How the Patterns of Students' Scientific Problem-Solving Skills in SMPN Kota Jayapura

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Abstract. The purpose of this research was to examine and describe the profile on how the patterns of students' scientific problem-solving skills in SMP N Kota Jayapura, Papua, Indonesia. Descriptive quantitative method was chosen to be the research approach. The population of this research were students in seventh class at SMP N Kota Jayapura. Samples taken in this study were 79 students and chosen from random sampling technique. Data collecting was done through test and interview in second term of VIII class. The results of this study showed that 25.32% of students were able to define the problem, 22.78% of students were able to explore the problem, 20.25% of students were able to plan the solution, 20.25% of students were able to check the solution, and 0% of students were able to evaluate. The mean results of test technique using test instrument showed that the students' scientific problem-solving skills was 54.73. This finding was interpreted and categorized through descriptive quantitative analysis. It is obtained that students in SMP N Kota Jayapura has low scientific problem-solving skills.

Keywords: Scientific problem-solving skills pattern, solutions, students.

1 Introduction

Society has developed to enhance their knowledge in the technology using and engaging. It is due to the occurrence movement as a result of the rapid development of information and communication technology in human civilization. According to Schmidt & Cohen, currently human live in the digital age of 4.0 industry [1]. Generation Z, the reference of nowadays generation between 16-27-year-old, were born in an era where half of the world's population is connected to the internet and digital technology so that they are able to survive in both conventional and digital field during their lifetime.

The digital era or digital age is part of the challenges to face by the generation Z in the 21st century. The 21st century has an enormous impact on the science, technology, and other major sectors' development. As stated by Binkley et al., Nur'asiah et al., and Siahaan et al., there is a very rapid development of science and technology and it requires humans to have adequate skills in order to define themselves in society [2-4]. This is in line with the opinion of [5], students in this century are required to have 21st century skills, which are used to compete in the face of globalization and the rapid development of information flows.

According to Barak and Binkley et al., there are several skills to master to survive in 21st century, namely the way of thinking, the way of working, tools for working, and the way of living in the world [6,7]. According to Hesse et al., Griffin et al., Ngang et al., Rahmadani et al., the ways of thinking skills consist of some benefactors related to the scientific process. The indicators are creative thinking, innovative thinking, critical thinking, problem-probing and problem-solving, how to learn thinking, and metacognition thinking [8,9].

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Thinking is an ability or skills to process the information from numerous sources and it can be used to probe and solve problems or tasks due to rational way of analytical method. It is proven that students can explain and determine the solutions to be used to solve existing problems [10]. A good thinker will have high metacognitive abilities so that it can be used to solve existing problems. Based on this statement, we can determine that high-order thinking skills (HOTS) are one of the most crucial or important things to be owned by the students. HOTS must be developed during the process of learning and must be possessed by students to survive of challenges during the lesson [11]. It will relate to how these students will solve problems that occur in life.

Problem-solving skills are one of the essential skills to have along with the challenge appeared in 21st century. Students must have to face the challenges and demands of the 21st century using the thinking skills to pursue their existence in society. Problem-solving skills are related to the activity in which a person uses their observation, experience, understanding of skills and expertise to deal with a situation they don't know yet to be analyzed and evaluated in the learning process and apply what they have to new circumstances [12,13]. In addition, if the problem-solving skills possessed by students, then the students will become more motivated during the lesson. The problem-solving skills will provoke curiosity in students to solve existing problems.

Rotherham & Willingham noted that the success of a student depends on mastery of 21st century skills [14]. Just knowing the knowledge of life that is increasingly complex and can change rapidly Partnership for 21th Century Skills identifies that one of the 21st century skills is problem-solving skills. These skills can help students make correct, careful, systematic, logical decisions and consider various points of view. This lack of ability results in students doing various activities without knowing the purpose and reasons for doing them. The skills possessed by students will have many benefits. One of the benefits is that students are able to achieve high knowledge in order to be ready for the challenges and demands of the 21st century. In addition, according to Dyer et al., that their problem-solving skills will help students to become innovator [15]. It can be preserved because the problem-solving skills are trained in several skills such as observing, asking, reasoning, trying, and forming networks in the social system.

