

## Analysis of Student Problem Solving Skills in Harmonic Motion Materials

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### Abstract

The purpose of this research is to analyze the problem solving ability of harmonic motion material. Problem solving skills are one of the important components of learning. Therefore, it is necessary to analyze the extent of student problem solving skills. The method used in this study is a descriptive analysis method with data collection techniques using the instrument of the description problem along with aspects of problem solving capability assessment. The subjects of this study were 24 physics education students who had obtained harmonic motion material. The results showed that students had difficulty in harmonic motion material. In the first phase of useful description, the average problem-solving ability of students was only 41.21%. The second stage of physics approach, the average student ability of 32.24%. The third phase of the specific application of physics, the average student's ability is only 14.21%. The fourth stage of mathematical procedure, student ability by 10.11%, the fifth stage of logical progression averages student ability by 2.23%. Therefore, it can be said that problem solving skills are still relatively low, so learning is needed that can improve students' problem solving skills. Based on the results of the analysis, it can be concluded that the most common mistakes made by students in solving physics problems are errors in the process of conveying results and assessing solutions. Mistakes that are rarely made by students are mistakes in understanding problems by using correct representations.

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## INTRODUCTION

Physics learns about applications in everyday life and events that exist in nature. The purpose of physics learning is to equip students in terms of knowledge, understanding and high-level thinking skills. In the face of real life, a high level of thinking skills are required which include creative thinking, critical thinking, and problem solving skills (Tseng *et al.*, 2013).

Metacognition skills, problem solving processes, critical and creative thinking, core thinking skills and the intert association between knowledge and thinking is one of the thinking abilities that can be trained to students (Marzano *et al.*, 1988). One of the thinking skills is problem solving ability as a cognitive process that includes systematic completion steps to get answers (Santrock, 2011). Therefore, in problem solving skills students must be able to connect their knowledge to find a solution to existing problems. In addition, problem solving skills need to be used during the lecture process, in the hope that students can solve problems faced in daily life (Misbah, 2016).

Problem solving skills as individual thought processes in solving problems through the initial stages of gathering facts, analyzing information, putting together alternative solutions, up to choosing the most effective solution. Practice Problem solving skills need to be habituated because in this ability it is necessary to understand concepts and principles in a context of problems to be solved (Larkin & Reif, 2007). The things that make students able to solve a problem are the type of problems, great ideas, well-integrated knowledge and structured problem solving procedures (Reif, 1982). Steps of problem solving ability in physics learning that is interpreting the situation or problem both symbolically and visually (useful description); choosing the right principles and concepts of physics against the given problem (physics approach); choosing the approach of physics taken on the specific conditions of the given problem (specific application of physics); follow the proper mathematical procedures and rules (mathematical procedure); leads to the development of logical solutions, focus on goals, coherent, and consistent (logical progression) (Dockett, *et al.*, 2015). In problem solving requires interactive, interdependent and temporal collaboration. The problem-solving process also varies depending on how students solve problems. Collaborative problem solving is needed to solve complex problems (Swiecki *et al.*, 2019).

One of the most important components of solving a problem is knowing and understanding the fundamental principles of physics. The basic principles of physics can lead students to analyze problems, if students don't understand the basic

principles then they will tend to make mistakes when solving problems. Therefore, to be able to improve problem-solving skills, students are advised to read and summarize the topics to be studied first (Malik *et al.*, 2019). In addition, teachers have an important role in teaching problem-based learning. If this problem-based learning is successful then students will have good problem-solving skills (Suparman, 2020). Problem solving is very important, because problem solving is a key thing in improving students' high-level thinking skills, in order to explore the knowledge and skills they already have to solve problems that students rarely encounter. In fact, problem solving is a goal so that students more easily apply with other science links to develop in the modern world (Chotimah, 2018). Therefore, students need to get used to being able to think high levels in order to be able to solve various problems provided by teachers and problems in real life (Heong, 2012). Problem solving is a learning approach that engages optimally active students that allows students to conduct exploration, observation, experimentation, and investigation. This aims to facilitate students' understanding of the subject matter obtained also as a supporting medium, way or technique to make students more active and independent.

