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Analyzing Student's Problem Solving Abilities of Direct Current Electricity in STEM-based Learning

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ABSTRACT This research has been conducted to analyze students' problem-solving abilities in direct current electricity in STEM-based learning. The implementation of STEM in this research is to train the domain of scientific practices and engineering practices that are associated with model problems and project-based learning. The research method used was pre-experiment with the design of one group pretest-posttest. The subjects of the research consist of 27 students at the 10th grade of one of the Vocational Schools in Kabupaten Bandung Barat. The instrument of problem-solving ability in this study are four structured description questions, each of which consists of 5 questions, indicators of problem-solving ability, namely visualize the problem, describe the problem in physics description, plan the solution, execute the plan, and check and evaluate. As a result of the research, it was found that there was an increase in students' problem-solving abilities with the application of the integration model problem and project-based learning in STEM-based learning.

Keywords STEM, Problem based learning, Project-based learning, Problem solving ability

1. INTRODUCTION

In the life of the 21st century requires a variety of skills that must be mastered by someone in facing every life problem, so that education can prepare students to learn the various skills needed to live life in the 21st century (Pacific Policy Research Center, 2010). The attachment was issued by the Minister of Education and Culture Regulation number 21 of 2017 concerning the contents of Primary and Secondary Education Standards. The 21st century skill is used to meet the future needs and to meet Indonesian Gold Generation in 2045. It has established Competency Standards for Graduates based on 21st Century Competence consisting of four competencies. Consequently, students must have communication, critical thinking, and problem-solving, collaboration, and creative and innovative. This ability must be owned by graduates in Indonesia (Kemendikbud, 2016).

One of the 21st-century skills is problem-solving ability. Problem-solving ability as a mental and intellectual process used by students to relate previous knowledge and problems they face, and also recall the experience of solving problems in the past so that they get a solution to the problem. Problem-solving ability is one of the competencies that students must have. In another opinion, Adolphus, Alamina, & Aderonmu (2013) problem solving is identifying the gap between the issues and solutions using information (knowledge) and reasoning. With the adequate problem-solving ability, it will facilitate students in facing work situations that are filled with various problems that must be solved by them (Yulindar, 2018).

Problem-solving ability is needed by students to face global competition. Thus, students will be ready to jump in and participate in the real word (Patnani, 2015). Therefore, various efforts need to be made to improve problem-solving ability in students. These efforts include improving students' skills related to solving their problems and improving the quality of teaching by improving teacher methods and characteristics. Thus, it is expected that students will be better prepared to face some problems, especially if they have been directly involved in the community. This is because when solving problems, an individual not only needs to think, but they need to think critically to be able to see the issues and think creatively to be able to solve problems.

The ability to solve problems, in essence, learning to think or learning to reason, namely thinking or reasoning, applies the knowledge that has been obtained previously to

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address new problems that have never been encountered (Heller & Heller, 2010). Whereas according to Ahiakwo (in Adolphus, Alamina, & Aderonmu, 2013) states that, problem-solving is identifying gaps between problems and solutions using information (knowledge) and reasoning.

To solve the problem at hand, an individual will take steps related to the problem-solving process. Steps or steps that must be passed by students in solving problems there are five stages, namely (1) visualize the problem, (2) describe the problem in physics description, (3) plan the solution, (4) execute the plan, and (5) check and evaluate by Heller and Heller (2010).

Based on the facts in the research that has been done before, it was found that students' problem-solving abilities were still low. As in the study conducted by Yulindar (2018); Sutiadi & Nurwijayaningsih (2016); Jua, Sarwanto, & Sukarmin (2018); and from the results of a preliminary study in one of the high schools in West Bandung district, it was found that students' problem-solving abilities for each indicator were still low.

