Categorization intermediate conception of the third year students’ of physics education program in electromagnetism wave sub-concepts

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Abstract. Some results on the conceptual change, indicated a discriminate between alternative and scientific conceptions. This could be represented as a medium conceptions, called the intermediate conceptions. Researches on the electromagnetic wave sub-concept generally assessed based on modern physics conceptions, on the other hand it needs to be assessed based on the concept of electricity and magnetism. This research aims to identify and describe category of intermediate conception of third year physics education students in electromagnetic wave sub-concepts. This research used descriptive method. The subjects of this research were 73 third year students in a University of Teacher Training at Bandung. Data collection have been done by essay test and interview. The analyzed data shows that 77% of the students are on ‘lateral intermediate conception’ category and none of them were on ‘naïve physics’. Other results showed that the students have difficulty on describing, explaining, interpreting qualitatively about electromagnetic wave sub-concepts.

1. Introduction
Conceptual knowledge is something that is a very important for college students in solving problems concerning the phenomena of physics in everyday life. Students’ conceptual knowledge is related to the students conception. Conception is an ability to understand concept, either through interaction with the surroundings or formal education. Conception is more individual understanding and may be differ from experts conception [1]. Conception developed by learners, as results of several factors such as: sensory experience, language experience, cultural background, mass media and formal education [2]. Furthermore, the unique conception of natural phenomenon are often resistant toward learning process, especially if it comes from learning and life experiences with learners [3]. Based on these views, it can be concluded that the conception of the students tends to be acquired through formal learning that integrated experiences in everyday life.

Related into the context of learning students’ conception in learning process are generally diverse. The conceptions are generally come from previous formal education or interacting with the surroundings by direct observation, or various media. Students’ conceptual difference with scientific conceptions cause students change their conception, that give conceptual change. A conceptual change is a change in a conception that occur in learners such as beliefs, ideas or thoughts from the initial conception toward
scientific conception. The process of changing the conception is associated with changes to the alternative conceptions of scientific conception. Alternative conceptions are seen as a pre-instructional conceptions or conceptions before learning, that is owned by learners and often inconsistent or not in accordance with scientific concepts [4]. Alternative conceptions are described as concepts of learners to a study [5]. An alternative conceptions of learners are fragmented knowledge [6].

At the time of changing process from alternative conceptions to scientific conceptions, sometimes there are differ from these two conceptions. A divergence between scientific and alternative conceptions on concept changing process [7]. This divergence can be represented as a medium or intermediate conceptions. Intermediate conception is a conception between alternative conceptions and scientific conceptions, which represents pieces of idea, thought, concept which goes into scientific conception and learners’ difficulty in understanding a sub-concept. Pieces of ideas or thought intermediate conceptions is generally influenced by the conception and learners’ thoughts that are unchanging, permanent and likely persistent. Intermediate conception generally obtained by the students when they have finished studying a concept in formal education. In other words, we can assume that in students’ have had 2 knowledge acquired through formal education and from everyday experience.

Intermediate conception is important to be inspected in educational research because in intermediate conception, educators can see learners’ progress in receiving concepts in learning process [8]. Intermediate conception category in this research is categorized by 2 perspectives which become bases, those are epistemological perspective [9] and ontological perspective [10]. Epistemological perspective is emphasizing on how learners gain a concept while ontological perspective is more on relation between categories or characteristics of a concept. The category is based on Dega et al. [11] in categorizing alternative conceptions into several categories, those are: naive Physics, phenomological primitives (Ohms-P-Primes), ontological alternative conception, lateral alternative conception, mixed conception and loose ideas.

There are some differences done in categorizing intermediate conception with previous research those are: research subjects are students who just completed electric magnet course, the process of analyzing data is gained using a ‘scale 2 category’ in the grouping and categorization of ‘intermediate conception’. The intermediate conception will be categorized into 4 categories, those are: ‘naive physics, phenomological intermediate primitives (P-Iprims), lateral intermediate conception and ontological intermediate conception’.

Sub-concept that is to be studied in this research is electromagnetic wave. Electromagnetic wave sub-concept is studied based on the concept of electricity and magnetism. The concept electromagnetic wave sub-concept has characteristics as an abstract, difficult and complex concepts. The degree of complexity this sub-concepts is caused students difficulty to understand the sub-concepts of electric field and magnetic field that students have learned previously. Some researches indicate that the difficulty of students lies on studying previous sub-concepts. Basic topics such as Gauus law, electric current and electric potential requires more understanding [12]. Electromagnetic wave sub-concept at the electricity and magnetism course are discussed commonly through Maxwell equations in explaining the process of an electromagnetic wave. The difficulties students faced generally lies in interpreting qualitatively a Maxwell equation in electromagnetic wave sub-concept. It is relevant to the results of research conducted by Finkelstein [13] which states that the difficulties experienced by students are making meaning of the concept of magnetic electricity. In this case meaning an idea of a concept does not only provide an explanation, but also explaining on why and how the concept happen.

