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The Profile of Student Physics Education Mental Model in Electricity and Magnetism Concepts Using Problem Solving Test

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Abstract: ***The final goal of physics education is to provide students to be able to solve the problem. The results of the study that the mental model of the respondents did not show any ability to access, analyze, and construct knowledge in problem solving. Identifying of this mental model is an alternative evaluation in determining the appropriate learning approach.***

Keywords: Student Physic Education, mental model, problem solving

1. Introduction

Today the college is no longer only preparing graduates with skills provision department, teacher education institutions are no exception. But also must prepare them for jobs outside his field of expertise. A graduate teacher education does not always become a teacher. Thus becoming the main thing for educational institutions to prepare its graduates adept at using this knowledge to solve problems. No doubt that the ultimate goal of learning physics is the problem-solving ability (Korsunsky, 2004).

The process of solving the problem requires the ability to analyze the context of the problem, and construct access the elements of the knowledge gained during the lecture and coherently representing them in the context of problem solving to produce the exact problem. Students not only good answer based on experience is seen, heard and done (Gilbert; 2005), but also more critical understanding of the causal interactions and functional relationships of entities systemic (Chan and Black, 2006).

Based on the experience of the researcher while teaching basic physics course (the concept of electricity and magnetism), many of the students are not able to resolve the problems. In fact the same concept used as examples and basic concepts has been gained since high school and the elementary physics course. The weakness is due to students not being able to analyze access, construct the elements of the knowledge gained during the lectures and represent the answer coherently. As student teachers, it is very alarming. Conceptual construction which is not true cause false conception (misconception), and will be forwarded to the student when the student later worked as an educator. Mental model is an internal representation of students in accessing the structure of knowledge (content knowledge and everyday experience owned) that are used in solving the problem. Mental model error can because they ave an errors in the problem solving (Wang, 2007; Mansyur, 2010; and Corpuz and Rebello, 2011b) and tend to one concept (the misconception) (Wang, 2007; Coll, 2007; Corpuz and Rebello, 2011a, and Yayla and Eyceyurt, 2011). While the mental model a person can't be observed directly, but based on the problem-solving process claims made problem solver.

How mental models of physics student teachers on the concept of electricity and magnetism before following class-based problem solving? Those issues will be explored through this research. Student mental models is evaluated based on the results of solving the problem by referring to categories made by Grosslight, Unger, Jay, and Smith (1991 in Jansoon. et al, 2009).

Table 1: Category of mental model levels and its characteristics (according to Grosslight, Unger, Jay, and Smith (1991) in Jansoon. et al, 2009)

Characteristics	*Category of Mental Models*
Models seen as "toys" or a "copy" of reality	Level 1
Models serve to be explicitly and specific objectives	Level 2
models constructed to develop and test an idea (thought), and can be manipulated and subjected to the test.	Level 3

Jansoon, *et al* (2009) also made a mental model categories based on the level of representation that is displayed problem solver. Namely the macroscopic and sub-microscopic level. Macroscopic level is related to the level of concrete object that can be observed. At this level, students observe physical phenomena in experiments. Examples of students at this level, can only explain the electrical current due to changes in the value indicated by the ammeters and voltmeter. Sub-microscopic level is that opinion based on an abstract level phenomenon observed at the macroscopic level. At this level the student uses concepts, theories, and principles to explain the results of observations at the macroscopic level, such as the current increases because there is a flow of electrons. Symbolic level is using a representation of physics and macroscopic phenomena. Using formulas, mathematical equations, graphs, images, and analogies.

2. Methodology

The research was done by giving the test to 21 students participating in a course of electric magnets. The test is done twice, for the first test problem solving electricity concept and the second test on other days is problem solving on magnetism concept.

The instrument problem-solving skills test (problem solving test) electricity and magnetism concepts of basic physics course level 2 test was used to reveal the respondent's mental models in solving the problem. So that there are additional instructions on each test so that the respondent write anything thought (related context) when the process of problem solving. Data representation of the results of the respondents during the problem solving process was collected and analyzed using the rubric to the problem solving test.

Categorization of student mental models related to the ability to explain refer to Table 1. While the analysis of student mental models related to the ability of a solution to the problem represents the grouped based on the macroscopic, the sub-microscopic and symbolic levels.

