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Learning Devices for Biological Diversity: Examining the use of Troubleshooting to Improve Student Learning Outcomes

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ABSTRACT
This research aims to describe the validity of practicality and the effectivity of learning instruments for biodiversity conservation concepts using a troubleshooting learning model to increase the student learning result of grade VII SMPN 21 Banjarmasin. The study was conducted in two stages: (1) The first phase entailed developing a device following an Assure design, and (2) The second phase involved the implementation of a learning device at a class by using the one-group pretest-posttest design. A quantitative descriptive analysis technique and qualitative descriptive evaluation were done on the data collected. The result of this research shown that a device that was developed was valid, practical, and effective. Valid can be seen from the validator judgment to RPP, LKS, teaching materials, knowledge learning result judgment instrument, attitude, psychomotor, and interpretational skills. Effectiveness of the intervention was demonstrated by increased knowledge acquisition, individual completeness, psychomotor learning result completeness. The primary limitation of the study was the lack of time to guide the students to experiment and teach the sain skill process. However, the results of the study show that the troubleshooting model was a valid, practical, and effective method that could be used to improve the students' learning result and train the sciences skill process. The troubleshooting model was a valid, practical, and effective method that could be used to improve the students' learning result and train the sains skill process.

Keywords: Conservation of biodiversity; biology; learning result; learning outcomes; troubleshooting.

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1. INTRODUCTION

Sains education has significantly improved students' objectivity and contributed to the realization of better academic results. The sains education is designed to promote the values of honesty, discipline, humanity reward, caring, humility, and protecting people's lives through the learning activities done at school (Ma-Kellams & Blascovich, 2013). Biology is one of the subjects that students learn in Junior High School (SMP) level. Students must be able to create a concept and build the abstract concept in Biology to understand it, and other students focus on memorizing ideas related to biology but fail to apply it in life (Prahatamaputra, 2015). It is worth stating that sains and biology learning must be not focused only on the knowledge and understanding of the concepts (Basey, Maines, Francis, & Melbourne, 2014; Taylor & Gemmell, 2016). Instead, it should be directed more on how to make someone describe a phenomenon, draw a conclusion based on a fact, construct the new ideas, and realize how information and technology can positively impact on life of every person (Clary & Wandersee, 2013; Dieser & Bogner, 2016; Hopwood, Flowers, Seidler, & Hopwood, 2013; Trautmann, MaKinster, & Batek, 2013). Students who master biology are sensitive to their surroundings and always use their knowledge and skills to solve problems and improve quality of life.

The results of the international Trends in International Mathematics and Science Study (TIMSS) and Programme for International Student Assessment (PISA) studies illustrate the extent to which science learning outcomes have been realized in Indonesia. TIMSS has an assessment framework with three processes, namely knowing, applying, and reasoning. The average science skills of Indonesian students in the TIMSS study in 1999, 2003, 2007, and 2011 were 435, 420, 433, and 406, respectively (Ministry of Education and Culture, 2013a). Achievement of Indonesian students compared to other state students in the TIMSS study in 2011 showed that only 3% of Indonesian students reached high levels, 0% achieved advanced levels (compare: Singapore students 69% reached high levels, 40% achieved advanced levels) and 54% got low-level skills). The results show that the average Indonesian students could recognize several basic facts, communicate and associate various scientific topics and apply complex and abstract concepts (Ministry of Education and Culture, 2013). In the 2011 TIMSS study, Indonesia reached 3rd place from the bottom, only higher than Morocco and Ghana.

The results of the PISA study show things that are not much different from the results of the TIMSS study. PISA studies emphasize science literacy. The average scores of Indonesian students in the PISA study in 2000, 2003, 2006, 2009, and 2012 were 393, 395, 395, 383, and 382 respectively (Ministry of Education and Culture, 2013a). The results were below the average international score and reflected that Indonesian students' scientific literacy was still very low (Ministry of Education and Culture, 2013). Moreover, they suggest that science and biology education in Indonesia is not satisfactory, because the average new Indonesian student can remember simple and basic facts and mastering problem-solving skills in everyday life is still low (Ministry of Education and Culture, 2013). The 2013 Curriculum stipulates that one of the Graduates Competency Standards (SKL) in junior high school science subjects according to the Annex to the Regulation of the Minister of National Education Number 23 of 2006 dated May 23, 2006, is to show the ability to deal with problems that people face in their daily lives (Ministry of Education and Culture, 2013). Science process skills are one approach that must be used as a reference for teachers in carrying out the learning process designed in such a way that students can find facts, build concepts and theories with intellectual skills, and students' scientific attitudes. The problem-solving skills intended here are science process skills.

2. METHODOLOGY

The study was done to determine whether learning devices for biological diversity could improve learning outcomes. It entailed developing a biological learning device with a problem-solving model, according to Polya (1973) and testing its ability to enhance learning outcomes and science processing skills among junior high school (SMP) students. Learning tools developed are Learning Implementation Plans (RPP), Teaching Materials, Student Activity Sheets (LKS), Learning Outcomes Assessment Sheets, and Assessment of Science Process Skills. The stages of developing learning devices (Pribadi, 2011) can be seen in Figure 1.

The tools were assessed by 3 validators before a small group of the primary research was conducted in the VIIA class of SMPN 21 Banjarmasin. Data collection techniques used were observation, tests, and questionnaires. The data were analyzed through a descriptive and quantitative approach.

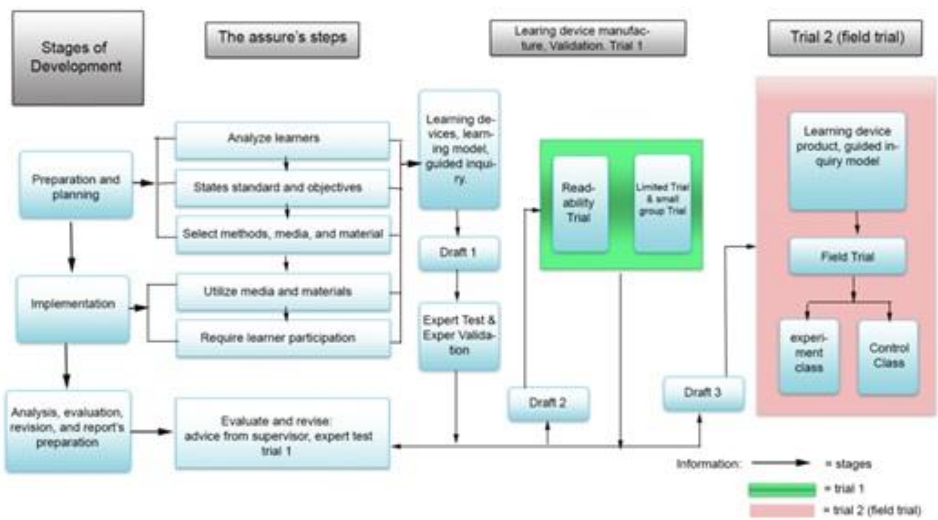

Fig. 1. Flow chart of learning device development

The quality of Learning device (RPP, Teaching Materials, LKS, and Learning Outcomes Assessment) were reviewed by the validator to determine the feasibility of their use. RPP, Teaching Materials, and LKS are reviewed with instruments that have been developed. For the Learning Outcomes Assessment Sheet, content validation was carried out, and the language and question writing were per the instrument (Table 1). The information was taken through a descriptive analysis method.

