The assessment of understanding biological concepts: a systematic review

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Abstract. Assessment is one of the most important components in learning strategies are used to improve student learning and achievement check. The purpose of writing this article is to determine the types of assessment on the understanding of the concept of biological material, material characteristics, and influences assessment of the understanding of biological concepts. This article discusses the 20 articles published in international journals from 2004 to 2019. The article analyzed the author obtained from database 6, which is Google Scholars, ScienceDirect, CBE, and Taylor & Francis. The analysis showed that the assessment is used to determine the understanding of biological concepts, are the concept of inventory, diagnostic tests, molecular and cell biology assessment, measuring of understanding macroevolution, genetic concept assessment, Gen-bio MAPS, biology core concept and multiple-choice instrument with a drawing activity. Forms of matter used in the form of multiple-choice, multiple-choice T/F, and an open-ended question. Topics to be used in the assessment of understanding the concept, are Plantae, genetics, molecular biology, evolution, microbiology, and photosynthesis. The assessment has used the positive and negative impact on the understanding of biological concepts.

1. Introduction

Biology is one of the science branches that study living beings. Biology has a broad range of material, diverse and unstructured. Coverage of complex material, linkage with various sciences, and the mechanism of the process can not be seen to directly target the biological difficult to learn and be taught[10]. Therefore, it requires a good understanding of the concept of understanding the biological material.

Understanding the concept refers to grasp abstract concepts, main principles, and the relationship between the principle [17,25]. One of the most important components in understanding the concept is the beginning of knowledge which affects the processing of new information in the understanding of scientific concepts [12]. If the initial knowledge following the scientific concept or free misconception that new information can be accepted easily by students [2].

The process of adjustment of prior knowledge to new knowledge sometimes the difference or discrepancy with scientific knowledge [18]. The discrepancy of students’ knowledge with scientific
knowledge will form a knowledge/alternative concepts in the concept of thinking of students. Alternative concepts will obstruct the process of the construction of new knowledge and make no meaningful learning [9,35]. The concept is at odds with scientific knowledge is called misconceptions. The misconception is stable to prevent a change in concept, but it also can make the barriers to re-construct knowledge[37]. Therefore, the need for assessment and identification of misconceptions students before or after learning so that learning can be efficiently[18].

Assessment of understanding of the concept needs to be done to determine the level of students' understanding of scientific concepts. Besides, an assessment of understanding the concept can be used to determine the student's difficulties in understanding the material and rectify misconceptions occur. A good understanding of the concept characterized by the ability to relate new information with the information they already have used to solve a problem [29]. Understanding the concept of a low marked by the lack of use of scientific concepts in solving the problem, as shown by the many students who answered questions correctly than to answer interview questions involving the scientific concept so that it can be said that the students were only given formulas and processes involved without understanding the concept of scientific[34]. The triggering factors of the lack of understanding of concepts are the lack of provision of practice in learning so that students are not accustomed to linking new knowledge with old knowledge and difficulty sorting out the necessary knowledge to solve problems [28].

Assessment is one of the most important components in the learning process. The purpose of the assessment is to evaluate the teaching and learning activities and determine the learning strategies to reduce the difficulty of students to understand the learning[39]. Assessment is an integral part of the learning process that is done when the learning process is not at the end of the lesson. Assessment of learning includes the interaction between teachers and students and students with students, questions and answers, structured classroom activities, and feedback is used to help students understand difficult concepts[21].

Application of assessment in learning much oriented to the scores/grades obtained by students at the end of the learning that has not been by the purpose of assessing the real. Along with development technology, it should be oriented towards the development assessment and metacognition assessment to improve the quality of teaching in schools [40]. The study of the literature on the biological understanding of the concept of assessment has not been done so that the authors conducted a study to determine the application assessment literature that has been done in measuring understanding concepts and is used to conduct further research. The study examines existing literature student misconceptions and the use of diagnostic tests in IPA [33]. The study examines the literature conducted on misconceptions that commonly occur in students and the use of diagnostic tests to determine the misconceptions in biology, physics, and chemistry.