3. Results and Discussion

3.1. Results of Research

3.1.1. The identification of the level of mental models of the students on the electricity concept

Identify the level of mental models refer to Table 1: Based on the test results obtained by solving the level of mental models. Following the recapitulation of students mental models levels to the five problems of electrical concept displayed.

Table 2: Percentage of student's mental model level at any electrical problems

				No. Test/ Percentage of students mental model levels	*Category of Mental Models*
5	4	3	2	1	
18,2	12,1	6,1	39,4	15,2	Not Clear
30,3	39,4	78,8	42,4	66,7	Level 1
36,4	48,5	15,2	18,2	12,1	level 2
15,2	0,0	0,0	0,0	6,1	level 3
100,0	100,0	100,0	100,0	100,0	Sum

3.1.2. The identification of the level of mental models of students to the concept of magnetism

Here is the recapitulation of the student mental models level in magnetism concept on the four problems that refers shown in Table 3.

Table 3: Percentage of student's mental models level of each problem in magnetism concept

			No. Test/ Percentage of students mental model levels	*Category of Mental Models*
4	3	2	1	
66,7	3,7	7,4	0,0	Not Clear
25,9	29,6	51,9	37,0	Level 1
7,4	48,1	29,6	33,3	level 2
0,0	18,5	11,1	29,6	level 3
100,0	100,0	100,0	100,0	Sum

3.2. Discussion

3.2.1. Profiles of students mental models of electricity concept

Table 2 shows that of the five problems in the electrical concept of students mental models are mostly located on level 1 (with an average of about 51.5%). It's a mental model that tends to experience everyday reality without the support of the true physics concepts.

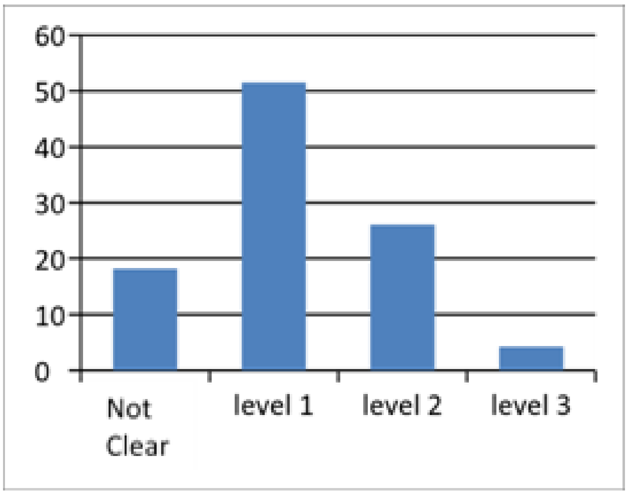


Figure 1: Diagrams of percentage of respondent's mental models level on the concept of electricity.

Here are some examples of the level of mental models in the student taking the test problem solving number one on the concept of electric charge.

Problem: *As a physicist you are involved in a team assigned by company of photocopy ink to conduct research to improve the quality of the ink adhesion. Your team decides to star this investigation using the configuration to manipulate the electrical charge photocopy ink powder. How do you and the team in order to manipulate the photocopy ink powder is stronger glue on the paper?*

Student's answer: That this is *"Not clear mental model category"*
Thought: *How the working principle of the photocopy*?
Answer: *"Since the copy is not known what the tool is in it, as well as the principle works like what? If the laws of*

physics what to wear? So to resolve the issue in this problem still lacking (not know)"

Respondents cannot access their knowledge, so that the macro can only remember the photocopy machine. Respondents also did not analyze the context of the issues presented.

Level 1 mental model category:
"The first we did the electric current must be stabilized with multiple sources of current required by photocopy machine then produces a greater light to be attached photocopy ink."

Respondents are not qualitatively analyzing the context in which the problem will manipulate the configuration of the electric charge to increase the adhesion of ink on paper. Respondents were more focused on the fact that with good lighting will generate a good photocopy any way.

Level 2. Mental models category:
"In my opinion, to the concept of electric charge we need to know in advance the electric charge consists of two charges, namely; the positive and negative charge"
When the two meet each other, then the charge will generate electricity.
- To solve the problem we need to use the concept static electricity, static electricity is electricity that is silent.
- Paper here, uncharged (neutral) or equal positive and negative charge, well when inserted into the photocopy machine and constant friction so that the paper become shot and the paper will be an excess of electrons so that when met will glue ink powder. So my opinion is that needs to be manipulated photocopy machine itself in order to produce the quality to be good ink adhesion.