Based from those reviews, the problem of this research were what categories of intermediate conceptions of the third year students’ of physics education on The University of Teacher Training at Bandung in electromagnetic wave sub-concepts? That also served as the purpose of this research that was describing and identifying intermediate conceptions categories. This research is hoped to be a new literature on conception in the conceptual change subject.
2. Methods
The research used a qualitative descriptive method. The subjects of this research are third-year students of physics education who have taken electricity and magnetism in one of the University of Teacher Training at Bandung. The subjects of the research consist of 73 physics education students. Sampling was taken by purposive sampling. The data about intermediate conception was being gathered by test and interview. The instruments were essay test and depth interview. The test adopted based on Electromagnetism Concept Inventory (EMCI) model. The test was used to describe intermediate conceptions of students who have learned magnet electric concepts. The test is consisted of three questions about electromagnetics. Interview was used to support the data from the test.

This research was conducted based on several related literatures on conception in concept change theory and electromagnetic wave content as a part of the magnet electric concept. Based on the literature review, it was found that there is a problem related to intermediate conception in conceptual change theory. Intermediate conception that was studied in this research is related to categorization of intermediate conception of students in electromagnetic wave sub-concepts. Furthermore, the problem was formulated in the research purposes. The data tabulation was a rubric scale form on the answer sheet. Scale ‘0’ indicated the respondents not answered. They only write what was known on question and answer is a repeat from the question. Scale ‘1’ indicated that the answer and reason of the respondents were wrong. Scale ‘2’ indicated that the answer was correct but the reason was wrong or vice versa. Scale ‘3’ indicated that the reason and the answer were both correct. The result of the respondents’ answers then were categorized into each scale and grouped. The result data from interview were used as supporting data in conception and suitability of students’ answers that will be the basis for categorization of intermediate conception.

The analysis was done by categorizing students intermediate conceptions base on the rubric answer on scale ‘2’ which was supported by interview. Then, the answers was analyzed and described qualitatively categorizing.

3. Results and discussion

3.1. Result
The data from the test and in-depth interviews are used as reference in categorizing the concept of intermediate for physics education students third year at one of the Teacher Education Institute (LPTK) in Bandung. Table 1 shows the percentage of intermediate category conceptions for the third-year physics education students on sub-concepts of electromagnetic wave at phenomenological intermediate primitives (P-Iprims) category.

Table 1. The concept of intermediate at phenomenological intermediate primitives (P-Iprims) category.

| Category | Students Conceptions                                                                 | Percentage (%) |
|----------|--------------------------------------------------------------------------------------|----------------|
| P-Iprims | Combination of electric field and magnetic field. This phenomenon occur if the direction is perpendicular toward magnetic field. | 5              |
|          | Electric field moves fast to deliver charge.                                         | 1              |
|          | Electric charge is fastened                                                          | 5              |
|          | Electric charge moving and the direction is perpendicular                            | 1              |
|          | Electric charge moving and spreading to every direction                              | 1              |
|          | Emitting energy per unit are of magnetic field so charge is moving                   | 1              |
|          | Electric field and magnetic field move perpendicularly                                | 3              |
|          | Electric charge harmonically moving fast                                             | 1              |
|          | Electric charge moving fastened in one area                                          | 1              |
|          | Electric charge moving fastened and jumping gap                                      | 1              |
|          | Electric charge moving at high speed                                                 | 1              |
| Total    |                                                                                      | 21             |
Table 1 shows that there are 21% of students’ conception answers are in the category of Phenomological Intermediate Primitives (P-Iprims). That shows that the students’ conceptions has been formed a concept. However, the concepts were still fragmented ideas or inconsistent concepts in explaining electromagnetic wave sub-concepts. For example, electric field spread quickly to propagate charge. Another example shows that the charge moves at high speed in radiating electromagnetic waves. The result of the research shows that there is another conception at the intermediate conception that is the lateral intermediate conception category.

Table 2 shows the percentage of intermediate conception for the third year physics education students on electromagnetic waves sub-concepts in the category of lateral intermediate conception.

