Investigating students’ preconception of some electromagnet topics

Ketut Suma*, I Wayan Sadia, Ni Made Pujani, and Ni Ketut Rapi
Ganesha University of Education, Jln Udayana No 11 Singaraja-Bali, Indonesia

*sumaketut@ymail.com

Abstract. The objective of this study is to describe students’ preconception of some electromagnet topics. The data obtained using the Three Tier Electromagnet Test which consisted of 18 items. This test was given to 328 twelve-grade students of the public senior high school in Bali. According to the students’ response to the test, students’ preconception could be categorized as a scientific concept, misconceptions, lack of concept and error. The data were analyzed descriptively. The results showed that average of 14.58% of students has a scientific concept, 27.86% of students experience a misconception, 39.99% of students experience lack of concept and 17.53% of students experience an error. It can be concluded that students’ prior knowledge were very diverse. It is important to indentify students’ preconception on electromagnetic as a consideration for effective conceptual change strategy.

1. Introduction
Research showed that students enter the physics class with bring preconception about some physics concepts [1] [2] [3] [4]. Preconception is knowledge that students have before learning starts [5]. Experts were given various labels to preconception such as; prior knowledge [6] children’s science [6, 7]; alternative conception [8] and misconception [9]. Student’s preconception can either suitable and not suitable with scientific concept. In this article the terms preconception and prior knowledge are used interchangeably. Students' preconception that was suitabet with scientific conception strongly support learning on student learning, while those that conflict to scientific concepts can be a barrier to student learning [10]. So, preconception was one of the defining factors to physics teaching in schools [11]. The importance of preconception in learning is emphasized by constructivism theory which views that students learn through the process of reconstructing existing knowledge. [10]. This means that learning is not the process of transferring knowledge from teacher to student [12].

Electromagnetism is one branch of physics that has a strategic role. This topic studies the relationship between electricity and magnetism. Electromagnets play an important role in modern technological inventions [13]. Electromagnetism has created a revolution on the field of engineering, medicine, space, construction etc therefore, a correct understanding of electromagnets topics is vital for student. To improve the meaningfulness of learning of electromagnet, a variety of students’ preconception about electromagnet need to be identified.

2. Theoretical Framework
Although many studies have been conducted relating to preconception, the clear definition of preconception is not easy to find. There are several simple definitions, but there are also some that
are quite profound. For example, Thijs and Van den Berg [14] state that preconception refer to the conception that has been formed before formal teaching in school. Preconception is also defined as preconceived knowledge bring by student to school [15].

Preconceptions is important in physics learning. According to cognitive learning theory, students build new knowledge based on their preconception. In constructivist literature, there are three main roles of prior knowledge in physics learning [16]. First, preconception as a theory that defines preconception as naïve theory that is incorrect but seems coherent and difficult to reconstruct. Second, preconception as elements, interpreting prior knowledge as scattered elements of knowledge developed by students based on daily experience. Third, preconception as a knowledge system highlights that most student concepts about nature have dynamic and heterogeneous properties.

Preconception provides a framework for assimilating new knowledge into existing cognitive structures. Preconception can influence how students perceive, organized, and make connection of new information [10]. Some research shows the influence of preconception on learning achievement. Preconception, especially procedural knowledge, significantly influences learning achievement [17]. Besides the positive impact, preconception also have a negative impact to learning because some preconception is contrary to the information that students will learn [18].

3. Method

3.1. Participant
This study was a survey research conducted at eight high schools in Bali Province. There were 328 of 12th-grade students as a participant. The participant had not previously received formal teaching about electromagnets. Thus, the students' answers to the questions in the test can be interpreted as their prior knowledge about electromagnet.

3.2. Instrument
In this study the data were collected by using Three Tier Electromagnet Diagnostic Test (TTEDT). This test consist of 18 items. This test identifies several electromagnetic subtopics like: the magnetic effect of electric current, the magnetic force on wire current, the force caused by moving charges, magnetic flux, electric motion force, and induction current. Test items related to each subtopic above are shown in table 1.

| Electromagnets Concepts                  | Item Number |
|-----------------------------------------|-------------|
| Magnetic Effects of Electric Currents   | 1, 2, 3     |
| The magnetic force on wire current      | 4,5,6,7     |
| The force caused by moving charges      | 8,9,10      |
| Magnetic flux                           | 11, 12, 13  |
| Electric motion force                   | 14, 15, 16  |
| Induction Current                       | 17, 18      |

3.3. Data Analysis
The data of students' preconceptions were analyzed descriptively. The students' preconceptions of electromagnet concepts were classified into four categories: Scientific Concept (SC); Misconception (M), Lack of Concept (LC), and Error (Er). The categorization was based on the combination of the student's responses in the first, second, and third tiers of TTEDT as shown in Table 2.

