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Improving The Prospective Biology Teachers' Understanding by Applying Formative Assessment in the Stages of Understanding by Design Learning

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Abstract

The purpose of learning is to change behavior with one of the indicators is increasing thinking skills such as understanding, which includes explaining, interpreting, applying, having perspective, having empathy, and having self-knowledge. The problem we found today is that assessment and learning have not fully promoted understanding. Given the importance of understanding for students, it is necessary to make efforts through integrating assessments into learning. In this research, the integration of formative assessment into understanding by design learning aims to develop students' understanding of the concepts of Plant Physiology. The instruments in this study were comprehension questions and observation sheets for formative assessment strategies of discussions, mind mapping, presentations and practicum. The results of the study concluded that the integration of formative assessment into understanding by design learning was able to develop students' understanding.

Introduction

21st century learning experiences a paradigm shift marked by changes in the subject of learning activities. Learning becomes student centered instead of previously teacher centered. This means the potential of students receive more attention. Various skills are needed, both hard and soft skills. In addition, the rapid development of technology and increasingly intense competition in the global era makes the problems faced by students more and more complicated.

The general purpose of learning is to change behavior, and one of the indicators is to have thinking and understanding skills. The criteria for someone to have a good understanding according to Wiggins & McTighe (2012) is that he/she has the skills to explain, interpret, apply, have perspective, empathy and self-knowledge. Facts obtained from several studies show that students' thinking and understanding skills are still classified as low. Students are not proficient in discovering and understanding the basic principles of science, especially in concepts related to metabolism in plants (Lynd-Balta, 2006; Wilson, 2006). Gloria et al.'s research. (2017) found the results of an analysis of students' understanding in Plant Physiology concepts still included in the low criteria. Research by Muspikawijaya et al., (2017) found that students' understanding of the concepts in cell metabolism was still low, while (Sipayung & Simanjuntak, 2022; Samaduri, 2022), found that on average students had difficulty understanding the concepts of plantae.

One of the problems that cause lack of students' understanding is errors in learning and giving assessments. Fencl (2010) found that most of the teachers in tertiary institutions tend to provide broad material to students.

Research by Smith et al. (2008) and Gotwals & Songer (2009) found that teachers only prioritize the final results or the grades of learning outcomes, so they tend to focus more on providing material. Meanwhile, Ronis' research (2011) states that currently many standard tests or summative tests in several exams are not valid, not reliable, and not consistent. Learning should lead to the improvement in students' thinking skills, and this also applies to the tests developed (Kelly et al., 2009).

Based on the problems above, solutions and ways to increase understanding are needed, one of which is through the learning process with formative assessments. Learning with formative assessment can provide concrete experiences, for example through discussions, presentations, questions and answers, and doing assignments, so that formative assessment is more contextual and leads to the development of thinking skills (Johnson, 2014; Rusman, 2014). Cognitive tasks given during the application of formative assessments will train students' skills in solving problems (Moulds, 2006). Formative assessment, one of which is feedback, can motivate students so that they can learn at ease (Kalfsvel, et al., 2023). According to Kusairi et al. (2017) formative assessment can help students master and better understand a concept. Ronis (2011) stated that the activities that occur in formative assessment show internal processing of student information, development of student understanding, interaction among students, discussions and expressing ideas. Formative assessment can provide space and opportunities for students to build their knowledge. According to Wiggins & McTighe (2012) activities in learning must be able to distinguish between lessons that are only interesting and learning that is truly effective. Janssen et al. (2009) and Fry et al. (2009) stated that learning should encourage the development of student's understanding such as explaining, interpreting, applying, and having perspective.

