JPII 6 (1) (2017) 55-62

Jurnal Pendidikan IPA Indonesia

http://journal.unnes.ac.id/index.php/jpii

PROBLEM SOLVING APPROACH IN ELECTRICAL ENERGY AND POWER ON STUDENTS AS PHYSICS TEACHER CANDIDATES

C. Riantoni[1]*, L. Yuliati[2], N. Mufti[2], Nehru[3]

[1]Postgraduate of Physics Education, Universitas Negeri Malang, Indonesia
[2]Department of Physics, Universitas Negeri Malang, Indonesia
[3]Physics Education, Universitas Jambi, Indonesia

DOI: 10.15294/jpii.v6i1.8293

Accepted: December 23th 2016. Approved: February 21th 2017. Published: 30th April 2017

ABSTRACT

In agreement with students' conceptual understanding, identifying of problem solving is an important part of physics. This article is to identify the approach used by students in solving a physics problem. The subject of the research were students of physics education year 2014 in Jambi University who had joined basic physics class. The instruments used in this research were DIRECT (determining and interpreting resistive electric circuit concept test) (Engelhardt & Beichner, 2004). Based on the result, 34,1% students still used the memory based approach in problem solving, 52,3% of them used no clear approach, 4,5% used structured manner, 6,82% used unstructured manner and only 2,27% students used a scientific approach to solving the problem. The result showed that many students used no clear approach and memory based approach to solve the problem. It mean that they did not use physics concept in solving the problem and generally they only used the equation they memorized related to the problem they ever did before.

Keywords: problem solving approach; power and electrical energy; DIRECT

INTRODUCTION

Students' problem solving ability in physics has become the focus in some recent researches in the last decades. Although problem solving is one of the categories of thinking ability that used by teachers to teach their students to think (Rufaida & Sujiono, 2013), the practice of problem solving is the main factor in science education and technology (Ceberio, et al., 2016; Ibrahim & Rebello, 2012), especially in physics education (Adam & Wieman, 2005; Docktor & Mestre, 2014; Docktor et al., 2010). A good problem solving framework was needed to buil physics knowledge or introduce science culture (Docktor et al., 2016). Students attitude towards learning and problem solving in science and their conception towards the purpose of learning science could give a significant effect on what they are learning (Mason & Singh, 2016). Problem solving is very important part In scientific reasoning because the skills in problem solving gives effect to change and improve emotional, cognitive and psychomotor improvement (Alshamali & Daher, 2016).

Modern cognitive science defines problem solving as a process to reach the goal when the way to it is unclear (Ryan et al., 2016; Docktor et al., 2016; Docktor & Heller, 2009). In physics education problem solving is usually used to understand physics and exact strategy to prove students' achievement (Docktor et al., 2016; Ceberio et al., 2016; Adams & Wieman, 2015; Ibrahim & Rebello, 2012). Besides, a good problem solving skills could help students transfer their knowledge and understand the pysical situation (Walsh et al., 2007) because one of physics purposes is to

***Alamat korespondensi:**
E-mail: cicynriantoni12@gmail.com

know the physical situation (Galili & Guihbarg, 2005).

When someone tries to solve a problem, they will make a model in their mind about how to solve that problem (Khasanah et al., 2016), because this model could improve students' ability to problem solving (Supriyanti et al., 2015). There are some ways used by students in problem solving. According to Docktor et al. (2015), there are two approaches used by students in problem solving; explicit problem solving and traditional problem solving. Students using explicit problem solving usually solve the problem by focusing on it, describing physics concept that will be applied, planning solution, finishing plan and evaluating solution, where as students using traditional problem solving will start from drawing sketch, defining a known and unknown variable, choosing equation, and correcting the answer. According to Walsh et al. (2007) students were tended to solve the problem using four ways, they are a scientific approach, plug and chug (structured manner and unstructured manner), memory based approach and no clear approach.