From the research that has been done before, it is known that, students' physics problem-solving abilities are improved by using appropriate learning models and approaches such as problem based learning models as in the research conducted by Sutiadi & Nurwijayantidingsih (2016), Wahyu, Sahyar, & Ginting (2017), Sahyar, Sani & Malau (2017), Sahyar & Fitri (2017), and Argau, Haile, & Ayale (2017), Ferreira & Trudel (2012); collaborative learning (Adolphus, 2013); direct instruction models; inquiry-based on just in time teaching-learning training models (Turnip, Wahyuni, & Tanjung 2016); engineering design-based modeling approach (Li, Huang, Jiang, & Chang, 2016); project-based learning (Tamba, Motlan, & Turnip, 2017); Real Engagement in Active Problem Solving (Yulindar, 2018); and so forth. So it can be concluded that the problem-solving abilities of students in Indonesia are deficient.

In practicing problem-solving skills, the right learning process is needed where students are motivated to solve problems faced. The difficulties faced cannot be separated from the use of technology, so the use of technology in learning is essential, so STEM-based knowledge is suitable learning in fostering community interest (Yasin, Prima, & Sholihin, 2018; Wandari, Wijaya, & Agustin, 2018).

STEM approach (science, technology, engineering, and mathematics) is learning by integrating science, technology, engineering, and mathematics. The application of STEM in learning can encourage students to design, develop, and utilize technology, sharpen cognitive, manipulative, and affective, and apply knowledge (Kapila & Iskander, 2014). Therefore, the application of STEM is suitable for use in physics learning. STEM-based learning can train students to apply their knowledge to create designs as a form of solving problems related to the environment by utilizing technology. In applying STEM can be supported by various learning methods. Integrative STEM allows multiple learning methods to be used to support its application (Wirkala & Kuhn, 2011).

There are three essential domains in STEM, namely: (1) Practice: scientific practice and engineering practice, (2) Discipline core ideas, and (3) crosscutting concept (National Research Council, 2011). In this study, the researcher took one domain, namely, practice. For scientific PBL models are used while for engineering practices, PjBL is used.

In the National Research Council explained that Scientific practice is a domain that discusses student involvement in science practice. The experience will help students understand how scientific knowledge develops; such direct relationship gives them an appreciation for the various approaches used to investigate, model, and explain the world. Moreover, engineering Practice or engineering practices assume that student involvement in engineering practice will help students understand the work of engineers, as well as the relationship between engineering and science. Participation in these practices also helps students form an understanding of the concepts and ideas of overlapping scientific and engineering disciplines; Besides that, it makes students' knowledge more meaningful and puts it deeper into their worldview.

The PBL model is used for scientific practice because this learning model is a model that presents a problem related to physics concepts to students and provides opportunities for students to solve problems by conducting investigations or experiments. PBL can provide opportunities for students to apply knowledge to issues/problems as a form of problem solving. Indirectly, the use of PBL also encourages students to master the knowledge needed to solve these problems (Permanasari, 2016). This knowledge can be in the form of information or data which is then used as material for consideration to choose the right way of solving the problem through logical, critical, and systematic thinking. Meanwhile, PjBL that is applied to engineering practices is able to guide students to solve the problem given and emphasize more on the product produced (ChanLin, 2008). The products produced can be ideas or ideas that can be seen. Products produced from the use of PjBL in science learning can be a student's contribution to improving the quality of life. The PjBL model is a student-centered learning model to develop and apply concepts from projects produced by exploring and solving real-world problems independently.

According to Bybee (Awad & Barak, 2014) STEM realizes the importance of science and mathematics, and places particular emphasis on technology and engineering as a field that influences our lives, and is very important for people who are interested in continuing to renew. Integration of STEM in learning models in this case PBL and PjBL can improve problem-solving ability and help build relationships in real life. Therefore it is possible to use the STEM approach to further enhance students' problem-solving abilities.

2. METHOD

In this study used the pre-experimental method with one group pretest-posttest design. The dependent variable in this study is the ability to solve students' physical problems in direct current electricity (O). While the learning model used is the PBL and PjBL model that is integrated into the STEM approach is an independent variable (X). Therefore, the study subjects used only one group without a comparison group. The design of one group pretest-posttest can be seen in Table 1.

