Analyzing Concepts Mastery and Misconceptions About Evolution of Biology Major Students

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Abstract. The purpose of this study was to analyze the concepts’ mastery and misconceptions of evolutions’ subject. This is a descriptive research and involve 2 biology major students from 2 universities in Bandung. Sample of the study is a biology major student who has attended the evolutions and genetics’ course. Using Diagnostic Question Cluster and interview as a instrument research. Result of the study indicated that concepts’ mastery is on the low level (41.25% on first data and 48.25% on second data) and misconceptions is on the high level (61.25% on first data and 60.25% on second data). Some types of misconceptions only found in specific subconcepts. We concluded that low level of concepts’ mastery lead to misconceptions, and it is also caused by low mastering of key concepts in evolution’s theory. Content-based misconception has a highest percentage of all kind of misconceptions (27.25% in first data and 28.5% on second data), because the biology major student’s don’t understand the scientific concept correctly.

1. Introduction

Biology education’s curriculum was compulsoring their students to possessed many biology topics, also encouraging their students, the biology major students, to become a high school biology teacher. As a biology teacher, the biology major students need a deep understanding about many biology topics. One of the topics which is need to be learned by the biology major students is evolution. Evolution is also one of the primary subjects in biology education’s curriculum. In biology class organics evolution is the most discussed topics in biology’s class. Organics evolution refers to the alteration of the living things [1, 2, 3, 4, 5]. There are three main aspects of organic evolution which is distinguished as (a) evolutionary devices (include DNA and gene), (b) evolutionary mechanism (include natural selection and reproductive success) and (c) the result of their combination in the form of macroevolution (include speciation and fossils) [1]. Evolution as a subjects or topics held a high percentage of low understanding [2] and misconception [3].

Students’ conceptions divided as preconception and concept assimilation [4, 5, 6, 7]. Preconception refers to the idea or understanding which is held by student before they had learning process [4]. After they had the learning process, their understanding called concept assimilation, this concept assimilation, ideally, directed to the concept mastery. But students’ apparently found hard to assimilating their conceptions after learning process, so misconceptions found as the lack-conceptions of the students. Misconceptions refers to the different conceptions [5], or the alternative conceptions [8, 9, 10]. Students who held misconceptions didn’t realize it and they did nothing to change those misconceptions [4, 11, 7, 12]. Misconceptions caused by teachers’ learning method [13, 14, 15, 16], different teachers’ interpretation of the concepts [13, 17] and by the reference [18, 19, 13, 17].
Misconceptions of evolution’s concept identified as common-sense misconception, content-based misconception, nature of science-based misconception, non-scientific misconception and vernacular misconception [10]. Table 1 shows the characteristics of misconceptions’s kind which is found in this study.

| Kind of misconceptions            | Characteristics and descriptions                                                                 |
|-----------------------------------|--------------------------------------------------------------------------------------------------|
| Common-sense misconception        | The answer suggest reason by comparing 2 unequal evolution’s phenomena                           |
| Content-based misconception       | The answer is using uncorrect scientific term/ concepts about evolution but the students believe that the term/ concepts is the right concepts |
| Nature of science-based misconception | The answer is using sceptical-belief to the evolutions evidence                                   |
| Non-scientific misconception      | The answer is denying the scientific concepts using religious concept/ statement                |
| Vernacular misconception          | The answer is purposively exchange the terms because lack-understanding of evolutions’ terms    |

Concepts’ mastery and misconceptions can be measured by the Diagnostic Question Cluster (DQC) [20], type three-tier test [21, 22]. The DQC type three-tier test have 3 levels question, the first level was to identify the students understanding [20]. This first level question using a Bloom’s taxonomy revision from the C3 to C4 [21]. On the second level we identify the certainty degree. This certainty degree used as a cosideration about the concept mastery and the misconceptions. On the third level, we identify the misconceptions reasoning [10]. The three tier test reputed better to identify misconception than the two tier test [22]. This study explains the analysis of the concept’s mastery and the misconceptions about the evolution on biology major students.

