



THE EFFECT OF FEEDBACK AS SOFT SCAFFOLDING ON ONGOING ASSESSMENT TOWARD THE QUANTUM PHYSICS CONCEPT MASTERY OF THE PROSPECTIVE PHYSICS TEACHERS

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ABSTRACT

Many recent studies have reported that feedback plays a very important role in students' learning outcomes. However, currently, feedback has not been utilized by lecturers and students in the learning process effectively. This study aimed to explore the impact of feedback as a soft scaffolding in the ongoing assessment of Quantum Physics class for the students as prospective Physics teachers. A quasi-experimental design non-equivalent pretest-posttest control group was used to examine the effectiveness of feedback based on ongoing assessment. The results of the study revealed that students who received feedback based on metacognitive and social constructivism on studying Quantum Physics showed better average results compared to students who received traditional feedback based on the cognitivism in the form of correction.

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INTRODUCTION

Quantum physics is a domain that is still usually viewed as a field of science resulting in "cognitive dilemma" which impacts the understanding of physics and its development. Quantum Physics is sometimes deemed as an interesting and challenging topic to study and develop in the field of physics, because Quantum Physics itself is one of the fields of physics that requires mastery of high-level math as a tool to understand it comprehensively (Rusli et al., 2011; Asikainen et al., 2005; Hobson, 1996; Saregar, 2016). One of the high-level math, which is difficult to understand is a random calculation such as the numerical method used to determine the price of an option (Monte Carlo simulation or Ameri-

can put) (Syazali, 2011), the concept of random determination can also be used in the search of the particles in the box that are often discussed in Quantum Physics. Likewise with the concept of "Bilateral Matching with Latin Squares" in determining the diversity of a limited numerical value using a matrix (Syazali, 2008), this concept is also used in quantum physics, especially in finding the probability of a value. Several research results show that Quantum Physics is likely to be an interesting research topic for students. This is quite reasonable because it has been known that the development of modern science and technology today directly related to the development of Quantum Physics. Therefore, the study of Quantum Physics requires a number of innovations, including the simulation of abstract and complicated concepts to be easily understood (Wieman et al., 2008).

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(Bao & Redish, 2002), reveals that many physics teachers in high school level possess a very low level of Quantum Physics concepts mastery. Consequently, the learning process of Quantum Physics concepts in high school becomes an unimportant part or even missed, so that the students do not have high interest in studying the concept of Quantum Physics (Aprilyawati & Abdurrahman, 2009). Therefore, for prospective teachers, various strategies and methods of quantum physics learning have been developed in universities by various researchers to improve the achievement of Quantum Physics subjects or modern physics (Hobson, 1996; Mason & Singh, 2010; Wittmann et al., 2006; Zhu & Singh, 2011). Even the use of information technology in the study of Quantum Physics or Modern Physics is currently a new trend in physics learning (Robblee & Abegg, 1999; Wieman et al., 2008; Zollman et al., 2002). The Efforts to improve students' understanding are mostly focused on learning innovations, especially improvements in the syntax or learning phase in addition to media and learning resources. However, the researchers rarely innovate and improve the study of quantum physics in the context of assessment, especially the application of formative assessment (Ongoing assessment) as an alternative to improve learning performance of the students by involving feedback activities effectively in it (Stiggins & DuFour, 2009).

Feedback is one of the continuum factors of learning that has a very strong impact on the success of the learning process and achievement of students (Black & Wiliam, 1998; Hattie & Timperley, 2007). Further, Hatti and Timperley argue that it is basically defined as the consequence of performance, meaning that students can monitor their learning achievements through a number of improvement responses to each "evaluation," either self-assessment, teacher (ongoing and formative assessment), other students (peer-assessment), or parents. Feedback, when viewed from its role attributes can be divided into five categories: correction, reinforcement, forensic diagnostic, benchmarking, and longitudinal development (Price et al., 2010).

