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STEM Learning to Improve Problem Solving Ability on the Topic of Environmental Education

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Abstract: STEM learning is a new innovation in 21st century education. The ability to solve problems is important for students to learn to be able to solve environmental problems. The purpose of this study is to measure the effect of STEM on the ability to solve problems on the topic of environmental change. The method used in this research is Quasi Experiment. The sample used in this study was students at high school (SMAN) 4 Cibinong, Bogor Regency. The results of this study indicate that the instrument is valid and reliable. The results of the hypothesis test show that t-count > t-table which can be interpreted that the score there is an effect of lesson study-based Science, Technology, Engineering, and Mathematics (STEM) learning on students' problem-solving abilities on Environmental Change topic. Environmental Education plays an important role in shaping students' problem-solving skills. STEM-based learning in this case must prioritize solving environmental problems that are integrated with environmental education. The conclusion from this study is that STEM learning has an impact on students' problem-solving abilities.

Keywords: 21st education; Environmental education; STEM learning

Introduction

The skills that students must possess in the 21st century must be aligned with the 4 pillars of education according to UNESCO, namely learning to know, learning to do, learning to be, and learning to live. together (Priscilla & Yudhyarta, 2021). Learning in the 21st century must be able to prepare a generation that is able to face advances in technology, information and communication in social life. All 21st century skills such as collaboration skills, critical thinking skills, creative and effective communication skills can be fostered through activities such as problem solving and projects, design innovation (Boholano, 2017; Ferrari et al., 2012; Koh et al., 2015; Motallebzadeh et al., 2018; Sadiqin et al., 2017; Siong and Osman, 2018). One of the competencies that is important to develop in schools is problem solving skills. Based on the results of interviews with biology teachers at school, it was stated that problem solving abilities were rarely practiced in class because teachers were still experiencing problems in preparing questions that were able to bring up these problem solving abilities. Basically problem solving skills are important at all levels of education, especially at the senior high school level which requires students to start learning by thinking logically, critically and having great curiosity about the problems faced in their surroundings (Anagun, 2018; Camacho & Legare, 2015; Čipková et al., 2018; Muhibbin et al., 2019; Rao & DiCarlo, 2017; Yusuf et al., 2020). Efforts that can be made in improving students' skills can be circumvented by using other learning that is helping students in improving problem solving abilities. One of them is learning by using Science, Technology, Engineering, and Mathematics (STEM).

Science, Technology, Engineering, and Mathematics (STEM) learning is closely related to the development of skills in the 21st century where learning using STEM does not only understand learning concepts but can relate them to everyday life. Science, Technology, Engineering, and Mathematics (STEM) approach that combines science, technology, engineering, and mathematics which aims to prepare students for the future. STEM can be implemented with

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learning models that have been tested, namely Problem Based Learning (PBL), Project Based Learning (PjBL), and Inquiry Based Learning. One study explained that the application of STEM learning is beneficial for students because students will do learning by interpreting and understanding concepts and researching deeper into projects so that students will be active in the learning process. This makes STEM learning able to grow problem solving skills in students (Gryczka et al., 2016; Gu & Belland, 2015; Lou et al., 2017; Park & Park, 2020; Priantari et al., 2020; Tharayil et al., 2018). However, in the field problem solving skills are rarely trained in class because teachers experience problems in preparing questions that can trigger problem solving skills. Suwarma (2017) revealed that the application of STEM in science learning can improve cognitive in problem solving by increasing the score after the test. Based on the background above, the formulation of the problem in this research is whether there is an influence of Science, Technology, Engineering, and Mathematics (STEM) learning on students' problem solving abilities in the topic on Environmental Change. This study aims to determine the influence of STEM on students' problem solving abilities in the topic on Environmental Change.