Many studies have been conducted to measure students' problem solving skills. The results showed that the concept of student physics in terms of problem solving skills of students is still low, more importantly due to lack of exercise and lack of habituation of problem solving problems make students difficult in solving physics problems (Purnamasari *et al.*, 2017). Research has been conducted showing that the high level of thinking ability of students who are in the category is enough only by 23.80%, the rest of the students are in the lesser category. If high-level thinking skills are in the low category, this indicates that students' problem solving skills are also in the low category (Lestari, 2019). Previous research on math subjects using the IDEAL model problem solving, showed that indicators that identified problems were categorized as very bad (8%), problem definition indicators were categorized as very bad (8%), indicators exploring solutions were categorized as bad (49%), indicators acting on strategies were categorized as sufficient (67%) and backwards and learning indicators were categorized as very bad (31%). Most students are unable to identify the problem and define it as the resulting objectives leading to the results of interpretation (Permata *et al.*, 2018).

The results of research that has been done before, that the results of students' problem-solving skills are still relatively low if applied in ordinary learning. Then students are given another treatment, namely by laboratory-based problem solving. The results showed that students' problem-solving skills improved at a moderate level. The role

of the teacher is certainly needed to guide and direct students during the practicum (Malik *et al.*, 2019). Other research that has been done in physics subjects, students are given problems related to problem solving as many as 5 questions, the suspension results obtained are relatively low because only 12% of students who have good problem-solving skills, 31% of students who have problem-solving skills are classified as average and 57% of students who have relatively low problem-solving skills. Thep-frills applied in schools still use conventional learning so that it affects students' problem-solving abilities (Wahyuni, 2020). The low ability of students in problem solving is because the learning process is still teacher-centered. This causes students to be less involved in the learning process so that students get material passively and less ability to solve problems (Wanya *et al.*, 2016). Based on the results of previously conducted research that the physics problem-solving skills of students who use problem-based learning models are better than conventional learning (Sihaloho *et al.*, 2017). Based on the importance of students' thinking skills, especially problem-solving skills, it is still necessary to conduct research on physical materials, especially harmonic motion materials. This material was chosen because students still have a lot of difficulties. The aim of the study is to analyze the extent of the problem-solving abilities of Physics education students in harmonic motion materials.

## METHOD

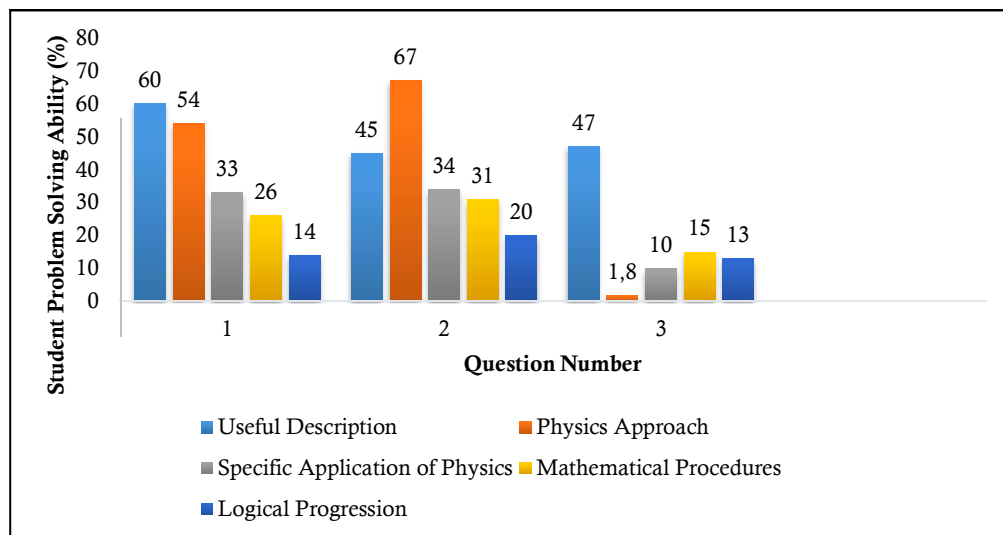
This study uses descriptive analysis methods. The research procedure is (1) Preliminary activities where in this research in the form of determining research places, making research letters, and coordinating with physics education lecturers at the

research site. (2) Instrument Manufacturing, where the researcher prepares the instrument to be used. (3) Data collection, where the researcher gives tests and conducts interviews. (4) Data analysis, this stage is done analysis of the tests conducted by students. (5) The selection of respondents, at this stage, interview respondents are selected based on the results of analysis of the answers to the test questions that have been done (6) Withdrawal of conclusions is carried out based on the results of data analysis that has been done. The subject of this study was 24 physics education students in Walisongo State Islamic University who had obtained harmonic motion material. The research was conducted by giving tests to students. The tests are specially designed to be able to find out information about students' problem solving skills. Test in the form of a description with a total of 3 points of question. In this test the assessment instrument uses a rubric of problem solving skills adapted from research (Doctor & Heller, 2009).

