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Submission date: 22-Feb-2023 04:17PM (UTC+0700)
Submission ID: 2020343552
File name: 23840-Article_Text-82988-1-10-20221029.pdf (488.03K)
Word count: 5922
Character count: 33138

Biosfer: Jurnal Pendidikan Biologi, 15 (2), 231-241 (2022)

Biosfer: Jurnal Pendidikan Biologi

Journal homepage: http://journal.unj.ac.id/unj/index.php/biosfer

Student problem solving skills in PBL model: Viewed from the discourse sheet

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ARTICLE INFO

Article history
Received: 18 November 2021
Revised: 02 February 2022
Accepted: 11 May 2022

Keywords:
Problem Based Learning
Problem Discourse Sheet
Problem Solving Ability

ABSTRACT

Problem solving ability relates to a person's ability to manage and find appropriate solutions in unexpected and complex conditions. Problem solving skills are not something that is innate, but these skills can be developed when a person is given the opportunity to solve problems. This ability is very important for students, especially when they enter the world of work. This study aims to determine the problem-solving ability of students when completing the problem discourse sheet in the PBL model. The type of research used is descriptive quantitative using a sample of 37 students who take the Human Physiology Anatomy course in the biology education study program at the Islamic University of Riau. The research instrument is in the form of problem discourse and scoring rubric. Problem solving indicators consist of identifying terms, formulating questions, considering, and finding solutions from problem formulations and making and determining conclusions. The data obtained were analyzed by scoring each answer given by students. The results showed that students' problem-solving abilities differed on each indicator. The indicator that occupies the highest score is formulating questions and the lowest is making and determining conclusions. Based on the results of the study, it can be concluded that the problem-solving ability of students while completing the problem discourse sheet in the PBL model is in the very good category.

Hidayati, N., Idris, T., & Handayani, P. H. (2022). Student problem solving skills in PBL model: Viewed from the discourse sheet. *Biosfer: Jurnal Pendidikan Biologi, 15*(2), 231-241. https://doi.org/10.21009/biosferjpb.23840

INTRODUCTION

Problem Based Learning (PBL) is a constructivist learning strategy with the active involvement of students and instilling the learning process in solving real-life problems (Hmelo-Silver, 2004; Savery, 2015). In the early stages of learning, students are introduced to relevant problems to motivate and provide a learning context to students (Prince, 2004) so that this learning is designed in such a way as to facilitate students to learn collaboratively and deeply (Hack et al., 2015). The problems provided in the problem-solving phase should be problems related to things that are already recognized by students. The goal is that students have prior knowledge and ideas so that learning is more effective.

Previous studies have suggested the use of PBL in facilitating long-term retention, increasing satisfaction and developing various skills (Chowdhry, 2016; Oliveira et al., 2013) and also having a positive impact on prospective teachers (Nicol & Krykorka, 2016) as well as facilitating learning (Aslan & Duruhan, 2019). And improving critical thinking (Hidayati et al., 2022) many studies have also demonstrated the effectiveness of PBL in developing problem solving skills (Gallagher & Gallagher, 2013; Phungsuk et al., 2017; Shin & Kim, 2013). Problem solving has four techniques, namely understanding the problem, formulating a plan, implementing the plan and reflecting on what has been done. The independent learning aspect of PBL encourages the development of students' abilities to conduct logical assessments and formulate interventions so that they lead to making the right decisions (Stahovich et al., 2019). In PBL, students face problems through situations designed by educators (Hmelo-Silver, 2004). Problem is a phenomenon that requires an individual to choose a strategy and make decisions for solutions in every situation encountered (Özsoy & Ataman, 2009). Problem-solving efforts require self-regulation. When encountering obstacles in solving problems, we need to consider other possibilities in solving problems (Davis et al., 2019). During the problem-solving process, students are more controlled. They try to break complex problems into simple parts and ask their own questions to clarify their thoughts (Özsoy & Ataman, 2009).

Problems in the PBL model can come from textbooks read by students because the book contains sections devoted to problem solving (Davis et al., 2019). Problems can be grouped into two, namely routine and non-routine problems. In routine problems, the problem solver may not know the answer but knows how to calculate it. Meanwhile, with non-routine problems, the problem solver does not know how to calculate the solution, so it is necessary to first design and revise the solution plan. Problem solving knowledge determines whether the problem is routine or non-routine (Mayer, 2013). PBL uses unstructured problems, namely problems that do not only have one solution so that students can argue and discuss their solutions. If this is done correctly it can develop students' problem solving skills (Cho & Jonassen, 2002).