This is in line with what was stated by Trilling & Fadel that problem-solving skills are one type of expert thinking who have a strong desire to solve problems in their life [16]. Problem-solving skills will make someone who has a long life starting with a question and ending in finding the answer to that question. It has been explicitly formulated in The Rules of Ministry of Education and Culture Number 22 of 2006 concerning Content Standards for Junior High School of science subjects which states that it is necessary to develop analytical, inductive, and deductive thinking skills to solve problems related to natural events around them [17]. When teaching science, problem-solving skills and thinking insights for a good future life can be trained to students [18,19]. When referring to the National Research Council USA, the low contribution of science learning to the livelihoods of citizens is due to one of the causes of the use of inaccurate assessments [20].

The results of interviews conducted with 3 science teachers from 3 junior high schools in Jayapura City showed that teachers had not stimulated HOTS in the learning process. The importance of problem-solving skills to meet 21st century skills is urge. Whereas it is necessary to conduct the research to rethinking the solution of determining the problem-solving skills pattern in science. This study focused on the students from 8th grade at SMP in Jayapura City.

2 Method

This research used descriptive quantitative approach. The population of this study were students from eight grade of junior high school in Jayapura city. Test were deliberately delivered to the samples and the results were analyzed to get the mean score of students' scientific problem-solving skills based on six parameters or aspects. The samples were 79 students. The sampling technique used was purposive sampling. The samples consisted of 3 junior high school in Jayapura city, namely: SMPN 2, SMPN 11, and SMP YPPK St. Paulus. Data were obtained through tests and interviews. The problem-solving skills test refers to the theory of Mourtos et al. [12]. The problem-solving skills test materials used were all science material for students in class VII during the second semester. The test was developed in the form of multiple choice with a total of 50 items. Interviews were conducted to clarify and validate the students' test answers.

3 Results and Discussion

The results of this study indicate that there are many problems found in every aspect of problem-solving skills in science, especially in the last aspect, evaluate, which has a percentage of 0%. The results of data analysis are drawn in percentage due to students' problem-solving skills pattern. In this study, students are obtained to have a low percentage for each aspect of scientific problem-solving skills. The results for each aspect of the percentage of scientific problem-solving skills are shown in Table 1.

Table 1. The results on students' science problem-solving skills.

Scientific problem-solving skills aspects [12]	Percentage (%)			
	SMPN 2	SMPN 11	SMP YPPK St. Paulus	Mean
Define the problem related to science	26.67	28.57	21.43	25.32
Explore the problem given	23.33	23.81	21.43	22.78
Plan the solution to the problem	20	19.05	21.43	20.25
Implement the solution plan	20	19.05	21.43	20.25
Check the solution	10	9.52	14.29	11.39
Evaluate the results	0	0	0	0

The first aspect of problem-solving skills is to define the problem. To define the problem, students can carry out an analysis activity from a picture or discourse that is presented. This activity is expected that students can: (1) find several problems related to images and discourse; (2) sketch the analysis process that has been carried out; (3) check what information is contained in the image or discourse; and (4) determine and define the problem.

The following is an example of the results from students that are relevant to the first aspect, namely to define the problem (Figure 1). The student answered that the muscles between the ribs experienced relaxation, so that the ribs were lifted and the air could enter (the process of breathing). The student's answer was incorrect and then we conducted an interview to confirm the answer. The students' answer shows that the student has not been able to define the problem through pictures. After conducting telephone interviews, it turned out that the students did not understand the concepts of contraction, relaxation and breathing through two processes namely inspiration and expiration. In the process of inspiration, the muscles between the ribs contract, so the ribs are lifted and air can enter. Thus, it can be also said as the process of human breathing.

It is in line with the research of DiCarlo stating that teaching alveolar ventilation to students need to be done by using HOTS approach [21].