In each problem item there are several problem solving indicators measured. Scoring technique with a score of 4: Useful, precise, and complete description; Score 3: Description is useful but contains minor errors; Score 2: Some descriptions are missing, useless, or there are errors; Score 1: The entire description is useless and contains errors. Data analysis using descriptive analysis method is analyzing the value obtained at each stage of problem solving capability.

## RESULTS AND DISCUSSION

The percentage of physics education students who complete the problem solving process on each problem number if adjusted to the troubleshooting stage can be seen in Figure 1.



**Figure 1.** Percentage of Each Problem Number According to The Stages of Solving Physics Problems

Figure 1 percentage in the first indicator useful description explains that in question number 1 the highest shows that 60% of students (as many as 14 students out of 24 students) can describe the problem in the form of images and symbols of physics. In question number 2 the highest percentage in the phase 2 problem solving indicator Physics Approach shows 67% of students (as many as 16 students out of 24 students) who can determine the right formula and concept in solving problems. In question number 3 the highest percentage in the first stage of problem solving indicators is useful description shows 47% of students (as many as 11 students out of 24 students) able to write information correctly. The above results show that in the final stages of problem solving indicators have not reached 50%, this indicates that most students do not recheck the final result that has been obtained. In addition, in question number 3 students still have difficulty in solving problems because some students do not know what physics concepts are used to work on the problem.

Based on the results of the analysis from Figure 1, it can be known that the ability to solve students on the concept of mechanics, especially in harmonic motion materials is still in the low category. Students acknowledge that the lack of problem-based practice and lacks in understanding the concepts that have been taught before. The recognition is in line with previous research that mentions that problem solving skills are also influenced by other factors such as motivation, interest in learning, high curiosity, understanding of concepts and problem-solving skills of physics (Kudsiyah *et al.*, 2017). This research is equipped with a grouping of each problem solving indicator grouped into five stages, namely (Useful Description, Physics, Specific Application of Physics, Mathematical Procedures and Logical Progression) so that it can be known to what extent the student's ability has been achieved in problem solving. Once it is known the extent of the student's ability, it will make it easier for teachers to give treatment to improve students' problem-solving abilities. Not many studies that examine problem solving, especially on each indicator, most studies only review the entire problem solving process and do not detail each indicator. Even if there is a polya stage that is usually used in problem solving in the field of mathematics. The results of research in the

field of physics that uses the stages of Polya problem solving are showing that students' ability to work on problem solving problems is still at a low level, as much as 68.97% and 90.32% of students are still under the minimum completion criteria (KKM) for IPA subjects (Astuti *et al.*, 2020).

Before heading to more complex physical materials, the concept of harmonic motion is one of the basic concepts of physics, especially in the part of mechanics that needs to be studied first. Starting from junior high school level to the university level harmonic motion concept has been studied. The concept of harmonic motion begins to be given to students from the most basic material to more difficult material, such as oscillations contained in the concept of waves, muffled harmonic motion and forced harmonic motion (Pujayanto *et al.*, 2007) so that in understanding the concept of harmonic motion required understanding, carefulness, and understanding the right concept so that the understanding of wrong concepts or misconceptions does not happen. Because by mastering the concept or theory of mechanics by 85% people can apply mechanics correctly and if the mastery of the concept only 65% one can only be said "ready" to learn mechanics. Therefore, it is necessary to develop and assess the learning of harmonic motion materials (Syuhendri, 2014).

Other research that has been done before, which is not analyzed on each of the problem-solving indicators but directly on analyzing the overall average of problem-solving skills, so it is not known which part of the student's weakness in solving the problem. The results of his research are the ability to solve mathematical problems students in understanding problems, planning solutions, implementing a solution plan and re-checking all steps that have been done classified as less than 53% percentage (Bernard *et al.*, 2018). So, it is still rare to find research that examines each of the problem-solving indicators. Existing research mostly reviews thoroughly whether the ability is low, medium or high without regard to the important parts of each problem-solving indicator.

The data of the study results on the average overall number of questions in each indicator of student problem solving ability is presented in percentage form. The percentage results show how the problem solving skills of Physics education students in full can be seen in Table 1.