Method

This research was conducted at Cibinong 4 Senior High School, located on Bojong Koneng street, RT.01/RW.01, Cibinong, Bogor Regency, West Java. The time for carrying out the research is in the even semester of the 2021/2022 school year from March to July 2022. The research uses a quantitative approach with the Quasi Experiment method. There are two variables in this research. The treatment variable is the Lesson Study-based Science, Technology, Engineering, and Mathematics (STEM) Approach. The dependent variable is students' problem solving abilities. The research design used was the Pretest-Posttest Control Group design. This quasi involved 2 groups, the treatment group used the PjBL Science, Technology, Engineering, and Mathematics (STEM) approach and the control group used the inquiry method. This design is used in accordance with the objectives to be achieved, namely wanting to know the increase in problem solving abilities applied to problem-based learning models. The following is a table of the Pretest-Posttest Control Group design research. The population in this study were all students of class X Science 3 and X Science 4 at Senior High School (SMA) 4 Cibinong, Bogor Regency. Sampling was carried out using the Random Sampling technique where samples were taken randomly without looking at the order of values or student attitudes. Instruments for indicators of problem solving ability are Visualize The Problem (Understanding the Problem), Describe The Problem (Describing the Problem) Plan A Solution (Planning the Solution), Execute The Plan (Using the Solution), Check And Evaluate (Evaluate the Solution). Instrument calibration Quantitative data that has been collected is in the form of creative thinking skills scores on Environmental Change topic obtained by providing test instruments in the form of essay questions. Data analysis techniques: Prerequisite test (normality and homogeneity), T test, learning implementation and N Gain.

Result and Discussion

Test data instruments in this study in the form of validity tests and reliability tests which aim to show how far the effectiveness of the measuring instruments (questions) used to measure what will be measured. Provisions for measuring validity, namely if rcount > rtable then the data instrument is considered valid, whereas if rcount <rtable then the data instrument is considered invalid. The results of the pretest instrument validation analysis are presented in Table 1.

Table 1. Results of the Analysis of the Validity of the Pretest Question Instruments

Item	r-count	Sig Value	Validity
1	0.716	0.334	Valid
2	0.480	0.334	Valid
3a	0.598	0.334	Valid
3b	0.519	0.334	Valid
4	0.723	0.334	Valid

Based on the data from the results of the pretest instrument validation analysis in Table 1, it is known that all posttest item items have a value of rcount > rtable which can be concluded that all item items are declared valid. The results of the instrument validation analysis of the posttest questions are presented in Table 2.

Table 2. Results of the Instrument Validity Analysis on the Posttest Questions

Item	r-count	Sig Value	Validity
1	0.624	0.334	Valid
2a	0.222	0.334	Valid
2b	0.786	0.334	Valid
3	0.745	0.334	Valid
4	0.441	0.334	Valid

Based on the data from the results of the posttest instrument validation analysis in Table 2, it is known that all posttest item items have a value of rcount > r table which can be concluded that all item items are declared valid.

Reliability test analysis is used to measure the error of a measuring instrument calculation (question). In determining whether the item items are reliable or not, then the value of r-count with t-table (significance level

0.05) must be compared. Items are said to be reliable if the value of r-count > t-table. But if the value of rcount < t-table, the items are said to be unreliable (Mudanta, 2020). The results of the reliability test analysis are presented in Table 3.

Table 3. Results of the Reliability Analysis of Posttest Question Instruments

Total Item	Pre-test	Post-test
5	0.708	0.70

Based on the results of the analysis of the reliability test of the pretest and posttest items using Cronbach's Alpha with the coefficient stipulation that if the reliability test results are rcount > ttable, then the instrument is declared reliable.

The statements presented in this questionnaire were discussed with the Lesson Study group and then given via Google form to students in the experimental class. From the results of the student response questionnaire, it was found that each student gave a very strong response because based on the student response diagram, each statement had a percentage value ranging between 81% -100%, according to Riduwan in Lijana (2018) The student response category is said to be very strong if the vulnerable percent (%) ranges from 81% - 100%, strong ranges from 61% - 80%, moderate ranges from 41% - 60%, weak ranges from 21% - 40%, and very weak ranges from between 0% - 20%.

Analysis of the requirements test was carried out before the data was tested on the group parametric statistical hypothesis, so the normality and homogeneity tests of the data variance from the control class group and the data variance from the experimental class group were first carried out.

The normality test was carried out with the aim of knowing whether the distribution of the research data came from the normal population or not. The data normality test used the Kolmogorov Smirnov Z test. The data normality test was carried out in the control class and the experimental class based on the results of the pretest and posttest. The normality test results are presented in Table 4.