The population in this study were all students of class 10th grade in one of the Vocational Schools in Kabupaten Bandung Barat, Jawa Barat who were enrolled in the even semester of the 2018/2019 academic year. The sampling technique of this study is by taking a class randomly (random class). This sampling technique is because it does not allow changing the formation of students in an existing class if randomly chosen individual samples. So that one class is taken to be used as the research subject group.

The instrument for problem-solving abilities used is tests and non-tests. The problem-solving ability test is given in two trials. The pretest and posttest in the description of the problem questionnaire consist of 4 structured items. Each item consists of five problem-solving indicators. It refers to the indicator of problem solving according to Heller where there are five steps to solving the problem, namely (1) visualize the problem, (2) describe the issue in physics description, (3) plan the solution, (4) execute the plan, and (5) check and evaluate each item. The non-test instruments used are student worksheets, which refer to the Heller problem-solving indicators which consist of three meetings, namely Ohm's law, electrical circuit and Kirchoff's law, and household electrical installations.

The instrument test was carried out by three experts. After the data is collected, the problem-solving ability score is from the pretest, posttest, and worksheets by calculating the average N-gain.

3. RESULT AND DISCUSSION

The integration of the problem-based learning (PBL) and project-based learning (PjBL) models with the STEM approach in this study aims to analyze the problem-solving abilities of SMK students. Learning is carried out in five meetings with direct current electricity. The first and fifth meetings were used to do the test and posttest while the meeting for learning used three meetings with the first and second learning details to train the scientific practices using the PBL model with the STEM approach and the third meeting to prepare engineering practices using the PjBL model with the STEM approach. Direct current electricity is taught divided into three submissions, namely Ohm's law, electrical circuits, and electrical installations.

Tabel 1 *One group pretest-posttest* design

Pretest	Treatment	Posttest
O	X	O

Data on students' problem-solving abilities obtained in this study were from the data from the pretest and posttest results as well as student answers to the worksheet. The results of the pretest and posttest were measured using a problem-solving ability test in the form of a description problem with a score range of 0 - 4. The distribution of students' problem-solving abilities can be shown by comparing the average scores of the pretest and posttest and the gain and N-Gain scores of all students direct current electricity. The improvement of students' problem-solving abilities as a whole from the results of the pretest, posttest, and gain data is presented in Figure 1.

Students' problem-solving abilities are abilities that students must possess along with the development of the 21st century (OECD, 2014). The problem-solving ability referred to in this research is the ability of students to use their knowledge based on their experience in electricity or dynamic electricity laws that they learn to solve various problems that are often encountered in everyday life, especially those related to equipment or technological work. Figure 1 is the average value of students ' problem-solving abilities before learning, which is measured using the problem-solving ability test shows 17.55 from a maximum amount of 100. Whereas, the average value of students' problem-solving abilities after learning shows 73.75 from the maximum value 100. It is increasing students' problem-solving ability based on average gain values of 56.2. The average gain is then normalized into N-Gain; the result is 0.68. The N-gain results were confirmed by the category from Hake (1999), so the improvement of students' problem-solving abilities as an impact of the integration of PBL and PjBL models in STEM-based

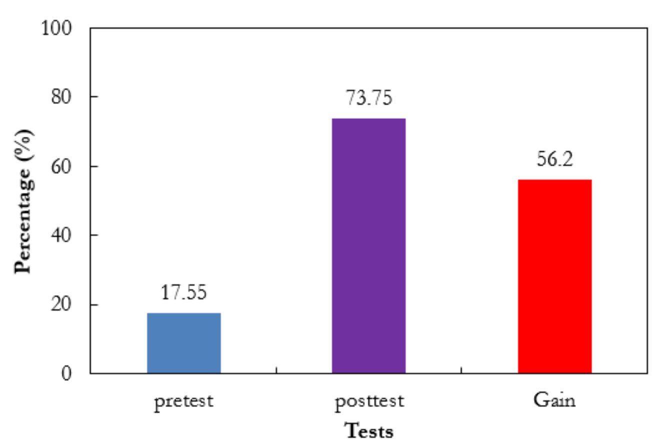

Figure 1 Percentage diagram of the average problem-solving ability of students

Table 2 Percentage of the number of students in each category of improvement in problem-solving ability