Problem solving skills can be defined as a person's ability to engage in cognitive processing to understand and resolve problem situations where methods for solving problems are not immediately available (Mefoh et al., 2017). Problem solving skills can also be interpreted as the ability to find the best solution when faced with problems (Kim et al., 2018) by identifying opportunities by utilizing new information (Mandina & Ochonogor, 2018). The stages that are passed during problem solving include focusing on the problem, detailing it into various concepts, making plans, implementing plans, and evaluating the solutions offered (Docktor et al., 2016). The process involves understanding the problem, selecting the right concept and checking the suitability of the problem with the proposed solution. It requires a good understanding of concepts and higher-order thinking skills (Hermansyah et al., 2019; Yuliati et al., 2018).

Problem solving skills are increasingly needed in the world of work, but the results of the analysis show that there are still few college graduates who can analyze and solve complex problems in the workplace. Whereas problem solving skills are one of the skills needed in the 21st century (Kuo et al., 2017) in various fields of work (Burkholder et al., 2021). Numerous studies have reported the inability of university students to solve problem. The low problem-solving skills because in the learning process there is still a gap between theory and practice. Students have not been trained optimally to put the theory gained in class into practice so they find it difficult and too theoretical (Ancel, 2016). Burns et al. (2010) asserts that the low mastery of problem-solving skills is influenced by various challenges faced by educators in teaching skills in realistic situations. In other words, the more accustomed students are to the learning process in the form of solving real problems, the problem-solving skills will increase (Aurah et al., 2014).

Problem-solving skills are skills that are needed by students throughout their life journey because these skills will be needed when dealing with various problems that are present in daily activities (Gojkov et al., 2014). Problem-solving skills help students face problems and find solutions to these problems. Any problems that arise in everyday life can be more easily overcome when we have problem-solving skills. These skills can also be a determinant of student success in the academic field so that these skills become one of the skills needed in the 21st century (Aurah et al., 2014; Ocak et al., 2021). Therefore, developing good problem-solving skills is critical to successfully navigating through school, career, and life in general. In addition, problem solving skills are one of the most important cognitive skills in any profession, as well as in everyday life (Jonassen, 2011). Problem solving ability has been shown to be better in students who carry out the learning process using PBL compared to students who receive direct learning. PBL can train independent learning students needed to solve problems (Simanjuntak et al., 2021). PBL is a learner-centered learning model and empowers students to integrate theory and practice so that they are able to solve problems (Kong et al., 2014). There are various stages during the learning process through PBL including orienting students to problems, formulating problems, guiding investigating and analyzing and evaluating the problem solving process (Arends, 2012). When students are asked to formulate problems, students will learn to construct their prior knowledge by identifying as many problems as possible. Presentation of problems encourages students to improve problem solving skills (Hedjazi et al., 2012). In addition, during the process of finding solutions, it can also encourage students to take the initiative and conduct analysis to be able to solve the problem (Hu et al., 2018).

Problem solving skills are not something that is innate, but these skills can be developed when a person is given the opportunity to solve problems. The problems given are problems that deeply reflect the real-life context that students may face (Hmelo-Silver, 2004). This problem is unstructured and requires several solutions (Jonassen, 2011). An unstructured problem solving process requires the application of knowledge from diverse subject domains (Toy, 2007). Unstructured problems require analysis to fully understand. The problem discourse sheet prepared contains dynamic problems so that when students are asked to formulate problems, many variations will be found. From this problem they will pour a lot of arguments and analyzes so that they find various alternative solutions. Analysis refers to seeing how different alternatives can be evaluated using selected criteria (Jonassen, 2011). Unstructured problems require a combination of fact-based data analysis and highly subjective and even intuitive judgments about aspects of the problem so as to arrive at a solution (Cassidy et al., 2005). This is where the role of a well-designed problem discourse sheet becomes relevant and can be utilized in the learning process. Referring to the explanation at the beginning, research was conducted to determine the problem-solving ability while working on the problem discourse sheet in the PBL model.