Table 2. Conceptions of intermediate on the category of lateral intermediate conception.

| Category                      | Students Conceptions                                                                 | Percentage (%) |
|-------------------------------|-------------------------------------------------------------------------------------|----------------|
| Lateral Intermediate Conceptions | 1. There is a change from electric field to magnetic field, vice versa              | 25             |
|                               | 2. Charge moving cause electric current which resulted in a change from electric field to magnetic field | 13             |
|                               | 3. Moving charge is fastened which resulted in a change from electric field to magnetic field, vice versa | 7              |
|                               | 4. Flux change cause induction GGL. When GGL occur then there will be an induction current | 2              |
|                               | 5. Fastened charge creates magnetic field and it create electric field.              | 3              |
|                               | 6. Electric charge moving in changing field                                        | 1              |
|                               | 7. Electric load is moved quickly and turned at magnetic field.                     | 1              |
|                               | 8. Electric charge moving in electric field at one point of speed                   | 1              |
|                               | 9. Based on the direction of the electron which caused by electric field and magnetic field | 1              |
|                               | 10. With right hand rule, it is that electric field is moving straight with magnetic field and electric current is perpendicular with magnetic field. | 5              |
|                               | 11. Seeing form or type of waves which is created by electric field or magnetic field | 1              |
|                               | 12. Electric field and magnetic field are perpendicular base on Gauss and Maxwell   | 1              |
|                               | 13. Electric field and magnetic field are perpendicular based on Hertz experiment   | 1              |
|                               | 14. Electric field and magnetic field are perpendicular based on Maxwell’s experiment | 1             |
|                               | 15. By channeling current on wires and by seeing its direction orientation which is perpendicular towards electric field and its current | 3              |
|                               | 16. By multiplying E and B which resulted in not equal to zero to find value | 1              |
|                               | value $|E$ and $B| = EB \sin \theta$, $\theta$ is angle between $E$ and $B$, which gain that $\theta=90^\circ$ which means perpendicular |     |
|                               | 17. Magnet can inducted electric and electric can inducts magnet if it is pictured in graph, electric field and magnetic field are perpendicular | 1              |
|                               | 18. By Maxwell equation for electromagnetic wave which states that $E$ and $B$ are perpendicular | 3              |
|                               | 19. By Hertz’s experiment that is if a series with closed switch, will result in flux change which caused current. | 3              |
|                               | 20. Electric field and magnetic field are moving perpendicularly                     | 3              |
|                               | Total                                                                               | 77             |

Based on Table 2, it shows that the majority of students were in the Lateral Intermediate Conceptions which amounted to 77%. That means majority of students’ answers refer to the ontology of the same category but different sub-category. Students study a few things about electromagnetic wave based on the concept of electric field and magnetic field. For example, electromagnetic wave is caused by changes...
in from electric field into the magnetic field. Another example shows that electric field and magnetic field will move perpendicularly to each other. In general, electromagnetic wave sub-concept is studied by modern physics concepts such as: wave spectrum, wave energy and the application of electromagnetic waves in everyday life. However, for this research, the researchers want to see students’ conception on electromagnetic sub-concept based on magnet electric concepts.

Table 3 shows the percentage on intermediate category conception physics education students third year on the electromagnetic waves sub-concept in the category of ontological intermediate conception.

| Table 3. Intermediate conceptions on ontological intermediate conceptions category. |
|-----------------------------------------------|
| Category                        | Students Conceptions                                                                 | Percentage (%) |
|-----------------------------------------------|
| Ontological Intermediate Conceptions | Electric charge moving and striking in a space which cause an increase in speed | 1            |
|                                 | Electric charge gaining speed which in form of AC current                                | 1            |
|                                 | Total                                                                                  | 2            |

Based on Table 3, it shows that there are 2 % of students that are in the category of ontological intermediate conception. That means that the conceptions of the students are from the same source of ontology category but have a different properties. For example, a students explains that in radiating electromagnetic waves, the charge will strike another charge which will lead to the increase of the movement speed. Another example shows that the charge will gain speed in the AC current source in radiating electromagnetic waves.

The results of this research shows that there is no answer from the students on the category of naïve Physics. It shows that students already integrated the knowledge that were obtained by experience with the knowledge that were obtained from the learning that related to electricity and magnetism concepts. The knowledge related to the concept of electricity and magnetism is used as the basic by the students in answering questions that are related to the electromagnetic wave sub-concept.

3.2. Discussion
This research intend to describe the student’s intermediate conceptions category. There are several reasons why this research on the intermediate category conceptions has been done. The first reason is to see the gap between the alternative conception and scientific conception [7]. The conception of intermediate are able to represent the gap between alternative and scientific conception. The second reason, conceptions categorization are based to see the pieces of students conceptions among the alternative and scientific conceptions. Another reason is as a theoretical implication that can contribute on the conceptual change theory. Those are the reasons that encouraged researcher to conduct descriptive-qualitative study in conducting intermediate category conception that refers to Dega et al. [11] studies, that undertake students’ alternative conception categorization on the concepts of electricity and magnetism.