In general, according to Walsh et al. (2007), students solving problem using scientific approach start solving problem by evaluating physical situation by focusing on seen physics concept, whereas students using plug and chug are divided into two group, students who solve evaluate problem by determining kind of formula that they will use in problem solving as well as known structured manner approach and students who concentrate only on identifying variable needed as well as known unstructured manner approach. Besides those approaches, there are two kinds of approach in problem solving; they are memory based approach and no clear approach. Students who solved the problem with memory based approach usually analyze the problem based on the situation they found in the past and try to remember the equation they used or similar problem they ever did before. Whereas students using no clear approach will solve the problem not based on the related concept and certain method, in which they are tended to manipulate variable given randomly to give the answer.

In previous researches, many students at Senior High School and University have faced difficulties in solving a physics problem, especially when they are facing a complex problem (Sujarwanto et al., 2014). Some researches results showed that although students could solve qualitative problem by inputing quantity to the equation (Rosengrant, 2009; Walsh et al., 2007; *Redish*, 2005) or they did not find difficulty in using mathematics and formula (Ceberio et al., 2016), they did not build their skill by applying concept so they faced difficulties in solving more complex problem (Rosengrant, 2009; Walsh et al., 2007; Redish, 2005). Besides, most university students solve the problem by using traditional procedure, those students novice than expert procedure (Ryan et al., 2016; Caberio et al., 2016).

The students' lack in problem solving is due to their less attention to problem solving, in addition, they have aweak understanding of physics concept and law (Ceberia et al., 2016). In the learning process, the strategy which only focuses on how to solve a problem that needs mathematics calculation has become the cause of students' lack problem solving skill (Sujarwanto et al., 2014). Besides, many students also do not get well about the process in problem solving during learning (Brown et al., 2016).

In certain material like power and electrical energy, students have to understand the concept of power conservation which is the statement of second Kirchoff law in solving problem. According to Serway & Jewett (2004), in some books there are some mistakes which say that dissipated power in resistor which shows its energy disappears. The power does not disappear, but it changes into internal energy connected to atomic vibrations in the resistor. Misunderstanding the concept is also the main cause of students' lack ability in problem solving.

Some researchers in physics education have conducted research towards students problem solving skill by looking at how expert and novice attitude in solving a physics problem. Expert usually organizes their understanding about basic physics principle and decide to choose the relevant principle which help their to solve the problem (Docktor et al., 2016; Docktor & Mestre, 2014), whereas novice solves problem by taking their understanding, and will decide to do simple context based on the formula (Docktor et al., 2016). An expert will describe again the problem, and they often uses qualitative arguments to explain the solution before elaborating mathematically (Sujarwanto et al., 2014; Hull et al., 2013), evaluates the solution and use representation (Sujarwanto et al., 2014). Novice solve the problem by determining the formula and mostly faces difficulty (Hull et al., 2013; Walsh et al., 2007). Experts organize their understanding in a very structured mannner and enable to explain when needed. Whereas novices do not use structured manner, their understanding is based on random fact and equation which are very little (Walsh et al., 2007).

The research about problem solving skill following by expert and novice attitude has often been conducted, but there is small amount the research about approach used by students in problem solving has been conducted especially in power and electrical energy. Indeed, the approach of solving problem used by students can influence their success on solving physics problem (Balta et al., 2016) and affect significantly to what they have learned (Singh & Mason, 2009; Mason & Singh, 2010). In this article, we would discuss the approach used by students in solving problem limited to power and electrical energy material, which is based on 5 problem solving levels, those are scientific approach, plug and chug (structurred manner & unstructured manner) memory based approach, no clear approach.

METHODS

Subjects in this research were students S_1 of physics education at Jambi University who had joined basic physics class. One of the topics discussed in the class was power and electrical energy concepts. Based on the curriculum used in Natural Science Department, study programme of physics education at Jambi University, power and electrical energy is discussed in basic physics class which is part of electrical dynamic material.