The reason is: *"According to the concept of static electricity"*. Respondent at this level has been able to explain the context of the problem is based on qualitative analysis, can access knowledge about the concept of electric charge. But the model used in explaining the concept cannot resolve the problem. Because no concept mistakes when saying "hot paper and the paper will be an excess of electrons". Though the paper made positively charged and negatively charged ink (Hallyday & Resnick, 2010). It is clear that the level of mental models is not a problem solver can lead to the expected solution.

Level 3 mental model category: "To get started is done by measuring the amount of charge that is used as the measure is then connected to the ink tube in order to know how big the load function to glue ink. Seen on the photocopy machine, after the machine-read able image then loaded on paper with ink the greater payload, the more glue the ink on the paper after the pens. So to make the ink more glue then increase the electrical load configuration. As can be formulated by $E=kq/r^2$

The greater the charge it will cause a large electric field. Respondents in this category start solving the problem with a qualitative analysis of the context of the problem and evaluate it before proceeding to the expected solution. Respondent also describes the solution by using mathematical representations that guide and clarify the process of the solution offered.

3.2.2. Profiles of students mental models on the concept of magnetism

Table 3 shows that of the four issues shown on the concept of magnetism majority of students at the level of the mental model of level 1and level 2. Its a mental model based on the experience of everyday life without the support of the true physics concepts (level 1 average of 36,1%) and mental models are based on the context that led to the goal of completion problem (level 2 average of 29.6%) but a student can't develop and test these models in problem solving.

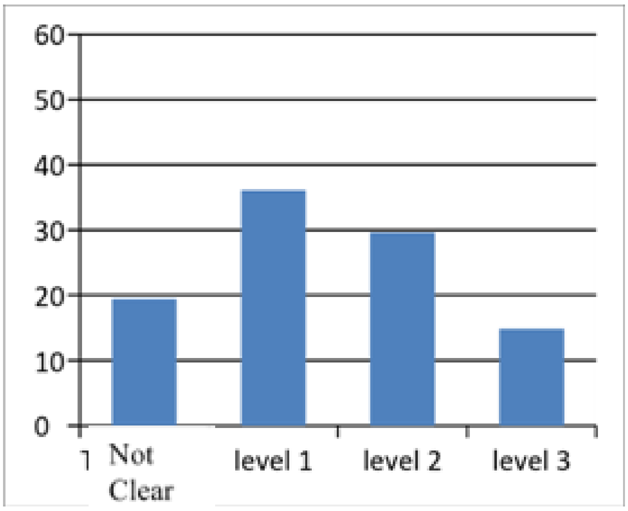


Figure 2: Diagram of the percentage of respondent mental models levels of the concept of magnetism

Here are some examples of the level of mental models in the student taking the test problem solving number three on the concept of induction.

Problem: "One day you carry out social service in remote areas of the utilization of alternative energy. You and your friends then use the river that crosses the village as a source of energy to drive an electric generator that you have prepared. But in the trial which resulted lights blinking makes your eyes uncomfortable and lights still dim. So the team discusses this in the post. Discussion resulted in two solutions to overcome this, first accelerate the flow of water so that the turbine will spin faster, and secondly by increasing the number of coils. Explain why the team decided to take on the two alternative solutions?. Answer respondents by level of mental models:

Not clear mental model category: "With these two solutions that use the river that crosses in the village as a source of energy to drive an electric generator, and an added the number of coils. The reason why the use of the two solutions is to give speed up the flow of the river can be offset between the energy source that is produced if the river flow starts to slow down then it can affect the lights.

