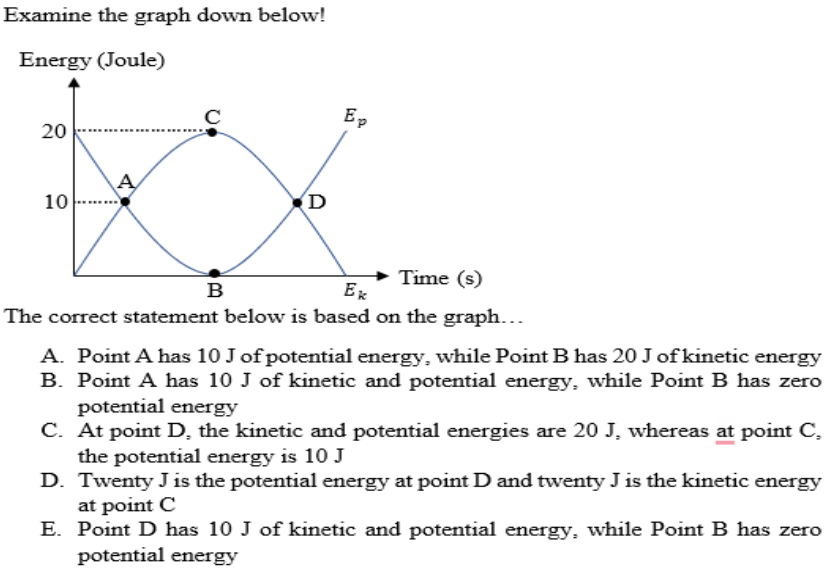


Figure 3. Analytical ability questions

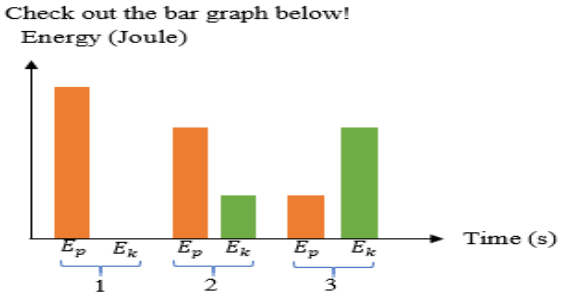
Based on Figure 3, the correct answer is option B. At point A the potential energy is 10 Joules, while at point B the potential energy value is zero. The indicator for this problem is analyzing the graph of the relationship between mechanical energy and time. Mechanical energy is divided into two, namely kinetic energy and potential energy. Kinetic energy is the energy an object has due to its motion. The faster an object moves, the greater its kinetic energy. Potential energy is the energy that an object has because of its position or height. The higher an object is, the greater its potential energy. Based on this explanation, kinetic energy and potential energy at a point are always the same in a conservative style.

With this project-based learning, students are used to solving problems or solving problems related to projects. PjBL is student-centered learning that seeks students to conduct research, combine theory and practice, and apply knowledge and skills to build viable solutions to discovered problems (Naji et al., 2020). It helps students in planning to solve the problem and carrying it out, and making decision based on the problem given (Susanti et al., 2021).

Analysis of Evaluation Skill (C5)

Based on the average score obtained in the evaluation domain, the experimental class was higher than the control class. The high learning achievement of the experimental class

compared to the control class is due to the fact that in the assessment domain (C5), experimental class students are used to assessing or evaluating products that have been completed. The projects that have been made by students are making parts of a power plant project, a simple windmill project, a simple waterwheel project, and a simple garden lamp project. Experimental class students are used to assessing products that have been completed, whether the product is successful or not. Examples of questions that fall into the evaluation domain (C5) are as follows.



The right mechanical energy inference from the given bar chart is....

A. Potential energy and mechanical energy, or $E_p < E_k$, constitute mechanical energy in state 2
B. Kinetic energy is the mechanical energy in state 1
C. Potential energy and kinetic energy, or $E_p > E_k$, make up the mechanical energy in state 3
D. Potential energy is the mechanical energy in state 1
E. Mechanical energy in state 2 is potential energy and kinetic energy, $E_p = E_k$

Figure 4. Evaluation skills questions

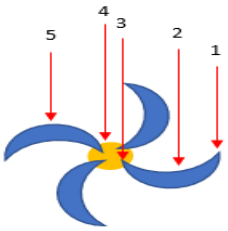
Based on Figure 4, the correct answer is option D. The indicator of this problem is the conclusion about the law of conservation of mechanical energy. One of the operational verbs of the assessment domain (C5) is to conclude. Inferential skills are important for students to have in science learning. Students can have concluding skills after carrying out investigative, observation or practicum activities. PjBL helps students to perform well in solving the problem, one of which is in the concluding process (Yensy et al., 2023). Kinetic energy and potential energy at a point are always the same if only a conservative force is applied. If the kinetic energy is minimum then the potential energy is maximum. When the kinetic energy is maximum, the potential energy is minimum.