The respondents were 44 students who were divided into 3 class during the learning process. They were taught by two lecturers. During the learning process, the lecturers used some media such as PhET interactive simulations, moving animation, video and other strategies relevant with their own ways of teaching. The analysis approach used by students were based on the explanation of their answers adapted with indicators of problem solving approach level showed in Table 1. Each students' answers were grouped and adapted to the kind of problem solving approach they used. The data in this research were collected through the test. The instrument used were multiple choices with open ended questions referring to DIRECT (Determining and Interpreting Resistive Electric Circuit Concept Test) (Engelhardt & Beichner, 2004). DIRECT were developed to evaluate the conceptual understanding of Senior Hight School and first year university students about electricity (Engelhardt & Beichner, 2004). DIRECT consist of 29 multiple choices question, but in this research, the researcher only

Table 1. Indicators of Assessment Level in Problem Solving Approach

Level of problem solving approach	Indicators
Scientific approach	• Analyzing physical situation qualitatively and referring to involved physics concept. • Planning and finding solution in a systematic manner based on the analysis • Focusing on concept in the process of problem solving • Evaluating solution
Plug and chug	
Structured manner	• Analyzing qualitative situation based on the formula • Planning solution based on the variables and systematic procedure • Referring to the concept of problem solving • Evaluating solution
Unstructured manner	• Analyzing situation based on seen variable • Starting by choosing formula based on variables in trial and error system • Referring to the concept as variable • Not evaluating solution
Memory based approach	• Analyzing problem based on the situation they have experienced before • The procedure is started by matching variable given with the example they have already faced • Referring concept as variable • Not evaluating solution
No clear approach	• Analyzing situation based on the given variable • The procedure is started by using variable in random ways • Applying variable as a term • Not evaluating solution

(Walsh et al., 2007)

focused on some questions adapted with a research focus. Besides, in answering multiple choice, the students were asked to give their explanation, reasons of their answers based on the physics concept that they knew. It was to know what kind of approach they used in problem solving.

RESULTS AND DISCUSSION

There are two forms in applying power and electrical energy tested to reveal the kind of approaches used by students. The first form was given in the context of two electrical series where one of them was arranged with a battery and a resistor while the other was arranged with a battery and two resistors in series. The second form was given in the context of three electrical series arranged with an energy source, which is a battery, in different ways. To solve these problems well, students needed to have the understanding of the following concepts: (1) Ohm law; (2) concept of current in series and parallel; (3) applying Kirchoff law about current and voltage; and (4) conservation law of charge and energy.

The percentage of students answering corectly in each concept of power and electrical energy, based on figure 1, from 44 students, 65% of them answered correctly whereas for electrical power only 24% students could answer correctly.

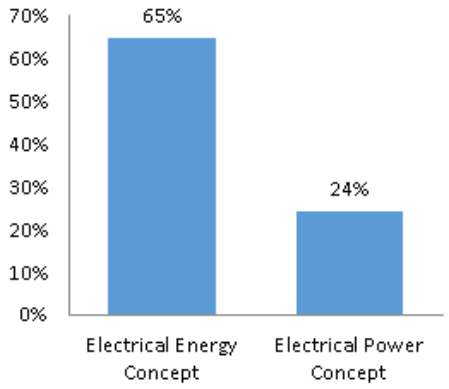

Figure 1. The Percentage of Students Answering Correctly In Power And Electrical Energy Concept

But, being seen from the approach used by students in explaining their answers, based on table 2, it showed that they were tended to use no clear approach mostly, there were 23 from 44 students or about 52,3%, the second order after it was memory based approach, it was 15 students or about 34,1%, and it was only one student or 2,27% who could apply scientific approach in solving problem concept of power and electrical energy. The rests, 11,32% students used to plug and chug approach in solving the problem which consisted of structured and unstructured manners.

Table 2. Category of Problem Solving Approach (N = 44)

The level of problem solving approaches	The percentage of approaches used by students (%)
Scientific approach	2,27
Plug and Chug	
• Structured manner	4,5
• Unstructured manner	6,82
Memory based approach	34,1
No Clear Approach	52,3

If the result was adjusted with the assessment indicators of problem solving approach in table 1, it showed that very few students who applied the scientific approach to problem solving. It cause by the students tended to focus on variable and mathematical equation they knew and had experienced before while solving the problem without involving the physical situation and concept. This finding was in agreement with Docktor et al., (2010) & Jonassen et al. (2006) that showed students often solved the problem based on the numeric statement and finished it by determining the equation they knew and adopted it to the numeric statement. However, to succeed in problem solving students should know the problem, understand the relevant concept and know how the process to get the answer (Sabella & Redish, 2007; Jonassen et al., 2006) or apply the concept in a certain condition of the problem (Docktor & Mestre, 2014). Besides, learning process could be considered as a success if students could reach basic competences in problem solving like being able to think based on the relevant physics concept, able to make the representation, and able to interpret the physical description into the equation (Hull et al., 2013). It is done to the fact that problem solving is a strategy which is not only filled with knowledge but also technique and procedure (Halim et al., 2016).