Formative assessment can be an alternative way to train and encourage students to acquire various thinking skills, however, an effective learning design is needed and can be integrated with formative assessment. One of the effective and sophisticated learning designs is Understanding by Design (UbD) from Wiggins & McTighe (2012). In this study we incorporate formative assessment into a learning design that use the UbD stages. The tasks carried out in learning that

use formative assessment in the UbD learning stages will encourage students to master the six facets of understanding. The feedback will train the development of explaining, interpretation, and application while self-assessment and peer assessment will train students' perspective, empathy, and self-knowledge, so that choosing the right learning approach is the main goal, namely focusing on achieving understanding. Therefore the purpose of this study is to analyze the development of understanding through the integration of formative assessments into the learning stages of Understanding by Design. The novelty in this research is integrating formative assessment into Understanding by Design learning.

Methods

This is a quantitative research, with a quasi-experimental method. The sample in this study were 6th semester students, totaling 32 people from a population of 145. The process of developing understanding is carried out for one semester, namely 16 theoretical meetings and 8 practicum meetings.

Learning with UbD stages are: 1) identifying the desired results, 2) determining learning evidence, 3) designing learning experiences and instructions. Formative assessments are integrated into the second and third stages, while evidence of learning is in the form of mind map assignment scores, presentations and practicum reports.

The research instrument was a formative assessment rubric with comprehension indicators by Wiggins & McTighe (2012). The formative assessment strategies applied to develop understanding are presentation assignments, mind mapping, practicum reports, and self-knowledge tests. Understanding of the presentation task is assessed in 2 facets, namely explaining and interpreting. Understanding of the mind map task is assessed for 4 facets namely, explaining, interpretation, application, and perspective, while the understanding value for self-knowledge is obtained through a self-knowledge test. For practicum assignments the facets of understanding that are assessed are explaining, interpreting, applying, perspective, and empathy. Grades are taken from practicum reports. The measured understanding of students was observed in each lecture topic, namely the Topic of Biophysics, Biochemistry, and Bio growth.

The development of increased understanding of explaining was seen based on the results of assessments on formative assessment strategies in the form of presentations, mind maps, and practicum reports, which were carried out on learning each topic of Plant Physiology during 12 theoretical lectures and 5 practicum sessions.

The development of understanding of interpretation is seen from the results of the assessment on the formative assessment strategy in the form of presentations, mind maps, and practicum reports, which were carried out when learning each topic of Plant Physiology.

Development of understanding of the application based on the results of the assessment on a formative assessment strategy in the form of mind map and practicum report, which were carried out on each topic of Plant Physiology, which applies the integration of formative assessment through the stages of UbD learning.

The development of perspective is obtained from the results of perspective understanding assessments on formative assessment strategies in the form of mind maps and practicum reports, which were carried out on each Plant Physiology Topic by implementing formative assessment integration into the UbD learning stages.

The development of empathy is seen from the results of the assessment on understanding empathy in the formative assessment strategy in the form of a practicum report, which was carried out on each Plant Physiology Topic by implementing the integration of formative assessment into the stages of UbD learning.

Understanding the formative assessment strategy used to develop students' self-knowledge is in the form of a self-knowledge test. Self-knowledge tests were given on each topic which were carried out after learning is finished, so that each student will get three opportunities to take self-knowledge tests, namely Biophysics, Biochemistry, and Bio-growth Topics. To be able to assess the understanding of self-knowledge, 5 indicators were used which are described from understanding self-knowledge. The result of the assessment is a qualitative value which is converted into a quantitative value.

The five indicators of the self-knowledge test consist of, 1) clearly recognizing and knowing the topic of Plant Physiology being studied, 2) being able to explain and describe the topic of Plant Physiology that has been studied, 3) knowing the benefits for oneself after studying the topic of Plant Physiology, 4) being able to mentioning the benefits for others regarding the topic of Plant Physiology that has been studied, 5) knowing clearly and being aware of one's own weaknesses and strengths when studying the topic of Plant Physiology.

Result And Discussion

The results of research on the development of students' understanding through formative assessment in the UbD stages are presented in Figure 1. Understanding is formed on each lecture topic, namely the topics of biophysics, biochemistry and bio-growth. The six facets of understanding developed can be seen through the increasing value of each facet of understanding from the topic of Biophysics to the topic of Biochemistry and then to the topic of Biogrowth. Almost all facets of understanding experienced an increase, the highest in the perspective aspect, namely from Biophysics Topics to Biochemistry Topics increased by 33%, while the lowest was in the interpretation facet, namely Biophysics Topics to Biochemistry Topics increased by 0.03%.