Table 4. Data Normality Test for Control Class and Experiment Class

Treatment Group	x^2_{count}	x^2_{table}	Note
Control Group	0.128	0.227	Normal distribution
Experiment Group	0.223	0.230	Normal distribution

Based on Table 4 presented, the results of the calculation of the normality test of the N-Gain data on the results of the problem-solving ability test of the control class x^2 count is 0.128 with a total sample of 36 students with a value of x^2 table 0.227. While the normality test of the N-Gain data on the problem-solving ability test results of the experimental class x2 counts at 0.223 with a total sample of 35 students and the x2 table value is 0.230, with a significant level of $\alpha = 0.05$. Because the value of x2 count <x2 table, the data from the test results of the problem solving abilities of each class are normally distributed.

The homogeneity test was carried out with the aim of analyzing problem solving abilities and knowing whether the data from the two sample populations can be said to be homogeneous or not. This test uses the Fisher test. The results of the homogeneity test for creative thinking skills can be seen in Table 5.

Table 5. Homogeneity Test Results

Group	*n*	Varians (s)	F_{count}	F_{talel}	Category
Control	36	298.41	0.529	0.567	Homogen
Experiment	35	563.83			

Based on the results of the calculation of the homogeneity test at a significance level of $\alpha = 0.05$, the results of Fcount were 0.529 and Ftable 0.556. It can be concluded that Fcount < Ftable, the variance comes from a homogeneous population.

After obtaining the data analysis which states that the data is normally distributed and the variance is homogeneous, the next step is to test the hypothesis using the t test with the aim of knowing whether the proposed hypothesis can be accepted or rejected. The results of hypothesis testing are presented in Table 6.

Based on the calculation of hypothesis testing on problem solving abilities using the t test with a significance level of $\alpha = 0.05$, the results obtained are t-count of 2.587 and t-table of 1.999, so that the test criteria show t-count > t-table, thus the null hypothesis (H0) is rejected and the alternative hypothesis (Ha) be accepted. So it can be concluded that there is an effect of lesson study-based Science, Technology, Engineering, and Mathematics (STEM) learning on students' problem-solving abilities on Environmental Change topic.

Table 6. Calculation of Hypothesis Test Results

Group	Average Score			t_{count}	t_{table}
	Pretest	Posttest	N-Gain(%)		
Control	62	75	36	2.587	1.999
Experiment	55	78	49		

Solving problems is used as a form of thinking. The ability to solve problems in environmental education is not only related to the accuracy of the solutions obtained, but the ability shown since recognizing the problem, finding alternative solutions, choosing one of the alternatives as a solution, and evaluating the

answers that have been obtained. Research related to environmental change topic was carried out using 2 models, the Problem Based Learning (PBL) learning model in the control class and the Lesson Study-based PjBL-STEM learning model in the experimental class. The problem solving instrument used is included in the valid category with high reliability. This shows that the instrument used is feasible to measure the expected problem-solving abilities of students. The results of calculations related to problem solving skills in the experimental class and control class after statistical calculations show a significant difference between the abilities in the control class and in the experimental class. The experimental class has a higher N-Gain (%) calculation of 49% compared to the control class's N-Gain (%) value of 36%, this can be interpreted that learning using the STEM learning model has an effect on improving students' problem solving abilities.

The experimental class uses the Project Based Learning (PjBL) learning model with a Science, Technology, Engineering, and Mathematics (STEM) approach and Lesson Study-based students who not only learn actively, but can mention each subject matter, can describe these problems, and produce , establish and correct ideas for solutions to each problem presented. The learning that is carried out is directed so that students can bring up the problem-solving abilities that they already have. STEM learning can assist students in solving the problems that have been given and solving them with critical thinking, like research Mubarika et al. (2019), that STEM-based learning can provide a positive response to the learning process, especially in increasing the development of critical thinking patterns and increasing problem-solving skills related to the environment and the use of technology.

An increase in problem solving abilities is evidenced by the success of students in representing the given Students Worksheet into recycled goods produced from a variety of organic and inorganic waste. Where this activity is closely related to the goals of Science, Technology, Engineering, and Mathematics (STEM), the STEM approach has the goal of helping students to overcome various problems that will come and provide the best solutions in the future, supported by research Winarni (2016) where STEM has the benefit of helping students solve problems, have logical thinking and be able to relate every aspect of STEM to life in the world of work.