2. Research Methodology
This study using a descriptive method. Descriptive method used to picture the situation [23], so we used this method to identify concepts’ mastery and misconceptions of biology major students who already attended the evolutions course in college. We purposively choose two universities in Bandung as the sample of this study and involved 20 biology major students from each university. Data collection conducted two times by using the DQC’s test, the second data collection conducted 4 weeks after the first test, so we can identify the consistency of the students’ answer. We also use interview as the second and complement data.

3. Result and Discussion
The DQC’s test type three-tier test result showed that each biology major students from two universities possessed different level of concepts’ mastery and misconceptions. As a simplification to comparing two universities, we use code A and code B to describe comparation of those two universities. Biology major students from university code A just passed evolution’s subject last semester, and biology major students with code B passed evolution’s subject for two semesters ago. Different semester from this universities did not caused a remembrance factor [24] [25], because we tested the concept mastery and understanding not the recitations.

On Table 2, we can see the comparation of the concepts mastery’s biology major students of two universities. Those data collected by DQC’s test from the first tier. First data collection shows that biology major students from university with code A has a highest percentage (21,75%) of concept mastery than the biology major students from university with code B (19,5%). Second data collection shows that biology major students from university with code B has a highest percentage (29%) of concept mastery than the biology major students from university with code A (19,3%). Based on interview data, those biology major students passed the evolution’s subject with high score from 85 to
From the DQC’s test, this two biology students still held low concept mastery (41.25% to 48.25%) of the evolution’s subjects from the first data collection. Although there’s a enhancement percentage of biology major students code B from the first data collection to second data collection, it doesn’t mean that the biology major students understanding the concept better on the second data [26]. The level of understanding and concepts’ mastery must fill three requirement, (a) there’s an alteration of the answer, (b) the subject can explain the alteration answer and (c) understand the key concepts [26]. From the interview data, 60% students remember the test’s question, so the alteration of the answer also caused by the memory of the question [25]. Alteration of the answer is a factor that caused this enhancement percentage.

| Table 2. Concepts’ mastery of the biology major students |
|----------------------------------------------------------|
| Code of the university | First data collection (%) | Second data collection (%) |
|------------------------|---------------------------|----------------------------|
| A                      | 21.75                     | 19.3                       |
| B                      | 19.5                      | 29                         |
| TOTAL                  | 41.25                     | 48.25                      |

The second tier from DQC’s test is measuring the certainty response of the first tier (concept mastery). In this tier, we asked students about their answer’s confidence. Certainty response help us to assessing students’ answer and determine which students is mastering the concept, not mastering the concept and misconception [27, 28]. Table 3 shows the certainty response of the right answer. First data collection shows that only 50% students that certain with their right answer, also there is 24.5% which is guessing the right answer and 8% students not certain with their right answer. Although there is 50% students choose the right answer with certain, but it doesn’t mean that those students did not possessed misconception [29].

| Table 3. Certainty response of the right answer |
|-----------------------------------------------|
| Sample of the university                      |
|                                              |
| First data collection (%)                     |
| Sure | Guess | Not sure | Sure | Guess | Not sure |
|-------|-------|----------|-------|-------|----------|
| A     | 45.5  | 6.5      | 1     | 33.5  | 9        |
| B     | 4.5   | 18       | 7     | 37    | 10.5     |
| TOTAL | 50    | 24.5     | 8     | 70.5  | 19.5     |

Based on the Table 3, the certainty response shows indicate that sample A has decreased percentage of the sure options’ answer (from 45.5% to 33.5%) and increased percentage of the guess and not sure options’ answer. Based on interview data, 60% of biology major students from the sample A did not remember the questions, they also thought that the second test was using another questions test. Those data indicate that the sample A had a low level of understanding and the concepts’ mastery. The sample B has increased percentage of the sure options’ answer and decreased percentage of the guess and not sure options’ answer. Based on interview data, 80% of biology major students from the sample B alternated their answer to the most-choosen answer. It is also indicate the low level of understanding and the concepts’ mastery.