Category	Number of students	Percentage (%)
low	0	0
medium	15	55,6
high	12	44,4

learning was included in the medium category. As explained earlier, this assessment was carried out by integrating two models, namely the PBL and PjBL models as stages of scientific practices and engineering practices. The same was found by other studies that conducted research to analyze the problem-solving abilities of students using problem-based learning models such as in research by Wahyu, Sahyar, & Ginting (2017); Sahyar, Sani, & Malau (2017); Sahyar & Fitri (2017); Ferreira & Trudel (2012) which could improve problem-solving abilities. The results of the study were the improvement of students' problem solving and critical thinking skills. A similar study was conducted by Tamba, Motlan, and Turnip (2017) which aimed to analyze the effect of a project-based learning model (PjBL) on creative thinking skills and problem-solving. This finding also supports Berry's (2012) statement that STEM integration in learning models can improve problem-solving ability and can help with relationships in real life.

Based on Table 2 it is known that there are 15 students experiencing an increase in problem-solving ability in the medium category with a percentage of 55% and 12 students in the high grade with a percentage of 45%. None of the students experienced an increase in the low category. This shows that the integration of PBL and PjBL models in STEM-based earning can improve students' problem-solving ability in direct current electricity.

The improvement of problem-solving ability in learning on direct current electricity is the impact of the integration of PBL and PjBL models in STEM-based learning that is built through five stages in PBL (equipped with eight steps of scientific practices) and six stages in PjBL (equipped with eight engineering practices). Each stage in the PBL and PjBL models is done using experiential learning. Learning through direct experience is a process to get meaningful learning from direct encounter by Mughal & Zafar (2011). Direct experience, including active experiments, makes it possible to implement STEM in dealing with real situations (Gilmore, 2013). This can strengthen the results of the study that the integration of PBL and PjBL models with STEM-based learning can improve problem-solving abilities.

In this study, the problem-solving abilities used in this study consisted of the ability to focus problems, describe problems in physical descriptions, plan problem-solving solutions, use problem-solving solutions, and examine and evaluate problem-solving solutions (Heller, Ronald & Scott, 1992). The percentage of the average score of the pretest and posttest in each indicator of the problem-solving abilities measured is shown in Figure 2.

Figure 2 shows the percentage of the average score of the results of the pretest and posttest of students' problem-solving abilities in each indicator. The average rate of the pretest score on the indicator (a) visualize the problem of 35.69%, (b) describe the issue in physics description of 26.16%, (c) plan the solution of 14.81%, (d) execute the idea of 7, 87%, and (e) check and evaluate of 3.24%. While the posttest results on the indicators focusing the problem were 94.91%, described the problem as 87.73%, planned a solution of 80.09%, used a solution of 61.11%, and evaluated 51.85%. Based on Figure 2, it can be seen that when compared between the average percentage of pretest scores and posttest on all indicators, the problem-solving ability has increased. The improvement of students' problem-solving skills based on the calculation of N-Gain for each indicator is shown in Figure 3.

Based on Figure 3, it can be seen that the highest N-Gain is in the indicator visualize the problem. It was namely 0.92 as the high category. The lowest is to describe the issue in physics description with the N-Gain value of 0.83 in the high category. Planning the solution with the N-Gain value

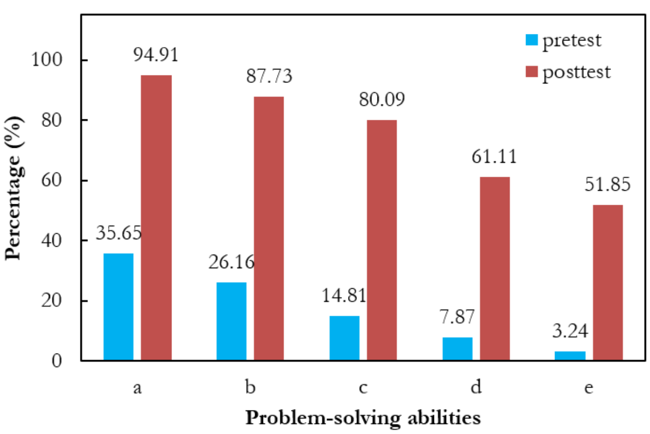

Figure 2 Percentage of the average pretest-posttest score of students' problem-solving abilities for each indicator

