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Applying Formative Assessment through Understanding by Design (UbD) in the Lecture of Plant Physiology to Improve the Prospective Teacher Education Students' Understanding

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ABSTRACT

One of the successes of learning is the formation of thinking skills and understanding. Therefore in this study the formative assessment is implemented through Understanding by Design (UbD). The research objective is to find out the formation of understanding and to analyze the correlation between formative assessments and UbD. The study used quantitative method with a quasi-experimental design. Formative assessment strategies used were presentations, discussions, practicum learning, mind-mapping, and analyzing articles. The results of the study found that there was a significant increase in understanding after the implementation of formative assessment through UbD and a positive correlation between formative assessment and understanding. Formative assessment integrated into UbD is the originality of this research.

Keywords: Formative assessment, understanding.

INTRODUCTION

The tight competition in the global era requires students to have various skills and high understanding. This is especially true for prospective teachers who have a specific task of transferring knowledge. Crowe, Dirks and Wenderoth (2008), say "the essence of science education reform is the shifting of learning objectives, from lower order thinking skills to higher order thinking skills, one of them is understanding". Wiggins and McTighe (2011), give indicators of understanding as the capacity to explain, interpret, apply and adjust, shift perspective, empathize, and self-knowledge. Whereas according to Janssen, Tigelaar and

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Verloop (2009) and Fry, Ketteridge and Marshall (2009), students who have understanding will have the ability to explain, interpret, apply and have perspective.

Given the importance of the understanding, teaching and learning in higher education are expected not only to teach the content, but also to apply a strategy that trains the formation of higher-order thinking skills (Fry et al., 2009). One indicator of higher-order thinking skills is to understand. Understanding is very different from knowing. Understanding is not just knowing facts, but knowing the meaning. For example, students who understand photosynthetic reactions not only can write reaction equations but also know the role of each molecule, compound, and enzyme associated with the photosynthesis. Thus understanding is more broad and profound. Understanding requires a clear and very real definition (Gardner, 1991). Students' understanding will be revealed through innovation in the applications (Piaget, 1973). Understanding leads to one's own or self-understanding (Gadamer, 1994).

The understanding or thinking skills that students must have is related to the content knowledge. For example the content knowledge in Plant Physiology courses is closely related to the understanding that students must have. The material learned in the journal contains abstract concepts that require higher-order thinking skills. Students should be able to explain the concepts and interpret these explanations into relevant images. Students also can apply the knowledge they have received, and have perspective and empathy related to the content being learned. Knowing their own weaknesses and strengths related to the topic being studied are things that need to be mastered by students. For this reason, appropriate science learning is needed: learning that can encourage the formation of students' understanding.

In reality, the level of student understanding is still below expectations. Wilson's (2006) study find that there are still many students who do not understand the phenomenon of cell respiration and photosynthesis in plant cells. Research by Gloria, Sudarmin, Wiyanto and Indriyanti, (2017), reveals that students' understanding of the Plant Physiology course, on average, is still in the moderate category. Lynd-Balta's (2006) study show that there are still many students who are still unable to apply the basic principles of science, such as the principle of conservation of matter in the metabolic process, among others, the process of photosynthesis and cell respiration. This shows that students lack the ability to think, analyze, and solve problems. Students should have the ability to explain, interpret, apply and shift perspective, in accordance with the concept of Janssen and her colleagues (2009) and Fry and her colleagues (2009).

Lack of thinking and understanding skills can be caused by problems related to the teaching and learning process that occurs in college. Fencl (2010), argues that most lecturers in higher education tend to provide extensive material to students, while the more important aspects in teaching such as the opportunities for students to interact directly with objects and act as practitioners in the field are often forgotten. In other words, students are given less opportunity to develop critical thinking and problem-solving skills. Other studies, such as Smith, Wood and Knight (2008) and Gotwals and Songer (2009), find that teachers tend to focus more on giving as much material as possible, without considering ways to form thinking and understanding skills. Another problem is that teachers and lecturers focus more on the final results rather than the learning process.

Given the importance of thinking and understanding skills, it is necessary to improve a learning strategy with appropriate design. The tendency of teachers and lecturers who only focus on the final results of a learning strategy can be overcome by formative assessment. Formative assessment is an assessment carried out during the learning process so that academic progress can be monitored. The assessment process carried out during the learning process is useful for obtaining information about the progress of students during learning (Tanner & Allen, 2004; Furtak & Primo, 2008). The components in formative assessment can help form understanding. There are five attributes in formative assessment implementation:

learning progression, learning goals and criteria for success, descriptive feedback, self-assessment and peer assessment, and collaboration between teachers and students (McManus, 2008).