| Students' answer on 1st tier | Students' Preconception Category | 2nd tier | 3rd tier |
|-----------------------------|----------------------------------|----------|----------|
| Right                       | SC                               | Right    | Sure     |
| Right                       | LC                               | Right    | Not Sure |
| Wrong                       | LC                               | Right    | Not sure |
4. Results and Discussion

4.1. Student's Prior Knowledge Category about Electromagnets

From the student respond to TTEDT the students’ preconception on electromagnets could be classified into: SC, M, LC, and ER. The percentage of the students experience of SC, M, LC, and ER were shown in Table 3.

| Sub concepts of electromagnetic                  | SC (%) | M (%) | LK (%) | ER (%) |
|------------------------------------------------|--------|-------|--------|--------|
| Magnetic Effects of Electric Currents            | 21.95  | 34.15 | 26.32  | 17.58  |
| The magnetuc force on wire current              | 21.72  | 21.72 | 35.98  | 20.43  |
| The force caused by moving charges              | 7.42   | 29.67 | 47.56  | 15.35  |
| Magnetic flux                                    | 14.84  | 30.18 | 43.60  | 11.38  |
| Electric motion force                            | 9.76   | 18.09 | 45.22  | 26.93  |
| Induced Current                                  | 6.86   | 39.18 | 43.90  | 10.06  |

From Table 3, it was showed that: (1) the highest percentage of students who experience a scientific concepts was on the magnetic effect of electric current, and the lowest on the induced current, (2) the highest percentage of students who experience a misconception was on the concept of induced current, and the lowest is on electric motion force, (3) most of the students’ conception categorized into lack of concept except for concept of magnetic effect of electric currents, the highest percentage of students who were experience it is on the force caused by moving charges and the lowest is on magnetic effect of electric current; (4) the highest percentage of students who experience an error was on electric motion force and the lowest was on induction current. For whole electromagnets concept, only 14.58% students whom their preconception categorized into scientific concept. There were 27.86% of students whom their preconception categorized into misconception. Most of the students (39.99%) whom their preconception categorized into lack of concept. Meanwhile, 17.53% of students experience an error.

4.2. Variety of students’ misconceptions about electromagnets

According to students’ responses to the TTEDT, various students' misconceptions about electromagnet concepts can be described. There were 16 types of misconceptions experienced by 12th-grade students of public senior high school in Bali, namely:

1. Students stated that the direction of the magnetic field due to a wire current is the same to the electric current.
2. Students described the direction of the magnetic field at a point around the wire current is towards the wire. In this case students equate magnetic field due to a wire current as electric field electric field caused by electric charge. In this case students treating the magnetic field as an electric field [19].
3. Students described the direction of the magnetic field at a point around the wire current is away from the wire. In this case students equate magnetic field caused by a wire current as electric field caused by a positive charge.
4. The farther the point of the wire current, the bigger magnetic field because the magnitude of the magnetic field at a point directly proportional to the magnitude of the electric current and the distance of that point to the wire current.
(5) The direction of the force on a wire current placed perpendicular to the direction of the homogeneous magnetic field is in parallel to the current, this finding corresponds to the findings of Maloney [20].

(6) Students perceived that the two wires with parallel current repel each other, while the two wires with anti-parallel attract each other. Here students perceive the two wires with parallel current as the two electric charges of the same kind and the two wires with anti-parallel currents as the two electric charges of a different kind. The similar misconception was founded by [21].

(7) A positive charge Q at rest in a magnetic field will experience Lorentz Force. Students equate this situation to the case of a charge that rest in the electric field. The similar misconception was found by [20].

(8) A positive charge Q released in a uniform magnetic field will move to the the magnetic field direction with a constant acceleration. This finding consistent with [20] state that the force on a charge in a magnetic field is in the direction of the field.

(9) A positive charge in a uniform magnetic field will move in the opposite direction to the magnetic field. Students equate charge motion in the uniform magnetic field with charge motion in the uniform electric field.

(10) Students define magnetic flux as the number of electric line force per unit area.

(11) A rod magnet was moved close to the coil, does not cause an induced current as long as the magnet does not enter the coil.

(12) Students stated that the induced current direction that arises in a coil opposite to the north pole motion of the magnet.

(13) If a rod magnet was moved near or away from the coil in a closed circuit, no induced current occurs because the coil is not connected to the voltage source.

(14) The part of the + Q charge travel in a uniform magnetic field was straight because it gets constant acceleration.

(15) A positive charge released from rest in magnetic field will moves to the right in the magnetic field whose direction up, will move with a straight line path with a downward acceleration.

(16) If a coil covers a number of magnetic forces, magnetic fluxes were inversely proportional to the number of coils.

5. Conclusion and Suggestion

5.1. Conclusion
Before starting formal teaching students had preconceptions of electromagnets topics. There were four types of student preconceptions, namely: scientific concept, misconceptions, lack of concepts, and errors. Most of students experience lack of concept and only a small percentage have scientific concept. This study found seventeenth of misconceptions, some of which are similar to those found in the literature on misconceptions.