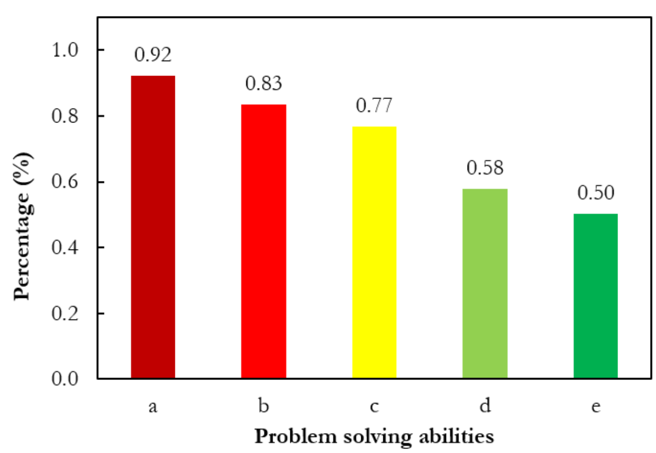

Figure 3 Average N-Gain score of students' problem solving abilities for each indicator

of 0.77 is in the high category. Executing the plan with an N-Gain value of 0.58 in the medium category, and the lowest increase in the indicator and check and evaluate with an N-Gain value of 0.5 at the medium category. So it can be concluded that indicators with a high category are visualized the problem, describe the problem in physics description, plan the solution, execute the plan, and check and evaluate. The indicator checks and evaluate is the indicator with the lowest increase. This happened because at the first and second meeting, there were still many students who ignored the indicators check and assess. Some students do not review whether the problem-solving solution is in accordance with the problem or not. In general, the ability to solve problems in dynamic electrical material on each indicator has increased as a result of the integration of PBL and PjBL models in STEM-based learning.

Based on the description of the data described illustrates that the integration of PBL and PjBL models in STEM-based learning can improve students' problem-solving abilities on each indicator. Increasing the indicator of the problem-solving skill which is calculated using the highest N-Gain is the indicator visualize the problem (0.92), while the lowest is the indicator check and evaluate (0.50) this is similar to the findings of the research conducted by Yulindar (2018) and Sutiadi & Nurwijayaningsih (2016).

Improved problem-solving skills at pretest and posttest both overall average and each indicator of problem-solving is not directly increased but first students are trained in solving problems in learning with the integration of PBL and PjBL models in STEM-based learning. The value of problem-solving ability of each meeting which is reviewed from the student's worksheet answers can be seen in Figure 4.

Based on Figure 4 can be seen for each student's problem-solving abilities at each meeting. The meeting in this study was divided into three meetings, namely the first meeting to discuss Ohm's law, the second meeting discussed the electric circuit and Kirchoff's 1 law, and the third meeting discussed household electrical installations. For meeting 1, the average score of students is 38.31%, meeting 2 is obtained by the average value of students is 53.20%, and meeting 3 is obtained the average value of students is 75.32%. With the value of N-Gain for meeting 1 to meeting 2 is 0.32 which is in the medium category and an increase in problem-solving ability from meeting 2 to meeting 3 increases to 0.47 which is still in the medium category. This proves that from each meeting the students' problem-solving abilities are increased seen from the value of N-Gain students.