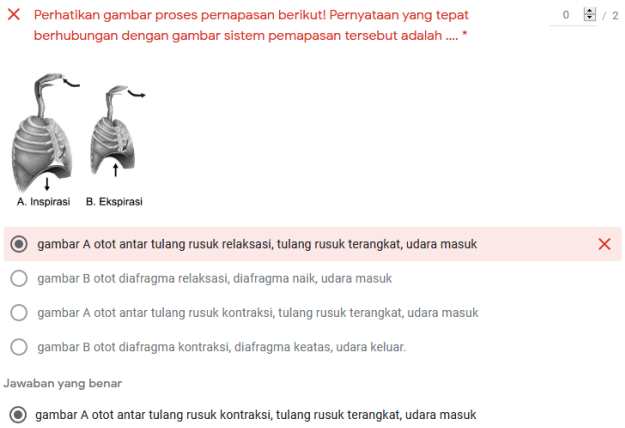

Fig. 1. The example of students' answer in to define the problem aspect.

The second aspect of problem-solving skills is to explore the problem. To explore the problem, students can carry out activities to carry out literacy studies or literature studies related to problems that have been applied and determined. This activity is expected that students can: (1) determine the object of the problem; (2) determine problems related to the defined problem object; (3) create assumptions from the problems that have been determined; and (4) establish answers to predetermined assumptions.

Figure 2 is an example of students' answer in the second aspect, namely explore the problem. Students did not respond, nor did they answer. After the interview by telephone, the students forgot to answer the question. The results of the interview showed that the students did not understand the concept of myopia and hypermetropy eye defects, because the students could not explain the position of the image captured by the retina for myopia and hypermetropy eye defects. This students' answer shows that the student has not been able to export a problem through pictures. It is in line with the research of Rahmadani et al., stating that teaching optical device material to students need to be done by using computer simulations to enhance students' problem-solving skills during the lesson [16].

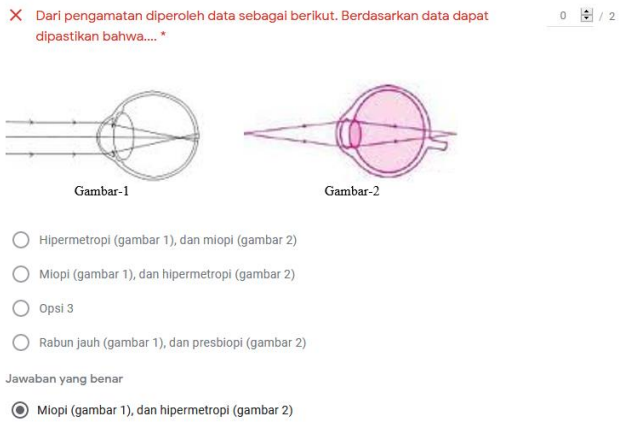

Fig. 2. The example of students' answer in to explore the problem aspect.

The third aspect of problem-solving skills is to plan the solution. To plan the solution is the process of analyzing several expert studies of the theory, including the principles and concepts that have been studied and then selected according to the predetermined assumptions. Students are required to choose the theory, principles, and concepts being studied, at this stage students are required to make a design or procedure that is used to prove the assumptions that have been made in the form of a map or chart.

The following is an example of the results from students that are relevant to the third aspect, namely to plan the solution (Figure 3). The students answered that the surface of the liquid in the vessel was not at the same level if: (1) there was a different type of liquid; (2) one of the pipes is closed; and (3) one of the pipes is a capillary tube. This student's answer is incorrect. Then interview is needed to confirm the answer. After conducting telephone interviews, it was obtained from the answer that the students did not have proper understanding related to the concept of balance. In the connected vessel, balance of the matter is needed when on a flat surface. It is in line with the research of Kurniawati & Ermawati stating that students' conception in learning capillary tube phenomenon rise misconception due to the lack of probing the problems given [22].

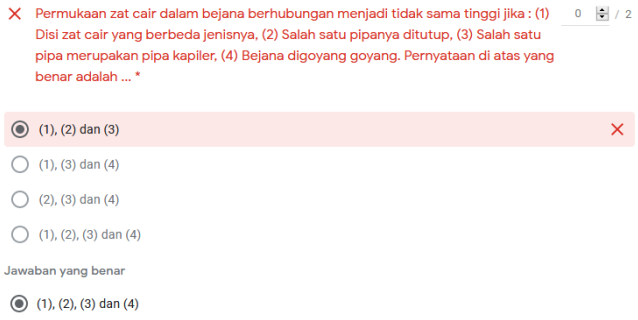

Fig. 3. The example of students' answer in to plan the solution aspect.