This result was relevant to the research finding by Ceberio et al., (2016) & Walsh et al., (2007), that most students did not find difficulty in applying mathematic equation during problem solving, but they could not develop their skills needed to transfer knowledge and complex prob-

lem solving. In addition, students did not build their skills by applying the concept to problem solving, so they found difficulties in solve more complex problem (Rosengrant, 2009; Walsh et al., 2007; Redish, 2005).

Students understanding on was the topic which was being done taught or could they connect the material with the problem influenced the approaches used by students in problem solving (Kohl & Finkelstein, 2006). Students structure of knowledge and the problem character could also influence problem solving process (Sujarwanto et al., 2014). Besides that, the students' understanding, their experience with the topic, and how they were taught to solve the problem during learning process also could influence the kind of approach they used (Ibrahim & Rebello, 2012). Another factor was students' weakness in applying mathematics into the process of problem solving (Tuminaro & Redish, 2004).

The answer in Figure 3a above showed how one of 44 students solved the concept of electrical energy if three circuits were set into three different circuits (Figure 2). The explanation was the example of the only student who applied the concept in problem solving, which was a scientific approach. To get the answer, the student tried to describe the situation qualitatively by explaining the form of the circuit and solved the problem by referring to the concept. Besides, he also searched the solution with systematic ways. It was in agreement with Walsh et al., (2007)'s statement, that student who uses a scientific approach to solving the problem will start by analyzing physical situation qualitatively, referring to the concept and applying systematical ways based

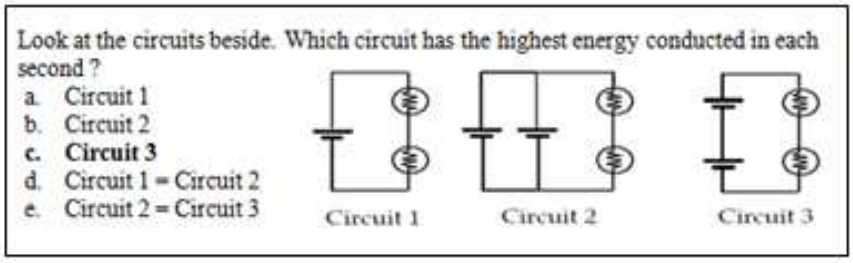

Figure 2. Question to know the level of understanding and problem solving skill about power and electrical energy