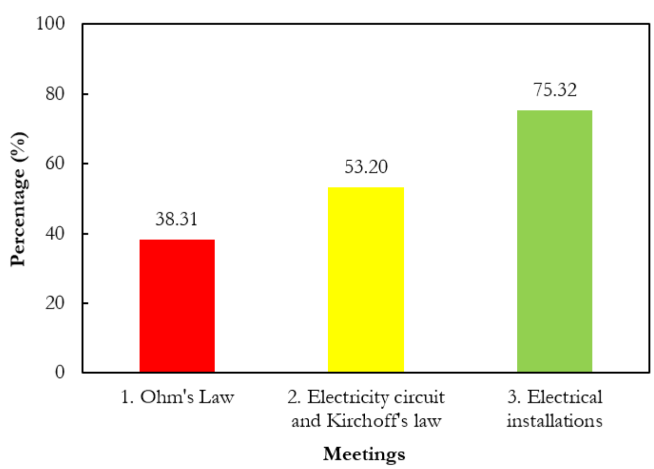

Figure 4 Average percentage diagram of students' problem-solving abilities at each meeting

The percentage of problem-solving abilities at each meeting for each indicator of problem-solving ability which is reviewed from the student's worksheet answers can be seen in Figure 5. From Figure 5 it can be seen that the score for each indicator is getting to the high indicator level, the smaller the score the student receives. Based on Figure 5, it can be seen that when compared to the average percentage of the first, second, and third meeting scores on all indicators, the problem-solving ability has increased. For further information, we will look at the capacity of each student's problem-solving in each of the indicators.

From the findings, it can be concluded that the ability to visualize the problem has the highest increase taken from the scores obtained by students on the pretest and posttest problem-solving abilities in each question in part a with indicators focusing the problem. This is assumed because this learning model trains students to focus on problems. Students must first understand the problem before solving a problem that must be faced. The question that is to be solved in the learning process is based on issues that have been encountered by students in everyday life. The ability to focus problems is trained with the STEM approach in the Asking Questions and Defining Problems stage and in the PBL and PjBL models respectively at the first stage/phase, namely student orientation to the problem and determining the necessary questions. At this

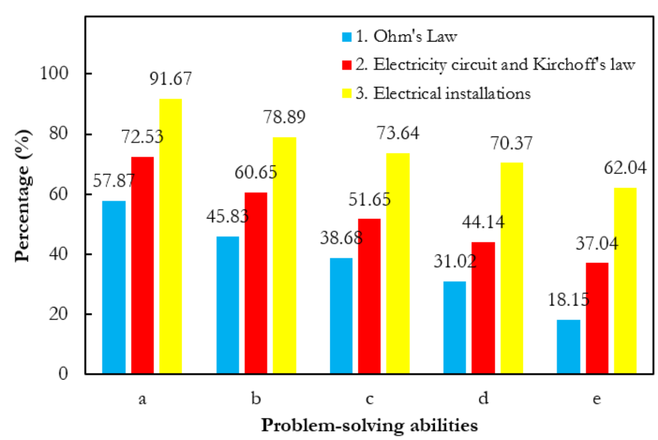

Figure 5 Percentage of the average score for students' problem-solving abilities for each meeting for each indicator

stage, the teacher acts as a facilitator who guides students to visualize the problem based on issues/problems that have been known or experienced by students. Issues related to the topic regarding energy cycles that occur in the world, especially electricity. Data on the implementation of teacher and student activities at this stage are in the overall category of activities carried out or are in an excellent grade (100%), meaning that both teachers and students do this stage very well.

Unlike indicators visualize the problem that has the highest increase, indicators check and evaluate the lowest growth, which is equal to 0.50 but still in the medium category. Indicators check and assess at this meeting were trained with the STEM approach at the Engaging in Argument from Evidence and Obtaining, Evaluating, and Communicating Information stages in the PBL model and Obtaining, Evaluating, and Communicating Information on successive PjBL models at the last stage/phase, namely Analyzing and evaluating problem solving process (PBL) and experience evaluation (PjBL). At this stage, students are trained to test the solutions they have made. The teacher guides students to evaluate problem-solving solutions that students make. Then students evaluate whether the solutions they have made are by the problems they face or not. But this was done in one of the groups who made the presentation. This can be one of the causes of low ability to evaluate problems. From the data on the implementation of teacher activities the overall category of events was carried out or was in an excellent category (100%) but global student activities only 94% were in an outstanding category but not all were implemented, but in categories meant that both the teacher and students did the stages this very well.