This article has the objective to identify the use of assessment as a means of measuring biological learning and knowing the use of assessment of student understanding of concepts. The problems of writing this article, are: (1) how to use assessments that have been used to measure the understanding of biological concepts? (2) how the characteristics of the topics/materials assessment understanding of the concept? (3) how to influence the assessment used to the understanding of biological concepts students?

2. Experimental Method
This review article is to review research on the assessment used to measure the understanding of concepts in biology learning that was published in the year 2004 to 2019. The method of selection of articles using the PRISMA approach by Moher (2009) can be seen in Fig. 1. Articles acquired through several databases are Google Scholar, ScienceDirect, CBE-life sciences education, and Taylor & Francis. Search articles focused on using the keyword "assessment" "conceptual understanding" and "biology concept".

Results of some of the database search found 126 articles, then performed the analysis of the general text of the abstract, the content of biological material, the use of assessment and understanding of the concept. The results of the analysis, in general, there are 35 articles were then analyzed further to see the relevance of the content and results of the study. The results of the content analysis of 20 articles that were analyzed contained more. Analysis of articles focused on the use of assessment, assessment development, a concept that is measured, and the influence assessment of the understanding of the
concept. The result of the analysis is then used as preparation materials systematic review of the assessment used to measure the understanding of biological concepts.

![Flow Diagram](image_url)

**Figure 1.** Flow diagram of the review process

3. Result and Discussion

3.1. Assessment understanding of the concept

Based on the content analysis of the assessment data obtained were used to measure the understanding of biological concepts include diagnostic tests (two-tier, three-tier, and four-tier), concept inventory, and other assessments. The use of diagnostic tests starting in 2004-2019, a diagnostic test used ranging from two-tier to four-tier. There are 6 articles discuss the application of diagnostic tests to measure the understanding of biological concepts [4,11,19,27,30,31]. Diagnostic tests provide information about students' mastery of knowledge and misconceptions of the material[7]. Therefore, a diagnostic test used to identify the strengths and weaknesses of students in the learning materials [41]. Use of the concept inventory assessment starting in 2009-2019, inventory concept is an instrument of multiple-choice questions designed to measure students' understanding of the concept[11]. Besides, the application of inventory concept to determine the effectiveness of learning strategies to improve alternative concepts or misconceptions[22]. There are 4 articles that discuss the concept of application inventory to measure the understanding of the concept[1,6,20,23]. There are 10 articles that use other assessments. Additional assessments were used that, genetics concept assessment, measuring of understanding macroevolution, molecular cell assessment, genBio MAPS, and the biology core concept of the instrument, Another assessment used to measure the understanding of the concept of loading the questions to specific material. The use of an assessment understanding of the concept can be seen in Figure 2.
Form of matter which is used, that of multiple-choice, multiple-choice true/false, and open-ended question. Assessment of understanding of the concept that has been used predominately uses a form of multiple-choice questions, there are 18 articles, multiple-choice T / F there are two articles, and the open-ended question contained five articles. Concept inventory assessment and diagnostic tests using a form of multiple-choice questions. Multiple-choice questions using a 4-5 choice answers compiled based on interviews with students. The use of multiple-choice question form has several advantages are easy to make an assessment, it can be used on a large scale, and gives the effect of increasing student performance[8]. The open-ended question used asks students to explain concepts to be measured. The use of open-ended questions has advantages are to find a response directly from the students to minimize bias arising from student responses. Also, the open-ended question has flaws that require extensive coding related to the students' responses [24].