The development of understanding that has the highest score is in the facet of application with an average value of 87, included in the very good criteria, while the lowest is in the empathy with an average value of 63, included in the good criteria. This shows that in general the integration of formative assessments in the stages of UbD learning is effective in developing and increasing students' understanding, which consists of explaining, interpretation, application, perspective, empathy, and self-knowledge.

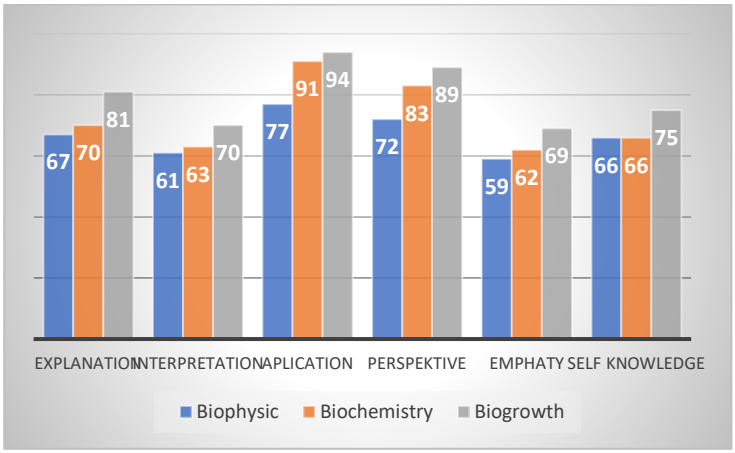

Figure 1. Student Understanding During the Learning Process

The increase in the value of understanding from biophysics to the topic of Biochemistry is closely related to the application of formative assessment in the learning process, therefore it is necessary to discuss how to increase the value of understanding in each formative assessment strategy applied.

The first, namely the understanding of explaining, experienced an increase in each application of the formative assessment strategy, except for the presentation where the value of understanding explaining decreased from the Topic of Biophysics to the Topic of Biochemistry, but increased again on the Topic of Biogrowth. The mean score for understanding explaining is generally included in the good criteria, except for writing practicum reports. For the Topic of Biogrowth the value for understanding explaining is included in the very good criteria.

Formative assessment in the form of presentation assignments is able to train students to have an understanding of explaining because during presentations students will be required to make good and complete explanations, especially after receiving criticism and suggestions from colleagues. The dissatisfaction of colleagues at the time of the presentation encouraged the students who made the presentation to try to make a complete and in-depth explanation of the concept. Presentations train students' thinking skills to be more critical. Besides that presentations train students to be independent. The results of Mitasari and Prasetiyo's research (2016) found that discussions and presentations combined with article analysis through lesson study can improve conceptual understanding, critical thinking skills, and communication.

The second formative assessment strategy, namely the task of making a mind map, experienced increased development and proved that mind maps can develop the facet of explaining. The mind map assignment provides an opportunity for students to try to provide an explanation of the concept being discussed, so that understanding of explaining increases. Increased understanding of explaining shows an increase in thinking ability. Several studies have proven that mind maps can increase creativity and thinking skills (Keles, 2012). Besides that mind maps can improve students' cognitive structure and have an effect on improving learning outcomes (Wijayanti, at al., 2017). This study proves that the average value of understanding the mind map has increased from the first to the third topic.

The third strategy in developing understanding of explaining is writing a practicum report. Understanding of explaining is developed when students try to write a practicum report which is done five times. Making a practicum report trains students to try to describe what must be explained and interpreted in relation to the practicum they are undertaking, especially at the discussion writing stage. The task of writing practicum reports improves students' creative thinking skills because students try to relate their various knowledge to discuss problems in practicum. One indicator of creative thinking is having the ability to express ideas and being free to express opinions (Sulistiarmi, 2016).