In the experimental class, worksheets were presented with problems regarding environmental changes that occurred and through these problems students were asked to design a project so they could solve problems in the worksheet. In practice, when identifying the problem students will discuss with their group to plan ideas or ideas so that the project can be carried out. Furthermore, students are asked to make a project design that will be created and visualized in the form of an image. Then students will begin to realize the project design and design and present the results of their projects so that they can be evaluated from the results of the projects that have been designed. The steps for working on students worksheet and making this project able to help students improve their problem-solving skills in the process of making projects and are able to determine the most effective ideas in solving problems. This is supported by the results of the student response questionnaire which stated that 90.3% of students felt learning by using Project Based Learning (PjBL) with the Science, Technology, Engineering, and Mathematics (STEM) approach, was able to help students more easily understand the subject of change environment and make students more active in group discussions in solving the problems given. Backed by research Sumarni (2019) where every aspect of STEM allows students to acquire cognitive knowledge and skills. When integrated, each aspect of STEM provides students with training to help them solve their problems in a more comprehensive manner and helps increase their knowledge of the subject being studied to increase student understanding.

The difficulties faced by students in this experimental class when implementing the PjBL model using the Lesson Study-based STEM approach are where students find it difficult to work together to solve the problems given and there are still some students who have not concentrated in the learning process due to various factors, one of which is student habits. in studying online. This learning transition can have negative impacts such as decreasing student learning motivation and reducing student activity in the learning process, as explained in Umam (2021) transitional learning with minimal preparation can have a negative effect both for education and for the perpetrators.

Whereas in the control class the learning was given using conventional learning models or learning that is often applied in class, namely Problem Based Learning (PBL) with a scientific approach which has a lower influence result than the experimental class. In the control class, students are given lessons on the topic of environmental change in environmental education with the PBL model where the students worksheet provided contains several topics of environmental problems such as problems of soil contamination, polluted rivers, air pollution, and the impact of moving the capital. Students are presented with articles and students are asked to analyze problems based on the questions that have been given. The work on this students worksheet was carried out in groups with the group being freed. In the process it is not done directly in class but is done at home so that the work process cannot be seen directly. After completing the students worksheet work, students are welcome to present the results of their discussions in front of the class. Based on the results of the

presentation, the ideas submitted still only rely on friends' ideas and are still based on the internet so that the ideas for solving problems do not vary. In this case the PBL learning model has several deficiencies in learning such as the lack of student enthusiasm in solving problems, the use of each student's ideas has not been implemented, and requires a little longer time as stated. Tyas (2017) that each learning model has advantages and disadvantages, deficiencies that arise during learning such as students' reluctance to solve problems, the Problem Based Learning (PBL) model requires a long time.

In carrying out Lesson Study, it starts at the planning stage (Plan). Teacher's ideas in carrying out the learning process, as described Sairo (2021) that the planning or Plan stage has a goal in designing all forms of student-centered learning activities so that students can be active in learning. The second stage in the Lesson Study process, namely implementation (Do), Implementation or Do is carried out by realizing the learning tools that have been arranged into the class. The implementation of learning is carried out with model teachers and observers to help observe and document the process of group learning activities in environmental education. The observer in the implementation stage acts as an observer who observes and records the aspects observed in the observation sheet such as student behavior, activeness in discussions, and the delivery of ideas or design ideas in the group. The reflection or see stage of the Lesson Study group consisting of lecturers, teachers, model teachers, and observers carry out discussions related to the learning activities that have been carried out. In discussing the results of the implementation of learning activities, it was found that the aspects of student assessment appeared the most, namely generating new solution ideas, which were seen in the calculation of the observation sheet getting 57% of the 35 students. This can happen because students have been able to express their opinions in solving the problems given in order to solve them. At the see stage it was also carried out for students in the form of a questionnaire which gave several statements related to STEM learning that had been given in class.

This student response questionnaire was given in order to find out student responses to the implementation of learning during class. Student response questionnaires are used to determine the achievement of student learning processes and student behavior in learning (Mania, 2008). In the reflection stage, the lesson study group unit cooperates in evaluating and improving the learning that has been done, in line with research Fauziah (2018) in the implementation of Lesson Study, the reflection stage is carried out to discuss the lessons that have been studied and improve the learning process so that the next lesson can be designed to be better.