5.2. Suggestion
It is suggested to teachers to identify students' preconceptions about the topics of electromagnet before taking a formal teaching. Students preconception can be used to designing the right strategy to reconstruct the students preconceptions to become scientific concept.

Acknowledgement
Thank you to The Director of Research and Community Service, The Ministry of Research and Technology and Higher Education for funding this research through Graduate Research Grant in 2017-2018.
References

[1] Suma K, Sadia I W and Pujani N M 2018 The identification of the 11th grade students’ prior knowledge of electricity concepts Journal of Physics: Conf. Series 1040 012038. International Conference on Mathematics and Natural Sciences (IConMNS 2017).

[2] Suma K, Sadia, I.W and Pujani, N.M 2018 Investigating 12th grade students’ prior knowledge of static electricity concepts International Journal on New Trends in Education and Their Implications pp 47-56.

[3] Bilal E and Erol M 2009 Investigating Students’ Conceptions of Some Electricity Concepts. Lat. Am. J. Phys. Educ. 3 pp 193-201.

[4] Daud N S N, Karim M M A., Hasan, S W N W and Rahman N A 2015. Misconception and Difficulties in Introductory Physics Among High School and University Students : An Overview in Mechanics EDUCATUM - Journal of Science, Mathematics and Technology 2 pp 34 – 47.

[5] Edinyang S O 2006 Prior knowledge of general objectives and specific behavioral objectives on students’ achievement and retention in social studies in Akwa Ibom State of Nigeria An Unpublished Ph.D. Thesis, University of Calabar, Calabar.

[6] Ausubel D 1968 Educational Psychology: A Cogniotive View Holt USA. Rinchard and Wilston Inc.

[7] Bell B F 1993 Children’s Science, Constructivism, and Learning in Science (Victoria Deakin University) p-12

[8] Petersson G 2002 Description of cognitive development from a constructivist perspective. Paper presented at The third European Symposium on Conceptual Change, June 26-28. 2002, Turku, Finland Brown, D. E., & Clement, J. 1989. Overcoming misconceptions via analogical reasoning: Abstract versus explanatory model construction. Instructional Science, 18, 237-261.

[9] Brown D E & Clement J 1989 Overcoming misconceptions via analogical reasoning: Abstract versus explanatory model construction Instructional Science 18 pp 237-261.

[10] Svinicki M 1993 What they don't know can hurt them The role of prior knowledge in learning. Essays on Teaching Excellence Toward the Best in the Academy 5, pp1993-94.

[11] Hewson M G Hewson PW1983 Effect of instruction using students’ prior knowledge and conceptual change strategies on science learning. Journal of Resesearch and Science Teaching. 20(8), pp731-743.

[12] Driver R, Asoko H, Leach J, Mortimer E and Scott P 1994 Constructing Scientific Knowledge in the Classroom Educational Researcher 23 pp 5-12.

[13] Griffith WT and Brosing J W 2009 The Physics For Everyday Phenomena A Conceptual Introduction to Physics Seventh Edition. United State: Mc Graw Hill, p. 282.

[14] Thijs G D and Van den Berg E 1995 Cultural factors in the origin and remidiationof alternative conception in physics. Science Education 4 pp 317-347.

[15] Zhou G, Nocente N, and Brouwer W. 2008. Understanding Student Cognition Through an Analysis of Their Preconception in Physics. The Alberta Journal of Education Research 54 pp14-29.

[16] Jaleel S and Verghis A M 2015 Knowledge Creation in Constructivist Learning. Universal Journal of Educational Research 3 pp 8-12.

[17] Esanu A and Hatu C 2015 The significance of prior knowledge in physics learning. The 11th International Scientific Conference Learning and software for Education Bucharest, April 25-26 pp1-6.

[18] Hailikari T Katajavuori N and Ylanne S L 2008 The Relevance of Prior Knowledge in Learning and Instructional Design American Journal of Pharmaceutical Education 2008 72 (5) Article 113 pp. 1-8

[19] Cordova J R, Sinatra G M, Jones S M, Taasoobshirazi Gand Lombardi 2014 Confidence in prior knowledge, self-efficacy, interest and prior knowledge: Influences on conceptual
changeContemporary Educational Psychology 39, pp 164–174.

[20] Smaill C and Rowe G 2012. Electromagnetics: how well is it understood by first- and second-year electrical-engineering students? American Society for Engineering Education. available on https://www.asee.org/public/conferences/8/papers/4051/download, accessed on November 25 2018

[21] Maloney D P, O’Kuma T L, Heigelke CJ and Van Heuvelen A 2001 Surveying students’ conceptual knowledge of electricity and magnetism Physics. Education. Research., American Journal of Physics. Suppl 69, pp S12-S23.