The third tier of DQC’s test used to determine the kind of misconception which is held by the biology major students. Table 2 shows that the concepts’ mastery of the biology major students is on the low percentage, this low percentage indicated the low level of understanding about the evolutions’ subject and lead to misconception [26, 30]. And there’s a positive correlation between low level of understanding and misconception [31]. Based on the students’ answer from third tier of DQC’s test, this is the common answer of the student which is found by analyzing their answer. Common-sense misconception found when the subject believe that use and disuse theory immediately change the organism’s genotipe. The content-based misconception found when the subject using a mutation’s term to answer the use and disuse phenomena [32]. The nature of science-based misconception found when the subject believe that no evidence of the use and disuse theory in organism [2]. Non-scientific misconception and vernacular misconception found as unstable misconceptions, it found only on first
or the second data collection only. The non-scientific misconception found when the subject held religious conception and reject the scientific misconception, in this study we also found a local wisdom conception which is held by the students. Vernacular misconception found when the subject using scientific term out of the right scientific terms. Table 4 below shows percentage of misconception which is held by biology major students. Content-based misconception possessed the highest percentage of misconception, it caused by low level of understanding the concept whenever the students learn the concept. Vernacular misconception possessed the lowest percentage of misconception, it is caused by the failure understanding of the key concept. Non-scientific misconception possessed high percentage on other study [26, 16, 31, 33, 10], but in this study we only found 3.5% misconception on first data collection and 3.5% on second data collection from DQC’s test. There is dissimilarity data from the DQC’s data and the interview data about the non-scientific misconception. Most students denying the evolutions concept and believe that evolution is not a feasible explanation [34]. We also found that there’s students who believed that evolution never happen because God is created all thing perfectly. Those answer did not go out on the DQC’s test, the students explain that they need to answer scientifically on the test because the test asked for the scientific answer.

Table 4. Misconceptions in biology major students

| Kind of misconceptions                  | First data collection (%) | Second data collection (%) |
|----------------------------------------|---------------------------|----------------------------|
| Common-sense misconception             | 10.5                      | 10.75                      |
| Content-based misconception            | 27.25                     | 28.5                       |
| Nature of science-based misconception  | 15.5                      | 14.75                      |
| Non-scientific misconception           | 4.5                       | 2.75                       |
| Vernacular misconception               | 3.5                       | 3.5                        |
| TOTAL                                  | 61.25                     | 60.25                      |

Based on previous explanations, we merged the concepts’ mastery and misconceptions based on the evolutions’ subject. Table 5 shows the concepts’ mastery and misconceptions based on the evolutions subject. According to all subconcepts, the organic evolutions’ theory has the highest percentage of concepts’ mastery and the lowest percentage of misconceptions. It is indicated that higher level of understanding caused lower level of misconceptions. Based on organics evolutions’ theory, it has the highest average percentage of concepts’ mastery but also has the highest average percentage of misconceptions. Although there’s a positive correlation between concepts’ mastery and misconceptions, but rejection of evolution’s theory also caused misconceptions [16, 35, 36, 9, 37, 32, 38]. Evolutionary devices subconcepts has the lower percentage of concepts’ mastery and the higher percentage of misconceptions. Genetics variation subconcepts has the lowest percentage of concepts’ mastery and the highest percentage of misconceptions. Based on previous subconcepts, this subconcepts also positively correlated from the low level of concepts’ mastery to the high level of misconceptions.

Table 5. Concepts’ mastery and misconceptions based on evolutions’ subject

| Subconcepts                      | Concepts’ mastery | Misconceptions |
|----------------------------------|-------------------|----------------|
|                                  | First data collection (%) | Second data collection (%) | First data collection (%) | Second data collection (%) |
| Organics evolution’s theory:     |                   |                |                           |                            |
| Lamarck, Darwin, Neo-Darwinism   | 56.9              | 59.4           | 58.8                      | 52.5                       |
| Evolutionary devices: DNA, Genes, Chromosomes | 33.1           | 38.8           | 59.4                      | 66.3                       |
| Genetics variation               | 26.3              | 45             | 65                        | 71.3                       |
4. Conclusions
The low level of concepts’ mastery caused the misconceptions. Based on certainty response, the concepts’ mastery is also on the lowest percentage. It shows that biology major students apparently not mastering the concepts and the key concepts. Misconceptions found in a high percentage. It indicates that biology major students held wrong conceptions about evolution. Organisms evolution’s theory subconcepts held the highest percentage of concepts’ mastery and the lowest percentage of misconception. Genetics variation’s subconcepts held the lowest percentage of concept mastery and the highest percentage of misconception.

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