Lesson study groups are said to be used as a way for teachers to improve teaching quality by collaborating with different subject teachers and developing different learning methods in each learning process. Lesson study can also help students better understand the learning provided by the teacher. Lesson Study conducted by the Lesson Study group gives a good impression to students in environmental education because through this activity the teacher himself can do self-reflection to improve learning or teaching in class and also get feedback from observers present in class (Akiba & Wilkinson, 2016; Bruce et al., 2016; Sairo, 2021; Takahashi & McDougal, 2016; Tsukui & Saito, 2018).

The application of PjBL learning with the Lesson Study-based STEM approach can develop teacher teaching skills and plan lessons for students and be able to make careful observations of student behavior in the learning process as conveyed by Caterine Lewis in (Hadi, 2016). PjBL learning with the STEM approach is proven to be able to improve problem solving skills, because the STEM approach collaborates 4 learning combinations namely Science, Technology, engineering, and mathematics which can help students solve real-life problems (Lou et al., 2017; Lukitawanti, 2020; Thys et al., 2016; Tsai et al., 2015)

Conclusion

Based on the results of the research and discussion that has been submitted, it can be concluded that there is a difference between the results of the problem-solving ability test for students who use the Project Based Learning (PjBL) model with the Lesson Study-based Science, Technology, Engineering, and Mathematics (STEM) approach to changing topic. environment. It is proven that in the experimental class the N-Gain result was 0.49 with moderate criteria, so the STEM learning model applied to the experimental class is more effective than conventional learning models in improving problem solving abilities.

References

Akiba, M., & Wilkinson, B. (2016). Adopting an International Innovation for Teacher Professional Development: State and District Approaches to Lesson Study in Florida. *Journal of Teacher Education*, *67*(1), 74–93. https://doi.org/10.1177/0022487115593603

Anagun, S. S. (2018). Teachers' perceptions about the relationship between 21st century skills and managing constructivist learning environments. *International Journal of Instruction*, *11*(4), 825–840. https://doi.org/10.12973/iji.2018.11452a

Boholano, H. B. (2017). Smart social networking: 21st century teaching and learning skills. *Research in*

Pedagogy, *7*(1), 21–29. https://doi.org/10.17810/2015.45

Bruce, C. D., Flynn, T. C., & Bennett, S. (2016). A focus on exploratory tasks in lesson study: The Canadian 'Math for Young Children' project. *ZDM - Mathematics Education*, *48*(4), 541–554. https://doi.org/10.1007/s11858-015-0747-7

Camacho, D. J., & Legare, J. M. (2015). Opportunities to create active learning techniques in the classroom. *Journal of Instructional Research*, *4*, 38–45. Retrieved from https://eric.ed.gov/?id=EJ1127696

Čipková, E., Karolčík, Š., Sládková, K., & Ušáková, K. (2018). What is the level of scientific literacy among geography students studying bachelor's studies in natural sciences? *International Research in Geographical and Environmental Education*, *27*(4), 295–310. https://doi.org/10.1080/10382046.2017.1389044

Fauziah, C. (2018). Model Project Based Learning (PjBL) Berbasis Lesson Study Terhadap Kemampuan Berpikir Kreatif Siswa SMA. *Jurnal Penelitian Pembelajaran Fisika*, *9*(2), 125–132. https://doi.org/10.26877/jp2f.v9i2.3170

Ferrari, A., Punie, Y., & Redecker, C. (2012). Understanding digital competence in the 21st century: an analysis of current frameworks. *21st Century Learning for 21st Century Skills*, *March 2019*, 79–92. https://doi.org/10.1007/978-3-642-33263-0_7

Gryczka, P., Klementowicz, E., Sharrock, C., & Montclare, J. (2016). Interactive online physics labs increase high school students' interest. *Journal of Technology and Science Education*, *6*(3), 166. https://doi.org/10.3926/jotse.191

Gu, J., & Belland, B. R. (2015). Preparing Students with 21st Century Skills: Integrating Scientific Knowledge, Skills, and Epistemic Beliefs in Middle School Science Curricula. *Emerging Technologies for STEAM Education*, 39–60. https://doi.org/10.1007/978-3-319-02573-5