METHODS

Research Design

This research was a survey with quantitative descriptive study to determine students' problem-solving abilities. The learning process was carried out using the PBL model which was equipped with a problem discourse sheet to determine students' problem-solving abilities.

Population and Samples

Participants were students who take the Human Physiology Anatomy course, totaling 37 students from the biology education study program at the Islamic University of Riau. The age range of the participants was 19-21 years. The sampling technique was total population sampling, namely all students who take the human physiology anatomy course.

Instrument

The instrument used to collect data on problem-solving abilities was the discourse of the problem and its scoring rubric. Problem solving indicators consist of identifying terms, formulating questions, considering, and finding solutions from problem formulations and making and determining conclusions. Before data collection, all instruments had to undergo expert validation. Two lecturers conducted the validation of the lesson plans, student worksheets, and problem-solving skills rubric with expertise in learning and instructional materials. The results showed high scores for the validity of the lesson plans (95.42), student worksheets (94.58), and problem-solving skills rubric (94.23).

Procedure

During the lecture process, students are given a worksheet containing the discourse of the problem and a list of questions. This worksheet was designed to measure students' problem solving abilities.

Data Analysis Techniques

Problem solving ability data were analyzed by scoring each answer given by students. The determination of the score follows the provisions as shown in Table 1. After determining the score, it is continued by calculating the percentage and determining the criteria. The criteria are as follows: Very Good (81-100), Good (61-80), Fair (31-60), and Poor (0-30).

Table 1

Problem Solving Ability Scoring Criteria (Modified from Greenstein, 2012)

No	Indicator	Description	Score
1	Identify important terms/concepts	Identify more than one term and provide a complete explanation of the term	4
		Identify more than one term but the explanation given is incomplete	3
		Identify one term and provide a complete explanation of the term	2
		Identify a term but the explanation given is incomplete	1
		Does not answer questions	0
2	Formulating questions	Formulate more than one question correctly and identify criteria to properly consider possible answers	4
		Formulate more than one question correctly but the criteria for considering possible answers are less precise	3
		Formulate one question correctly and identify criteria to properly consider possible answers	2
		Formulate one question correctly but the criteria for considering possible answers are not correct	1
		Does not answer questions	0
3	Consider and find solutions to the problem formulation	Consider and find a solution from the formulation of the problem posed correctly and integrate other theories or facts in making the solution	4
		Consider and find a solution from the problem formulation that is put forward correctly but other theories or facts in making the solution are not appropriate	3
		Considering and finding solutions to the problem formulation correctly but unable to integrate theory or facts	2
		The solution to the formulation of the problem posed is not correct	1
		Does not answer questions	0
4	Make and determine conclusions	Make and determine conclusions correctly based on the facts and state reasons that are general to specific or vice versa towards drawing conclusions	4
		Make and determine conclusions correctly based on the facts and state the reasons for making conclusions but not carried out in a sequential manner	3
		Make and determine conclusions correctly based on the facts and do not state reasons in drawing conclusions	2
		Make and determine conclusions but are not precise because they are not based on facts	1
		Unable to draw conclusions	0

In addition, the researchers also grouped student responses or answers based on the keywords used to determine the concepts that most often appear in the problem sheet. NVIVO 12 is used to group these keywords. NVIVO provides a way to get a broad overview of what concept terms exist in the data and allows us to search for various terms for analysis.

RESULT AND DISCUSSION

The problem-solving ability of students after carrying out learning by utilizing problem sheets can be seen in Table 2.

Table 2
Student problem solving ability

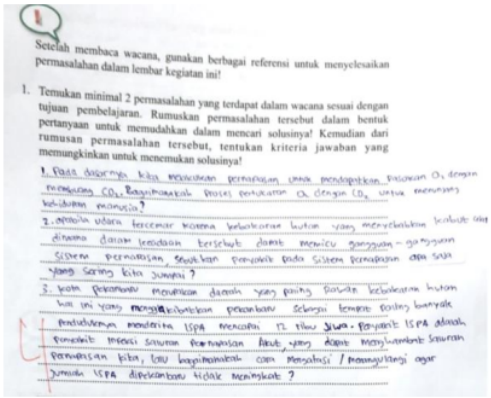
No	Indicator	Percentage	Category
1	Identify important terms/concepts	85.14	Very Good
2	Formulating questions	100.00	Very Good
3	Consider and find solutions to the problem formulation	84.46	Very Good
4	Make and determine conclusions	83.78	Very Good
	Average	88.35	Very Good