The success of formative assessment has been known from several studies where the integration of assessment in learning can improve performance quality, both for teachers and students (Reynolds & Moskovitz, 2008; Smith et al., 2008). Formative assessment involves communication between the teacher and students, so that students get meaningful learning (Lee Hang, 2015). Tasks that are often carried out in formative assessments such as writing, reviewing, and communicating. These taks provide effective results in increasing learning outcomes and mastery of concepts (Kusairi, Alfad & Zulaikah, 2017; Noblitt, Vance & Smith, 2010; Quitadamo & Kurtz, 2007). Formative assessment can provide concrete experience through learning activities such as discussion, question and answer, and work on tasks (Johnson, 2014; Rusman, 2014). Formative assessment has proven that its success in motivating and encouraging students to become more interested in the topic being studied, improving learning outcomes, providing confidence, forming habits of mind, and generating feelings of optimism in students (Gloria, Sudarmin, Wiyanto & Indriyanti, 2018; Sriyati & Rustaman, 2010; Smith, 2011; Saptono at al., 2013: Thin, 2006; Ziman, Meyer, Plastow, Fyfe, Sanders, Hill, & Brightwell, 2007). Formative assessment can make students interested in learning biology (Gun & Pitt, 2003). These strategies of formative assessments play a crucial role in helping teachers and students to improve their instruction (Alanazi, 2017). Feedback which is part of a formative assessment can help leaners more aware of their mistakes (Orsmond, 2004; Sadler, 2010). Giving feedback on formative assessment can guide students in achieving the expected learning goals (Boston, 2002). Orsmond, Merry and Reiling (2005) and Milton (2015) assert feedback can potentially lead to motivation, can help students improve learning and the ability to do tasks, become more reflective, and know the achievements and progress of their own learning. Glover and Brown (2006), argue that if the feedback is given correctly and effectively, it will improve the quality of thinking and motivation to learn. Egelandsdal and Krumsvik's research (2015), concludeds that 90% of students, who received "formative feedback", experienced an increase in understanding of the material being studied.

The formative assessment component of peer-assessment, the assessment given by a friend, greatly helps in achieving learning objectives (Crane & Winterbottom, 2008). Yusuffs' research (2015) proves that peer assessment can facilitate the formation of students' confidence in the use of critical thinking and decision making. Raaheim (2006) also states that, regarding the positive impact of peer-assessment is better than the assessment given by the teacher.

Ronnis (2011) says that formative assessment can develop student understanding. Similarly Wiggins and McTighe (2011) stated that: activities in learning must be truly effective, so choosing the right learning approach is the main goal, namely focusing on achieving understanding. Therefore in this study, the formative assessment was carried out to form six facets of understanding. In order for formative assessments to be more effective, the formative assessment strategy was determined through the stages of UbD (Wiggins & McTighe, 2011; Wiggins & McTighe, 1999).

UbD is known as backward design, according to Wiggins and McTighe (2012). This design begins with answering the questions "why" and "what's next". These questions are very important and given especially at the beginning of learning. In the UbD, the questions are called the essential questions. UbD has three stages: 1) identifying what students want and what knowledge students must have, 2) determining acceptable learning evidence, namely how to know that students have achieved the desired results, 3) designing learning experiences and instructions, namely determine what activities should be done so that all desired goals can be achieved. The UbD design aims to shape aspects of the understanding, which consist of explaining, interpreting, applying, having perspective, empathizing, and having self-knowledge.

Based on description above, the research questions in this study are:

1. Can formative assessment trough the stages of UbD improve students' understanding?
2. Is there a correlation between formative assessment in the UbD stages to students' perceptions of understanding?

Based on the formulation of the problem, the purpose of this study is to know the increase in understanding of students of Biology teacher candidates after receiving the formative assessment through the UbD stages, the correlation of formative assessment with UbD understanding, and the contribution of formative assessment to UbD.

METHODS

a) Research Design

This study is a quantitative research with a quasi-experimental design (Creswell, 2015; Creswell, 2014). The experimental class was given treatment. Studetnts were given a pre-test before the treatment, and a post-test after the treatment. Table 1 shows the research design.

Table 1. *Research design*

Pretest	Treatment	Postest
O_1	X_1	O_1

Note: O_1 = a test to measure students' understanding, X_1 = the use of formative assessment through UbD

b) Sample of Research

The study population consisted of all sixth semester students majoring in Biology at one of the Islamic colleges in West Java, Indonesia in 2016-2017. The population was 120 studets, while the sample was taken is 31 students. Courses that apply formative assessment learning at the UbD stage were courses in Plant Physiology.

c) Procedures and Instruments

The instruments used in this study were questionnaires and tests. The questionnaire was used to determine students 'perceptions about the application of formative assessments, while tests were used to determine students' understanding. The test questions were on understanding with indicators of understanding from Wiggins and McTighe's (2011) study. The measured understanding included explaining, interpreting, applying, having perspective, empathizing, and having self-knowledge. The test consisted of a pretest that was done before learning and a post-test was done after the learning.

The formative assessment was carried out for one semester which consisted of 12 theoretical learning sessions and 5 practicum sessions. Formative assessment strategies applied to the learning theory were discussion, presentation, analysis of scientific articles, and mind mapping. Whereas formative assessment strategies in practicum learning were discussions, presentations, and lab reports. The applied formative assessment consisted of three components; feedback, peer-assessment, and self-assessment.

d) Data Analysist

To find out the effectiveness of formative assessment in UbD, questionnaire results and comprehension test results, namely the scores of the pre-test and post-test, were analyzed. t-test wa used to find out the differences in the increase of students' understanding, and ANOVA test was used out the difference in improvement in each aspect of understanding and each topic of Plant Physiology. The correlation test was to determine the relantionship between formative asessment based on student perceptions and understanding.