Analysis of Creative Skill (C6)

Based on the average score obtained in the creation domain, the experimental class was higher than the control class. This is because the group of experimental class students immediately carried out projects related to alternative energy sources. The experimental class plans more projects, assembles tools, completes projects, and performs experimental activities. Making projects according to the guidelines in the worksheet consists of a simple windmill project, a simple waterwheel project and a simple garden lamp project. Therefore, on average, experimental class students were able to answer the ability to make questions compared to classes that did not apply this learning compared to control class students who only listened to the teacher's explanation. This is in line with research conducted by Aristiadi & Putra (2018) that the learning outcomes of the experimental class that used the PjBL student worksheet were higher than the learning outcomes of the control class that did not use the project-based student worksheet, because the experimental class was actively involved in project implementation through the project LKS guide. In their learning, the control class also received non-experimental worksheets. However, these worksheets

do not lead to the creation of projects like those given in the experimental class. Examples of questions that fall into the creation domain (C6) are as follows.

Look at the image down below!



A group of pupils wished to construct a basic waterwheel project. The precise location of the water's fall is one of the things they must plan in order to ensure that the wheel's spinning is powerful. The waterwheel that the student group will use is shown in the image above. The number indicates the precise location of the water fall needed to ensure a robust waterwheel spinning....

A. 1
B. 2
C. 3
D. 4
E. 5

Figure 5. Questions about creative skill

Based on Figure 5, the question indicator is presented with a picture of a waterwheel, students can plan a simple waterwheel project. One of the verbs in the creation domain is planning. Students are asked to plan the position of the water falling on the water wheel so that the resulting voltage is large. The number of experimental class students who were able to answer questions was 51 students, while the number of control class students who were able to answer questions was 21 students. The experimental class that has implemented PjBL to make a simple water wheel can answer questions on average compared to the control class that has not implemented project-based learning. During the experiment, students tried various points where the water fell, and the result was that if the water fell right at the end of the wheel (number 1), the rotation of the water wheel would change. becomes strong so that it produces a large voltage. Thus, can improve aspects of scientific creativity which include creative problem solving skills, experimental design skills, and product design skills (Anazifa & Djukri, 2017).

The experimental class is used to working on project-based student worksheets that lead to higher order thinking learning, students are used to working on things related to HOTS, so that implementing PjBL can improve learning outcomes in the HOTS category. This is in line with research conducted by Khoiriyah et al. (2023) that the PjBL model has a significant effect on students' high-level thinking abilities in analyzing the concept of kinetic theory of gases. This is also in line with research Hujjatusnaini et al. (2022) that the blended PjBL model which is integrated with 21st century skills is influential and effective in increasing students' HOTS.

Conclusion

Based on statistical analysis, student learning outcomes in the LOTS category obtained a sig. 0.127 ≥ 0.05, which means there is no significant difference in student cognitive learning outcomes between classes that apply PjBL on renewable energy material and classes that apply conventional learning on renewable energy material. Meanwhile, statistical analysis on HOTS questions with a sig (2-tailed) value of 0.000 ≤ 0.05 means that there is a significant difference in student cognitive learning outcomes between classes that apply PjBL on renewable energy materials and classes that apply conventional learning on renewable energy materials. Based on these results, it can be concluded that the KIT

renewable energy project can improve students' cognitive learning outcomes in the HOTS category. Apart from that, by implementing KIT, this project can increase students' motivation and activeness in learning. The results of this research provide implications for physics learning in the future. Teachers, especially physics teachers, are expected to be able to implement PjBL and develop this project and apply this learning model to different materials to train students' high-level thinking abilities.

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Reference

Abosalem, Y. 2015. Assessment techniques and students' higher-order thinking skills. *ICSIT 2018 - 9th International Conference on Society and Information Technologies, Proceedings*, 4(1):61–66. https://doi.org/10.11648/j.ijsedu.20160401.11

Akbar, A.M.I., Ahmad, M.A., Anshari, & Taufan, A.M.I. 2021. Elaboration of active knowledge sharing learning model to improve high order thinking skills integrated 4C. *Asian Journal of Applied Sciences*, 9(4):260–266. https://doi.org/10.24203/ajas.v9i4.6693

Almulla, M.A. 2020. The effectiveness of the project-based learning (pbl) approach as a way to engage students in learning. *SAGE Open*, 10(3):1–15. https://doi.org/10.1177/2158244020938702

Anazifa, R.D. & Djukri. 2017. Project-based learning and problem- based learning: Are they effective to improve student's thinking skills? *Jurnal Pendidikan IPA Indonesia*, 6(2):346–355. https://doi.org/10.15294/jpii.v6i2.11100

Anderson, L.W. & Krathwohl, D.R. 2001. *A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives*. Longman.