The fourth aspect of problem-solving skills is to implement the plan. Implementing the plan is the stage of applying or determining the solution from the study of theories, principles, and concepts that have been selected and embodied in a chart. It is used to prove the problem assumptions that have been made. At this stage students are trained to do a research based on scientific method. From this research students can get data that is used to answer predetermined problems.

Figure 4 is an example of students' results in the fourth aspect, namely to implement the plan. Students give wrong answers. The results of the telephone interview showed that students did not understand the concept of Archimedes, because students could not apply the mathematical equation of Archimedes law. This students' answer shows that the student has not been able to implement a concept to determining the solution of the problem. It is in line with the research of Berek et al., stating that students' concept comprehension in Archimedes law material can be achieved when students were able to plan the solution of the problem given [23].

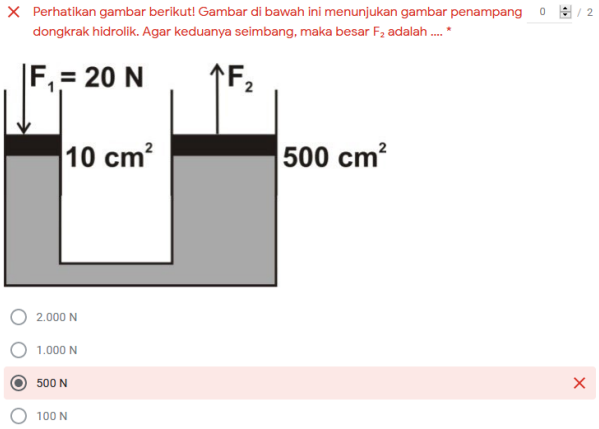

Fig. 4. The example of students' answer in to implement the plan aspect.

The fifth aspect of problem-solving skills is to check the solution. Check the solution is the stage to verify or see whether the design used in order to prove the answer is correct. It is also used to verify the finding in accordance with the theory being studied. At this stage students explain how from the process of problem definition to obtaining data and explain the reasons that are used as the basis of the theoretical study, the principles and concepts used.

Figure 5 is an example of students' results in the fifth aspect, namely to check the solution. Students give wrong answers. The results of the telephone interview showed that the students did not understand the concept of breathing, that humans breathe in oxygen and emit carbon dioxide. The meaning of the word exhaled air is blowing or removing carbon dioxide. Students did not understand the meaning of the word. When humans exhale into the element tube, they emit carbon dioxide. Thus, the lime water in the element tube will become cloudy when it reacts with carbon dioxide. This students' answer shows that the student has not been able to check the solution. It is in line with the research of Cheng & Hoe stating that students were not able to check the solution of inspiration and expiration process due to the mismatch of clarification of the answer [25].

Fig. 5. The example of students' answer in to check the solution aspect.

The sixth aspect of problem-solving skills is to evaluate. To evaluate is the last stage of problem-solving skills aspects. At this stage students use their cognitive skills to re-analyze what has been done and assess the statements that have been put forward, provide descriptions and training that has been done and put together. At this stage students are required to use strong logic to connect statements, descriptions, and questions given by other students. Students are trained to be able to compare what has been obtained with a literature review that has been reviewed and analyzed and whether the solution applied is acceptable or not.

Figure 6 is an example of students' results in the sixth aspect, namely evaluate. Students' answer was incorrect. The students' answer is to blow balloon A. This is not possible because balloon A was inside balloon B. The result of the interview by telephone showed that the student did not understand the concept of breathing in the lungs. Students are not able to evaluate the experimental design of simulated lung breathing. Balloon A will expand when balloon B is pulled down. This student's answer shows that the student has not been able to evaluate. It is in line with the research of Silva & Almeida stating that students were incapable to evaluate the respiration process using the balloon asked in the question [25].