Table 1. Criteria for categorizing Learning Implementation Plans (RPP) assessment, teaching materials, and Student Activity Sheets (LKS)

Score interval	Evaluation category
> 3,50	Very descent
3,00 < ≤ 3,49	Descent
2,00 < ≤ 2,99	Average
1,00 < ≤ 1,99	Less
≤ 1,00	Low

The level of readability is an interesting measure as it shows the learner's comprehension of Teaching Material and LKS. The analysis technique was carried out in descriptive quantitative percentages. Students are asked to give their opinions regarding the readability of Teaching Materials and LKS by filling in the Instruments.

The criteria for each learning phase are assessed by giving a checklist the implementation column (yes or no) and in the assessment column (4 = very good, 3 = good, 2 = good enough, 1 = not good). The data obtained were then analyzed descriptively quantitatively by percentage techniques. The percentage of implementation of the lesson plan uses criteria as listed in Table 2 and for the Implementation of the RPP as shown on Table 3. Morever, student activity is measured by two observers using instruments and the data obtained then analyzed by quantitative descriptive.

Table 2. Criteria for categorizing Learning Implementation Plans (RPP) assessment

No	Percentage	Information
1	0,0%–24%	Not implemented
2	25%–49%	Less implemented
3	50%–74%	Well implemented
4	75%–100%	Very well implemented

Table 3. Criteria for the implementation of the Learning Implementation Plans (RPP)

No	Assessment average	implementation	Information
1	1,00–1,49		Less good
2	1,50–2,49		Enough good
3	2,50–3,49		Good
4	3,50–4,00		Very good

The outcomes related to knowledge and skills are determined by completeness, namely individual and classical completeness. Individually the students were considered to have improved if the average achievement of the indicators represented by the learning objectives meets the Minimum Completion Criteria (KKM) for science subjects at state SMP 21 Banjarmasin which is 75. Classical learning is said to be complete if ≥ 80% of individuals complete. The value given by two observers is determined on average, and then the results obtained are matched with the attitude assessment criteria in Table 4 and students' completeness is said to be complete if the score is at least showing moderate. Classical completeness is achieved if 80% of students complete.

Table 4. The criteria of attitude assessment

No	Mark range	Information
1	80–100	Very good
2	70–79	Good
3	60–69	Enough
4	< 60	Less

Based on the data from the science process skill test, a qualitative descriptive analysis was carried out from the student's score. Analysis of students' science process skills is done by giving students scores in answering essay test questions. Scoring is based on the scale of the science process, which is not skilled (1), less skilled (2), skilled (3), and highly skilled (4). Student questionnaire responses are used to find out the opinions of students on learning devices with the problem-solving model developed, the atmosphere of learning, and the way educators teach. Student responses were analyzed quantitatively by using percentages.

3. RESULTS

The results of the development of science-biology learning devices using problem-solving in the Polya model to improve learning outcomes and practice science process skills developed have been valid for use in learning. The RPP developed follows the flow of learning with the problem-solving syntax of the Polya model. The following are the results of his research:

3.1 Learning device validation

From Figure 2, it is evident that the average value was 3.89, showing that the validated RPP could be used in learning. The results of the Teaching Material Validation by the validator can be seen in Figure 3.

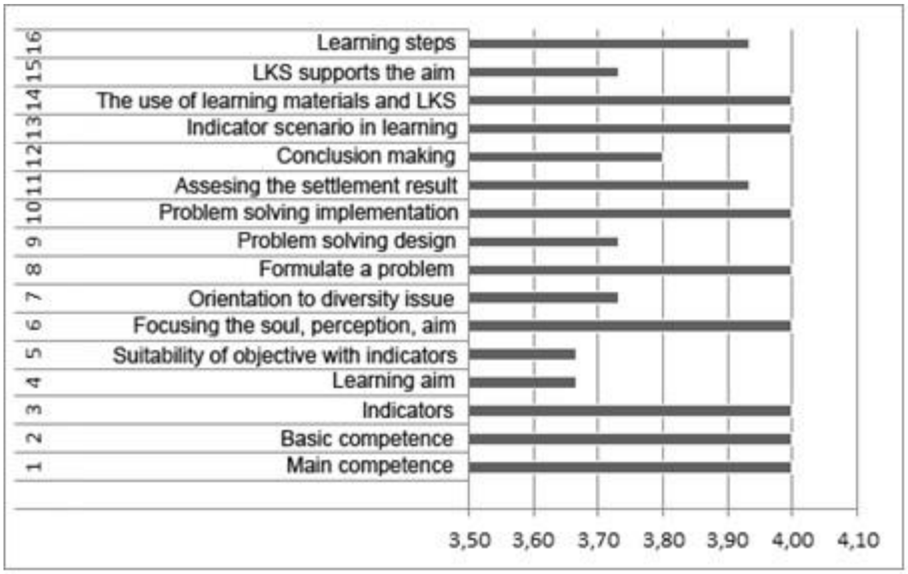

Fig. 2. Learning Implementation Plans (RPP) result validation

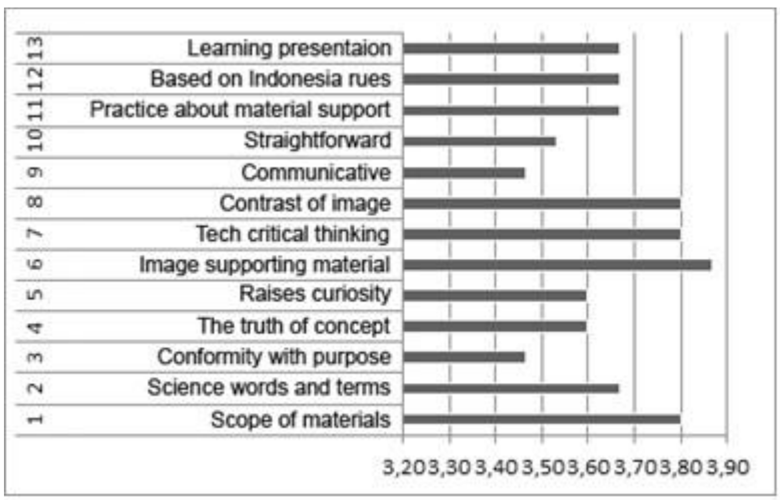

Fig. 3. Result of teaching materials validation

Based on the information presented in Figure 3, it is evident that the average value of 3.66, which is feasible. Therefore, the learning material that has been validated and can be used in learning. The Validation result of students' LKS by validator can be seen in Figure 4.

