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THE CONCEPTUAL CHANGE ASSESSMENT BASED ON ESSAY QUESTIONS IN CASE STUDY OF DNA/RNA AND INTRON TOPICS

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Abstract

Most of the study on conceptual change was analysed using multiple-choice, true/false and true/false-reason type of questions. However, these questions are unable to reveal the variation in understanding of the university students. In this study, we developed a new conceptual change assessment based on essay questions. Here, student responses on DNA and intron term are presented as case studies in order to show the application of this assessment. The assessment is able to classify the various degree of understanding in university students such as construction, revision, complementation, static and disorientation. Our findings in university students studying DNA term showed that of 70 university students, 34% (construction), 36% (revision), 21% (complementation), 4% (static) and 5% (disorientation). On intron term finds construction (4%), revision (14%), static (44%) and disorientation (38%). Overall analysis using various categories of understanding reveals that DNA term is easier to understand by the university students than the intron term. This assessment is useful to evaluate the conceptual change level of university students in the class. Therefore, the assessment might also be useful to evaluate various teaching strategies and other topics.

Keywords: *conceptual change, essay, assessment, DNA, Intron*

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PENDAHULUAN

Conceptual change is a process of changing students' understanding from some initial knowledge into scientific understanding. Therefore, the process of characterizing conceptual change requires; (1) initial representation, (2) final representation and (3) specification of the learning process mechanism that has modified changes (Lappi, 2013). Conceptual change is built by two patterns of change that are similar to the Piaget concept, namely assimilation and accommodation. Assimilation is the use of previous concepts to adjust to new phenomena, while accommodation is a change or rearrangement of the core conceptions in students, this accommodation process involves freeing the previous conception and accepting the new conception so that it shows a sudden change. Conceptual change is also referred to as a process of changing previous conceptions from students to intermediate conceptions and ending with scientific conceptions. Posner et al., (1982) provide 4 (four) hypotheses which are important conditions for conceptual change which include; (1) dissatisfaction, (2) intelligible, (3) plausible, and (4) fruitfull. In the dissatisfaction condition, the student realizes that there are some inconsistencies so that his understanding cannot solve the problem. In the intelligible condition, university students learn to assimilate with their understanding. In plausible conditions, university students can accommodate new understanding with understanding the old. In fruitfull, conditions, that is, when making accommodations university students must have the desire to increase their understanding. Students have a variety of ways of thinking in specific domains (Driven et al., 1994).

Learning is the result of interaction between prior knowledge from learning with the concepts or ideas that are presented by illustrating the cognitive structure of university students who help in determining the learning process (Cakir et al., 2002). Previous student knowledge becomes an important role in the learning process. According to Vosniadou (2004) in Chi et al., 2008) there are three conditions that occur in the process of learning science. First university students may not have the initial knowledge (missing knowledge) so the learning process is the process of adding knowledge. Both university students already have a stock of knowledge but are still incomplete, so the learning process is a gap-filling process. Thirdly, university students 'knowledge experiences conflicts with daily experiences in school or in their environment so that university students' understanding is not in accordance with scientific rules or misconceptions. The process of acquiring learning in the third condition is conceptual change because in this condition learning is the process of changing the understanding of the previous concept into a scientific understanding. According to Lappi (2013) that the conceptual change experience can be observed as a process of transformation from some initial knowledge into final knowledge (having a new concept). Therefore, the process of characterizing conceptual change requires; (1) initial representation, (2) final representation and (3) specification of the learning process mechanism that has modified changes. This learning process causes university students to have concepts that they did not previously possess or know incorrectly.

In this study, an assessment method has been developed for the analysis of conceptual change in student responses based on essay questions. The results of the analysis of this method can identify the level of conceptual change of each individual and can assess the achievements of the learning process that has been done.

METHOD

This research is qualitative research involving 70 senior university students of Biology Education Study Program which programed Biotechnology Course. The study was conducted on June 2015. The conceptual change assessment method in this study is different from the method produced by McDonnald and Gomes (2013). In this study, the resulting assessment method can identify the level of understanding and achievement of the learning process based on the response categories achieved.

RESULT AND DISCUSSION

The conceptual change assessment that is commonly used is to use true/false, true/false types of questions with multiple reasons and choices. All types of questions used are the results of surveys in various schools and universities so that the questions used can explore all difficult concepts with various misconceptions contained therein, such as in Genetic Literacy Assessment (GLA), Genetic Concept Assessment (GCA), Biological Concept Inventory (BCI), Host-Pathogen Concept Inventory (HCI) and Inventory of Natural Selection (Tanner & Allan, 2005; Bowling et al., 2008, Marbach-Ad et al., 2009; Smith et al., 2008; Smith & Knight, 2010; Anderson, 2002).