Some researchers indicate that feedback is sometimes only a unilateral effort of the teacher without any active involvement from the students in responding and applying it in the subsequent learning (Taras, 2003). Thus, the feedback will not be optimally applied if the students are not actively involved in a series of learning processes. In fact, sometimes students rarely read or respond to feedback given by teachers or lecturers.

This phenomenon happens because they do not understand the purpose and process of feedback, so few of them devote themselves to the feedback process (Duncan, 2007).

The impact of variations in feedback interventions in the learning process has been extensively investigated (Hattie & Timperley, 2007; Shute, 2008), and the results show a number of facts leading to the same conclusion that feedback is instrumental in improving students learning outcomes (Black & Wiliam, 1998; Kluger & DeNisi, 1996; Shute, 2008). Nevertheless, the effectiveness of feedback done in the classroom as a mean of improving process quality and learning achievement is often a factor of dissatisfaction among practitioners in their implementation (Price et al., 2010). One of the factors of dissatisfaction is the low involvement of students in responding to feedback made by teachers or lecturers in the classroom, even though students have the best position to assess the effectiveness of the feedback. This happens because students have no knowledge or literacy about the importance of the role of feedback in the learning process. In this case, a lecturer should provide a number of strategies to perform some scaffolds in feedback activities. Soft scaffolding such as questioning, encouraging, directing, giving guidance in problem-solving and other strategies, is a very important factor in engaging students actively and critically in the learning process (Brush & Saye, 2002; Nyamupangu & Lelliott, 2012; Sousa, 2014).

In addition to the feedback characteristics mentioned previously, there are many variables that contribute to the relationship between feedback and learning outcomes. Stobart (2008) States that there are three conditions that must be fulfilled in order to achieve effective and useful feedbacks in learning: (1) students need feedback, (2) students receive feedback and have time to use it, (3) students are willing to use and able to utilize feedback. The first reason that students need feedback is the gap between the learning objectives and the achievement of the students' learning outcomes (Hattie & Timperley, 2007). The implication is that if there is no gap, such students do not require feedback. Furthermore, Timmers & Veldkamp (2011) state that in the feedback process, not all students show the same enthusiasm when feedback is given. The students' attention is usually focused on correcting errors in an assessment that is incorrectly answered, while very little time is given for feedback on the correct answer.

Another result indicates that the longer the assessment (time and number of questions), the less interesting for the students to respond to the

feedback given by the teacher (Timmers & Veldkamp, 2011). In line with these findings, (Stobart, 2008) claims that the interaction between item difficulty, length of assessment and students' characteristics determine the amount of attention toward the feedback and its effects in the process of achieving the learning objectives. The willingness to use feedback is closely related to learning motivation that allows the students to find and provide learning resources to improve their learning performance (Azevedo & Bernard, 1995; Mory, 2004; Saregar et al., 2017). Contrary, if the feedback refers to the students' inability to acquire learning resources, then they will not be able to utilize the feedback (Stobart, 2008). Furthermore, feedback should be given clearly without any disruption so that it can determine the success of the feedback and sustainability of its application (Mory, 2004).

METHODS

This study used quasi-experimental methods with a non-equivalent quantitative design of pre-post control group design (Creswell, 2013). Data on the mastery of quantum physics concepts was obtained by using the Inventory test of Quantum Physics concepts (IPKFK). A total of 37 students were involved in the study, with 19 students in the experimental class and 18 students in control class. The experimental class was given feedback as soft scaffolding based on social and metacognitive constructivism learning theory in applying ongoing assessment using the flash card, whereas the control group only used regular feedback on formative assessment based on cognitive learning theory. Table 1 below presents the demographics of the research sample.