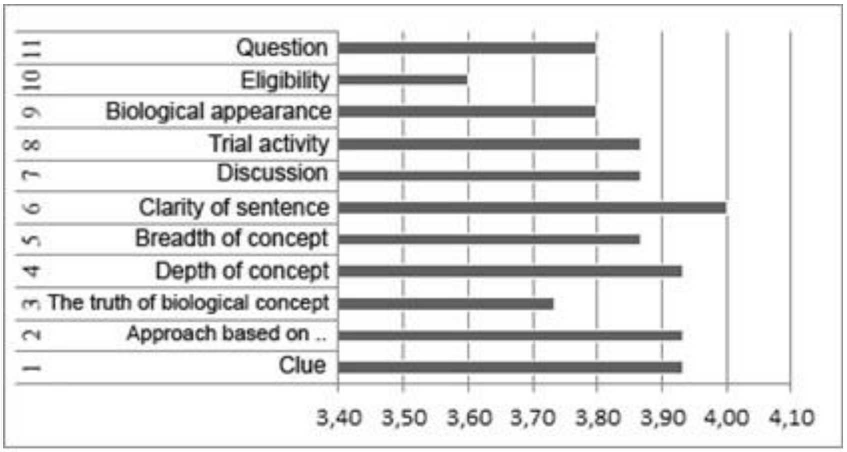

Fig. 4. Student Activity Sheets (LKS) validation result

From the results presented in Figure 4, the average value was 3.85 were, and it indicated that the validated worksheets could be used in classrooms. The results of the instrument validation of student learning outcomes by the validator are presented in Figures 5, 6, and 7 below.

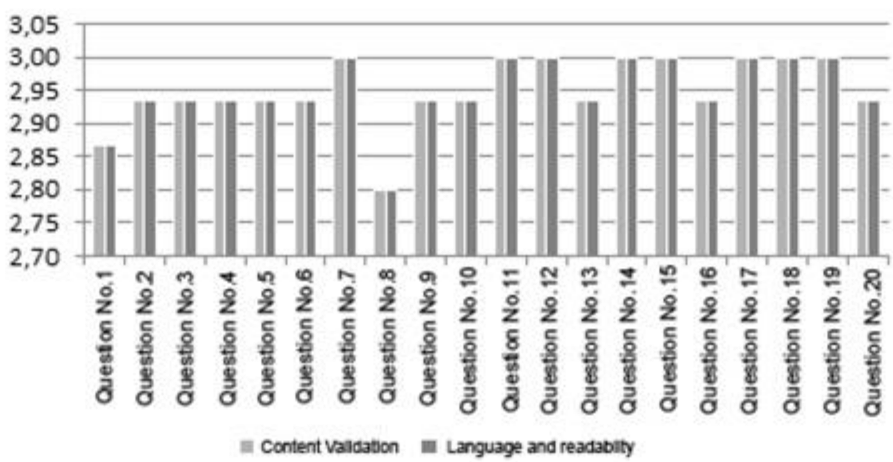

Fig. 5. Result of knowledge learning outcomes instruments validation

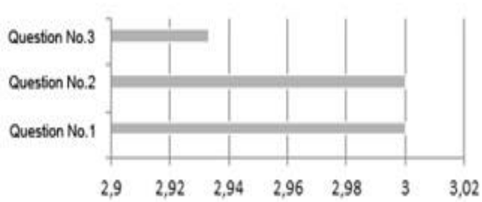

Fig. 6. Validation result of skill learning outcomes instruments

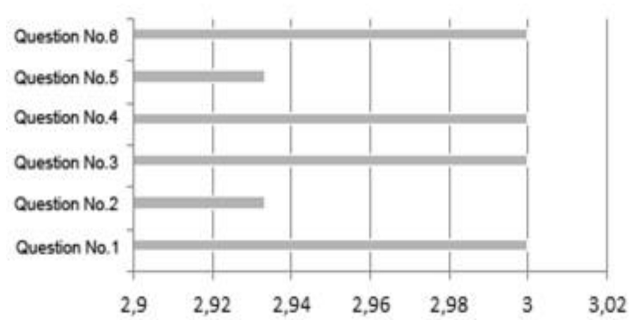

Fig. 7. Validation result of learning science process skills

3.2 Limited test

The results of observations on the developed learning devices implementation revealed that they were practical and could be used in the teaching of biology. The observations were made by two biology science subject teachers, and the outcome is presented in Figure 8 below.

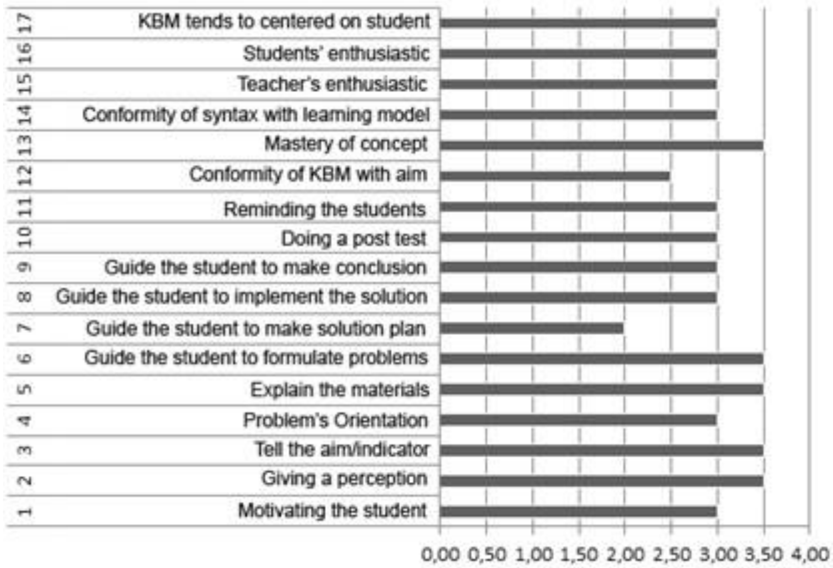

Fig. 8. Result of Learning Implementation Plans (RPP) implementation observation

Teaching biology is a complex process because of a wide range of factors including the content (Bayrhuber, 2016; Fleischner *et al.*, 2017; Liu & Beaujean, 2017; Ndeke, Okere, & Keraro, 2016). Furthermore, some students fail o relate the ideas being taught in class to the things that take place in the real world (Clancy, Nelson, Rutherford, & Hinde, 2014; Corwin, Graham, & Dolan, 2015; Haywood, Parrish, & Dolliver, 2016; Zogza, 2016). In other instances, the use of the wrong teaching methods may hinder students from learning biology concepts and acquire new knowledge (Lambert & Reiss, 2014). Therefore, it is upon the teacher to assess the situation and determine the best approach that can be used to improve learning outcomes (Khanova, Roth, Rodgers, & McLaughlin, 2015; Medina, Conway, Davis-Maxwell, & Webb, 2014; Tal, Lavie Alon, & Morag, 2014). In the current project, the observers were expected to determine the challenges that the students were facing when it comes to the content and concepts being taught in class.

