University Students’ Misconception in Electromagnetism

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Abstract. This aim of the research was to analyse the university students’ conception of electromagnetism. This research used a mixed-method design, the combination of a quantitative and qualitative method. For the quantitative part, the research utilised a concept test of electromagnetism, for the qualitative part, the research focused on the descriptive analysis that generated by the university students. The participant in this research was 15 physics students from 9 different classes in the Physics Department of a national university in East Java Indonesia. A conception test included ten different multiple-choice problems and followed by the descriptive analysis of these problems. The participants asked to choose the right answer and write their reasons or arguments that support their answer. In this study, the test was given without giving any treatment for the participant. The analyse method that used in this research was the quantitative and qualitative description. The result showed that the conception of students ranged between 2nd semester (freshman) and 4th Semester (sophomore) in the physics department. Therefore, it is concluded that the students have electromagnetism misconception.

1. Introduction

Electricity and magnetism have been studied separately until 1819 when Oersted found if there is a relation between electricity and magnetism [1]. Nowadays, Electromagnetism becomes one of the most important branches of physics since its use in many ways. Even though it is used in many ways, there are only a few people that understand the concept of electromagnetism well. It indicates that this concept state in abstract concept, need more illustration to explain certain electricity concepts.

In education purpose, electricity and magnetism are available both on a junior and senior high school in the national curriculum. As the pedagogic and pre-service teacher campus, well understanding of the particular concept is inevitable. For that reason, this research aimed to analyse the misconception among students in a public university in Surabaya Indonesia.

The concept is things, phenomenon, situations, or characteristics which have to define nature and represented in cultures by a sign or symbol [2]. The concept explanation by someone called as conceptions. Even though there are clear meanings about the physics concept by physicist, in reality, these meaning commonly different for each student.

The misconception is the student inability to connect knowledge to others. This inability leads the student having contradicted views than what scientist about the concept of physics [3]. There are a lot of causes of misconception such as interaction between students and their environment that lead them to their own analyse which is wrong [4-5]; “dead leaves model” of learning where the teacher teaches only the equations and formulas, not the concept [6]; book; and themselves [7].
Physics is not only about an algorithm, but also the concept and analysing as the concept of 21st-century learning outcome. One of these outcomes supports the analysing part of the environment to the physics learning process. It will realise why some concept needs to learn and applied to their lives. However, this activity has more possibility to get the students understanding into a misconception. Hence there are five common misconceptions in physics. Those are: a) Preconceived notions, b) non-scientific beliefs, c) Conceptual misunderstandings, d) vernacular misconceptions, and e) factual misconceptions [3].

The sample of this research is the pre-service physics teacher. These students have been taught electromagnetism when they were in senior high school or at the beginning of the year. The reason is why students of doing physics department chosen for this research because they are the people who will teach the physics concept. If the teacher themselves has misconceptions, it can be assumed if their students will have misconceptions too. As this research published wishfully, there will be a solution to solve the misconceptions among students in the Physics department.

2. Method
This research used the descriptive quantitative and qualitative method. The main reason was “it wants to get a general description of the misconception that occurred in the physics students about electromagnetism concept” [8-9]. The collecting data was conducted for 3 months, starting from April until June 2019. The research process was organised by preparing proposal, composing instrument in the form of test, judgment instrument by experts and researcher.

2.1. Participants
Initially, the target of the participants was 20 physics students; finally, the participant of the study was 15 physics students from 9 different classes in the Physics Department of a public university in East Java Indonesia. The sampling by the purposive sample characterised of student of level 3 who has received the subject of electromagnetism. For small sample size, we followed the Slovin’s formulation with margin of error 0.1(10%) [13,14].

\[ n = \frac{N}{1 + Ne^2} \]

(1)

Where \( n \) is the sample size, \( N \) is the population size, and \( e \) is the margin of error to be decided by the researcher. Therefore, \( n = 20/(1+20.0.01) = 16.67 \). Thus, the number of 15 physics students was enough for a group with a small sample size according to the Slovin’s formulation.