Based on the analysis it is seen through the increase in the score of comprehension test result. Improve understanding is seen based on the N-Gain value. The N-Gain criteria used are according to Meltzer (2002), with the N-Gain formula as follows.

$$N\text{-}Gain = \frac{Spost\text{-}Spre}{Smaks\text{-}Spre}$$

Note :

N-Gain = normalized gain

S_{post} = post-test score

S_{pre} = pre-test score

S_{maks} = maximum score

Criteria for N-Gain result can be seen in the following Table 2.

Table 2. *N-Gain Criteria*

N-Gain Criteria	N-Gain
Low	0- 0.30
Moderate	0.31-0.69
High	0.70-1.00

RESULTS and DISCUSSION

a) Students' Understanding

1. Improved Students' Understanding after Application of Formative Assessment through Understanding by Design (UbD)

Data of students' understanding were taken through test questions with indicators of understanding from Wiggins and McTighe (2005), which consisted of six aspects of understanding: explaining, interpreting, applying, having perspective, having empathy, and having self-knowledge. Data consisted of pretest and posttest results.

To find out the increase of students' understanding value t-test was done using paired t-test. The output results showed a t count value of 13.051 with a significance of 0.000 < 0.005. The conclusion is there is a significant difference between the pre-test and the post-test value. This means that the formative assessment through the UbD stage had an effect on increasing the students' understanding. Criteria of increase consisting of low, moderate, and high are seen based on the N-gain value. Table 3. shows the N-Gain students'understanding based on the criteria.

Table 3. *N- Gain of Students' Understanding*

No	N-gain Criteria	Quantity	Percentage
1	Low	5	16
2	Moderate	24	77
3	High	2	7

Formative assessment through the stages of UbD enhanced students' understanding by a moderate criterion of 77% proving that this learning has had a positive effect. Formative assessment strategies that are carried out continuously can train the formation of student understanding. Formative assessment components in the form of feedback, peer-assessment, and self-assessment have trained and established students' understanding. Although the N-Gain is still in moderate criteria, there is still a significant increase in the value before and after the implementation of formative assessment through UbD. The successful application of formative assessment has also been proven by several studies on formative assessment (Furtak & Ruiz-Primo, 2008; Hall & Burke, 2004; McManus, 2008; Saptono at al., 2013; Sriyati, 2010; Torrance & Pryor, 2002)

Each aspect of understanding had a different increase, the students' understanding per aspect with each of the N-Gain criteria are seen in Figure 1. In Figure 1 shows the criteria of increased understanding per aspect. The low N-Gain criterion held by the students is on empathy aspect 81%. Students who had high N-Gain in the aspect of empathy were only 6%, and students who had the understanding in moderate criteria were 13%. The highest criterion was found in aspect of self-knowledge which is 39%.

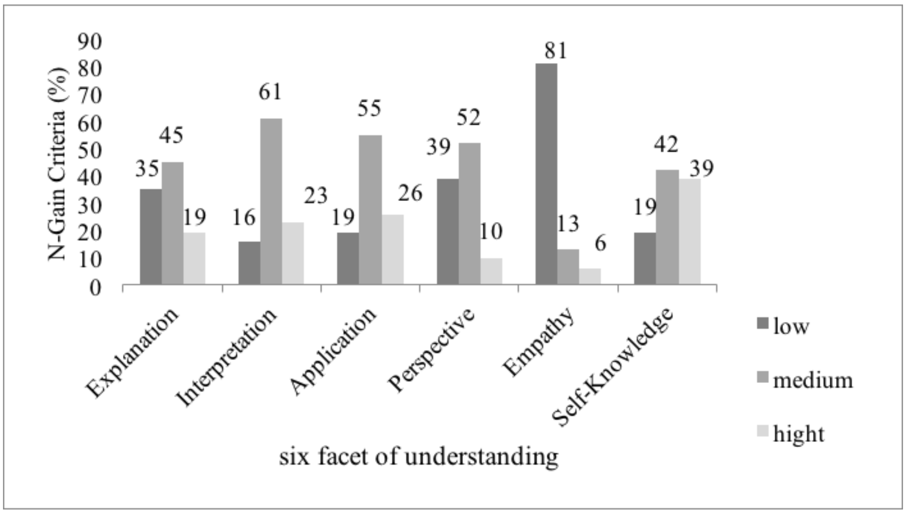

Figure 1. Percentage N-Gain Criteria

Aspect of empathy was included as, the difficult aspect, to the form. Empathy is the ability to see something which is strange to others but it is found to be meaningful (Wiggins & McTighe, 2011). From Figure 1, it can be concluded that formative assessment through UbD had not been able to form a high understanding aspect of empathy, unlike the other aspects of explanation, interpretation, application, perspective, and self-knowledge.

2. Differences in the Increase of Students Understanding per aspect after the Application of Formative Assessment through UbD

ANOVA test was used to know the difference in the improvement of students' understanding per aspect after applying formative assessment through UbD. The result showed the value of count equals to 8.674 with significant value of 0.00 < 0.05, so it can be concluded that the improvement of each aspect is different. More details can be seen in Table 4.