The results of this study also prove that a formative assessment strategy in the form of practicum which includes writing practicum reports can develop understanding of explaining. Research by Muamar & Rahmi (2017) proves that the practicum method has a positive effect on science process skills and learning outcomes, this is closely related to increased understanding.

The second is the establishment of understanding of interpretation. This understanding increases on every topic of Plant Physiology. The average value of understanding interpretation increased from the Topic of Biophysics to the Topic of Biochemistry and then to the Topic of Biogrowth, the lowest score was on the Topic of Biophysics, and the highest was obtained on the Topic of Biogrowth.

In general, there is an increase in understanding of interpretation on each topic, this proves that there is a development in the understanding of interpretation in integrating formative assessments in the stages of UbD learning. The increase in understanding mainly occurred in the formative assessment strategy in the form of presentations and mind maps and practicum reports. The facet of interpretation has developed and increased on each topic. The Biophysics Topic has the lowest average score, while the highest score is obtained on the Bio-growth Topic. The

Biophysics Topic has a lower average score because the Biophysics Topic is the first topic given, so that the formative assessment strategy has not been repeated, whereas for the Bio-growth Topic the formative assessment strategy has been carried out repeatedly. This shows that there has been an increase in the interpretation of each formative assessment strategy applied. Presentations and mind maps are able to develop more effective understanding of interpretation. Presentations encourage students to interpret material and when there are questions from other students, while mind maps encourage students to find ways to explain concepts on each topic in various ways through pictures or illustrations used in the mind map. Mind maps can increase creativity and thinking skills (Keles, 2012).

The third understanding is the application, and this understanding is formed through a formative assessment strategy in the form of a mind map and practicum report. The understanding of the application has developed in each Plant Physiology topic, where the average value of understanding the application has increased from one topic to another. There is an increase from one topic to the next, indicating progress on each topic. The development of application occurs in every formative assessment strategy applied. Mind maps train students to apply concepts they already understand, namely when students try to convey their ideas through pictures and arrows that connect between concepts. Putri's research (2016) shows that mid-maps can improve students' creative abilities. This creative ability can be demonstrated by understanding of the application. Another study, namely Diki (2013), states that there is a close relationship regarding the success of students in learning natural sciences with the creativity of students that are formed.

The fourth understanding developed in this study is perspective. Perspective development occurs in each topic, increasing from the Topic of Biophysics to the Topic of Biochemistry, and to the Topic of Bio growth. Perspectives are developed through the application of formative assessment strategies in the form of mind maps and practicum reports. This shows that the mind map task succeeded in shaping student perspectives. Students are trained to be more critical when making a mind map that is appropriate to the topic being studied, students are able to make connections between ideas that can be understood in the concept. The results of this study are related to the results of other studies, including the results of research by Keles (2012) stating that mind maps can increase creativity and thinking skills to be more critical. Besides that mind maps can improve students' cognitive structure and have an effect on improving learning outcomes (Wijayanti, at al., 2017). Other research related to mind maps gives positive results on thinking skills. Research by Mardiana (2016) shows that the mind map task can increase student creativity and learning outcomes. Research Adhitama, at al. (2015) found that mind mapping worksheet-assisted learning provides an opportunity to construct knowledge and makes it easier to understand concepts. The results of some of these studies reinforce the effect that occurs when students do the task of making a mind map, this is also closely related to the development of perspective skills occurred in this study.

Development of the fifth facet of understanding is empathy. The formative assessment strategy applied to develop empathic understanding is in the form of practicum reports made for each practicum, namely five practicum reports. The task of making a practicum report at the point of giving advice on practicum activities trains students' understanding of empathy. The understanding of empathy has developed from topic to topic. Empathic understanding is developed through a formative assessment strategy of practicum reports.

The development of the sixth facet of understanding is the self-knowledge. The understanding of self-knowledge has developed, namely from the Topic of Biophysics to the Topic of Bio-growth which has increased by 14%. Self-knowledge tests encourage students to assess themselves, and by working on these questions students are encouraged to try to find out what material they have learned and have understood. Students know and are aware of what topics

they find difficult, and they also know their own shortcomings which hinders understanding of the topic being studied. The process of understanding occurs when there is something that leads to oneself, or self-understanding (Gadamer, 1994). Research A'izzah at al. (2017), self-assessment allows students to measure their strengths and weaknesses.