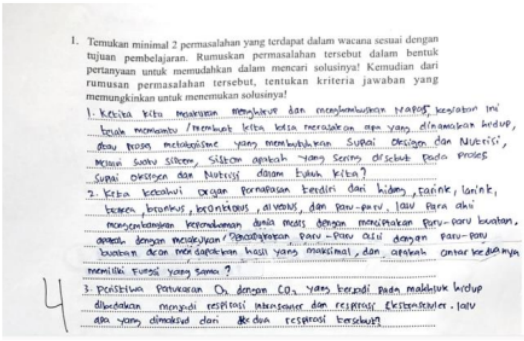
The data in Table 2 shows that students have excellent problem-solving skills when asked to solve problems contained in the discourse sheet. The average problem-solving ability of students is 88.35 with the indicator formulating questions being the highest indicator (100). Other indicators also have a high percentage, for example on indicators identifying important terms/concepts reaching a percentage of 85.14, considering and finding solutions from problem formulation (84.46) and indicators making and determining conclusions (83.78).

The problem-solving ability when completing the discourse sheet in the PBL model is very good. Students can formulate problems based on the discourse given. The ability of students to determine the correct formulation of the problem cannot be separated from their ability to identify the various issues raised in the discourse. Students need to read carefully and determine the essence of the problem because to be able to solve problems requires analogical reasoning (Holyoak & Morrison, 2005).

The ability of students to formulate questions is an important part of problem-solving abilities. Students need the ability to identify and carefully examine the discourse of the problem to be able to make the right problem formulation. Examples of problem formulations made by students can be seen in Table 3.

Table 3
Example of a Problem Formulation

Example of Problem Formulation	Translate
	Find at least 2 problems contained in the discourse according to the learning objectives. Formulate the problem in the form of a question to make it easier to find a solution! Then from the formulation of the problem, determine the answer criteria that allow to find a solution! 1. Basically we do breathing to get a supply of O_2 by removing CO_2. How is the process of exchanging O_2 with CO_2 to support human life? 2. If the air is polluted because of forest fires that cause smog which in that situation can trigger respiratory problems, what diseases of the respiratory system do we often encounter? 3. Pekanbaru City is the area most prone to forest fires. This is what causes Pekanbaru as the place with the most people suffering from ARI, which reaches 12 thousand people. ARI disease is an acute respiratory infection disease, which can inhibit our breathing, then how to overcome it so that the number of ARI sufferers in Pekanbaru does not increase?

Example of Problem Formulation	Translate
	Find at least 2 problems contained in the discourse according to the learning objectives. Formulate the problem in the form of a question to make it easier to find a solution! Then from the formulation of the problem, determine the answer criteria that allow to find a solution! 1. When we inhale and exhale, this activity has helped us to feel what is called life, or metabolic processes that require oxygen and nutrient supply, through a system, what system is often referred to in the process of supplying oxygen and nutrients to our bodies? 2. We know that the respiratory system consists of the nose, pharynx, larynx, bracts, bronchi, bronchioles, alveoli, and lungs. Experts develop the medical world by creating artificial lungs. Will doing a real lung transplant with an artificial lung get maximum results and do the two have the same function? 3. The exchange of O_2 with CO_2 that occurs in living things is divided into intracellular and extracellular respiration, then what do these two terms mean?

In addition to the ability to identify problems, the high percentage of students who are able to formulate problems may be influenced by the student's foresight in grouping the main ideas in the given discourse. Someone who is able to solve problems well starts from their ability to see new problems and relate them to problem solving schemes th3 they already recognize and understand so that they know how to solve them (Stahovich et al., 2019). PBL can encourage students to play an active role in identify problems based on existing phenomena and seek solutions problem. The stages in PBL begin by asking students to formula3 a problem. This can stimulate students' thinking ability to solve problems. Many studies have shown the effectiveness of PBL in improving students' problem solving abilities (Gallagher & Gallagher, 2013; Phungsuk et al., 2017; Shin & Kim, 2013).

The problem discourse sheet given to students contains various important concepts. Students have succeeded in identifying these important concepts based on their accuracy in analyzing the problem discourse. The results of the identification of these important concepts can be seen in Figure 1.