In the preliminary stage, the observers noted that students faced challenges in 'understanding' the problem to be discussed. The problems were evident when the teacher tried to determine whether the students had comprehended the concepts being taught. For instance, the understanding of Apersepsi during the lesson was a challenge. Apersepsi is a typical type of South Kalimantan animals such as probosci's monkeys, anteaters, orangutans, parrots, and swamp buffaloes. Students struggled to understand the subject and determine how the animals were grouped in the same category. In such cases, the teachers had to help the students to make observations, see, read, and listen, and formulate questions/problems. Observation entailed taking students to the real world that has a lot of biodiversities, experiences of daily life, or bringing nature to class if possible. The goal is to enable students to see, hear, and touch various animals and plants that are difficult to obtain.

In the second phase of the problem-solving activity, the teacher guided students to form a hypothesis. The hypothesis must be very specific and limited to research because it will be tested for truth (Clément & Caravita, 2014; Gericke & Ottander, 2016; Lederman & Lederman, 2015, 2016); Rustaman, 2011). The role of the hypothesis is to guide researchers and ensure that the project remains on track (Arismendi & Penaluna, 2016; Pace, Fleischner, Weisberg, & Moline, 2017).

In the core activities of communicating the outcomes, students present the outcome of their group discussions alternately in front of the class (Farland, Franks, Barlow, Shaun Rowe, & Chisholm-Burns, 2015; Ghorbani, Karbalay-Doust, & Noorafshan, 2014; Remington, Hershock, Klein, Niemer, & Bleske, 2015). Appreciating how science works or more importantly mimicking how scientists work enables them to understand and share insights with their colleagues (Rustaman, 2011; Kimble, 2014; Momsen *et al.*, 2013; Prevost & Lemons, 2016; Singaravelu, 2013). Student activities during the learning process observed by two biology science subject teachers are presented in Figure 9.

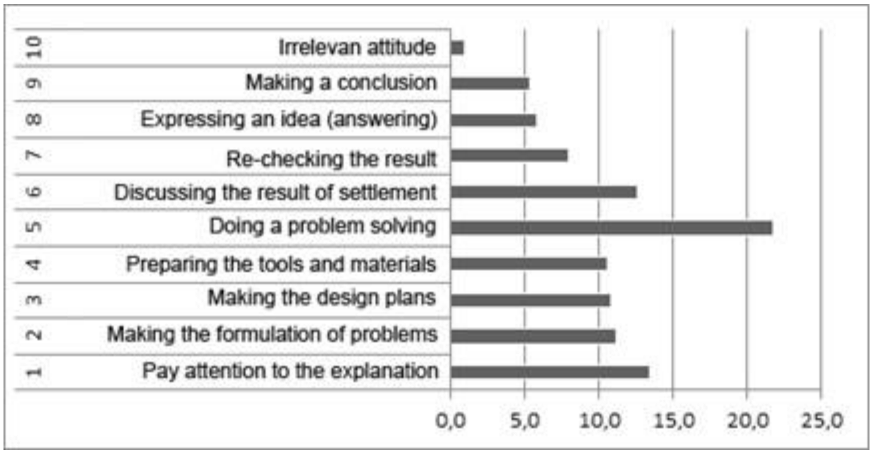

Fig. 9. Students' activity percentage (%)

Biological learning in the Concept of Conservation of Biodiversity places the teacher as facilitator and student as the subject of learning (Bleske *et al*., 2016; Frame *et al*., 2015; Rezaee & Mosalanejad, 2015). The trend is reflected in the activities of students who are dominant in following the learning process (Grünkorn, zu Belzen, & Krüger, 2014; Passmore, Gouvea, & Giere, 2014). Student activities related to the learning process include formulating problems, designing a problem solving, preparing tools and materials, carrying out a solution and then discussing it, checking the results obtained and answering some friends' questions (Abakpa, Achor, & Odoh, 2016; Bierema, Schwarz, & Stoltzfus, 2017; Mathews, 2014; Pany, 2014; Radeloff *et al*., 2015). The number of activities can be reduced by giving students enough freedom or responsibility to carry out tasks and experiments and find their work (Holmqvist & Olander, 2017; Matthews, 2015; Subramaniam, 2014; van Mil, Postma, Boerwinkel, Klaassen, & Waarlo, 2016). While making the adjustments, the teacher must also provide positive reinforcement when the results are correct and negative reinforcement when answers are incorrect (Koo *et al*., 2016; Svenning *et al*., 2016).

In this study, the student's responses after learning are presented in Figure 10 below. The results show that it is increasingly important to point out those concepts, models, teaching materials, and worksheets that are developed by educators. Besides, the intervention can improve most of the science process skills of students in learning science-biology through problem-solving. The positive response of these students is expected to provide hope for changes in the resolution of biology-science problems in more prudent ways. Therefore, the process is intended to improve the ability of students to realize, understand and master the series of forms of activities related to learning outcomes that have been achieved by students (Nur, 2011; (Burgess, McGregor, & Mellis, 2014). Moreover, students need to reason to believe in what is presented before them, gather supporting information, and provide valid arguments.

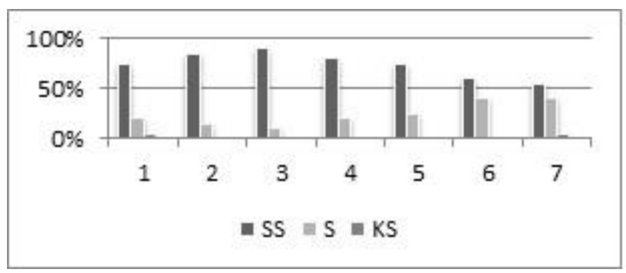

Fig. 10. Students' responds to a learning process

The limited test results of the learning devices developed have effectively improved learning outcomes and trained students' science process skills. Student learning outcomes in a limited test are presented in Figures 11, 12 and 13.