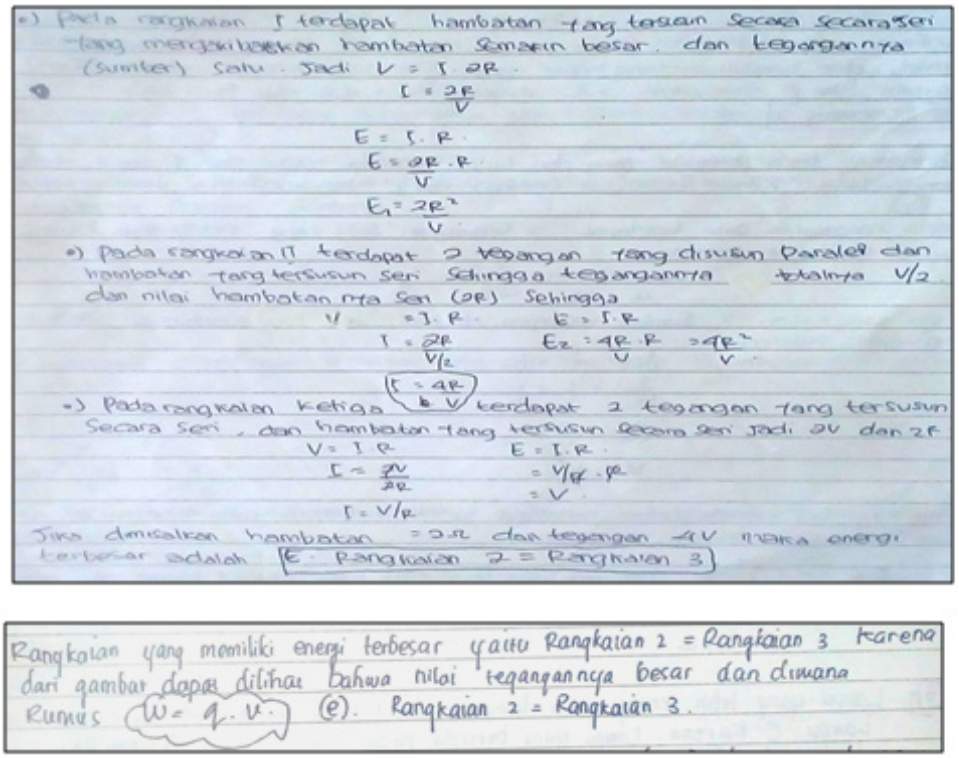

Figure 3. Examples of Students Answers (a) Applying Scientific Approach and (b) Applying No Clear Approach

on the analysis. The process of qualitative analysis like making a description, figure and graph to support the process of problem solving (Kohl & Finkeilstein, 2005). The application of qualitative analysis in problem solving process could improve students' achievement in explaining and predicting phenomena (Mualem & Eylon, 2007). In addition, a student who is expert in using conceptual reason during problem solving shows that he uses scientific approach (Hull., et al., 2013).

The answer in figure 3a showed that there were a mathematic mistake and students' formula in problem solving, especially when he counted the amount of source energy if the circuit was set in paralel and the formula of electrical energy used was not quite correct. Those mistakes did not omit the existence that the student used a scientific approach, because according to Walsh et al., (2007), a student who uses scientific approach can make mathematic and conceptual mistakes, but what is important is that he focuses on finding a solution with physics concept that they believes to be right.

Compared to 23 of 44 students or 52,3% who applied no clear approach to problem solving, which was the most approach used by students, it proved that they did not use qualitative analysis and concept in solving the problem. The example of student's answer in figure 3b, with the same problem as in figure 2, showed that the student solved the problem only based on the variable given and tried to used the equation he could possibly solve the problem. He did not analyze the situation of three circuits given in the question, so they made a mistake in determining the answer. This result was relevant to what was said by Walsh et al. (2007), that the focus of student using this approach was not on the concept but on the known variable. Applying many aproaches without concept could be effective in finding the answer, but it is weak in the conceptual understanding during the solution process (Docktor et al., 2015). Furthemore, conceptual understanding and its application are some things important to know in problem solving (Sabella & Redish, 2007). As the opposite, the ability to problem solving was also a method to understand the concept, because according to Usmeldi (2016), the cause why students less understand the concepts is their lack ability in problem solving, science process, thinking, and reasoning. Not to mention, students who use no clear approach often make a mistake in the answer and easily change the approach to problem solving (Walsh et al., 2007).

An interesting finding in this study was a student who could use a scientific approach to solving problem characterized that he followed expert attitude in problem solving. The similarities of expert person in problem solving and a person who was able to use scientific approach were: 1) every step of problem solving was always started with analyzing physical situation qualitatively and based on the concept (Hull et al., 2013; Rosengrant et al., 2009; Ogilvie, 2009; Kohl & Finkeilsten, 2008; Walsh et al., 2007), 2) the problem was solved with systematic and structured ways (Hull et al., 2013; Walsh et al., 2007), 3) always evaluate the solution (Rosengrant *et a.l*, 2009; Walsh et al., 2007). Whereas students who used memory based approach and no clear approach tend to solve the problem characterized that they were a novice. The similarities between person used memory based approach and no clear approach and novice were: 1) every step was always based on the given variable (Hull et al., 2013; Rosengrant et al., 2009; Ogilvie, 2009; Kohl & Finkeilsten, 2008; Walsh et al., 2007), 2) they found the difficulties if the were given more complex problem (Rosengrant et al., 2009; Walsh et al., 2007).