Figure 1. Results of Identification of Important Terms/Concepts in the Materials of the Respiratory System

Figure 1 provides an overview of important terms/concepts discussed by students during the learning process. The bigger the concept/term appears in the picture, then this shows that the term is most often put forward by students. The data in Figure 1 shows that the terms breathing, oxygen and carbon dioxide are most often discussed by students. The frequency of the various important terms/concepts is the highest compared to other concepts. Other terms such as sinusitis, colds, pleura are less frequently discussed by students.

In addition to the indicators of formulating questions, there are several other problem-solving ability indicators that are also measured in this study. For example, indicators identify important terms/concepts. The problem discourse given to students contains many paragraphs to explain a problem. When reading these paragraphs, students should be able to mark important concepts that are relevant to the topic being studied. Not all students are able to determine these important topics because it requires skill and the habit of reading carefully. The more important topics/terms that students can mark, the more their curiosity about the concept will increase. Therefore, students look for various references in order to provide an explanation of the important concepts they find. Arends (2012) in his book writes that one of the stages that is passed in PBL is collecting appropriate information to obtain explanations and problem solving. The results of research by Zwaal & Otting (2016) show that one of the important stages in PBL is collecting various information from various sources. Someone who has curiosity about something, he tends to be motivated to learn many things, think of various new ideas to the stage of solving problems (Richards et al., 2013) which can be done when the learning process involves the activeness of students (Kibga et al., 2021).

The next problem-solving ability indicator discussed is considering and finding solutions from the problem formulation. This indicator also obtained a high percentage in research. After students formulate the problem, the problem needs to be solved. For example, students formulate problems about the dangers of forest fires and their relation to ARI. From the formulation of the problem, students must be able to provide solutions so that forest fires do not occur so that people are not exposed to ARI. To provide a solution to this problem, there will be differences between one person and another. This difference can be caused not all students have the same experience in finding solutions to problems. There are students who are used to solving problems but there are also those who are not. Problem solving skills show a big difference in the problem-solving process of experts and beginners. When it comes to problem solving, an expert is different from a beginner. Experts when encountering problems will think, consider, and examine the problem before starting to work on solutions and get fully involved. In addition, the expert also classifies a problem according to the underlying principles, decides to enter what class the problem is. This is different from beginners because a beginner when they encounter a problem, they don't think about it in a structured way but immediately face it. During the learning process, to overcome the gap between experts and beginners, lecturers can provide guidance for beginners Experts tend to work systematically from problem statement to answer because they can easily execute their solution plan. Instead, the novice must develop a solution plan, sometimes through a process of means-goal analysis (Elvira et al., 2015).

The last indicator is the ability to make and determine conclusions. This indicator is in the good category which means that students can make conclusions correctly based on the solutions that have been found when solving problems. The ability of students to determine the right solution to existing problems leads to accuracy in determining conclusions. In the PBL stage, the lecturer helps students to define learning tasks related to the problem because it is possible for each student to have different prior knowledge. When the lecturer has directed the students, the students can continue the analysis so that the right solution is obtained. The learning process occurs when students try to solve problems. Learners are faced with cognitive conflicts, interact with the environment, and build knowledge based on previous experiences (Savery, 2015). The results of Komarudin et al. research (2020) show that previous knowledge affects problem solving. Initial knowledge is a comprehensive application to improve individual abilities and acts as a basic scheme in learning. Prior knowledge helps in forming knowledge hierarchies. The results of other studies also show that prior knowledge activation during problem based learning can improve problem solving skills (Turşucu et al., 2022). Therefore, during the problem-solving process students need to search for various references. The problem-solving process

refers to the processing performed by the problem solver while generating a solution, including representing the problem, drawing up a plan, and executing the plan. Problem solving results refer to the solutions produced so that the problem-solving process and the result of problem solving are two different but interrelated things. Success in obtaining the right solution is related to the smoothness of the problem solving process (Stahovich et al., 2019).

CONCLUSION

The problem-solving ability of students in completing problem discourse sheets with the Problem Based Learning Model is in the very good category. Sequentially, the indicators of problem-solving abilities that occupy the highest to the lowest percentages are formulating questions, identifying important terms/concepts, considering, and finding solutions from problem formulations. During the implementation of the lecture process using problem discourse sheets, not only problem-solving skills can be trained and measured but also critical thinking skills. Therefore, for the next research, it is better to measure this critical thinking skill. To improve problem solving skills, in the learning process students need to be faced with various problems.