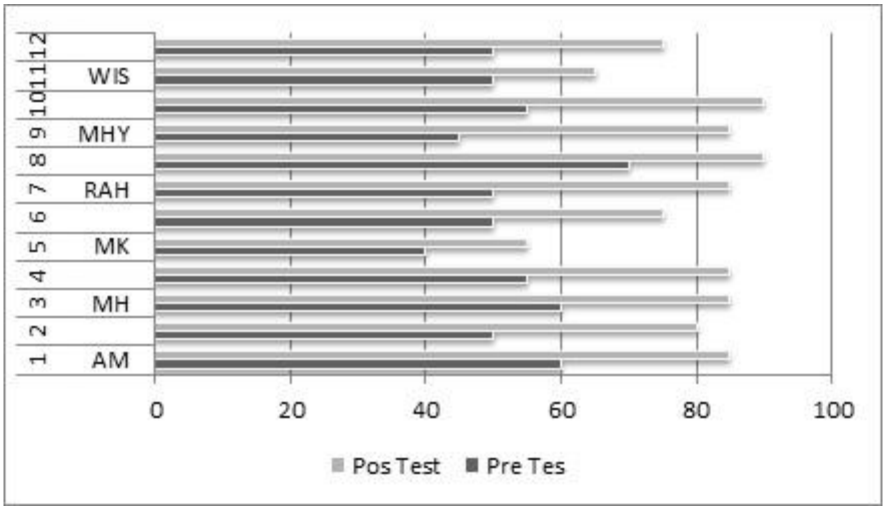

Fig. 11. The average of student cognitive learning outcomes

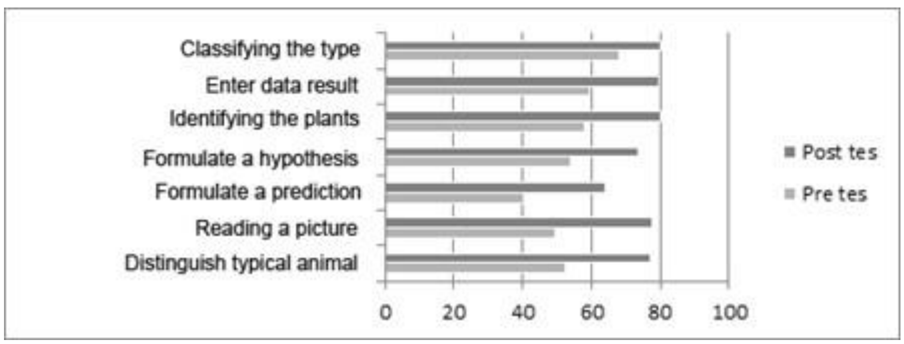

Fig. 12. The average of students' science process skill

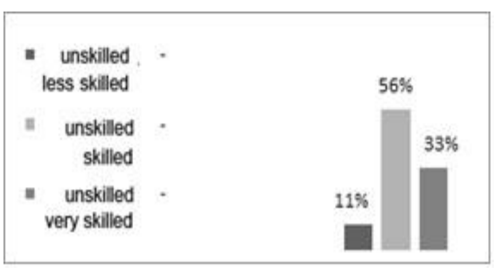

Fig. 13. The percentage of students' science process skill percentage

4. DISCUSSION

Knowledge learning outcomes had individual completeness above 75%. The results indicate that the problem-solving model enabled students to remember, understand, apply, analyze, synthesize, and evaluate concepts, laws, and theories related to the subject of interest. Furthermore, all indicators were linked to high levels of completeness. The top three were indicators 4, 8, and 9 that were completed with an average score of about 75%. This is in accordance with Gagne's opinion that students know how to solve the problem (process) as long as they develop a certain attitude (scientific attitude), and find the answer to the problem as a product (Ibrahim, 2003).

Learning activities with problem-solving, starting to formulate problems, design, and solve problems change students' views on biology. The teachers should strive to make students view biology as an important and interesting subject through the use of problem-solving methods (Chen *et al.*, 2018; Wiener, Plass, & Marz, 2009). In solving problems, students must understand a problem and have the desire to find a solution. Resolving the problem per the completion plan requires, among other things, the knowledge gained, concentration on the goal and one more important, and success (Bleske et al., 2016). Furthermore, it entails the examination of steps and results obtained by checking the truth of each statement (Balas & Momsen, 2014; Nyberg & Sanders, 2014). If students work following the plan, write a solution to the problem, and check each step of completion, they are likely to come up with a valid and correct solution (Muhson, 2007).

Biology, as one of the fields of science, provides a variety of learning experiences to understand scientific concepts and processes. The skills include observation, submission of hypotheses, proper and correct use of tools and materials, and compliance with work classroom regulations (Remington *et al.*, 2017; Wakabayashi, 2015). In other instances, biology learning entails asking questions, classifying and interpreting data, and communicating findings orally or in writing, exploring and sorting relevant factual information to test ideas or solve everyday problems (Pribadi, 2011). The results of learning science process investigations show that all students experienced an increase in ability, the greatest change being among those who were previously unskilled becoming skilled. The increase occurred because problem-solving models can be used to motivate students and encourage them to practice science process skills like the ability to draw conclusions that are trained through LKS (Boerwinkel, Swierstra, & Waarlo, 2014; Castéra & Clément, 2014; Clément, 2015). In other words, students are trained to make conclusions and are written on LKS.

Based on data from learning process science experiments, it is apparent that science process skills support other learning outcomes such as the ability to relate concepts to those in the real world. Nur (2011) stated that when students are actively involved in scientific inquiry, they use a variety of process skills, not just a single scientific method. The skills of the process are observation, classification, inferencing, forecasting, communicating, measuring, and interpreting data (Bleske *et al.*, 2014; Farland et al., 2015) Pribadi, 2011). Similarly, Rubba in Kurniati (2001) opined that science process skills are cognitive skills used by scientists as a systematic approach to solving problems. Therefore, they are central to the success of students in a science classroom.

5. CONCLUSION AND RECOMMENDATIONS

The data gathered in this study indicate that the biology science learning device with the problem-solving model was a valid, practical, and effective intervention that could be used to improve learning outcomes. Furthermore, it can be used to improve the student's science process skills. Therefore, it is a strategy that educators can use in science classrooms to impart the right skills for students and enable them to acquire the right knowledge.

Based on the results, three recommendations can be put forward to guide future research projects and enhance the teaching and learning of biology. First, some activities that have not been optimally implemented should be further enhanced in further testing. Second, there is a need to explore how teacher creativity, especially in directing students in formulating problems and making design completion can affect the outcomes of the experiments. Finally, there is a need to implement a problem-solving model on other concepts of biology.