The intermediate conception categorization is based on the student’s answers on scale ‘2’. The open-ended questions from the interview are used to view the suitability of the student’s answers in test and also to view pattern and students’ knowledge in answering the given questions. During the analysis there are 4 categories conceptions developed based on epistemology and ontology perspectives. Results of the data analysis show the percentage of each categories on the conceptions of intermediate, that are: lateral intermediate conception (77 %), phenomological intermediate conception (21%), ontological intermediate conception (2 %), and did not shows any conception on the category of naïve physics.

The lateral intermediate conception is the most dominant category conception, among the other category conception. Lateral intermediate conception category emphasis more on the same conception of the students in conducting clarification of same ontology category but on the different sub-category.
The student’s conceptions on the sub-concept of electromagnetic waves are mainly correct and refers to the concept that are questioned. But, the explanation of the answers on this category is still less precise and tend to be incomplete. For example, in explaining how to prove that the electromagnetic waves, the direction of electric field vibration and magnetic field moves perpendicularly. Student’s answers generally based on the right-hand and Maxwell’s equation rules without any apparent reason. Theoretically the student’s answers correctly, using the right-hand rule which assumed that electric current is in the same direction with the electric field so it shows that electric field is perpendicular with the magnetic field.

The next intermediate conception is the phenomenological intermediate conception which amounted to 21%. This category is based on the epistemology perspective that is developed [9]. This category emphasize the student’s conception based on the previous learning that has been formed, but still in concept pieces. For example, in a situation, when the electric charge will radiate the electromagnetic waves. Most of the students answered when the charges moves, propagating in all directions and perpendicular to each other. Students though that moving charges may lead to electrical current that caused magnetic field changes. However, theoretically, the movement of the charges can be accelerated, slowed down or moving constantly.

As much as 2% of the student’s conception belong to ontological intermediate category. Reveal that categorization is a process to identify or define a concept into a category where the concept originated, because it is an important process in learning physics [14]. Ontological intermediate conception category emphasize to the same ontological source but have a different properties. As an example, students assumed and reasoned that when the charges radiates electromagnetic waves, a collision process will occur. The collision process that occur between the charges that cause the charges gain the speed to move. In addition to the collision process, Alternating current source (AC) led to be charges to move even faster in radiating electromagnetic waves. Theoretically, charges will radiates electromagnetic waves when the movement of the charges being accelerated.

The results of this research shows that there is no conception in the category of naïve physics. Naïve physics as a theoretical view of students that are simple, less organized and has not established a concept that is obtained, based on intuition or previous learning experience [15]. This result shows that student’s conceptions generally has from a concept, although it is still in form of concepts pieces. This happen because students had already 2 knowledge, that are knowledge that is gained when learning and prior learning about sub-concepts of electromagnetic waves, thus causing the absent of the students conceptions on naïve physics category. The results also showed that in the study of electromagnetic waves sub-concept, it require the knowledge of electrostatics (electric potential, electric current, electric force and electric field) and the knowledge of magnetism which includes magnetic force and magnetic field.

This result also shows that there are some difficulties for the students on the sub-concepts of electromagnetic waves. Students generally have problems in describing, explaining, qualitatively interpret things that related with the sub-concept of electromagnetic waves. The results of this study are relevant to the results of a research conducted by Finkelstein [13] which states that the difficulties experienced by students is the interpretation of the concept of magnetic electricity. This is because, in defining the idea of a concept, not only have to provide an explanation of the meaning, but why and how the concept can occur. In general, students understand electromagnetic waves sub-content easier, quantitatively and mathematically. This is shown from some of the answer by the students that used Maxwell’s equation mathematically to explain question in electromagnetic waves sub-concept. The results of these studies are relevant to the research conducted [16] which states that in solving electric magnet problems, students easily resolve problems that is mathematical rather than problems that shaped in concept.

4. Conclusion
Based on the results and discussion of the research, it is concluded that 77% of students are in lateral intermediate conception category. That means that the majority of students’ answers refers to the
ontology of the same category but different sub-category which is studied based on the concept of electric field and magnetic field. Furthermore, there are no students in naive physic category. That means the students have integrated the knowledge they gained from experience with the knowledge gained from learning magnet electric concept. Other results show that the difficulties most students faced are in describing, explaining, interpreting qualitatively based on mathematical equation in the electromagnetic waves sub-concept.

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