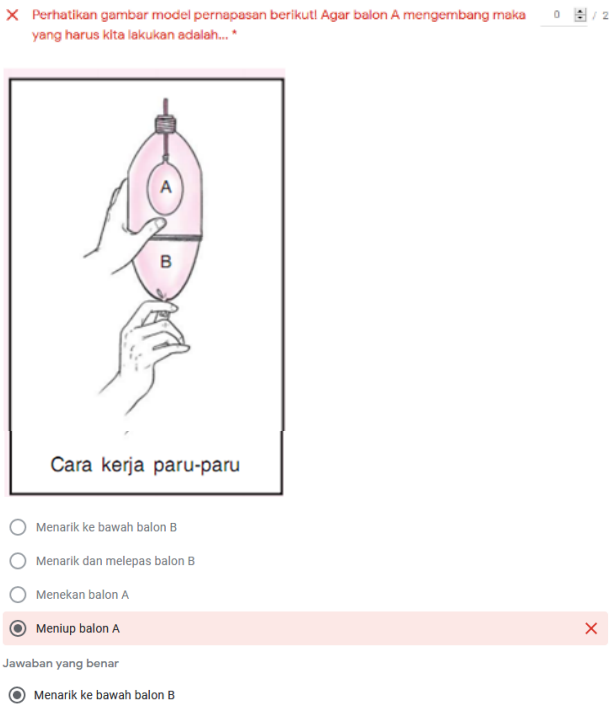

Fig. 6. The example of students' answer in to plan the solution aspect.

Figure 7 shows the average science score for class VIII students in SMP Kota Jayapura, which describes the scientific problem-solving skills. It can be seen in Figure 7 that the results show the mean score of students' answers in the test results in SMPN 11, SMPN 2 and SMP YPPK St. Paulus. The scores are respectively 49.24 (SMPN 11); 49.8 (SMPN, 2); and 64.14 (SMP YPPK St. Paulus). Figure 7 also draws the pattern of level related to students' mean score on scientific problem-solving skills. It can be concluded that SMP YPPK St. Paulus has the highest average score. Whereas the achievement score is still categorized in low category for the criteria of scientific problem-solving skills aspects. It shows that the scientific problem-solving skills possessed by students from class VIII at SMP Kota Jayapura is categorized in the low category. This finding is closely related to the previous study conducted by Kinay and Bagceci revealing the mean score of assessment results on scientific problem-solving. It was stated that the educators and policy makers needed to heed on the solution toward problem-solving skills. Other research conducted by Yildiz and Besoluk found that we needed to focus on the solution regarding low scientific problem-solving skills among teachers and students [26,27].

The findings from this study lead to the rethinking the solution of students' scientific problem-solving skills. If the pattern of scientific problem-solving skills level of students can be mapped, the educational practitioners will be able to stimulate the low category aspects so that students can achieve better conceptual understanding in the learning process. Dewi conducted a research to elevate students' scientific problem-solving skills through local potential and local wisdom [28]. Celik and Serin found that the influence and impact from the use of network-based science teaching can lead to the enhancement of students' scientific

problem solving skills [29]. Other advanced study on specific branch of problem-solving skills had been done by other researcher, Cheng et al., stating that interplays of knowledge, critical scientific reasoning, and problem-solving are needed to optimize to boost the students' problem-solving skills [30]. Meanwhile, there is a researcher developing new learning model to enhance student's problem-solving skills [31]. Visual mapping also can be one of solution to improve students' problem-solving skills [32].

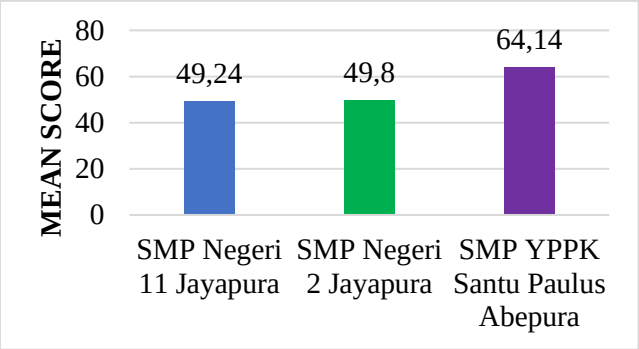

Fig. 7. The mean score of students' scienctific problem-solving skills of each school.