Table 4. *Differences in the Increase of Students Understanding per aspect*

No	UbD	Pretest	Postest	N-Gain	t count	t table	sig.	Criteria
1	Explaining	2.323	4.387	0.429	7.135	2.048	0.000	Significant
2	Interpreting	1.742	3.935	0.509	9.743	2.048	0.000	Significant
3	Applying	3.000	4.710	0.534	7.898	2.048	0.000	Significant
4	Perspective	2.032	3.000	0.197	7.182	2.048	0.000	Significant
5	Empathy	2.161	1.839	-0.032	7.068	2.048	0.048	Significant*
6	Self Knowledge	0.903	2.258	0.570	8.235	2.048	0.000	Significant

*Significance of pretest is greater than postest

Table 4 shows the differences in the average N-Gain values of each aspect. The highest N-Gain value is the self-knowledge aspect with an average of 0.57, while the lowest is in the empathic aspect with an average of -0.03. The value per aspect of understanding seen based on the N-Gain of each aspect of understanding is shown more clearly in Figure 2.

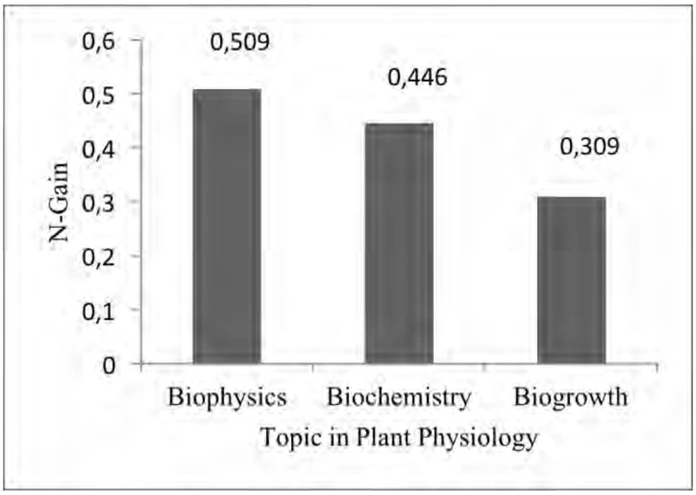

Figure 2. N-Gain of Understanding

Figure 2 shows the increased understanding per aspect. Empathy aspect has a low and negative increase, and this means the posttest value is lower than pretest. The aspect of understanding self-knowledge has the highest increase, N-Gain of 0.57. In addition to aspect of self-knowledge, aspects of interpretation and application have a respectively fairly high increase of 0.5 and 0.53 respectively.

The empathy aspect has the lowest increase. Table 2 shows the negative N-Gain for this aspect. The components of a formative assessment such as peer-assessment should be able to train students to have understanding of empathy, but it did not occur in this study. Except for understanding of empathy, the other five aspects of understanding had significant improvements. Self-knowledge is the highest understanding that improved. Questions in the comprehension tests that have self-knowledge indicators can be answered well by students. Formative assessment through UbD encourages students to better understand themselves; this is because the components of formative assessment such as feedback, peer-assessment, and self-assessment are applied. The feedback component of a formative assessment can help learners realize their mistakes (Ramaprasad, 1993; Sadler, 1998). The peer assessment implementation showed positive results on student learning at secondary school level (Crane

& Winterbottom 2008). Raaheim (2006) says peer-assessment is better than the assessment given by teachers.

Application of understanding aspect had a significant improvement, proving the strategy given to formative assessment through UbD effectively trained the understanding of application aspect. Practical problem-based activities that are undertaken by students, have stimulated critical thinking skills for students to solve problems. In addition to improve application aspect, other formative assessment strategies such as; discussion, presentation, mind-mapping, and scientific article analysis have significantly improved the understanding of explanation, interpretation, and perspective. Muhlisin, Susilo, Amin and Rohman (2018), found that learning by applying the RMS (reading mind-mapping, and sharing) learning model improves metacognitive skills, so as to improve understanding.

3. Understanding Per Topic on the Plant Physiology Course

The result of ANOVA test shows that the value of f count is 3.614 with significant value 0.031 smaller than 0.05. Thus the value of N-Gain biophysical topic, biochemical topic and bio product topic is different, meaning that each topic in the course of plant physiology has different understanding value. More clearly the results of the ANOVA test can be seen in Table 5.

Table 5. *ANOVA Test Results: Differences in increase per topic in the subject course Plant Physiology*

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	.647	2	.324	3.614	.031
Within Groups	8.063	90	.090		
Total	8.710	92			

Each topic in the course of Plant Physiology has a significant value of understanding after the application of formative assessment through UbD. This suggests that formative assessments through UbD give different effects on students' understanding of each topic in the course of plant physiology. Differences in value per topic are more clearly shown in Figure 3.