Other factors that might cause a low average increase in evaluating data-based solutions are the form of a problem-solving ability test instrument in the form of a structured description. The disadvantage of structured description questions is that students must be able to answer the initial questions in order to work on the next question (Prima & Kaniawati, 2011). The ability to check and evaluate in test instruments is measured on the last item, after other abilities. Therefore, the results obtained depend on the ability of students to work on the questions in the previous items. This is what causes the indicator to evaluate the solution is the indicator that has the lowest average increase among other problem-solving ability indicators.

4. CONCLUSION

Problem-solving ability with the integration of Problem and Project-based Learning models in STEM-based learning as a whole have improved both overall in the value of the pretest, posttest, and worksheets as well as the indicator of problem-solving. If seen from each indicator, it is found that the highest increase is found in the indicator visualize the problem decreases according to the Heller indicator stage where at the check and evaluate stage it has the lowest increase compared to other indicators and if it is seen from the tendency of the scoring results, the score decreases sequentially from visualizing the problem to check and evaluate. This is because the problem-solving ability is a series of mutually sustainable processes, where when you want to reach a good final stage you must go through the initial stages well.

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REFERENCES

Adolphus, T., Alamina, J., & Aderonmu, T. (2013). The Effects of Collaborative Learning on Problem Solving Abilities among Senior Secondary School Physics Students in Simple Harmonic Motion. *Journal of Education dan Practice, 5*(25). 95-11.

Argau, A. S., Haile, B. B., Ayale, B. T., & Kuma, S. G. (2017). The Effect of Problem Based Learning (PBL) Instruction on Students' Motivation and Problem Solving Skills of Physics. *EURASIA Journal of Mathematics Science and Technology Education, 13*(3). 857-871.

Arifuddin, M., Mastuang, & Mahardika, A. I. (2017). Improving Problem Solving Skill in Physics through Argumentation Strategy in Direct Instruction Model. *International Journal of Sciences: Basic and Applied Research (IJSBAR), 35*(3), 348-353.

Awad, N., & Barak, M. (2014). Sound, Waves and Communication: Students' Achievements and Motivation in Learning a STEM-Oriented Program. *Creative Education, 5*, 1959-1968.

Berry, M., Chalmers, C., & Chandra, V. (2012). *STEM Futures and Practice, Can We Teach STEM in a More Meaningful and Integrated Way? 2nd International STEM in Education Conference*. Brisben Australia: Queensland University of Technology.

ChanLin, L.-J. (2008). Technology integration applied to project-based learning in Science. *Innovations in Education and Teaching International, 45*(1), 55-65.

Ferreira, M.M. & Trudel, A.R. (2012). The impact of problem based learning on student attitude toward science, problem solving skill and sense of community in the classroom. *Journal of classroom interaction, 47*(1). 23-30.

Gilmore, M.W. (2013). Improvement of STEM Educatiom: Experiential Learning is the Key. *Modern Chemistry and Applications, 1*(3), 1-3.

Hake, R. R. (1999). Analyzing change/gain scores. *Unpublished.[online] URL: http://www. physics. indiana. edu/~ sdi/AnalyzingChange-Gain. pdf.*

Heller, K., & Heller, P. (2010). Cooperative problem solving in physics a user's manual. *Unpublished.[online] URL: http://www. aapt. org/Conferences/newfaculty/upload/Coop-Problem-Solving-Guide. pdf.*

Jua, S. K. (2018). The profile of students' problem-solving skill in physics across interest program in the secondary school. *Journal of Physics: Conference Series, 1022*(1), 012027.

Kapila, V. & Iskander, M. (2014). Lessons learned from conducting a K-12 project to revitalize achievement by using instrumentation in Science Education. *Journal of STEM Education*, *15*(1), 46-51.

Kemendikbud. (2016). *Minister of Education and Culture Regulation number 21 of 2017 concerning the contents of Primary and Secondary Education Standards*. Jakarta: Kementrian Pendidikan dan Kebudayaan.