ACKNOWLEDGMENT

Our deepest gratitude goes to Universitas Islam Riau, Indonesia.

REFERENCES

Ancel, G. (2016). Problem-Solving Training: Effects on the Problem-Solving Skills and Self-Efficacy of Nursing Students. *Eurasian Journal of Educational Research*, *64*, 231–246. http://dx.doi.org/10.14689/ejer.2016.64.13

Arends, R. (2012). *Learning to Teach: Connect, learn, succeed* (9th ed.). McGraw-Hill.

Aslan, S., & Duruhan, K. (2019). The Effect of Problem Based Learning Approach in Information Technologies and Software Course on Academic Achievement of Students. *Çukurova Üniversitesi Eğitim Fakültesi Dergisi*, *48*(1), 32–72. https://doi.org/10.14812/cufej.468432

Aurah, C. M., Cassady, J. C., & McConnell, T. J. (2014). Predicting problem solving ability from metacognition and self-efficacy beliefs on a cross validated sample. *British Journal of Education*, *2*(1), 49–70. http://ir-library.mmust.ac.ke:8080/handle/123456789/1272

Burkholder, E., Hwang, L., & Wieman, C. (2021). Evaluating the problem-solving skills of graduating chemical engineering students. *Education for Chemical Engineers*, *34*, 68–77. https://doi.org/10.1016/j.ece.2020.11.006

Burns, H. K., Donnell, J. O., & Artman, J. (2010). High-fidelity Simulation in Teaching Problem Solving to 1st-Year Nursing Students A Novel Use of the Nursing Process. *Clinical Simulation in Nursing*, *6*(3), e87–e95. https://doi.org/10.1016/j.ecns.2009.07.005

Cassidy, C. M., Brozik, D., & Brozik, D. (2005). Problem Discovery And Problem Solving In Unstructured Situations: Using The Pan-Pacific Enterprises Simulation With University Students. *Journal of Business Case Studies – Second Quarter*, *1*(2), 1–10. https://doi.org/10.19030/jbcs.v1i2.4916

Cho, K., & Jonassen, D. H. (2002). The Effects of Argumentation Scaffolds on Argumentation and Problem Solving. *ETR&D*, *50*(3), 5–22. https://link.springer.com/article/10.1007/BF02505022

Chowdhry, S. (2016). Student's perception of effectiveness of a technology enhanced problem based learning environment in a Mechanical Engineering module. *Journal of Today's Ideas – Tomorrow's Technologies*, *4*(1), 15–32. https://doi.org/10.15415/jotitt.2016.41002

Davis, J. D., McDuffie, A. R., Drake, C., & Seiwell, A. L. (2019). Teachers' perceptions of the official curriculum: Problem solving and rigor. *International Journal of Educational Research*, *93*, 91–100. https://doi.org/10.1016/j.ijer.2018.10.002

Docktor, J. L., Dornfeld, J., Frodermann, E., Heller, K., Hsu, L., Jackson, K. A., Mason, A., Ryan, Q. X., & Yang, J. (2016). Assessing student written problem solutions : A problem-solving rubric with application to introductory physics. *Physical Review Physics Education Research*, *12*(010130), 1–18.

https://doi.org/10.1103/PhysRevPhysEducRes.12.010130

Elvira, Q., Imants, J., DeMayer, S., & Segers, M. (2015). The quality of high school students' problem solving from an expertise development perspective. *Citizenship, Social and Economics Education*, *14*(3), 172–192. https://doi.org/10.1177/2047173416630012

Gallagher, S. A., & Gallagher, J. J. (2013). Using Problem-based Learning to Explore Unseen Academic Potential. *Interdisciplinary Journal of Problem-Based Learning*, *7*(1), 3–15. https://doi.org/10.7771/1541-5015.1322

Gojkov, G., Stojanović, A., & Gojkov-Rajić, A. (2014). Meta components of intellectual autonomy as higher education teaching quality indicators. 657–669. https://ideas.repec.org/a/osi/journl/v10y2014p657-669.html

Greenstein, L. (2012). *Assessing 21st Century Skills: A Guide to Evaluating Mastery and Authentic Learning*. Sage Publication Ltd. https://eric.ed.gov/?id=ED534306