The results of this study indicate that there are many problems found in every aspect of problem-solving skills in science, especially in the last aspect, evaluate, which has a percentage of 0%. Based on the results of research that has been done, the results of data analysis on the percentage of students' problem-solving skills in this study have a low percentage for each aspect. The results for each aspect of the percentage of problem-solving skills are shown in Table 1.

4 Conclusion

The results showed that 25.32% of students were able to define the problem, 22.78% of students were able to explore the problem, 20.25% of students were able to plan the solution, 20.25% of students were able to check the solution, and 0% of students were able to evaluate the solution. The results of the student's science problem-solving skills test had an average or mean score of 54.73. These results indicate that the students in class VIII have low category of science' problem-solving skills. To rethinking the solution toward low students' scientific problem-solving skills, we need to conduct wider and deeper research with different scope and sequence. The science learning process needs renewable method integrated with 21th century skills to elevate students' problem-solving and problem-probing skills.

References

[1] Schmidt, E. and Cohen, J. 2013. *The new digital age: Reshaping the future of people, nations and business*. Hachette UK.

[2] Binkley, M. 2012. "Defining twenty-first century skills," in *Assessment and teaching of 21st century*

skills, Springer. pp. 17–66.
[3] Siahaan, P., Suryani, A., Kaniawati, I., Suhendi, E., and Samsudin, A. 12017. "Improving students' science process skills through simple computer simulations on linear motion conceptions," in *Journal of Physics: Conference Series*, 2017, vol. 812, no. 1, p.
[4] Nur'asiah, R. R. F., Siahaan, P., and Samsudin, A. 2015. "Deskripsi instrumen tes keterampilan berpikir kritis materi alat optik," *Pros. Simp. Nas. Inov. dan Pembelajaran Sains 2015*.
[5] Turiman, P., Omar, J., Daud, A. M., and Osman, K. 2012. *"UKM Teaching and Learning Congress 2011* (Selangor) 59." Amsterdam: Elsevier.
[6] Barak, M. 2017. "Science teacher education in the twenty-first century: A pedagogical framework for technology-integrated social constructivism," *Res. Sci. Educ.*, vol. 47, no. 2, pp. 283–303.
[7] Hesse, F., Care, E., Buder, J., Sassenberg, K., and Griffin, P. 2015. "A framework for teachable collaborative problem solving skills," in *Assessment and teaching of 21st century skills*, Springer. pp. 37–56.
[8] Griffin, P., Care, E., and McGaw, B. 2012. "The changing role of education and schools," in *Assessment and teaching of 21st century skills*, Springer. pp. 1–15.
[9] Ngang, T. K., Nair, S., and Prachak, B. 2014. "Developing instruments to measure thinking skills and problem solving skills among Malaysian primary school pupils," *Procedia-Social Behav. Sci.*, vol. 116, pp. 3760–3764.
[10] Rahmadani, S., Samsudin, A., Danawan, A., Kaniawati, I., and Suhendi, E. 2019. "Improving students' conceptual knowledge on optical device materials with computer simulations," in *Journal of Physics: Conference Series*. vol. 1280, no. 5, p. 52049.
[11] Budiarti, I. S. B., Suparmi, S., Sarwanto, S., Harjana, H., and Viyanti, V. 2019. "Stimulating Students' Higher-Order Thinking Skills on Heat and Temperature Concepts," *J. Pembelajaran Fis.*, vol. 7, no. 2, pp. 103–112.
[12] N. J. Mourtos, N. D. Okamoto, and J. Rhee, "Defining, teaching, and assessing problem solving skills," in *7th UICEE Annual Conference on Engineering Education*, 2004, pp. 1–5.
[13] Carson, J. 2007. "A problem with problem solving: Teaching thinking without teaching knowledge," *Math. Educ.*, vol. 17, no. 2.
[14] Rotherham, A. J. and Willingham, D. T. 2010. "21st-century" skills," *Am. Educ.*, vol. 17, no. 1, pp. 17–20.
[15] Dyer, J., Gregersen, H., and Christensen, C. M., 2019. *Innovator's DNA, Updated, with a New Preface: Mastering the Five Skills of Disruptive Innovators*. Harvard Business Press.
[16] Trilling, B. and Fadel, C. 2009. *21st century skills: Learning for life in our times*. John Wiley & Sons.
[17] Nasional, M. P. 2009."*Peraturan Menteri Pendidikan Nasional Nomor 58 Tahun 2009 Tentang Standar Pendidikan Anak Usia Dini*". Jakarta: Depdiknas.
[18] Quinn, M. M., Kavale, K. A., Mathur, S. R., Rutherford Jr, R. B., and Forness, S. R. 1999. "A meta-analysis of social skill interventions for students with emotional or behavioral disorders," *J. Emot. Behav. Disord.*, vol. 7, no. 1, pp. 54–64.
[19] Rustaman, N. Y., Hamidah, I., and Rusdiana, D. 2017. "The Use of Classroom Assessment to Explore Problem Solving Skills Based on Pre-Service Teachers' Cognitive Style Dimension in Basic Physics Course," *JPhCS*, vol. 812, no. 1, p. 12047.
[20] Council, N. R. 2000. *Inquiry and the national science education standards: A guide for teaching and learning*. National Academies Press.
[21] DiCarlo, S. E. 2008. "Teaching alveolar ventilation with simple, inexpensive models," *Adv. Physiol. Educ.*, vol. 32, no. 3, pp. 185–191.
[22] Kurniawati, D. M. and Ermawati, F. U. 2020. "Analysis Students' Conception Using Four-Tier Diagnostic Test for Dynamic Fluid Concepts," in *Journal of Physics: Conference Series*. vol. 1491, no. 1, p. 12012.
[23] Berek, F. X., Sutopo, S., and Munzil, M. 2016. "Enhancement of Junior High School Students' Concept Comprehension in Hydrostatic Pressure and Archimedes Law Concepts by Predict-observe-explain Strategy," *J. Pendidik. IPA Indones.*, vol. 5, no. 2, pp. 230–238.
[24] Cheng, H.-M. and Hoe, S.-Z. 2017. "Students' responses under 'negative pressure' to respiratory