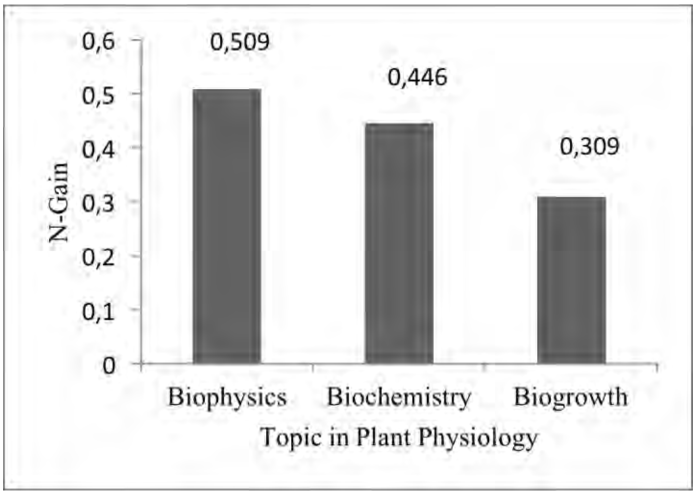

Figure 3. Improvement in Understanding Per topic on the Course of Plant Physiology

In Figure 3 there is a noticeable increase in understanding of each topic of lectures: biophysics, biochemistry, and biogrowth. Of these three lecture topics, biophysics has the highest value of understanding, and the biogrowth topic has the lowest increase in comprehension value. The difference between topics with the highest value of understanding with the lowest understanding is quite large which is 0.2.

On the topic of Biophysics, diffusion and osmosis, active transport, and transport in plants were studied. When viewed from the understanding obtained by students, this proved that formative assessment was very influential on the formation of understanding on the topic. The formative assessment strategies implemented had a significant effect, so the components of the formative assessment were used. Nevertheless, overall formative assessment through UbD has established a significant understanding of all topics in the course of plant physiology. It is proved by the fact that the difference in the value of N-Gain between the topics is not too far away, only about 0.1. Based on the N-Gain criterion (Melzer, 2002), the three topics of Plant Physiology course are included in moderate criteria (0.3-0.6).

Understanding that is formed on each topic of lectures on Plant physiology proves that formative assessment through UbD is effective in improving students' understanding (Furtak & Ruiz-Primo, 2008; Hall & Burke, 2004; McManus, 2008).

b) Correlation and Contribution of Formative Assessment to Student Understanding Based on Student Perceptions

To know the relation between students' perception about formative assessment correlation test was given. The correlated variable is the value of students' perception of the formative assessment through UbD with the value of the acquired understanding. Questionnaire on student perceptions on formative assessment through UbD consists of statements on three components of the formative assessment; feedback, peer-assessment, and self-assessment, while the value of understanding is the value of student tests in the issues of Plant physiology. More clearly the results can be seen in Table 6.

Table 6. *The results of the correlation test of the components of formative assessment with the UbD based on students' perceptions.*

Variable	r-count	r-table	Remark
FB –Understanding	0,365		Significant
PA –Understanding	0,668	0.3550	Significant
SA –Understanding	0,580		Significant

Note : FB=Feedback. PA=Peer-asssessment. SA=Self-assessment.

Table 6 shows the correlation test results between the three components of the formative assessment and the students' understanding value. From the results of the correlation test it was obtained that all r count > r table. The conclusion is all the students' perceptions about the components of formative assessment with the value of understanding have a significant correlation.

The test is continued with regression analysis to determine the value of contribution of formative assessment through UbD to students' understanding. The value of R2 is known at 0.547, meaning that the formative assessment through UbD contributes 54.7% to the formation of student understanding.

The presence of significant correlations between all components of the formative assessment cannot be separated from the application of formative assessment strategies. The three components of the formative assessment (feedback, peer-assessment, and self-assessment) were carried out in each formative assessment strategy. Formative assessment strategies used were discussion, presentation, mind-mapping, article analysis and practicum. The three formative assessment components were always applied.

The contribution of each component of the formative assessment consisting of feedback, peer-assessments, and self-assessment on understanding based on student perceptions is shown in Table 7.

Table 7. *Contribution of formative assessment based on students' perceptions of understanding.*

Variable	R^2	Percentage
FB –Understanding	0,134	13,4%
PA –Understanding	0,447	44,7%
SA –Understanding	0,337	33,7%

Table 7 shows that Feedback contributed the lowest (13.4%), while peer-assessment gave the highest contribution (44.7%). However, all three components of the formative assessment contribute to students' understanding. More clearly the contribution of the components of the formative assessment to each aspect of understanding is shown in Figures 4, 5, and 6.

In Figure 4, Feedback contribution is very dominant to the aspect of application, but does not contribute at all to the aspect of self-knowledge. In Figure 5, the dominant peer-assessment contributes to the understanding of self-knowledge aspect. In Figure 6, the self-assessment contribution is dominant to the explanation aspect, but is low for understanding the emphaty aspect.