Hack, C., Mckillop, A., Sweetman, S., & McCormack, J. (2015). An evaluation of resource development and dissemination activities designed to promote problem-based learning at the University of Ulster. *Innovations in Education and Teaching International*, *52*(2), 218–228. http://dx.doi.org/10.1080/14703297.2013.849610

Hedjazi, S. Y., Shakiba, H., & Monavvarifard, F. (2012). Effect of problem-solving Styles on academic achievement of agricultural students in the University of Tehran. *Annals of Biological Research*, *3*(8), 4154–4158. https://www.cabdirect.org/cabdirect/abstract/20123299827

Hermansyah, H., Gunawan, G., Harjono, A., & Adawiyah, R. (2019). Guided inquiry model with virtual labs to improve students' understanding on heat concept. *Journal of Physics: Conference Series*, *1153*(1), 012116. https://iopscience.iop.org/article/10.1088/1742-6596/1153/1/012116/meta

Hidayati, N., Zubaidah, S., & Amnah, S. (2022). The PBL vs. Digital Mind Maps Integrated PBL : Choosing Between the two with a view to Enhance Learners' Critical Thinking. *Participatory Educational Research (PER)*, *9*(3), 330–343. https://eric.ed.gov/?id=EJ1324993

Hmelo-Silver, C. E. (2004). Problem-Based Learning: What and How Do Students Learn? *Educational Psychology Review*, *16*(3), 235–266. https://link.springer.com/article/10.1023/B:EDPR.0000034022.16470.f3

Holyoak, K. J., & Morrison, R. G. (2005). *The Cambridge handbook of thinking and reasoning*. Cambridge University Press.

Hu, Y.-H., Xing, J., & Tu, L.-P. (2018). The Effect of a Problem-oriented Teaching Method on University Mathematics Learning. *EURASIA Journal of Mathematics, Science and Technology Education*, *14*(5), 1695–1703. https://doi.org/10.29333/ejmste/85108

Jonassen, D. (2011). Supporting Problem Solving in PBL. *Interdisciplinary Journal of Problem-Based Learning*, *5*(2), 9–27. https://doi.org/10.7771/1541-5015.1256

Kibga, E. S., Gakuba, E., & Sentongo, J. (2021). Developing Students' Curiosity Through Chemistry Hands-on Activities: A Case of Selected Community Secondary Schools in Dar es Salaam, Tanzania. *EURASIA Journal of Mathematics, Science and Technology Education*, *17*(5), 1–17. https://doi.org/10.29333/ejmste/10856

Kim, J. Y., Choi, D. S., Sung, C.-S., & Park, J. Y. (2018). The role of problem solving ability on innovative behavior and opportunity recognition in university students. *Journal of Open Innovation: Technology, Market, and Complexity*, *4*(4), 1–13. https://doi.org/10.1186/s40852-018-0085-4

Komarudin, Marji, Sutadji, E., & Widiyanti. (2020). Increase the problem solving ability through improved prior knowledge. *Journal of Physics: Conference Series*, *1700*, 1–7. https://doi.org/10.1088/1742-6596/1700/1/012043

Kong, L.-N., Qin, B., Zhou, Y., Mou, S., & Gao, H.-M. (2014). The effectiveness of problem-based learning on development of nursing students ' critical thinking: A systematic review and meta-analysis. *International Journal of Nursing Studies*, *51*(3), 458–469.

https://doi.org/10.1016/j.ijnurstu.2013.06.009

Kuo, H.-C., Burnard, P., Mclellan, R., Cheng, Y.-Y., & Wu, J.-J. (2017). The Development of Indicators for Creativity Education and a Questionnaire to Evaluate its Delivery and Practice. *Thinking Skills and Creativity*. https://doi.org/10.1016/j.tsc.2017.02.005

Mandina, S., & Ochonogor, C. (2018). Comparative Effect of Two Problem-solving Instructional Strategies on Students' Achievement in Stoichiometry. *EURASIA Journal of Mathematics, Science and Technology Education*, *14*(12), 1–9. https://doi.org/10.29333/ejmste/95125

Mayer, R. E. (2013). Problem Solving. In D. Reisberg (Ed.), *The Oxford Handbook of Cognitive Psychology*. Oxford University Press. https://doi.org/10.1093/oxfordhb/9780195376746.013.0048

Mefoh, P. C., Nwoke, M. B., Chukwuorji, J. C., & Chijioke, A. O. (2017). Effect of cognitive style and gender on adolescents' problem solving ability. *Thinking Skills and Creativity*, 1–22. https://doi.org/10.1016/j.tsc.2017.03.002

Nicol, C., & Krykorka, F. (2016). The Place of Problems in Problem Based Learning: A Case of Mathematics and Teacher Education. *Problem-Based Learning in Teacher Education*, 173–186.