3.2. The material characteristics

Based on the analysis of literature, some subjects are used to measure students' understanding of the concept. Topics to be used are Plantae, Genetics, Molecular Biology, Evolution, Microbiology, and Photosynthesis. The analysis showed that the topic of Molecular Biology frequently used, there are 8 articles. Topics include the concept of molecular biology molecular transfer process, energy, organelle structure and function in living cells. Topics Plantae there are two articles, including the concept of flowering plant reproduction, development and growth mechanisms, nutrients in plants, and the high level of plant classification. Topics genetics there is 4 article, includes the concept of cell reproduction, cell division, and the alternation of generations. Topics evolution there is 4 article, includes the concept of the process of mutation of genetic information, genetic drift, and changes in the gene variation due to natural selection. Topics microbiology there are two articles, including the concept of microbial structure characteristics, response to antibiotics, the infection of the host, microbial metabolism, microbial response to environmental and specific immune response. Photosynthesis topics are 1 article, includes the concept of photosynthesis mechanism. Distribution measurement topics students' understanding of the concept can be seen in Figure 3.
Several reasons could be given relevant interest in the concept measured, that topic is abstract (for example virus, cell, genetic material), dynamic or explain the process (for example cellular respiration, osmosis, diffusion, mutation, cell division, cell reproduction, displacement of molecules, the process of growth and development, the process of evolution), it is difficult to visualize in real life (for example molecular biology, virus, gene flow), and interdisciplinary science (for example the movement of molecules).

3.3. Influence assessment of the understanding of the concept
Based on the analysis of the journal, the assessment used to measure the understanding of the concept of the biological material either type of diagnostic test, inventory and assessment concept to another. In addition, the instruments used can be to identify misconceptions about the concept of biology. level the effectiveness of the instruments used is done by measuring the distinguishing item, about the difficulty level, and reliability problems.

Some research indicates that assessment has been used positively affect the understanding of biological concepts. Application of a two-tier assessment multiple choice on material growth and development of flowering plants in the 10-11 class shows the results of 75% understood the concept and identified 19 misconceptions, these assessments provide a positive influence on students’ understanding of the concept[10]. In addition, the three-tier diagnostic tests on the materials have a reliability level of 0.86 respiration so that the instrument can be to measure student understanding of concepts and applied online assessment to provide benefits to students and faculty[27]. Assessment understanding of the concept by presenting the image a positive influence on students’ understanding of the genetic material, the results showed the experimental class average grades higher than the control class[26]. In addition, the application of the assessment MUM provides effective results, consistent, and accurate way to measure students' understanding of the concept of matter macroevolution. It can be seen from the level of reliability and validity of 0.86 0.85[15]. Assessment of the genetic concept provides a positive correlation to the understanding of the concept of student-related genetic material seen from the mean score [30]. Concept inventory assessment implementation is a positive influence on the understanding of the concept[1,6,20,23]. In addition, there is some positive effect on the assessment of students’ understanding of the concept [3,5,16,36].

Application of a two-tier assessment on material diffusion and osmosis show <75% level of student understanding that the said related knowledge diffusion and osmosis process is not optimal [18]. In addition, the application of the assessment at a high level of plant material shows that the students' understanding of the concept of 10.5%; do not understand the concept of 45.6%; and misconceptions 29.4% so that it can be said that the students' understanding of concepts related to higher plants is still low [4].

![Figure 3](image_url)

Figure 3. Distribution graphs topics on understanding the concept of student
Based on the above findings of the assessment in the form of diagnostic testing, concept inventory, and other assessments could effectively be used as an alternative assessment instrument for the understanding of biological concepts. In addition, an assessment that is used can be used to determine the student's difficulties in understanding the concepts and detect misconceptions[4,10].

4. Conclusion

The assessment instrument in the form of diagnostic testing, inventory concept, multiple-choice with a drawing, measuring understanding of macroevolution, genetics concept assessment, genBio MAPS, and biology core concept can be used as an alternative assessment to measure the understanding of the concept in biological materials. The instrument has been used to give a positive and negative effect to the understanding of biological concepts. The use of assessment instruments used on the material that has the characteristics of an abstract, complex, and dynamic so that it requires specific instruments to measure the understanding of biological concepts.

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