Andriyani, N.L. & Suniasih, N.W. 2021. Development of learning videos based on problem-solving characteristics of animals and their habitats contain in ipa subjects on 6th-grade. *Journal of Education Technology*, 1(1):37–47. https://doi.org/https://doi.org/10.23887/jet.v5i1.32314

Arifianti, U. 2020. Project based learning dalam pembelajaran IPA. *Workshop Nasional Penguatan Kompetensi Guru Sekolah Dasar*, 3(3):2079–2082.

Aristiadi, H. & Putra, R.R. 2018. Pengaruh penggunaan lembar kerja peserta didik (lkpd) berbasis proyek terhadap hasil belajar peserta didik pada konsep pemanasan global. *Bioedusiana*, 3(2):77–84. https://doi.org/https://doi.org/10.34289/277886

Astalini, A., Kurniawan, D.A., & Sumaryanti, S. 2018. Sikap siswa terhadap pelajaran fisika di SMAN Kabupaten Batanghari. *JIPF (Jurnal Ilmu Pendidikan Fisika)*, 3(2):59–64. https://doi.org/10.26737/jipf.v3i2.694

Chistyakov, A.A., Zhdanov, S.P., Avdeeva, E.L., Dyadichenko, E.A., Kunitsyna, M.L., & Yagudina, R.I. 2023. Exploring the characteristics and effectiveness of project-based

learning for science and STEAM education. *Eurasia Journal of Mathematics, Science and Technology Education*, 19(5):1–7. https://doi.org/10.29333/EJMSTE/13128

Erika. 2020. Implementation of project based learning (pjbl) models in science learning in Elementary Schools. *Workshop Penguatan Kompetensi Guru 2022*, 5(5):430–437.

Fadhilah, Husin, M., & Fadia, R.R. 2023. The effectiveness of project-based learning (PjBL) on learning outcomes: a meta-analysis using JASP. *JIPF (Jurnal Ilmu Pendidikan Fisika)*, 8(3):327–336. https://doi.org/10.26737/jipf.v8i3.3701

Hujjatusnaini, N., Corebima, A.D., Prawiro, S.R., & Gofur, A. 2022. The effect of blended project-based learning integrated with 21st-century skills on pre-service biology teachers' higher-order thinking skills. *Jurnal Pendidikan IPA Indonesia*, 11(1):104–118. https://doi.org/10.15294/jpii.v11i1.27148

Karomatunnisa, A.-Z.A., Sholih, J.A.U., Hanifah, N., & Prihantini, P. 2022. Meta analisis model pembelajaran project based learning dalam meningkatkan kemampuan keterampilan abad 21. *Jurnal Pendidikan Sosiologi Dan Humaniora*, 13(2):522–528. https://doi.org/10.26418/j-psh.v13i2.54755

Khoiriyah, R.M.H., Sudarti, S., Nuraini, L., & Rozak, A. 2023. Pengaruh model project based learning dalam pembelajaran teori kinetik gas terhadap keterampilan berpikir tingkat tinggi siswa di SMAN 5 Jember. *Jurnal Pembelajaran Fisika*, 12(1):1–8. https://doi.org/10.19184/jpf.v12i1.36283

Mashudi, M. 2021. Pembelajaran modern: membekali peserta didik keterampilan abad ke-21. *Al-Mudarris (Jurnal Ilmiah Pendidikan Islam)*, 4(1):93–114. https://doi.org/10.23971/mdr.v4i1.3187

Nurjanah, M. 2021. Implementasi LOTS dan HOTS pada soal tema 3 kelas 1 Mi/Sd. *Jurnal Evaluasi Dan Pembelajaran*, 3(2):70–79. https://doi.org/10.52647/jep.v3i2.36

Mustika, N., Nurkamto, J., & Suparno. 2020. Teacher's questioning in senior high english classroom : an investigation of students' critical. *International Online Journal of Education and Teaching (IOJET),* 7(1):278–287.