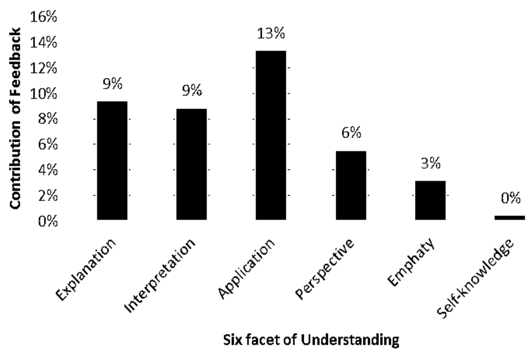

Figure 4. Feedback Contribution of Understanding

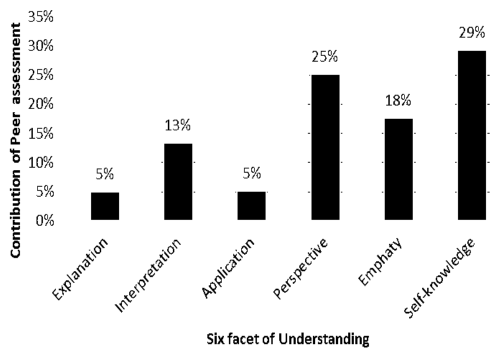

Figure 5. Peer Assessment's Contribution to Understanding

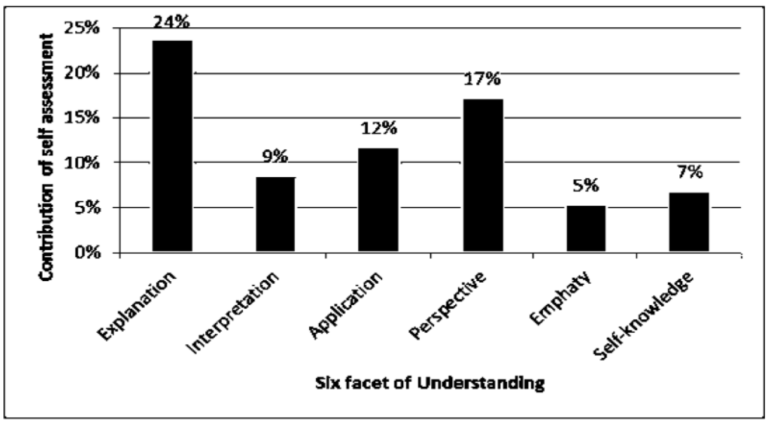

Figure 6. Self Assessment Contribution of Understanding

The component of formative assessment, feedback, gives the highest contribution to the application comprehension aspect of 13%, and gives the lowest contribution to the self-knowing aspect (Figure 4). The formation of every aspect of understanding is inseparable from the role of feedback given in each formative assessment strategy. The greatest contribution to the formation of application aspects can be explained because when feedback was given either in the form of oral feedback or written feedback, the student will understand what to do. Feedback given by the lecturer at the time of the lab will encourage the students to improve and know what to do at the next lab meeting. In accordance with Milton's (2005) opinion, feedback can potentially help the student in improving learning and ability in doing tasks. Meanwhile, according to Glover and Brown (2006), the feedback given correctly and effectively will provide motivation for students to learn.

The peer-assessment component contributes greatly to the self-knowledge aspect of understanding and contributes the least to the explaining and application aspects. This was proved by the peer-assessment given during the implementation of the formative assessment strategy made the student aware of his mistake. Self-awareness of mistakes encouraged the formation of self-knowledge. Criticism and input from peers affected the formation of aspects of understanding, especially aspects of self-knowledge. In general, however, peer-assessment contributes to each aspect of understanding, according to research on the positive impact of peer-assessment (Crane, 2008; Raaheim, 2006).

The self-assessment component of formative assessment provides the greatest contribution to the explaining aspect and gives the smallest contribution to the empathy aspect. Overall the self-assessment component contributes highly to every aspect of understanding. Students given the opportunity to conduct self-assessment will have greater control over themselves (Ezzahra, 2015). Formative assessment strategies applied over and over during learning make students more aware of their mistakes. By realizing the mistake, the student will try to improve the answers, which is why the explaining aspect of the students is increasingly being formed. Understanding is when something leads to self-understanding (Gadamer, 1994).

In general all components of the formative assessment have made an important contribution to the formation of understanding that includes six aspects. Repeated tasks on formative assessment can provide effective results in improving learning outcomes (Noblitt, Vance & Smith, 2010; Quitadamo & Kurtz, 2007). All formative assessment strategies selected through UbD were appropriate and had a positive effect, as evidenced by the positive correlation between all components of the formative assessment through UbD with understanding. In accordance with Ronnis's (2011) opinion the formative assessment can develop students' understanding, whereas according to Wiggins and McTighe (2011), the activities undertaken during learning that is truly effective and appropriate can achieve the ultimate goal of achieving understanding.

CONCLUSION

Formative assessment through the stages of UbD can improve students' understanding. Of the six aspects of the understanding, explanation, interpretation, application, perspective, empathy, and self-knowledge, the aspect of self-knowledge is the understanding that has increased the most. In the plant physiology course, biophysics is the topic that experiences the highest increase in understanding; the next topics are biochemistry and biogrowth.

Formative assessment through UbD has a significant correlation with students' understanding. The contribution given by the application of formative assessment through UbD to students' understanding is 54.7%. Among the three components of the formative assessment, feedback is the component that gives the lowest contribution to the understanding at 13.4%.

REFERENCES

Alanazi, F. H. (2018). Effectiveness of the Proposed Training Formative Assessment Programme and its Impact on Teaching Style Improvements of Saudi Science Teachers in Saudi Arabia . *Journal of Turkish Science Education.* 13(5) 35-56.