CONCLUSION

Based on the result and discussion above, it could be concluded that students tend to use no clear approach and memory based approach in solving the concept of power and electrical energy. It shows that most students do not solve the problem by analyzing the physical situation and applying physics concept to get the answer, but they only refer to the involved variable, random methods, and memorizing the same problem they have ever faced before. In addition, only a few students who could apply the scientific approach in solving the problem. It is caused by the lack of concepts belonging to students about power and electrical energy.

Based on these findings, during the learning process, it is suggested to apply a learning model which could help students to use a scientific approach. It is because that student who could apply scientific approach characterizes that he know the concept and has a good problem solving skill.

REFERENCES

Adams, W. K., & Wieman, C. E. (2015). Analyzing the many skills involved in solving complex physics problems. *American Journal of Physics*, *83*(5), 459-467.

Alshamali, M. A., & Daher, W. M. (2016). Scientific

Reasoning and Its Relationship with Problem Solving: the Case of Upper Primary Science Teachers. *International Journal of Science and Mathematics Education*, *14*(6), 1003-1019.Balta, N., Mason, A.J., & Singh, C. 2016. Surveying Turkish High School And University Students' Attitudes And Approaches To Physics Problem Solving. *Physical Review Physics Education Research*, 12 (1): 0101291-01012916.

Brown, B. R., Mason, A., & Singh, C. (2016). Improving performance in quantum mechanics with explicit incentives to correct mistakes. *Physical Review Physics Education Research*, *12*(1), 0101211-01012120.

Ceberio, M., Almudí, J. M., & Franco, Á. (2016). Design and Application of Interactive Simulations in Problem-Solving in University-Level Physics Education. *Journal of Science Education and Technology*, *25*(4), 590-609.

Docktor, J. L., Dornfeld, J., Frodermann, E., Heller, K., Hsu, L., Jackson, K. A., ... & Yang, J. (2016). Assessing student written problem solutions: A problem-solving rubric with application to introductory physics. *Physical Review Physics Education Research*, *12*(1), 0101301-01013018.

Docktor, J. L., Strand, N. E., Mestre, J. P., & Ross, B. H. (2010, October). A conceptual approach to physics problem solving. In C. Singh, M. Sabella, & S. Rebello (Eds.), *AIP Conference Proceedings* (Vol. 1289, No. 1, pp. 137-140). AIP.

Docktor, J., & Heller, K. (2009, April). Robust assessment instrument for student problem solving. In *Proceedings of the NARST 2009 Annual Meeting, Garden Grove, CA*, (pp. 1-19).

Docktor, J.L., & Mestre, J.P. 2014. Synthesis of Dicipline-Based Education Research in Physics. *Physical Review Special Topics-Physics Education Research, 10*(2), 0201191-02011958.

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*(2), 0201061-02010613.

Engelhardt, P. V., & Beichner, R. J. (2004). Students' understanding of direct current resistive electrical circuits. *American Journal of Physics*, *72*(1), 98-115.

Galili, I., & Goihbarg, E. (2005). Energy transfer in electrical circuits: A qualitative account. *American journal of physics*, *73*(2), 141-144.

Halim, A., Yusrizal, Y., Susanna, S., & Tarmizi, T. (2016). An Analysis Of Students'skill In Applying The Problem Solving Strategy To The Physics Problem Settlement In Facing AEC As Global Competition. *Jurnal Pendidikan IPA Indonesia*, *5*(1), 1-5.

Hull, M. M., Kuo, E., Gupta, A., & Elby, A. (2013). Problem-solving rubrics revisited: Attending to the blending of informal conceptual and formal mathematical reasoning. *Physical Review Special Topics-Physics Education Research*, *9*(1), 0101051-01010516.

Ibrahim, B., & Rebello, N. S. (2012). Representational task formats and problem solving strategies in kinematics and work. *Physical Review Special Topics-Physics Education Research*, *8*(1), 0101261-01012619.

Jonassen, D., Strobel, J., & Lee, C. B. (2006). Everyday problem solving in engineering: Lessons for engineering educators. *Journal of engineering education*, *95*(2), 139-151.