Naji, K.K., Ebead, U., Al-Ali, A.K., & Du, X. 2020. Comparing models of problem and project-based learning (PBL) courses and student engagement in civil engineering in Qatar. *Eurasia Journal of Mathematics, Science and Technology Education*, 16(8):1–16. https://doi.org/10.29333/EJMSTE/8291

Nurfitriyanti, M. 2016. Model pembelajaran project based learning terhadap kemampuan pemecahan masalah matematika. *Formatif: Jurnal Ilmiah Pendidikan MIPA*, 6(2): 149–160. https://doi.org/http://dx.doi.org/10.30998/formatif.v6i2.950

Partono, P., Wardhani, H.N., Setyowati, N.I., Tsalitsa, A., & Putri, S.N. 2021. Strategi meningkatkan kompetensi 4c (critical thinking, creativity, communication, & collaborative). *Jurnal Penelitian Ilmu Pendidikan*, 14(1):41–52. https://doi.org/10.21831/jpipfip.v14i1.35810

PH, Q.A., Sudarmin, Sumarni, W., Subali, B., & Saptono, S. 2020. Implementation of STEM integrated ethnoscience-based vocational science learning in fostering students' higher order thinking skills (HOTs). *International Journal of Active Learning*, 5(2):53–61. http://dx.doi.org/10.15294/ijal.v5i2.27498

Qamariyah, S.N., Rahayu, S., Fajaroh, F., & Alsulami, N.M. 2021. The effect of implementation of inquiry-based learning with socio-scientific issues on students' higher-order thinking skills. *Journal of Science Learning*, 4(3):210–218. https://doi.org/10.17509/jsl.v4i3.30863

Redhana, I.W. 2019. Mengembangkan keterampilan abad ke-21 dalam pembelajaran kimia. *Jurnal Inovasi Pendidikan Kimia*, 13(1):2239–2253. https://doi.org/https://doi.org/10.15294/jipk.v13i1.17824

Sevtia, A.F., Taufik, M., & Doyan, A. 2022. Pengembangan media pembelajaran fisika berbasis google sites untuk meningkatkan kemampuan penguasaan konsep dan berpikir kritis peserta didik SMA. *Jurnal Ilmiah Profesi Pendidikan*, 7(3):1167–1173. https://doi.org/10.29303/jipp.v7i3.743

Simatupang, M.M. & Simatupang, S. 2017. Pengaruh model problem based learning terhadap hasil belajar siswa pada materi listrik dinamis di kelas X SMA N 1 Tanjung Morawa. *INPAFI (Inovasi Pembelajaran Fisika)*, 5(12):33–38. https://doi.org/https://doi.org/10.24114/inpafi.v5i2.9110

Subarkah, C.Z., Trisnawati, A., Sundari, C.D.D., & Malik, A. 2020. Implementation of green chemistry-based electrolysis learning media to develop higher order thinking ability. *Journal of Physics: Conference Series*, 1503(1). https://doi.org/10.1088/1742-6596/1503/1/012032

Sugiyono. 2019. *Metode Penelitian Kuantitatif Kualitatif dan RND* (Ke 2). Alfa Beta.

Susanti, E., Maulidah, R., & Makiyah, Y.S. 2021. Analysis of problem-solving ability of physics education students in STEM-based project based learning. *Journal of Physics: Conference Series*, 2104(1). https://doi.org/10.1088/1742-6596/2104/1/012005

Takko, M., Jamaluddin, R., Kadir, S.A., Ismail, N., Abdullah, A., & Khamis, A. 2020. Enhancing higher-order thinking skills among home science students: The effect of cooperative learning student teams-achievement divisions (STAD) module. *International Journal of Learning, Teaching and Educational Research*, 19(7):204–224. https://doi.org/10.26803/IJLTER.19.7.12

Tsaparlis, G. 2020. Higher and lower-order thinking skills: The case of chemistry revisited. *Journal of Baltic Science Education*, 19(3):467–483. https://doi.org/10.33225/jbse/20.19.467

Vasiliene-Vasiliauskiene, V., Vasiliauskas, A.V., Meidute-Kavaliauskiene, I., & Sabaityte, J. 2020. Peculiarities of educational challenges implementing project-based learning. *World Journal on Educational Technology: Current Issues*, 12(2):136–149. https://doi.org/10.18844/wjet.v12i2.4816

Winarti & Istiyono, E. 2020. *Taksonomi Hingher Order Thinking Skill Untuk Penilaian Pembelajaran Fisika* (Vol. 1). Widya Sari Press.

Yensy, N.A., Danim, S., & Susanta, A. 2023. *Increasing the Students' Understanding of Analyzing Data Through Project-Based Learning*. 1:265–272. https://doi.org/10.2991/978-2-38476-012-1_34