According to Smith (2008), the types of questions are true/false, true/false with reason and multiple-choice can not explore the variation of understanding that exists in university students.

Hewsson (1992) conducted a conceptual change assessment by giving 3 (three) categories, namely extinction, exchange, and extension. Extinction is given for university students who are able to throw old understanding into a new understanding, the exchange is given for university students who are able to change their understanding into new understanding and extension is given for university students who are able to increase their understanding. Basically, every individual has a varied understanding scheme, so that the assessment of changes in understanding into 3 (three) categories above is still unable to assess the possibility of another level of conceptual change. Conceptual change assessment using essay type questions used by McDonnal & Gomes (2013). They do the conceptual change assessment by giving a score on the university students' answers, after that doing the quality identifier into 3 (three) categories, score 1, for answers B (blank), I (inaccurate), V (vague description); score 2 for answer L = limited definition, P = partially correct, N = novice language used (but otherwise, accurate). According to them the results of this assessment have not been able to provide an understanding grading assessment that occurs in university students. Based on the quality identifier above, it can be seen that in the assessment there is no difference in scores between university students who do not provide answers, wrong answers or vague answers, and likewise between university students who provide limited, partial, or accurate answers. The assessment is not able to assess the differences in answers between one category with other categories, so it can not indicate the variation of understanding that occurs in university students.

The stages of the conceptual change assessment process in this study include several stages;

(1) The Response Categories

The types of questions used as instruments in the pre-test and post-test are essay questions. This type of question can explore all variations of existing understanding in university students so that it will be able to accommodate the diversity of existing understanding. Response categories are carried out with the aim to summarize all variations of the answers in the pre-test and post-test university students and then grouped according to the level of the answer (Table 1).

Table 1. The Response Categories

Category	Description
***No response* (B)**	University students do not give any answers
***Incorrect* (IN)**	University students have alternative answers that are not in accordance with scientific principles
***Not complete* (NC)**	University students have incomplete answers
***Complete* (C)**	University students have correct and comprehensive answers

(2) The Classification of Conceptual Change Levels in University Students

According to Lappi (2013) that the conceptual change experience can be observed as a process of transformation from some initial knowledge into final knowledge (having a new concept). Therefore, the process of characterizing conceptual change requires; (1) initial representation, (2) final representation, and (3) specification of the learning process mechanism that has modified changes. This learning process causes university students to have concepts that they did not previously possess or know incorrectly. Therefore, changes in the level of student answers in the pre-test and post-test as a comparison of the results of the learning process in this study, then an analysis of the changes occurs. After experiencing the learning process, each student will have a different understanding of change. Changes in understanding that occur can result in an increase in understanding towards a better, no change in understanding or a change in understanding in a direction that is worse than the initial understanding (Table 2).

Table 2. Conceptual Change Levels

Level	Interpretation level
***Construction* (Co)**	University students are able to do knowledge construction
***Revision* (R)**	University students are able to revise their understanding
Complementation (Cp)	University students are able to integrate new knowledge with initial knowledge into comprehensive knowledge
Static (S)	University students can't change existing understanding into better understanding
Disorientation (D)	University students experience changes in understanding toward understanding that is worse than the initial understanding

(3) Validity through Interviews

The interview process is the final process carried out in this qualitative study which aims to obtain validation from university students involved in the conceptual change assessment process. Confirmation of the results of this research assessment was validated by conducting an interview process. To conduct this interview process, this research was conducted in accordance with the initial stages of data analysis until the end of the assessment process of learning process achievements that occur in each student.