**Table 1.** Physics Problem Solving Skills Data Physics Education Students

<b>process</b>	<b>Student Activities</b>	<b>Score (%)</b>
<i>Useful Description</i>	Students translate problems and understand problems by using correct representations to summarize information provided in the problem, it can be images, graphics, symbols and others	50
<i>Physics Approach</i>	Students conduct the selection process with the right concepts and principles of physics that will be used to solve problems	42
<i>Specific Application of Physics</i>	Students apply and connect physics concepts and principles to specific conditions in the problem	28.63
<i>Mathematical Procedures</i>	Students conduct the process of selecting solutions by choosing procedures and following the conditions in mathematics appropriately	25.41
<i>Logical Progression</i>	Students conduct the process of delivering results and assessing solutions	18.43

Table 1 shows that students' problem solving skills for each stage and other findings related to students' problem solving skills in harmonic motion materials have different percentages. In the first stage useful description, to translate the problem with the correct representation, both symbolically and visually the average ability of students is only 50%. The second stage of physics approach, choosing the appropriate physics principles and concepts from the given problem with an average student ability of 42%. The specific application of Physics, determines the physical approach that will be used to solve the problem given with the average ability of students only 28.63%. Mathematical procedure stage of student ability by 25.41%, logical progression stage is to examine the explanation of solutions of a problem, focused, logically and structured with an average student ability of 18.43%. The problem solving capability stage with the smallest percentage is at the logical progression stage.

Useful description stage shows that students' ability is still relatively low. At this stage it was found that most students scored 2 and 1. Score 2 is adjusted to the measurement instrument that some of the descriptions listed by students are unhelpful and contain errors. For example, students are wrong in illustrating the image of a spring hung according to the given question. Score 1 is that the whole description has no meaning and there are many errors. Therefore, students have incorrect descriptions, less descriptions, and no descriptions.

Physics approach stage that students at this stage have relatively low ability. The concept chosen by students at this stage there are several appropriate sections and there are also inappropriate. This stage there are several concepts that suit and some are not suitable all. An example of a student error is wrong in lowering the speed formula of the deviation equation. The reason students get low scores is that students are not

taught the problem solving process, students only get mathematical equations, students only know the equation as a center to get quantitative answers and rather ignore basic concepts (Dockett et al., 2015). Conceptual knowledge of students is very important, because in problem solving a mature concept is required (Yu & Fan, 2014)

The specific stage of application of Physics, the highest score of students scored 3 i.e. some of the answers were missing or containing errors. The low score of students is due to students' difficulty in connecting the concepts learned with the concepts that have been understood before, so students can not work on the problem. In addition, at this stage, students not only need the capital of the concept being studied but the previous concept is also needed. An example of a student's mistake is that students forget the relationship between Newton's law II if it is connected to the concept of spring. So at this stage, students must understand the concept of harmonic motion material and material that has been studied before.

The mathematical procedure stage averages students scoring below 2. This is because students are hampered by basic concepts that are understood, resulting in mathematical equations not being worked on. An example that occurs in students who are the subject of research is an error in calculating the magnitude of acceleration related to formulation  $a = -\omega^2 A \cos(\omega t + \delta)$ , here students have difficulty in determining the value on the same equation in parentheses. Students claim that they forget the trigonometric rules that have been learned in math materials. Based on the results of the student's recognition, the understanding of concepts to be able to solve problem solving is important and must be understood, so as to facilitate the process of decreasing mathematical equations.

Logical progression stage, most students have a score of zero. Because students are not used to re-examining all the solutions that have been worked

out and regardless of whether the answer is clear, focused, and logically organized. The process of examining answers to avoid mistakes can be seen from the planning further assessed and re-examined so that it can be written in the conclusion of the answer. An example of a student's mistake is not checking the final result that has been resolved, causing errors in the final conclusion and most students do not solve the problem according to the stage of problem solving. Therefore, it is important to be reminded again to double-check the final answer that has been obtained.

Based on the results of the study, the process of problem solving skills can be practiced by familiarizing students to solve a problem with proper procedures and proper steps (Misbah, 2016). Efforts to produce students who are smart in solving physics problems are required a problem-based learning process. Problem solving skills can have a significant effect if they learn using problem-based strategies. The learning process through this problem-based strategy will affect the student's activity in using his knowledge to solve problems will also increase (Selçuk, Çalışkan, & Erol, 2008). Learning with this strategy will make students have a higher curiosity, students often ask questions related to things that are not understood when compared to students in the class who do not use problem-based learning strategies. In addition, the direct teaching model oriented to problem solving skills can train students' problem solving skills in terms of procedural skills and academic knowledge gradually (Habibi *et al.*, 2017). The results of other studies also mention that the improvement of critical thinking skills in solving problems and behaviors of student character can be done through problem-based (Afrizon *et al.*, 2012). One of the problem-based learning models that can help students in the problem solving process is the Physics Problem Solving (PSF) model, based on previous research that PSF can significantly affect students' cognitive abilities, especially those related to problem solving (Lestari *et al.*, 2019).