REFERENCES

1. Abakpa, V., Achor, E. E., & Odoh, C. (2016). Effect of laboratory strategy on senior secondary students' achievement in biology. *Journal of the International Centre for Science, Humanities and Education Research (ICSHER),* 2(2): 68-75.
2. Arismendi I, Penaluna BE. Examining Diversity Inequities in Fisheries Science: A Call to Action. BioScience [Internet]. Oxford University Press (OUP); 2016 Apr 13;66(7):584–91. Available from: http://dx.doi.org/10.1093/biosci/biw041
3. Balas B, Momsen JL. Attention "Blinks" Differently for Plants and Animals. Holt EA, editor. CBE—Life Sciences Education [Internet]. American Society for Cell Biology (ASCB); 2014 Sep;13(3):437–43. Available from: http://dx.doi.org/10.1187/cbe.14-05-0080
4. Basey, J. M., Maines, A. P., Francis, C. D., & Melbourne, B. (2014). Impacts of digital imaging versus drawing on student learning in undergraduate biodiversity labs. *Bioscene: Journal of College Biology Teaching*, 40(2): 15-21.
5. Bayrhuber, H. (2016). Our double helix: ERIDOB in the face of the two strands of biology "didaktik.". In: Tal, T. & Yarden, A. (Eds.). *The Future of Biology Education Research. Proceedings of the 10th Conference of European Researchers in Didactics of Biology*, Pp. 149-154. Technion, Haifa, Israel.
6. Bierema AM-K, Schwarz CV, Stoltzfus JR. Engaging Undergraduate Biology Students in Scientific Modeling: Analysis of Group Interactions, Sense-Making, and Justification. Pelaez N, editor. CBE—Life Sciences Education [Internet]. American Society for Cell Biology (ASCB); 2017 Dec;16(4):ar68. Available from: http://dx.doi.org/10.1187/cbe.17-01-0023
7. Bleske BE, Remington TL, Wells TD, Dorsch MP, Guthrie SK, Stumpf JL, et al. Team-Based Learning to Improve Learning Outcomes in a Therapeutics Course Sequence. American Journal of Pharmaceutical Education [Internet]. American Journal of Pharmaceutical Education; 2014 Feb;78(1):13. Available from: http://dx.doi.org/10.5688/ajpe78113
8. Bleske B, Remington T, Wells T, Klein K, Tingen J, Dorsch M. A Randomized Crossover Comparison between Team-Based Learning and Lecture Format on Long-Term Learning Outcomes. Pharmacy [Internet]. MDPI AG; 2018 Aug 4;6(3):81. Available from: http://dx.doi.org/10.3390/pharmacy6030081
9. Boerwinkel DJ, Swierstra T, Waarlo AJ. Reframing and Articulating Socio-scientific Classroom Discourses on Genetic Testing from an STS Perspective. Science & Education [Internet]. Springer Science and Business Media LLC; 2012 Aug 24;23(2):485–507. Available from:

http://dx.doi.org/10.1007/s11191-012-9528-7

10. Burgess AW, McGregor DM, Mellis CM. Applying Established Guidelines to Team-Based Learning Programs in Medical Schools. Academic Medicine [Internet]. Ovid Technologies (Wolters Kluwer Health); 2014 Apr;89(4):678–88. Available from: http://dx.doi.org/10.1097/acm.0000000000000162
11. Castéra J, Clément P. Teachers' Conceptions About the Genetic Determinism of Human Behaviour: A Survey in 23 Countries. Science & Education [Internet]. Springer Science and Business Media LLC; 2012 Jul 19;23(2):417–43. Available from: http://dx.doi.org/10.1007/s11191-012-9494-0
12. Chen M, Ni C, Hu Y, Wang M, Liu L, Ji X, et al. Meta-analysis on the effectiveness of team-based learning on medical education in China. BMC Medical Education [Internet]. Springer Science and Business Media LLC; 2018 Apr 10;18(1). Available from: http://dx.doi.org/10.1186/s12909-018-1179-1
13. Clancy KBH, Nelson RG, Rutherford JN, Hinde K. Survey of Academic Field Experiences (SAFE): Trainees Report Harassment and Assault. Apicella CL, editor. PLoS ONE [Internet]. Public Library of Science (PLoS); 2014 Jul 16;9(7):e102172. Available from: http://dx.doi.org/10.1371/journal.pone.0102172
14. Clary, R., & Wandersee, J. (2013). Banking on the Future. Seed bank investigations and biocomplexity. *The Science Teacher*, 80(3): 66-71.
15. Clément P. Creationism, Science and Religion: A Survey of Teachers' Conceptions in 30 Countries. Procedia - Social and Behavioral Sciences [Internet]. Elsevier BV; 2015 Jan;167:279–87. Available from: http://dx.doi.org/10.1016/j.sbspro.2014.12.675
16. Clément P, Caravita S. Education for Sustainable Development: An International Survey on Teachers' Conceptions. Contributions from Science Education Research [Internet]. Springer Netherlands; 2013 Sep 28;175–91. Available from: http://dx.doi.org/10.1007/978-94-007-7281-6_11
17. Corwin LA, Graham MJ, Dolan EL. Modeling Course-Based Undergraduate Research Experiences: An Agenda for Future Research and Evaluation. Ledbetter ML, editor. CBE—Life Sciences Education [Internet]. American Society for Cell Biology (ASCB); 2015 Mar 2;14(1):es1. Available from: http://dx.doi.org/10.1187/cbe.14-10-0167
18. Dieser O, Bogner FX. Young people's cognitive achievement as fostered by hands-on-centred environmental education. Environmental Education Research [Internet]. Informa UK Limited; 2015 Dec 28;22(7):943–57. Available from: http://dx.doi.org/10.1080/13504622.2015.1054265
19. Farland MZ, Franks AS, Barlow PB, Shaun Rowe A, Chisholm-Burns M. Assessment of student learning patterns, performance, and long-term knowledge retention following use of didactic lecture compared to team-based learning. Currents in Pharmacy Teaching and Learning [Internet]. Elsevier BV; 2015 May;7(3):317–23. Available from: http://dx.doi.org/10.1016/j.cptl.2014.12.009
20. Fleischner TL, Espinoza RE, Gerrish GA, Greene HW, Kimmerer RW, Lacey EA, et al. Teaching Biology in the Field: Importance, Challenges, and Solutions. BioScience [Internet]. Oxford University Press (OUP); 2017 May 5;67(6):558–67. Available from: http://dx.doi.org/10.1093/biosci/bix036
21. Frame TR, Cailor SM, Gryka RJ, Chen AM, Kiersma ME, Sheppard L. Student Perceptions of Team-based Learning vs Traditional Lecture-based Learning. American Journal of Pharmaceutical Education [Internet]. American Journal of Pharmaceutical Education; 2015 May;79(4):51. Available from: http://dx.doi.org/10.5688/ajpe79451
22. Gericke, N., & Ottander, C. (2016). *On the issue of "research in the didactics of biology": definitions and demarcations.* In: Tal, T. & Yarden, A. (Eds.). The Future of Biology Education Research. Proceedings of the 10th Conference of European Researchers in Didactics of Biology, Pp. 155–162. Technion, Haifa, Israel.
23. Ghorbani N, Karbalay-Doust S, Noorafshan A. Is a Team-based Learning Approach to Anatomy Teaching Superior to Didactic Lecturing ? = هل نهج طريقة التعلم القائم على الفريق لعلم التشريح أفضل من إلقاء المحاضرات التعليمية ؟. Sultan Qaboos University Medical Journal [Internet]. Sultan Qaboos University Medical Journal; 2014 Feb;14(1):120–5. Available from: http://dx.doi.org/10.12816/0003345
24. Grünkorn, J., zu Belzen, A. U., & Krüger, D. (2014). Assessing students' understandings of biological models and their use in science to evaluate a theoretical framework. *International Journal of Science Education*, 36(10): 1651-1684.
25. Haywood BK, Parrish JK, Dolliver J. Place-based and data-rich citizen science as a precursor for conservation action. Conservation Biology [Internet]. Wiley; 2016 Apr 25;30(3):476–86. Available from: http://dx.doi.org/10.1111/cobi.12702
26. Holmqvist, M. O., & Olander, C. (2017) Analysing teachers' operations when teaching students: what constitutes scientific theories? *International Journal of Science Education*, 39(7): 840-862.
27. Race to Displace: A Game to Model the Effects of Invasive Species on Plant Communities. The American Biology Teacher [Internet]. University of California Press; 2013 Mar;75(3):194–201. Available from: http://dx.doi.org/10.1525/abt.2013.75.3.8
28. Ibrahim, M. (2003). *Model pemecahan masalah dalam pembelajaran biologi [Model of problem solving in learning biology].* In S Herawati (Eds), Kapita selekta pembelajaran biologi [Capita selekta learning biology]. Jakarta, Pusat Penerbitan Universitas Terbuka.
29. Khanova J, Roth MT, Rodgers JE, McLaughlin JE. Student experiences across multiple flipped courses in a single curriculum. Medical Education [Internet]. Wiley; 2015