Based on the assessment stages above, the results of the conceptual change research university students in this study are as follows:

1) DNA/RNA

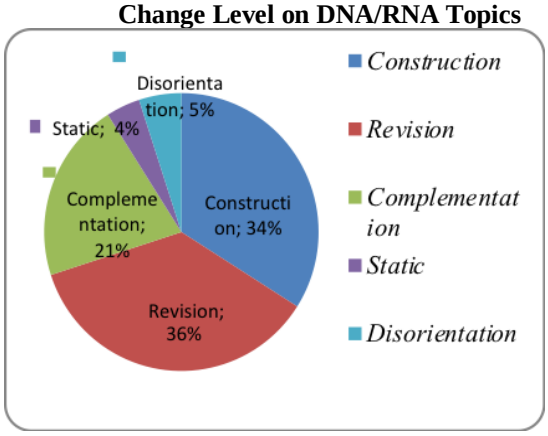
On this topic, university students were asked to draw a DNA double thread complete with base pairs and 3' and 5' end numbering. This question will be able to provide an illustration for us about university students' understanding of the basic concepts of complementary bases in DNA/RNA threads and the anti-parallel properties of DNA/RNA double threads. Pre-test and post-test results are presented in Table 3 below.

Table 3. Pre-test and Post-test Assessment Rubric (Topics of DNA/RNA)

Category	Pre-test (n)	%	Post-test (n)	%
No response University students don't write down any answers	1	1	0	0
Incorrect Translating every three bases of the genetic code in mRNA into an incorrect amino acid	29	1	9	12
Incomplete Translating every three bases of genetic code in mRNA into a correct amino acid but writing mRNA pairs with DNA version bases	8	1	0	0
Complete Translate each of the three genetic code bases in mRNA into a correct amino acid and write the mRNA pair with the RNA version bases	34	7	63	88

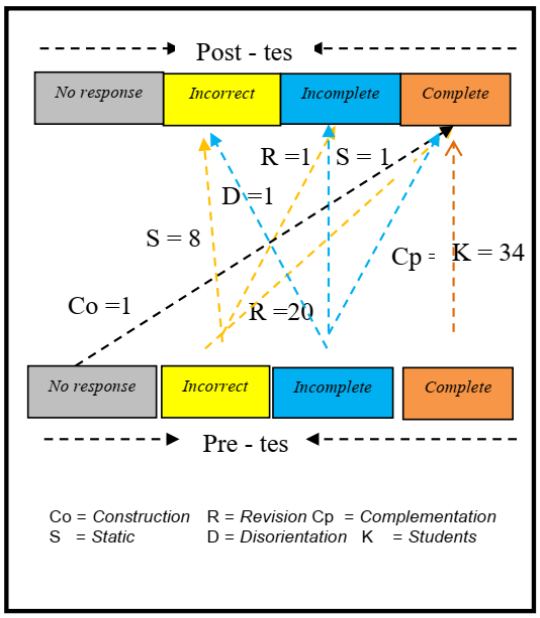
Based on the response categories above, university students' understanding of the topic of DNA (Figure 1).

Figure 1. University Students' Conceptual Change Level on DNA/RNA Topics



The achievement of the conceptual change level above is the result of a study of changes in the understanding of each student on the topic of DNA/RNA which can be described as follows:

Figure 2. Conceptual Change Analysis Process for Every University Student on DNA/RNA Topics



In Table 3 it can be seen the percentage of each level of conceptual change achieved by university students after going through the

learning process. The concept of DNA / RNA is a basic concept that must be understood by university students who are already at a high education level, bearing in mind that based on the 2013 curriculum that this concept had begun to be conveyed when they were in junior high school. However, the results of this study showed that only 47% had understood correctly. Twenty-nine percent of university students still understand the concept of DNA/RNA incorrectly. After experiencing the process of learning the picture changes the university students' understanding of the concept of DNA/RNA undergoes a very big change. We can see in Figure 2 it is known that there are 29% revised the understanding that initially wrong to be in accordance with scientific rules.

2) INTRON

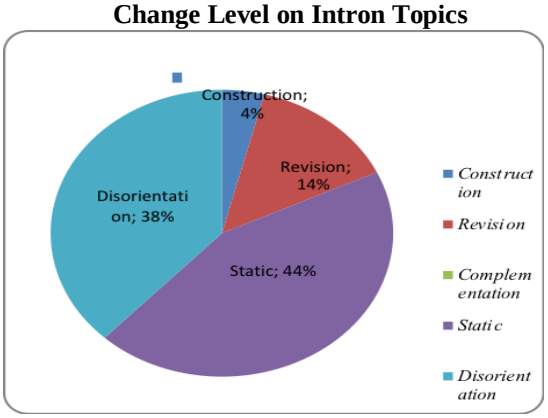
On this topic, university students are asked to explain about intron. This question can describe university students' understanding of intron and their position in DNA sequences especially genes. Pre-test and post-test results are presented in Table 4 below.