## CONCLUSION

Student problem solving skills are still relatively low. Problem solving capability is measured from several stages, namely Useful description by 50%, Physics approach by 42%, Specific application of Physics stage of students' ability by 28.63%, mathematical procedure stage by 25.41%, Logical progression stage by 18.43%. Many students score below 2 at each stage, for logical progression stage most students do not get a score. Factors that cause low problem solving skills of students are not trained in solving a problem, have not mastered the concept of harmonic motion, difficulty in associating between the concept of harmonic motion with the previous concept,

students only understand mathematical equations. So with these findings, it is necessary to provide a learning model that can develop concept understanding and can affect the improvement of student problem solving skills.

## REFERENCES

- Afrizon, R., Retnowulan., & Fauzi, A. 2012. "Peningkatan Perilaku Berkarakter dan Keterampilan Berpikir Kritis Siswa Kelas IX MTSN Model Padang Pada Mata Pelajaran IPA-Fisika Menggunakan Model Problem Based Instruction." *Jurnal Penelitian Pembelajaran Fisika* 1: 1–16.
- Astuti, N. H., Rusilowati, A., Subali, B., & Marwoto, P. 2020. Analisis Kemampuan Pemecahan Masalah Model Polya Materi Getaran, Gelombang, dan Bunyi Siswa SMP. *Unnes Physics Education Journal*. 9(1): 1-8.
- Bernard, M., Nurmala, N., Mariam, S., & Rustiyani, N. 2018. Analisis Kemampuan Pemecahan Masalah Matematis Siswa SMP Kelas IX Pada Materi Bangun Datar. *SJME (Supremum Journal of Mathematics Education)*. 2 (2): 77-83.
- Chotimah, S., Bernard, M., dan Wulandari, S. M. (2018). Contextual approach using VBA learning media to improve students' mathematical displacement and disposition ability. In *Journal of Physics: Conference Series*, 948(1), 012025.
- Docktor, J. L., Strand, N. E., Mestre J. P., & Ross, B. H. 2015. "Conceptual Problem Solving in High School Physics." *Physical Review Special Topics-Physics Education Research* 11.
- Docktor J. L., Strand, N. E., Mestre J. P., & Ross, B. H. 2015. Conceptual Problem Solving in High School Physics. *American Physical Society*.
- Doctor, J. & Heller, K. 2009. "Robust Assessment Instrument for Student Problem Solving." In *Proceedings of the NARST 2009 Annual Meeting*.
- Habibi, M., Zainuddin, & Misbah. 2017. "Pengembangan Perangkat Pembelajaran IPA Fisika Berorientasi Kemampuan Pemecahan Masalah Menggunakan Model Pengajaran Langsung pada Pokok Bahasan Tekanan di SMP Negeri 11 Banjarmasin." *Berkala Ilmiah Pendidikan Fisika* 5(1): 1–17.
- Heonga, Y. M., Yunosa, J. Md., Othmanb, W., Hassana, R., Kionga, T. T., & Mohaffyza, M. M. 2012. The Needs Analysis of Learning Higher Order Thinking Skills for Generating Ideas. *Procedia - Social and Behavioral Sciences* 59 ( 2012 ) 197 – 203.