Li, Y., Huang, Z., Jiang, M., & Chang, T. W. (2016). The Effect on Pupils' Science Performance and Problem-Solving Ability through Lego: An Engineering Design-based Modeling Approach. *Journal of Educational Technology & Society*, *19*(3).

Mughal, F., & Zafar, A. (2011). Experiential learning from a constructivist perspective: Reconceptualizing the Kolbian cycle. *International Journal of Learning and Development*, *1*(2), 27-37.

National Research Council. (2011). *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*. Washington DC: The National Academies Press.

Organisation for Economic Co-operation and Development (OECD). (2014). *PISA 2012 Result: Creative Problem Solving: Students Skills in Tackling Real Life Problems (Volume V)*. PISA: OECD Publishing.

Patnani, M. (2015). Upaya meningkatkan kemampuan problem solving pada mahasiswa. *Journal Psikogenesis*, *1*(2), 130-142.

Prima, E. C., & Kaniawati, I. (2011). Penerapan Model Pembelajaran Problem Based Learning dengan Pendekatan Inkuiri untuk Meningkatkan Keterampilan Proses Sains dan Penguasaan Konsep Elastisitas pada Siswa SMA. *Jurnal Pengajaran MIPA*, *16*(1), 179-184.

Pacific Policy Research Center. (2010). *21st Century Skills for Students and Teachers*. Honolulu: Kamehameha Schools, Research & Evaluation Division.

Permanasari, A. (2016). STEM Education: Inovasi dalam Pembelajaran Sains. *Prosiding Seminar Nasional Pendidikan Sains, 3*, 23-34.

Sahyar, & Fitri, R. Y. (2017). The Effect of Problem-Based Learning Model (PBL) and Adversity Quotient (AQ) on Problem-Solving Ability. *American Journal of Educational Research, 5*(2). 179-183.

Sani, R. A., & Malau, T. (2017). The Effect of Problem Based Learning (PBL) Model and Self-Regulated Learning (SRL) toward Physics Problem Solving Ability (PSA) of Students at Senior High School. *American Journal of Educational Research*, *5*(3), 279-283.

Sutiadi, A., & Nurwijayaningsih, H. (2016). Konstruksi dan Profil Problem Solving Skill Siswa SMP dalam Materi Pesawat Sederhana. *Jurnal Penelitian & Pengembangan Pendidikan Fisika, 2*(1). 37-42.

Tamba, P., Motlan, & Turnip, B. M. (2017). The Effect of Project Based Learning Model for Students' Creative Thinking Skills and Problem Solving. *IOSR Journal of Research & Method in Education, 7*(5). 67-70.

Turnip, B., Wahyuni, I., & Tanjung, Y. I. (2016). The Effect of Inquiry Training Learning Model Basedon Just in Time Teaching for Problem Solving Skill. *Journal of Education and Practice, 7*(15). 177-181.

Wahyu, E. S., Sahyar., & Ginting, E. M. (2017). The Effect of Problem Based Learning (PBL) Model toward Student's Critical Thinking and Problem Solving Ability in Senior High School. *American Journal of Educational Research, 5*(6). 633-638.

Wandari, G. A., Wijaya, A. F. C., & Agustin, R. R. (2018). The Effect of STEAM-based Learning on Students' Concept Mastery and Creativity in Learning Light And Optics. *Journal of Science Learning*, *2*(1), 26-32.

Wirkala, C., & Kuhn, D. (2011). Problem-based learning in K-12 education: Is it effective and how does it achieve its effects?. *American Educational Research Journal, 48*(5), 1157–1186.

Yasin, A. I., Prima, E. C., & Sholihin, H. (2018). Learning Electricity using Arduino-Android based Game to Improve STEM Literacy. *Journal of Science Learning*, *1*(3), 77-94.

Yulindar, A. (2018). Enhancement of problem solving ability of high school students through learning with real engagement in active problem solving (REAPS) model on the concept of heat transfer. *Journal of Physics: Conference Series, 1013*(1), 012052.