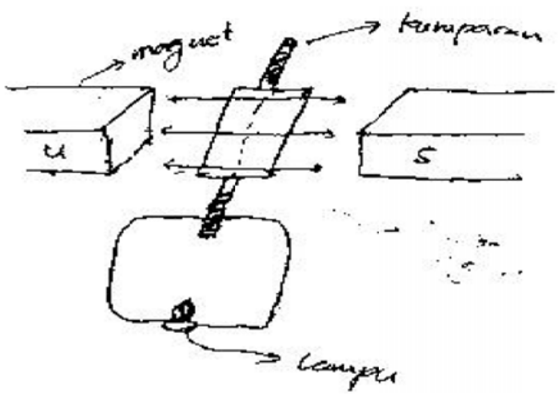
Then the lights will start modestly and can result in dim because of the lack of stability of energy sources. Because the river flow is used as an energy source, if there is no stability in the energy source will happen something fould. He adds the reason why the number of coils, more the number, the greater electromagnetic coil. The electromagnetic field is the result of magnetic and electrical energy, which is what moves electromagnetic power to the lights"

Looks respondents are unable to access their knowledge, since they have knowledge since the beginning of the school bench and application of the concept of induction. Respondents only repeated problems without solving it is presented based on the concept or reality based.

Level 1 mental model category:
"*In this section uses the concept of the benefits of water for energy sources”*. Here they take this as an alternative solution when speed up the flow of the river so that the turbine will move faster and will produce aflame that lights as much as possible and in this case they also added a number of coils so that a magnetic field that is used is also satisfactory. *“According to what I see as my village also uses the same case with the turbine above that when the water is reduced or less tight then the turbine will not spin and when added to the coil, the current will be more*"

This category of respondent, not a good concept that tends to remember it is based on reality in everyday life. Solving problems that not be expected also shown. Respondents test solution to measure their feelings with the words "*satisfactory*".

Level 2 mental model category: First, accelerate the flow of water to spin faster we can add an existing rotor on the generator. Because the rotor rotatable part. The rotor consists of a magnetic field produces a magnetic flux. Second, increasing the number of coils. Because when the coil spins leads to changes in the magnetic flux resulting in a flow, the flow into the external circuit by circuit, so that the lamp was lit, because of the coil that can be rotated through the magnetic field and produces magnetic flux. Rotating coil leads to changes in the magnetic flux that cuts the coils. This will result in the flow. As the picture below:



The working principle of generator: The respondents have been using the concept clearly, linking problems with the working principles of a generator until the invention of the reasons of the problem. Mental models have guided to the respondents goal specifically and explicitly. Respondents in explaining physical phenomena also use the representation in the form of pictures, diagrams, and analogies.

Level 3 mental model category: The reason why in the capture of two alternative solutions to the problem as:

a. Accelerate the flow of water so that the turbine will spin faster, because the water flows faster and faster the turbine spins an electric generator will work (based on the principle) is also growing rapidly, so that the resulting flame will light up and the light no longer lights are dimmed. Because basically lights are lit with the help of an electric generator was also going to die or get to the point of minimum (0), but we cannot see because the naked eye because the resulting frequency was approximately 60Hz. That is 60 for second wave.
b. To produce well-lit lights by increasing the number of coils on an electric generator was very supportive because the greater number of the coil will produce a magnetic induction that great any way so the current will be higher.

Respondent were able to build a mental model of the problem by connecting the flashing lights at the speed of water flow and turbine. Linking concept of AC wave with the lights through the concept of frequency. Respondents were also able to represent the mental models of macroscopic and microscopic, and use mathematical representations to further clarify the physical phenomena displayed.

Acquisition of the profile picture of the mental models of physics student teachers on various concepts of electricity and magnetism. Each individual has their own way in building a mental model based on experience, analytical skills, and also the reliability of the concept they have. The data show that the majority of student teachers of physics have a mental model of level 1 is fragile mental model in which students do not have an established concept and is not able to connect between the reality with this concept.

Results of interviews with some of the students when asked "what difficulties experienced when taking the test?”*Simultaneously they replied confused sir, what is asked*? Is not clear what known and being asked". It is clear here that the students are not ready to problem solving test which is different from the practice questions/ exercises (Korsunsky, 2004).

Exposure above shows that mental models are built very influential on the pattern of student problem solving taken, mental models also illustrate how students use the concept of depth or everyday life to analyze and solve problems. An evaluation of alternatives in determining the learning approach (Brock, et al, 2008).

4. Conclusion

As a conclusion from the above explanation that the mental model of the student profile is very diverse and tends to still is a record of daily experience without the support of an established concept. This profile can be used as an alternative in considering the appropriate approach in teaching the concept of electricity and magnetism.

5. Recommendations

Identification of mental models of learner's profiles can be used as an alternative evaluation for appropriate learning design. Future studies can be conducted in order to find alternative ways to increase the level of mental models of students related concepts of electricity and magnetism.

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