- Purnamasari, I., Yuliati, L., & Diantoro, M. 2017. "Analisis Kemampuan Pemecahan Masalah Fisika Pada Materi Fluida Statis." : 191-95.
- Kudsiyah, Mila, S., Novarina., Eka., Lukman., & Suryani, H. 2017. "Faktor-Faktor Yang Mempengaruhi Kemampuan Pemecahan Masalah Matematika Kelas X Di SMA Negeri 2 Kota Sukabumi." In Seminar Nasional Pendidikan,
- Larkin, J. H., & Reif, F. 2007. "Education Understanding and Teaching Problem - Solving in Physics Understanding and Teaching Problem- Solving in Physics." *European Journal of Science and Theology* 1(2): 191-203.
- Lestari, P. E., Purwanto, A., & Sakti, I. 2019. "Pengaruh Pembelajaran dengan Model Problem Solving Fisika Terhadap Hasil Belajar Kognitif dan Kemampuan Berpikir Kritis Siswa." *Jurnal Kumparan Fisika* 2(2): 121-28.
- Lestrari, Widy. 2019. "Pengembangan Instrumen Multiple Choice Reasoning Terbuka Berbasis HOTS dengan Pendekatan Literasi Sains untuk Mengukur Kemampuan Berpikir Tingkat Tinggi Siswa Kelas X SMAN Karangpandan pada Materi Gerak Harmonik." Universitas Negeri Walisongo Semarang.
- Malik, A., Yuningtias, U. A., Mulhayatiah, D., Chusni, M. M., Sutarno, S., Ismail, A., & Hermita, N. 2019. Enhancing Problem-Solving Skills of Students Through Problem Solving Laboratory Model Related to Dynamic Fluid. *International Conference on Mathematics and Science Education. IOP Conf. Series: Journal of Physics: Conf. Series* 1157 (2019) 032010.
- Marzano, R. J., Ronald S. B., Carolyn, S. H., Benu F. J., Barbara Z. P., Stuart C. R. & Charles S. 1988. *Dimension of Thinking: A Framework for Curriculum and Instruction.* USA: ASCD.
- Misbah. 2016. "Identifikasi Kemampuan Pemecahan Masalah Mahasiswa pada Materi Dinamika Partikel." *Jurnal Inovasi dan Pembelajaran Fisika* 3(2): 1-5.
- Permata, L. D., Kusmayadi, T. A., & Fitriana, L. 2018. Mathematical Problem Solving Skills Analysis About Word Problems of Linear Program Using IDEAL Problem Solver. *IOP Conf. Series: Journal of Physics: Conf. Series* 1108: 1-6.
- Pujayanto. 2007. "Identifikasi Miskonsepsi IPA (Fisika) pada Siswa SD." *Paedagogia* 10(1): 1-12.
- Reif, F. & Heller I. J. 1982. *Knowledge Structure and Problem Solving in Physics.*, Educational Psychologist.
- Santrock, J. W. 2011. "Educational Psychology." Library of Congress Cataloging-in-Publication Data.
- Selçuk, G. S., Caliskan, S., & Erol, M. 2008. "The Effects of Problem Solving Instruction on Physics Achievement, Problem Solving Performance and Strategy Use." *Journal Physics Education*, 2, 151-166.
- Sihaloho, S., & M, G. E. (2017). The Effect of Problem Based Learning (PBL) Model toward Student's Creative Thinking and Problem Solving Ability in Senior High School. *IOSR Journal of Research & Method in Education*, 7(4), 11-18.
- Suparman, Juandi, D., & Tamur. 2021. Review of Problem-Based Learning Trends in 2010-2020: A Meta-Analysis Study of the Effect of Problem-Based Learning in Enhancing Mathematical Problem-Solving Skills of Indonesian Students. *Journal of Physics: Conference Series* 1722 012103: 1-9.
- Swieckia, Z., Ruisa, A.R., Farrella, C., & Shaffer, D. W. 2019. Assessing individual contributions to Collaborative Problem Solving: A network analysis approach. *Computers in Human Behavior*: 1-15.
- Syuhendri. 2014. "Konsepsi Alternatif Mahasiswa pada Ranah Mekanika: Analisis untuk Konsep Impetus dan Kecepatan Benda Jatuh." *Jurnal Inovasi dan Pembelajaran Fisika* 1 (1).
- Tseng, K. H., Chang, C. C., Lou, S. J., & Chen, W. P. 2013. "Attitudes towards Science, Technology, Engineering and Mathematics (STEM) in a Project-Based Learning (PjBL) Environment." *International Journal of Technology and Design Education* 23(1): 87-102.
- Wahyuni, I., Tanjung, C. M. 2020. Pengaruh Model Problem Based Learning Menggunakan PhET terhadap Kemampuan Pemecahan Masalah Siswa. *Jurnal Ikatan Alumni Fisika Universitas Negeri Medan Vol. 6 No. 1*: 11-15.
- Wanya C.S. (2016). Performance and Determinants of Problem Solving Among College Physics Students. *15 International Journal of Advanced Research in Management and Social Sciences*, 5 (6).
- Yu, K. C., Fan, S. C., & Lin, A. K. 2014. "Enhancing Students' Problem-Solving Skills Through Context-Based Learning." *International Journal of Science and Mathematics Education*