Boston, C. (2002). The concept of formative assessment. Practical Assessment, Research & Evaluation, 8(9). Available online: http://PAREonline.net/getvn.asp?v=8&n=9.

Crane, L. & Winterbottom, M. (2008). Plants and Photosynthesis: Peer Assessment to Help Student Learn. *Journal of Biological Education,* 42(4), 150-156.

Creswell, J. W. (2012) *Educational Research (fourth edition)* PEARSON: University of Nebraska-Lincoln.

Creswell, J. W. (2014). *Research Design, Pendekatan Kualitatif, Kuantitatif, dan Mixed.* Yogyakarta: Pustaka Pelajar.

Crowe, A., Dirks, C. & Wenderoth, M.P. (2008). Biology in Bloom: implementing Bloom's taxonomy to enhance student learning in biology. *CBE-Life Sciences Education*. 7, 368-381.

Dorozhkina, Evgenij M., B, Marina., Chelyshkovab., Malyginc, Alexey. A., Toymentsevad, Irina A., & Anopchenko.T.Y. (2016). Innovative Approaches to Increasing the Student Assessment Procedures Effectiveness. *International Journal of Environmental & Science Education*, 11 (14), 7129-7144.

Ezzahra, K. F., Islam, O., & Mohamed, R. (2015). Self-assessment of the progress of thesis for the phd students in the Moroccan university. *Procedia-Social and Behavioral Sciences*, 197, 1789 – 1795.

Egelandsdal, K & Krumsvik, R. J. (2015). Clickers and formative feedback at university lectures. *Educ Inf Technol*. DOI 10.1007/s10639-015-9437-x. (online). http//www. Springerlink.com.

Fry, H., Ketteridge, S. & Marshall, S. (2009). *A Handbook for Teaching and Learning in Higher Education: Enhancing Academic Practice*. New York: Routledge.

Fencl, H. S. (2010). Development of students' critical-reasoning skills through content-focused activities in a general education course. *Journal of College Science Teaching*, 39(5), 56.

Furtak, E. M. & Ruiz-Primo, M. A. (2008). Making student' thinking explicit in writing and discussion: an analysis of formative assessment prompts. *Science Education*. February, 799-823.

Gardner, H. (1991). *The unschooled mind: How children think and how schools should teach*. New York : Basic Books.

Gadamer, H. (1994). *Truth and Method*. New York : Continuum.

Gloria, R.Y., Sudarmin, Wiyanto & Indriyanti, D. R. (2017). Pemahaman mahasiswa Calon Guru Biologi dengan Indikator Understanding by Design (UbD) pada Topik Fisiologi Tumbuhan. *The 5TH Urecol Proceeding UAD Yogyakarta*, 1248-1253. ISBN 978-979-3812-42-7.

Gloria, R. Y., Sudarmin, Wiyanto & Indriyanti, D. R. (2018). The effectiveness of formative assessment with understanding by design (UbD) stages in forming habits of mind in prospective teachers. In *Journal of Physics: Conference Series* 983 (1), p. 012158. IOP Publishing.

Glover, C & Brown, E. (2006). Written Feedback for Students: too much, too detailed or too incomprehensible to be effective? *Bioscience Education*, *7*(1), 1-16, DOI: 10.3108/beej.2006.07000004.

Gotwals, A.W. & Songer, N.B. (2009). Reasoning up and down a food chain: using an assessment framework to investigate students' middle knowledge. *Science Education*, *94,* 259-28.

Gun, A & Pitt, S. J. (2003). The effektiveness of computer-based teaching pacages in supporting student learning of Parasitology. *Bioscience education e-Journal*. [online]. http://www.bioscience.heacademy.ac.uk/journal/vol1/beej-1-7aspx.

Hall, K. & Burke, W.M. 2004.*Making Formative Assessment Work*. London: McGraw Hill-Education.

Hudson, J. N., & D. R. Bristow. (2006). Formative assessment can be fun as well as educational. *Adv Physiol Educ, 30,* 33-37.

Janssen, F.J.J.M., Tigelaar, D. E. H., & Verloop, N. (2009). Developing biology lessons aimed at teaching for understanding: a domain-specific heuristic for student teachers. *Journal of Science Teacher Education*, *20,* 1-20.

Lynd-Balta, E. (2006). Using literature and innovative assessments to ignite interest and cultivate critical thinking skills in an undergraduate neuroscience course. *CBE—Life Sciences Education*, *5,* 167–174.

Lee hang, D. M. & Bell, B. (2015). Written Formative Assessment and Silence in the Classroom. *Cult Studi of Sci Educ*, 10, 763-775. DOI 10.1007/s11422-014-9600-5.

McManus, S. (2008). *Attributes of effective formative assessment".Paper prepared for the Formative Assessment for Teachers and Students (FAST). State Collaborative on Assessment and Student Standards (SCASS) of the CCSSO (The Council of Chief State School Officers)*. Department of Public Instruction.

Meltzer, D.E. (2002). The Relationship between Mathematics preparation and Conceptual Learning Gain in Pgysics: a Possible hidden variable in diagnostic pretest score. Am. J.*Phys.*70(2), 1259-1267.