Ocak, G., Doğruel, A. B., & Tepe, M. E. (2021). An Analysis of the Relationship between Problem Solving Skills and Scientific Attitudes of Secondary School Students. *International Journal of Contemporary Educational Research*, *8*(1), 72–83. https://files.eric.ed.gov/fulltext/EJ1292178.pdf

Oliveira, A. M. C. A., dos Santos, S. C., & Garcia, V. C. (2013). PBL in Teaching Computing: An overview of the Last 15 Years. *Frontiers in Education Conference*, 267–272. https://doi.org/10.1109/FIE.2013.6684830

Özsoy, G., & Ataman, A. (2009). The effect of metacognitive strategy training on mathematical problem solving achievement. *International Electronic Journal of Elementary Education*, *1*(2), 68–83. https://files.eric.ed.gov/fulltext/ED508334.pdf

Phungsuk, R., Viriyavejakul, C., & Ratanaolarn, T. (2017). Development of a problem-based learning model via a virtual learning environment. *Kasetsart Journal of Social Sciences*, 1–10. https://doi.org/10.1016/j.kjss.2017.01.001

Prince, M. (2004). Does Active Learning Work? A Review of the Research. *Journal OfEngineering Education*, *93*(3), 223–231.

Richards, J. B., Litman, J., & Roberts, D. H. (2013). Performance characteristics of measurement instruments of epistemic curiosity in third-year medical students. *The Journal of the International Association of Medical Science Educators Med Sci Educ 2013*, *23*(3), 355–363. https://link.springer.com/article/10.1007/BF03341647

Savery, J. R. (2015). *Essential Readings in Problem-Based Learning Overview of Problem-Based Learning : Definitions and Distinctions*. Purdue University Press. https://muse.jhu.edu/book/42546

Shin, I.-S., & Kim, J.-H. (2013). The effect of problem-based learning in nursing education: a meta-analysis. *Adv in Health Sci Educ*, *18*, 1103–1120. https://doi.org/10.1007/s10459-012-9436-2

Simanjuntak, M. P., Hutahaean, J., Marpaung, N., & Ramadhani, D. (2021). Effectiveness of Problem-Based Learning Combined with Computer Simulation on Students' Problem-Solving and Creative Thinking Skills. *International Journal of Instruction*, *14*(3), 519–534. https://doi.org/10.29333/iji.2021.14330a

Stahovich, T. F., Arsdale, T. S. Van, & Mayer, R. E. (2019). How handwriting behaviors during problem solving are related to problem- solving success in an engineering course. *Contemporary Educational Psychology*, *58*, 331–337. https://doi.org/10.1016/j.cedpsych.2019.04.004

Toy, S. (2007). Online ill-structured problem-solving strategies and their influence on problem-solving performance [Iowa State University]. In *Retrospective Theses and Dissertations*. https://lib.dr.iastate.edu/rtd/15916

Turşucu, S., Spandaw, J., & Vries, M. J. de. (2020). The Effectiveness of Activation of Prior Mathematical

Knowledge During Problem-solving in Physics. *EURASIA Journal of Mathematics, Science and Technology Education*, *16*(4). https://doi.org/10.29333/ejmste/116446

Yulianti, E., Al Husna, I. Y., & Susilowati. (2018). The Role of Inquiry-Based Interactive Demonstration Learning Model on VIII Grade Students' Higher Order Thinking Skill. *Journal of Science Education Research*, *2*(1), 35–38. https://journal.uny.ac.id/index.php/jser/article/view/19333/0

Zwaal, W., & Otting, H. (2016). Performance of the Seven-step Procedure in Problem-based Hospitality Management Education. *Journal of Problem Based Learning in Higher Education*, *4*(1), 1–15. https://eric.ed.gov/?id=EJ1124227

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