Table 4. Pre-test and Post-test Assessment Rubric (Topics of Intron)

Category	Pre-test (n)	%	Post-test (n)	%
No response Students do not write down any answers	4	6	0	0
Incorrect				
a. The intron is a sequence with no pairs	0	0	2	3
b. Intron as an area that is not blocked	2	3	7	10
c. Intron as an area that is not removed during the splicing process	22	31	3	4
d. Intron as a coding sequences	0	0	6	9
e. Intron as shaded area/block	0	0	8	11
Incomplete				
a. Intron as a non-coding sequences	11	15	0	0
b. Intron as a sequence that is discarded during the splicing process	25	35	3	4
c. The intron is a sequence found in the structure of eukaryotic genes	7	10	42	59
Complete The intron is a non-coding region contained in the structure of genes (pre-mRNA) which will be removed in the splicing process to form mRNA. This intron sequence can function as a regional regulator or is an area whose function is unknown	0	0	0	0

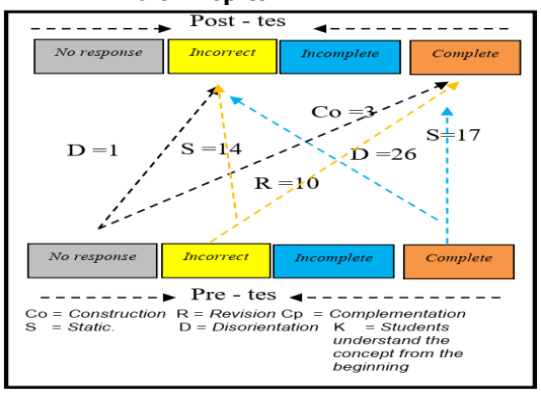
Based on the conceptual change level category of the assessment method of this study, it is obtained the level of understanding of intron concepts with various levels as shown in Figure 3.

Figure 3. University Students' Conceptual Change Level on Intron Topics



The achievements of the conceptual change level above are the results of a study of changes in the understanding of each student on the topic of intron which can be described as follows:

Figure 4. Conceptual Change Analysis Process for Every University Student on Intron Topics

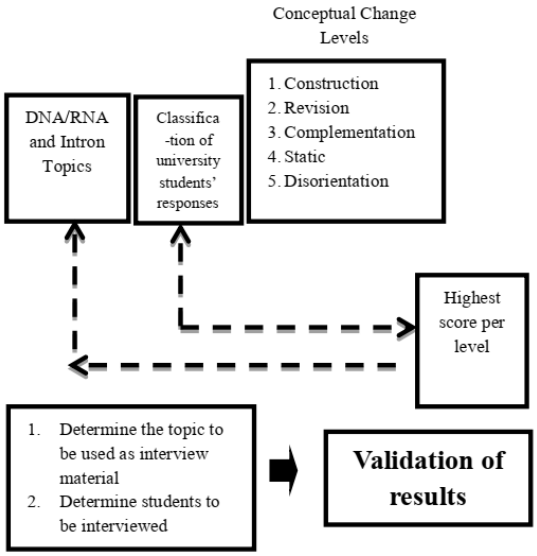


Based on the results of the pre-test showed that only 43% of university students had understood the concept of intron partially and none of the university students had understood the concept of intron completely. Even though the concept of the intron is part of learning in genetic subjects at the junior and senior high school level, but only at a glance, this concept is given to university students.

The conceptual change level of university students on the topic of intron experienced a big change, 38% of university students experienced disorientation (confusion) in their understanding, about 44% of university students did not experience a change of understanding, 14% of university students revised the initial wrong understanding and 4% of university students did an understanding construction to better direction scientifically.

To validate each level of conceptual change achieved by each of the university students above, we validate it by conducting an interview process. We took one student from each level to confirm the level of achievement change in understanding. The flowchart to determine which university students will be used as respondents in the interview (Figure 5).

Figure 5. Flowchart for Validating Performance Levels



Validation of results through interviews is the most important stage of this method, so we can get clear confirmation of the level of achievement each student has achieved.

CONCLUSION

The issue of how to do qualitative data analysis is still thought for every educator and researcher because there are several possibilities to be able to understand the phenomena experienced by university students. The results of this study have been able to develop student conceptual change assessment methods based on essay questions. This assessment method can identify possible variations in understanding changes in each student, diagnose learning experiences that have been experienced before and assess the achievements of learning outcomes that have been done. This method can also assess the level of conceptual change of each student and the learning process in general. The interview is the last set of methods to validate each level of achievement.

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