Sep 18;49(10):1038–48. Available from: http://dx.doi.org/10.1111/medu.12807

30. Kimble G. Children learning about biodiversity at an environment centre, a museum and at live animal shows. Studies in Educational Evaluation [Internet]. Elsevier BV; 2014 Jun;41:48–57. Available from: http://dx.doi.org/10.1016/j.stueduc.2013.09.005
31. Koo CL, Demps EL, Farris C, Bowman JD, Panahi L, Boyle P. Impact of Flipped Classroom Design on Student Performance and Perceptions in a Pharmacotherapy Course. American Journal of Pharmaceutical Education [Internet]. American Journal of Pharmaceutical Education; 2016 Mar;80(2):33. Available from: http://dx.doi.org/10.5688/ajpe80233
32. Kurniati, T. (2001). *Pembelajaran pendekatan keterampilan proses untuk meningkatkan keterampilan berpikir kritis siswa [Learning approach to process skills to improve students critical thinking skills].* Master Thesis, Graduate Program, Universitas Pendidikan Indoenesia, Bandung.
33. Lambert, D., & Reiss, M. J. (2014). *The Place of Fieldwork in Geography and Science Qualifications.* Institute of Education, University of London, London.
34. Lederman NG, Lederman JS. The Status of Preservice Science Teacher Education: A Global Perspective. Journal of Science Teacher Education [Internet]. Informa UK Limited; 2015 Feb 3;26(1):1–6. Available from: http://dx.doi.org/10.1007/s10972-015-9422-7
35. Lederman NG, Lederman JS. The Functions of a Teacher. Journal of Science Teacher Education [Internet]. Informa UK Limited; 2016 Nov 23;27(7):693–6. Available from: http://dx.doi.org/10.1007/s10972-016-9486-z
36. Liu S-NC, Beaujean AA. The effectiveness of team-based learning on academic outcomes: A meta-analysis. Scholarship of Teaching and Learning in Psychology [Internet]. American Psychological Association (APA); 2017;3(1):1–14. Available from: http://dx.doi.org/10.1037/stl0000075
37. Matthews MR. Introduction: The History, Purpose and Content of the Springer International Handbook of Research in History, Philosophy and Science Teaching. International Handbook of Research in History, Philosophy and Science Teaching [Internet]. Springer Netherlands; 2013 Dec 30;1–15. Available from: http://dx.doi.org/10.1007/978-94-007-7654-8_1
38. Niaz M. Review of Matthews, M.R. (2015). Science Teaching: The Contribution of History and Philosophy of Science (20th Anniversary Revised and Expanded Edition). New York: Routledge1,2. Educación Química [Internet]. Universidad Nacional Autonoma de Mexico; 2015 Apr;26(2):174–6. Available from: http://dx.doi.org/10.1016/j.eq.2015.04.012
39. Ma-Kellams C, Blascovich J. Correction: Does "Science" Make You Moral? The Effects of Priming Science on Moral Judgments and Behavior. Martinez LM, editor. PLoS ONE [Internet]. Public Library of Science (PLoS); 2013 Dec 30;8(12). Available from: http://dx.doi.org/10.1371/annotation/be99244d-5b8e-4dca-a3c0-59dbe55c22e8
40. Medina MS, Conway SE, Davis-Maxwell TS, Webb R. The Impact of Problem-Solving Feedback on Team-Based Learning Case Responses. American Journal of Pharmaceutical Education [Internet]. American Journal of Pharmaceutical Education; 2013 Nov;77(9):189. Available from: http://dx.doi.org/10.5688/ajpe779189
41. Ministery of Education and Culture (2013). *Materi Pelatihan Guru Implementasi Kurikulum 2013 SMA/MA dan SMK/MAK [Teacher training material Implementing Curriculum 2013 SMA/MA and SMK/MAK].*
42. Momsen J, Offerdahl E, Kryjevskaia M, Montplaisir L, Anderson E, Grosz N. Using Assessments to Investigate and Compare the Nature of Learning in Undergraduate Science Courses. Brewe E, editor. CBE—Life Sciences Education [Internet]. American Society for Cell Biology (ASCB); 2013 Jun;12(2):239–49. Available from: http://dx.doi.org/10.1187/cbe.12-08-0130
43. Muhson, A. (2007). *Penerapan metode problem solving dalam pembelajaran statistik lanjut [Implementation of the problem solving method in advanced statistical learning].* Retrived on 1 December 2019 from from https://www.academia.edu.
44. Ndeke GCW, Okere MIO, Keraro FN. Secondary School Biology Teachers' Perceptions of Scientific Creativity. Journal of Education and Learning [Internet]. Canadian Center of Science and Education; 2015 Dec 15;5(1):31. Available from: http://dx.doi.org/10.5539/jel.v5n1p31
45. Nur, M. (2011). Pengembangan perangkat pembelajaran IPA SD untuk memberi kemudahan guru mengajar dan siswa belajar IPA dan keterampilan berpikir [Development of IPA elementary School learning tool to give teachers easy teaching and students to learn SCIENCE and thinking skills]. *Jurnal Penelitian Pendidikan Widya Cendika*, 6(1): 7-15.
46. Nyberg E, Sanders D. Drawing attention to the "green side of life."Journal of Biological Education [Internet]. Informa UK Limited; 2013 Nov 4;48(3):142–53. Available from: http://dx.doi.org/10.1080/00219266.2013.849282
47. Pace, S., Fleischner, T. L., Weisberg, S., & Moline, A. B. (2017). *Saying Yes to Environmental Field Studies: A Guide to Proactive, Successful Administration and Operations.* Natural History Institute, Prescott.
48. Pany, P. (2014). Students' interest in useful plants: a potential key to counteract plant blindness. *Plant Science Bulletin*, 60(1): 18-27.
49. Passmore C, Gouvea JS, Giere R. Models in Science and in Learning Science: Focusing Scientific Practice on Sense-making. International Handbook of Research in History, Philosophy and Science Teaching [Internet]. Springer Netherlands; 2013 Dec 30;1171–202. Available from: http://dx.doi.org/10.1007/978-94-007-7654-8_36