Based on the results of research on understanding self-knowledge among students, it varies on each topic of Plant Physiology. The Biophysics topic had the highest average score, while the Bio-growth topic had the lowest average score. The data shows that the self-knowledge test questions did not increase students' self-knowledge from one topic to the others, the value of self-knowledge decreased from the Topic of Biophysics to the Topic of Bio-growth.

The self-knowledge test can explore the potential in students so that students know clearly the concepts on the topic of Plant Physiology being studied. They can explain and describe the topic of Plant Physiology that has been studied, know the benefits for themselves after studying the topic of Plant Physiology, can mention the benefits for other people regarding the topic of Plant Physiology that has been studied, and knowing the weaknesses and strengths that one has when studying the topic of Plant Physiology. Gadamer (1994) says that understanding occurs when there is something that leads to oneself, or self-understanding.

To find out more about the development of each facet of understanding, see Figure 2.

The development of understanding that has the highest value is in the application aspect, included in the very good criteria, while the lowest is in the empathy facet which is included in the good criteria. This shows that in general the integration of formative assessments in the stages of UbD learning is effective in developing and increasing student understanding, which consists of explanation, interpretation, application, perspective, empathy, and self-knowledge.

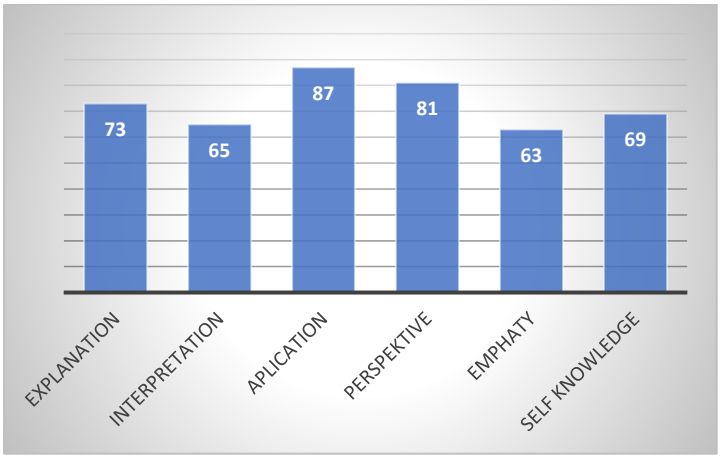

Figure 2. Understanding Value in Each Facet

The graph in Figure 2 generally illustrates the development of understanding through integrating formative assessments in the UbD learning stages. Facets of understanding application and perspective have respective values of 87 and 81, both of which are included in the very good criteria. Facets of explaining, interpretation, empathy, and self-knowledge have values that are included in the good criteria.

In general, the formative assessment strategies given during learning activities have developed students' understanding. The development of understanding is not only due to the implementation of a suitable formative assessment strategy because it is determined in the stages of UBD learning, it is also influenced by the existence of a formative assessment component that is implemented in an integrated manner during the learning activities. The formative assessment

component develops student understanding, and the successful implementation of formative assessment has been proven by several studies (Torrance & Pryor, 2002; Hall & Burke, 2004; Furtak & Ruiz-Primo, 2008; McManus, 2008; Saptono, 2013).

Conclusion

From the results of the research and discussion, several conclusions are obtained which answer the formulation of the problem and research objectives. Integrating formative assessment in UbD learning can develop students' understanding of Plant Physiology concepts, namely the concepts of biophysics, biochemistry and bio-growth. Understanding can be built up during the learning process so that it is developed gradually. The development of understanding can be seen from the increase in six facets of understanding during the learning process which integrates formative assessment into UbD. The facets of applications and perspectives have a high average score, while the facets of explaining, interpreting, and empathy have a moderate average score.

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