Milton, J. (2005). *Exploration of the Nature of Feedback to Students*. EAC : Learning and Teaching Development. RMIT University. [online]. http://www.iml.uts.edu.au/EAC2005/paper/ Milton EAC2005.pdf.

Muhlisin, A., Susilo, H., Amin, M. & Rohman, F. (2018). The Effectiveness of RMS Learning Model in Improving Metacognitive Skills on Science Basic Concepts. *Journal of Turkish Science Education, 15(4),1-14.*

Noblitt, L., Vance, D.E. & Smith, M.L.D. (2010). A comparison of case study and traditional teaching methods for improvement of oral communication and critical-thinking skills. *Journal of College Science Teaching*, 26-32.

Kusairi, S., Alfad, H. & Zulaikah, S., (2017). Development of Web-Based Intelligent Tutoring (*iTutor*) to Help Students Learn Fluid Statics. *Journal of Turkish Science Education.* 14(2), 1-20.

Orsmond, P. (2004). *Self and Peer-Assessment Guidance in the Biosciences. Teaching Bioscience Enhancing Learning Series*. Leeds: Higher Education Academy Centre for Bioscience.

Orsmond, P., S. Merry, & Reiling, K. (2005). Biology Students' Utilization of Tutors' Formative Feedback: A Qualitative Interview Study. Assessment & Evaluation in Higher Education, 30 (4), 369–386.

Piaget, J. (1973). *To Understanding to Invent: The future of education*. New York: Grossman's Publishing Co.

Quitadamo, I. J. & Kurtz, M. J. (2007). Learning to improve: using writing to increase critical thinking performance in general education biology. *CBE—Life Sciences Education*, 6, 140–154.

Raaheim, A. (2006). *Do Student Profit From Peedback?* [online]. http://www.seminar.net/ 2 (2) 2006/do-student-profit-from-feedback.

Ramaprasad, A. (1983). On the definition of feedback. *Behavioral Science*, 28 (1), 4-13.

Reynolds, J. &Moskovitz, C. (2008). Calibrated peer review assignments in science courses: are they designed to promote critical thinking and writing skills? *Journal of College Science Teaching*, 60-66.

Ronnis, D. (2011). Asesmen Sesuai Cara Kerja Otak. Jakarta : Indeks

Rusman. (2014). *Model-Model Pembelajaran*. Jakarta: PT Raja Grafindo Persada.

Sadler, D. R. (2010). Beyond Feedback: Developing Student Capability in Complex Appraisal. *Assessment & Evaluation in Higher Education*, 35 (5), 535–550.

Saptono, S., Rustaman, N.Y., Saefudin & Widodo, A. (2013). Model Intergrasi Atribut Asesmen Formatif (IAAF) dalam Pembelajaran Biologi Sel untuk Mengembangkan Kemampuan Penalaran dan Berpikir Analitik Mahasiswa Calon Guru. *Jurnal Pendidikan IPA Indonesia*, 2 (1), 31-40.

Smith, M.K., Wood, W. B. & Knight, J. K. (2008). The genetics concept assessment: a new concept inventory for gauging student understanding of genetics. *CBE—Life Sciences Education*, 7, 422–430.

Sriyati, S. & Rustaman, M. (2010). Kontribusi Asesmen Formatif Terhadap Habits of Mind Mahasiswa Biologi. *Jurnal Pengajaran MIPA*, 15(2), 77-86.

Tanner, K. & Allen, D. (2004). Approaches to biology teaching and learning: from assays to assessments—on collecting evidence in science teaching. *Cell Biology Education*, 3, 69–74.

Thin, A. G. (2006). Using online Micro assessment to Drive Student Learning. *BioscienceEducatione-Journal*.7-7.[online]. http://www.bioscience.heacademy.ac.uk/ journal/vol9/beej 7-7 .aspx.

Torrance, H. & Pryor, J. (2002). *Investigating Formative Assessment: Teaching, Learning and Assessment in the Classroom*. Philadelphia: Open University Press

Wiggins, G., & McTighe, J. (1999). *The Understanding by Design handbook*. Alexandria, VA: Association for Supervision and Curriculum Development.

Wiggins, G., & McTighe, J. (2005). *Understanding by Design (2nd ed)*. Alexandria, VA: Association for Supervision and Curriculum Development.

Wiggins, G., & McTighe, J. (2011). *The Understanding by Design Guide to Creating High-Quality Units*. Alexandria, VA: Association for Supervision and Curriculum Development.

Wilson, C.D. (2006). Assessing students' ability to trace matter in dynamic systems in cell biology.*CBE—Life Sciences Education*, 5, 323–331.

Yusuff, K. B. (2015). Does self-reflection and peer-assessment improve Saudi pharmacy students' academic performance and metacognitive skills? *Saudi Pharmaceutical Journal*, 23, 266–275.

Ziman, M., Meyer, J., Plastow, K., Fyfe, G., Fyfe, S., Sanders, K., Hill, J., & Brightwell, R. (2007). "Student Optimism and Appreciation of Feddback". *Teaching and Learning Forum 2007*.[online]. http://otl.curtin.edu.au/tif.tif2007/refereed/ziman.html