Khasanah, N., Wartono, W., & Yuliati, L. (2016). Analysis Of Mental Model Of Students Using Isomorphic Problems In Dynamics Of Rotational Motion Topic. *Jurnal Pendidikan IPA Indonesia*, *5*(2), 186-191.

Kohl, P. B., & Finkelstein, N. D. (2005). Student representational competence and self-assessment when solving physics problems. *Physical Review Special Topics-Physics Education Research*, *1*(1), 0101041-01010411.

Kohl, P. B., & Finkelstein, N. D. (2008). Patterns of multiple representation use by experts and novices during physics problem solving. *Physical Review Special Topics-Physics Education Research*, *4*(1), 0101111-01011113.

Mason, A. J., & Singh, C. (2016). Surveying college introductory physics students' attitudes and approaches to problem solving. *European Journal of Physics*, *37*(5), 0557041-05570423.

Mason, A., & Singh, C. (2010). Surveying graduate students' attitudes and approaches to problem solving. *Physical Review Special Topics-Physics Education Research*, *6*(2), 0201241-02012416.

Mualem, R., & Eylon, B. S. (2007). "Physics with a Smile"—Explaining Phenomena with a Qualitative Problem- Ogilvie, C. A. (2009). Changes in students' problem-solving strategies in a course that includes context-rich, multifaceted problems. *Physical Review Special Topics-Physics Education Research*, *5*(2), 0201021-02010214.

Redish, E. F. (2005). Changing student ways of knowing: What should our students learn in a physics class. *Proceedings of World View on Physics Education 2005: Focusing on Change, New Delhi*, (pp. 1-13).

Rosengrant, D., Van Heuvelen, A., & Etkina, E. (2009). Do students use and understand free-body diagrams?. *Physical Review Special Topics-Physics Education Research*, *5*(1), 0101081-01010813.

Rufaida, S., & Sujiono, E. H. (2013). Pengaruh model pembelajaran dan pengetahuan awalterhadap kemampuan memecahkan masalah fisika peserta didik kelas XI IPA MAN 2 Model Makassar. *Jurnal Pendidikan IPA Indonesia*, *2*(2), 161-168.

Ryan, Q. X., Frodermann, E., Heller, K., Hsu, L., & Mason, A. (2016). Computer problem-solving coaches for introductory physics: Design and usability studies. *Physical Review Physics Education Research*, *12*(1), 0101051-01010517.

Sabella, M. S., & Redish, E. F. (2007). Knowledge organization and activation in physics problem solving. *American Journal of Physics*, *75*(11),

1017-1029.

Serway, R.A., & Jewett, J.W. (2004). *Physics for Scientists and Engineers.* Singapura: Cangage Learning.

Singh, C., & Mason, A. (2009, November). Physics graduate students' attitudes and approaches to problem solving. In M. Sabella, C. Henderson, & C. Singh (Eds.), *AIP Conference Proceedings* (Vol. 1179, No. 1, pp. 273-276). AIP.

Sujarwanto, E., & Hidayat, A. (2014). Kemampuan pemecahan masalah fisika pada modeling instruction pada siswa SMA kelas XI. *Jurnal Pendidikan IPA Indonesia*, *3*(1), 65-78.

Supriyanti, F. M. T., & Mulyanti, S. (2015). The use of problem solving model in the material of the genetic information flow to improve the students'concept mastery. *Jurnal Pendidikan IPA Indonesia*, *4*(1), 73-78.

Tuminaro, J., & Redish, E. F. (2004, September). Understanding students' poor performance on mathematical problem solving in physics. In J. Marx, S. Franklin, & K. Cummings (Eds.), *AIP Conference Proceedings* (Vol. 720, No. 1, pp. 113-116). AIP.

Usmeldi, U. (2016). The development of research-based physics learning model with scientific approach to develop students'scientific processing skill. *Jurnal Pendidikan IPA Indonesia*, *5*(1), 134-139.

Walsh, L. N., Howard, R. G., & Bowe, B. (2007). Phenomenographic study of students' problem solving approaches in physics. *Physical Review Special Topics-Physics Education Research*, *3*(2), 0201081-020120812.