50. Polya, G. (1973). *How to solve it. A New Aspect of Mathematical Method.* New Jersey: Stanford University. Princeton University Press. Princeton, New Jersey.
51. Prahatamaputra, A. (2015). Indikator Penjenjangan Moral menggunakan Tiga Teori Perkembangan Moral dalam Penyelesaian Masalah Biologi [The Moral rationale indicator uses the three theories of Moral progression in biological problem solving]. *Prosiding Seminar Nasional Pendidikan Sains 2015 Program Studi Pendidikan Sains,* PPs UNESA, Surabaya.
52. Prevost LB, Lemons PP. Step by Step: Biology Undergraduates' Problem-Solving Procedures during Multiple-Choice Assessment. Sevian H, editor. CBE—Life Sciences Education [Internet]. American Society for Cell Biology (ASCB); 2016 Dec;15(4):ar71. Available from: http://dx.doi.org/10.1187/cbe.15-12-0255
53. Pribadi, B. (2011). *Model ASSURE untuk Mendesain Pembelajaran Sukses [ASSURE Model for designing successful Learning].* Jakarta, Dian Rakyat.
54. Radeloff VC, Williams JW, Bateman BL, Burke KD, Carter SK, Childress ES, et al. The rise of novelty in ecosystems. Ecological Applications [Internet]. Wiley; 2015 Dec;25(8):2051–68. Available from: http://dx.doi.org/10.1890/14-1781.1
55. Bleske BE, Remington TL, Wells TD, Dorsch MP, Guthrie SK, Stumpf JL, et al. Team-Based Learning to Improve Learning Outcomes in a Therapeutics Course Sequence. American Journal of Pharmaceutical Education [Internet]. American Journal of Pharmaceutical Education; 2014 Feb;78(1):13. Available from: http://dx.doi.org/10.5688/ajpe78113
56. Remington TL, Hershock C, Klein KC, Niemer RK, Bleske BE. Lessons from the trenches: Implementing team-based learning across several courses. Currents in Pharmacy Teaching and Learning [Internet]. Elsevier BV; 2015 Jan;7(1):121–30. Available from: http://dx.doi.org/10.1016/j.cptl.2014.09.008
57. Rezaee, R., & Mosalanejad, L. (2015). The effects of case-based team learning on students' learning, self regulation and self direction. *Global Journal of Health Science*, 7(4): 295–306.
58. Rustaman, N. (2011). Pengembangan Model Pembelajaran MIPA [Development of MIPA Learning Model]. *Seminar Nasional Pengembangan Pembelajaran MIPA, FPMIPA Universitas Pendidikan Indonesia*, Bandung.
59. G S. Learner � Oriented Virtual Learning: A Booster To Primary School Learners. i-manager's Journal on School Educational Technology [Internet]. i-manager Publications; 2013 Aug 15;9(1):31–6. Available from: http://dx.doi.org/10.26634/jsch.9.1.2400
60. Subramaniam K. Student teachers' conceptions of teaching biology. Journal of Biological Education [Internet]. Informa UK Limited; 2013 Oct 22;48(2):91–7. Available from: http://dx.doi.org/10.1080/00219266.2013.837405
61. Svenning J-C, Pedersen PBM, Donlan CJ, Ejrnæs R, Faurby S, Galetti M, et al. Science for a wilder Anthropocene: Synthesis and future directions for trophic rewilding research. Proceedings of the National Academy of Sciences [Internet]. Proceedings of the National Academy of Sciences; 2015 Oct 26;113(4):898–906. Available from: http://dx.doi.org/10.1073/pnas.1502556112
62. Tal T, Lavie Alon N, Morag O. Exemplary practices in field trips to natural environments. Journal of Research in Science Teaching [Internet]. Wiley; 2014 Jan 16;51(4):430–61. Available from: http://dx.doi.org/10.1002/tea.21137
63. Taylor HR, Gemmell NJ. Emerging Technologies to Conserve Biodiversity: Further Opportunities via Genomics. Response to Pimm et al. Trends in Ecology & Evolution [Internet]. Elsevier BV; 2016 Mar;31(3):171–2. Available from: http://dx.doi.org/10.1016/j.tree.2016.01.002
64. What Lives Where & Why? Understanding Biodiversity through Geospatial Exploration. The American Biology Teacher [Internet]. University of California Press; 2013 Sep;75(7):462–7. Available from: http://dx.doi.org/10.1525/abt.2013.75.7.4
65. Van MIL MHW, POSTMA PA, BOERWINKEL DJ, KLAASSEN K, WAARLO AJ. Molecular Mechanistic Reasoning: Toward Bridging the Gap Between the Molecular and Cellular Levels in Life Science Education. Science Education [Internet]. Wiley; 2016 Mar 29;100(3):517–85. Available from: http://dx.doi.org/10.1002/sce.21215
66. Wakabayashi, N. (2015). Flipped classroom as a strategy to enhance active learning. Kokubyo Gakkai Zasshi. *The Journal of the Stomatological Society*, 81(3)-82(1): 1-7.
67. Wiener H, Plass H, Marz R. Team-based Learning in Intensive Course Format for First-year Medical Students. Croatian Medical Journal [Internet]. Croatian Medical Journal; 2009 Feb;50(1):69–76. Available from: http://dx.doi.org/10.3325/cmj.2009.50.69
68. Zogza, V. (2016). *"Biology didactics": a distinct domain of educational research.* In: Tal, T. & Yarden, A. (Eds.). The Future of Biology Education Research. Proceedings of the 10th Conference of European Researchers in Didactics of Biology, Pp. 181–187. Technion, Haifa, Israel.