Hadi, S. (2016). Membumikan Lesson Study Dalam Meningkatkan Kemampuan Mengajar Berbasis STEM Bagi Guru Matematika SMK Negeri 1 Singkep Kabupaten Lingga. *Syntax Idea, 2*(11), 923–32. Retrieved from https://jurnal.syntax-idea.co.id/index.php/syntax-idea/article/view/707

Koh, J. H. L., Chai, C. S., Wong, B., & Hong, H. Y. (2015). Design thinking and 21st century skills. In *Design Thinking for Education: Conceptions and Applications in Teaching and Learning*, 33-46. https://doi.org/10.1007/978-981-287-444-3

Lijana. (2018). Respon Siswa Terhadap Media Pembelajaran pada Materi Ekologi di Kelas X SMA. *Jurnal Pendidikan Dan Pembelajaran Khatulistiwa*, *7*(3), 1–9. Retrieved from https://jurnal.untan.ac.id/index.php/jpdpb/article/view/24511

Lou, S.-J., Chou, Y.-C., Shih, R.-C., & Chung, C.-C. (2017). A Study of Creativity in CaC2 Steamship-derived STEM Project-based Learning. *Eurasia Journal of Mathematics, Science and Technology Education*, *13*(6), 2387–2404. https://doi.org/10.12973/eurasia.2017.01231a

Lukitawanti, S. D. (2020). Pengaruh PjBL-STEM Disertai Asesmen Formatif terhadap Kemampuan Pemecahan Masalah pada Materi Elastisitas dan Hukum Hooke. *JRPF (Jurnal Riset Pendidikan Fisika)*, *5*(2), 83–91. Retrieved from http://journal2.um.ac.id/index.php/jrpf/article/view/12987/0

Mania, S. (2008). Teknik Non Tes: Telaah Atas Fungsi Wawancara Dan Kuesioner Dalam Evaluasi Pendidikan. *Lentera Pendidikan : Jurnal Ilmu Tarbiyah Dan Keguruan*, *11*(1), 45–54. https://doi.org/10.24252/lp.2008v11n1a4

Motallebzadeh, K., Ahmadi, F., & Hosseinnia, M. (2018). Relationship between 21st century skills, speaking and writing skills: A structural equation modelling approach. *International Journal of Instruction*, *11*(3), 265–276. https://doi.org/10.12973/iji.2018.11319a

Mubarika, M. P., & Yaniawati, R. P. (2019). Implementasi pendekatan Science Technology Engineering and Mathematics (STEM) untuk meningkatkan kemampuan pemecahan masalah siswa SMK. *Pasundan Journal of Mathematics Education Jurnal Pendidikan Matematika, 9*(2), 56-67. https://doi.org/10.23969/v9i2.2713

Mudanta, K. A. (2020). Instrumen Penilaian Motivasi Belajar dan Hasil Belajar IPA Siswa Kelas V Sekolah Dasar. *Mimbar Ilmu*, *25*(2), 101. https://doi.org/10.23887/mi.v25i2.26611

Muhibbin, A., Fathoni, A., Arifin, Z., & Sufahani, S. F. (2019). Data analysis on civic education learning development based on controversial issues in the mass media in collaboration with active learning to increase the democratic higher order thinking skills. *International Journal of Scientific and Technology Research*, *8*(10), 2124–2131. Retrieved from http://www.ijstr.org/final-print/oct2019/Data-Analysis-On-Civic-Education-Learning-Development-Based-On-Controversial-Issues-In-The-Mass-Media-In-Collaboration-With-Active-Learning-To-Increase-The-Democratic-Higher-Order-Thinking-Skills.pdf

Park, Y. S., & Park, J. H. (2020). Exploring the Explicit Teaching Strategies in STEAM Program of Climate Change. *Asia-Pacific Science Education*, *6*(1), 116–151. https://doi.org/10.1163/23641177-BJA00002

Priantari, I., Prafitasari, A. N., Kusumawardhani, D. R., & Susanti, S. (2020). Improving Students' Critical Thinking through STEAM-PjBL Learning.