2.2. Instruments
The technique of data collection has been done by using different multiple-choice problems and followed by the descriptive analysis of these problems. The participants asked to choose the right answer and write their reasons or arguments that support their answer. They also asked whether they are sure or unsure about their answer. The test was given without giving any treatment to the participant. Students' answers are categorized into four categories (a) scientific conception; (b) false positive; (c) misconception; (d) false negative; and (e) lack of knowledge. “The criteria for selecting the instrument used in this study are (a) the instrument must be justified by the expert, (b) the instrument must be suitable for use in the science domain adapted to three chemical representations: macroscopic, sub microscopic and symbolic, and (c) uncovering misconceptions accompanied by reason and level of confidence in answering questions” [8].

3. Results and Discussions
The concept is things, phenomenon, situations, or characteristics which have to define nature and represented in cultures by a sign or symbol [10]. Hence, the concept defined as the abstraction of nature that proposed to make communication between people easier and enable people to analyse their environment. The result of those analyse can be different among people, for example, density, friction, or elasticity concept analyses.
The concept explanation by someone called as conceptions. Even though there are clear meanings about the physics concept by physicist, in reality, these meaning commonly different for each student. The most probable reasons about the difference of the meaning by the physicists and students are the complexity of the physicist conception. The physicist conception commonly related to another concept and more sophisticated than the students. If student conception has the same meaning with the simpler version of the physicist’s, then it cannot be called as a misconception. However, if the student conceptions are contradictive to the physicist, then it is called misconception [2]. Then misconceptions are strongly held cognitive structures that are different from the accepted understanding in a field and that are presumed to interfere with the acquisition of new knowledge [5].

Electricity and magnetism concept use in instruments follow the basic relating concepts. As the pre-service teacher, the basic concept should be understood well to answer application and practical problem. Commonly, the particular concepts learning method in junior and senior high level focused on a practical solution due to choosing the best answer in the final examination. Furthermore, that question transforms into high order thinking skill level. The teacher with no complete understanding of the basic concept of electricity and magnetism difficult to solve various problems. For gain this purpose, the misconception measurement uses ten questions in the basic concept of this case. The result of the population in this study show in Table 1.

| Indicator of Problem | Scientific Conception (%) | False Positive (%) | False Negative (%) | Misconception (%) | Lack of Knowledge (%) |
|----------------------|---------------------------|--------------------|--------------------|-------------------|----------------------|
| 1 Identify the Electric System | 33.33 | 0.00 | 0.00 | 46.67 | 20 |
| 2 Identify the influence of loop | 0 | 6.67 | 0.00 | 53.33 | 40 |
| 3 Identify two parallel wires | 20 | 0.00 | 0.00 | 60 | 20 |
| 4 Identify how could the magnetic field exist | 26.67 | 0.00 | 0.00 | 46.67 | 26.67 |
| 5 Identify the influence of magnet on the charge | 13.33 | 0.00 | 6.67 | 66.67 | 13.33 |
| 6 Identify Lorentz's Law | 26.67 | 0.00 | 6.67 | 26.67 | 40 |
| 7 Identify the influence of electricity on the magnetic field | 26.67 | 0.00 | 0.00 | 33.33 | 40 |
| 8 Identify the influence of material on the magnetic nature | 20 | 13.33 | 13.33 | 20 | 33.33 |
| 9 Identify the influence of the material conductivity and its magnetic nature | 33.33 | 0.00 | 0.00 | 60 | 6.67 |
| 10 Identify the force of a charge | 26.67 | 0.00 | 0.00 | 40 | 33.33 |
| **Average Percentage** | **22.67** | **2.00** | **2.67** | **45.33** | **27.33** |

Based on Table 1, most of the sample has a misconception with a range of 20% - 66.67%. It means they have a problem to master electricity and magnetism concept. The significant problem shows in the combination of both concepts, the influence of magnet and to the charge as the first aspect of the
electricity. The understanding of this combination makes the more difficult thinking process, need each concept understanding to determine the phenomena from these two parts. Most of the sample missing the fact that the current state from the moving electron, different from the fifth question as to the most significant score on a misconception. The eighth question ignores the current producing and shows the lowest score in misconception. Although those two questions discuss the influence of the two concepts, it shows the different results. In other words, two questions on the most significant and lowest misconception score caused by the incomplete concept understanding of both. Although there is the lowest and biggest score, the other concept mastering shows similar results. All the score classified to predetermined criteria to define the student’s conception. Since this research use three-tier questions we use criteria such this:

Table 2. The criteria for scoring [11]

| The first stage | The second stage | The third stage | Categories                  |
|-----------------|-----------------|----------------|-----------------------------|
| Correct         | Incorrect       | Not believed   | • Misconception             |
| Incorrect       | Correct         | Believed       | • Lack of knowledge         |
| Incorrect       | Correct         | No believed    | • Negative false or error   |
| Incorrect       | Incorrect       | Believed       | • Misconception             |
| Correct         | Incorrect       | Not believed   | • Lack of knowledge         |
| Correct         | Incorrect       | Believed       | • Positive False            |

The result shows that misconceptions among students reach 45%. Most of the students have a misconception in identifying the influence of magnet to the charge. This question gives 66.67% of students have misconceptions. It means most of the sample believe the inappropriate fact on electricity and magnetism influence. As explained before, that students believe the wrong current concept, these are shown as question and answer below:

Question: “*a particle with a positive charge is placed between two magnets as shown in the figure, will the magnet be giving force on the particle? Giving the explanation!*”

![Figure 1. Identify the influence of magnet on the charge](image)

Answer: “*the magnets giving force on the particle*”

Reason: “*the force that is caused is the object of reject or attraction, according to the direction of the poles. Reject it if the poles are same and pull if the poles are different*”.

The other question with the simple question but in the third-highest score of misconception is Identify the influence of loop. It was about 53.33% students have misconception to determine the brightest lamp on a closed-loop, connect a new wire to divide three lamps into two sides, one side consists of two series lamp circuit and another consist of one parallel lamp. Most of the sample writes that all the lamp dimmer than before as the wrong answer, even though the parallel lamp circuit will brighter due to the same voltage in every parallel wire. This misconception mostly caused by the direction sign of the current as of the disturbing part of this question, in other reason shows like this:

Question: “*If the circuit as shown in Figure 2 is connected by a wire (k) as shown in the figure, what about the lights L₁, L₂ and L₃?*”
Figure 2. Identify the influence of loop

Answer: $L_1$ is dim, while $L_2$ and $L_3$ are bright

Reason: “Because when the circuit is connected by a wire, the current flowing at $L_1$ gets smaller (the greater the resistance is, the smaller the current is so that the lights are dim) compared to $L_2$ and $L_3$, the light will turn brighter than $L_1$.”

Identify two parallel wires and identify the influence of the material conductivity and its magnetic nature is the high percentage on misconception score. Two parallel wires identification has been explained in the first-year subject on basic physics laboratory or senior high level. Besides, conductivity on metal is a piece of common knowledge. These two questions have similarity; it has the same result in the experiment setting and should be easy to remember. However, students shouldn’t gain this information in meaningful learning. Both of the questions gain 60% of students with misconception.

Question: “Is this statement true: "All metals are conductor, which means that metals can flow charged particles (electrons) easily. Therefore, all metals will be easily affected by magnets."

(a) true
(b) wrong”

Answer: (a) Right

Reason: “Because metals are electrical conductors, so it can flow electron charged particles easily.”

Conception and misconception itself commonly formed when students’ brain interacts with the environment. Since their childhood, Student has many experiences that related to the concept of force, momentum, speed, velocity, and acceleration. Even though it is not used yet, the conception and misconception formed related to those concepts [10]. The different interpretation between the observable and actual reason for some phenomena is the reason for believing the wrong concept. As a simple example, children will believe that all animals in the ocean are Pisces. They will believe that dolphin is Pisces, even dolphin is exactly a mammal.

This result inclined that there are many misconceptions among physics students. The cause of these students having misconception can come from the wrong learning method until the wrong way to meaning electromagnetic matter. Commonly, they learning a particular physics concept for practical use, answer the equation physics problem in the final examination. It makes physics has an image of the mathematically based subject without any physical phenomena interpretation. Furthermore, analysis skill on natural interpretation will be less trained, and this ability needs a basic understanding of the physics concept. For decrease this misconception, the students should have laboratory activity to synchronise the concept from class to the real phenomena [12].

4. Conclusion
From the study, the result showed that if there are misconceptions in the electromagnetic subject among physics students. The matter that has most misconceptions is “identifying the influence of magnet to the charge”. The factor of students’ misconceptions is the false meaning that student makes during their experience in the electromagnetic subject and the wrong learning method used by the teacher.
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