questions at the 15th physiology quiz international event: 100 medical school teams from 22 countries," *BLDE Univ. J. Heal. Sci.*, vol. 2, no. 2, p. 105.
[25] Silva, M. and Almeida, A. 2017. "Primary school pupils' misconceptions of the human respiratory system in primary school students: from identification to deconstruction," in *10th annual International Conference of Education, Research and Innovatio*. vol. 1, pp. 1205–1210.
[26] Kinay, I. and Bagçeci, B. 2016. The Investigation of the Effects of Authentic Assessment Approach on Prospective Teachers' Problem-Solving Skills. *Int. Educ. Stud.* vol. 9, no. 8, pp. 51–59,
[27] Yıldız, Ş. and Beşoluk, Ş. 2019. The Investigation of the Effect of Problem Based Teaching Approach on Students' Problem Solving Skills and Academic Achievements. *Science Course*.
[28] Dewi, I. N., Poedjiastoeti, S., and Prahani, B. K. 2017. "Elsii learning model based local wisdom to improve students' problem solving skills and scientific communication," *Int. J. Educ. Res.*, vol. 5, no. 1, pp. 107–118.
[29] Çelik U. and Serin, O. 2020. "The effect of network based science teaching on students problem solving skills and science attitudes (Izmir sample)," *Elem. Educ. Online*, vol. 19, no. 4, pp. 2183–2201,
[30] Cheng, S.-C., She, H.-C., and Huang, L.-Y. 2017. "The impact of problem-solving instruction on middle school students' physical science learning: Interplays of knowledge, reasoning, and problem solving". *Eurasia J. Math. Sci. Technol. Educ.* vol. 14, no. 3, pp. 731–743,
[31] Pratiwi, S., Prahani, B. K., Suryanti, S. and Jatmiko, B. 2019. "The effectiveness of PO2E2W learning model on natural science learning to improve problem solving skills of primary school students," in *Journal of Physics: Conference Series*. vol. 1157, no. 3, p. 32017.
[32] Jamhari, M. and Sipahutar, H. 2018. "The Effects of Visual Mapping and Science-Related Attitudes on Students' Problem Solving Skills".