Bioeducation Journal, *4*(2), 95–103. Retrieved from http://bioeducation.ppj.unp.ac.id/index.php/bioedu/article/view/283

Priscilla, C., & Yudhyarta, D. Y. (2021). Implementasi Pilar-Pilar Pendidikan UNESCO. *Asatiza: Jurnal Pendidikan*, *2*(1), 64–76. https://doi.org/10.46963/asatiza.v2i1.258

Rao, S. P., & DiCarlo, S. E. (2017). Active learning of respiratory physiology improves performance on respiratory physiology examinations. *Advances in Physiology Education*, *25*(2), 55–61. https://doi.org/10.1152/advances.2001.25.2.55

Sadiqin, I. K., Santoso, U. T., & Sholahuddin, A. (2017). Students' difficulties on science learning with prototype problem-solving based teaching and learning material : a study evaluation of development research. *Advances in Social Science, Education and Humanities Research*, *100*, 279–282. https://doi.org/10.2991/seadric-17.2017.58

Sairo, M. I. (2021). Pelaksanaan Lesson Study Menggunakan Metode Pembelajaran Mind Mapping di Kelas X MIPA 3. *Journal for Lesson and Learning Studies*, *4*(1), 26–32. https://doi.org/10.23887/jlls.v4i1.32188

Siong, W. W., & Osman, K. (2018). Pembelajaran Berasaskan Permainan dalam Pendidikan Stem dan Penguasaan Kemahiran Abad Ke-21. *Politeknik & Kolej Komuniti Journal of Social Sciences and Humanities*, *3*(1), 121–135.Retrieved from https://myjms.mohe.gov.my/index.php/PMJSSH/article/view/4678

Sumarni, W. (2019). Kemampuan Kognitif Dan Berpikir Kreatif Siswa Melalui Pembelajaran Berbasis Proyek Berpendekatan Stem. *J-PEK (Jurnal Pembelajaran Kimia)*, *4*(1), 18–30. https://doi.org/10.17977/um026v4i12019p018

Takahashi, A., & McDougal, T. (2016). Collaborative lesson research: maximizing the impact of lesson study. *ZDM - Mathematics Education*, *48*(4), 513–526. https://doi.org/10.1007/s11858-015-0752-x

Tharayil, S., Borrego, M., Prince, M., Nguyen, K. A., Shekhar, P., Finelli, C. J., & Waters, C. (2018). Strategies to mitigate student resistance to active learning. *International Journal of STEM Education*, *5*(1). https://doi.org/10.1186/s40594-018-0102-y

Thys, M., Verschaffel, L., Dooren, W. Van, & Laevers, F. (2016). Investigating the quality of project-based science and technology learning environments in elementary school: A critical review of instruments. *Studies in Science Education*, *52*(1), 1–27. https://doi.org/10.1080/03057267.2015.1078575

Tsai, C. W., Shen, P. Di, & Lin, R. A. (2015). Exploring the effects of student-centered project-based learning with initiation on students' computing skills. *International Journal of Information and Communication Technology Education*, *11*(1), 27–43. https://doi.org/10.4018/ijicte.2015010102

Tsukui, A., & Saito, E. (2018). Stroll into students' learning: Acts to unload teachers' values through the practices of lesson study for learning community in Vietnam. *Improving Schools*, *21*(2), 173–186. https://doi.org/10.1177/1365480217717530

Tyas, R. (2017). Kesulitan Penerapan Problem Based Learning Dalam Pembelajaran Matematika. *Journal Tecnoscienza*, *2*(1), 43–52. Retrieved from https://ejournal.kahuripan.ac.id/index.php/TECNOSCIENZA/article/view/26

Umam, K. & L. M. (2021). Problematika dan Efek Negatif Pembelajaran Daring Selama Pandemi COVID-19. *Tarbiyatuna: Kajian Pendidikan Islam*, *5*(2), 202–217. Retrieved from http://ejournal.iaiibrahimy.ac.id/index.php/tarbiyatuna/article/view/488

Winarni, J. (2016). STEM: apa, mengapa, dan bagaimana. In *Prosiding Seminar Nasional Pendidikan IPA Pascasarjana UM*, 1, 976–984. Retrieved from https://pasca.um.ac.id/wp-content/uploads/2017/02/Juniaty-Winarni-976-984.pdf

Yusuf, Slamet, P. H., Sukardi, T., & Khairudin, M. (2020). Learning model higher order thinking skills at vocational high school: Achievement and thinking behavior. *International Journal of Advanced Science and Technology*, *29*(7s), 158–170. Retrieved from http://sersc.org/journals/index.php/IJAST/article/view/9424