Table 1. The Demographics of the Research Samples and Treatments

Group	Treatment	Frequency Assessment	Number of Students (N)
Experimental	Ongoing assessment with feedback using flash card in combination with correction and reinforcement	3x	19
Control	Formative assessment with feedback through paper-based test with correction	1x	18

Schematically, the process of ongoing assessment and feedback activity in the experimental class using feedback model from metacognitive and social constructivism theory in the form of correction and cyclic Reinforcement can be seen in figure 1. The assessment of ongoing assessment was assisted by flashcards made of 5 x 10 cm cardboard paper with the letters A, B, C, and D. Each student in the experimental class got four flashcards. These cards served as clickers when the lecturer applied the ongoing assessment. While the feedback was given to the class

just after the students gave the previous answer by observing and recording the students' answer on ongoing assessment beforehand. This feedback cycle was repeated three times (3x) in each meeting with an aspect-oriented reinforcement to soft scaffolding activities in the form of a dynamic effort by the lecturer in diagnosing and improving the students' response in responding formative assessment results through guidance, motivation, reflection, and peer-collaboration (Xun & Land, 2004).

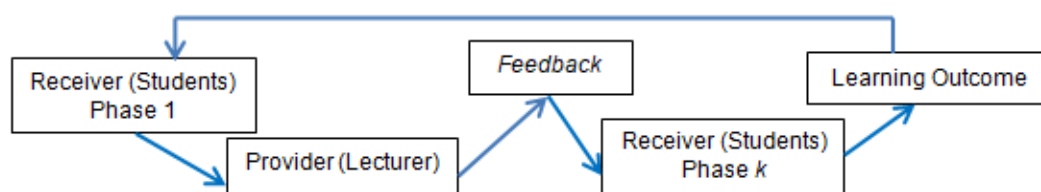


Figure 1. The Model of Metacognitive and Social Constructivism Feedback (Thurlings, et al., 2013)

Students in the control class received direct feedback after formative assessment at each meeting with feedback model based on the cognitive learning theory perspective (figure 2) in the category of correction only. The learning model applied to both groups was the same. The colla-

borative discovery learning model adapted from (Gijlers & de Jong, 2005) with the syntax: (1) orientation; (2) hypothesis submission; (3) Planning an investigation; (4) Implementation Monitoring; (5) interpretation of findings; (6) Evaluation.

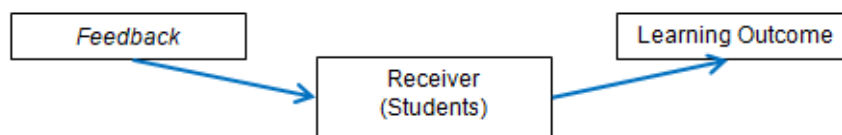


Figure 2. Cognitivism Feedback Model (Thurlings et al., 2013)

RESULTS AND DISCUSSION

This research was conducted to see the effectiveness of feedback on ongoing assessment in the context of assessment for learning in improving learning achievement on the Quantum Physics subject of the prospective physics teachers.

Based on the result of t-test toward prior knowledge gained through pre-test score on both groups showed that the prior knowledge of both groups was not significantly different ($t=1,59$; $sig.=1,22$; $p>0,05$). This information pointed out that before the treatment was conducted, the samples possessed similar prior knowledge level (see table 2).

Table 2. The Result of T-test of Pre-test

	Group	N	Mean	Standard Deviation	T_{observe}	P
Pre-test	Experimental	18	34,94	3,46	1,59	1,22*
	Control	19	32,81	4,61		

* $p > 0,05$

After the learning process involving feedback activity on ongoing assessment, the students' learning outcomes were analyzed using covariance analysts (ANCOVA) with pretest scores as covariates and post-test scores as dependent variables (table 3.). The analysis showed that there were significant differences in learning outcomes between the experimental group and the control group ($F = 5.42$, $sig = 0.026$, $p < 0.05$). These re-

sults indicated that students studying quantum physics by applying feedback in ongoing assessment based on social constructivism and metacognitive learning theory in the form of combination between correction and reinforcement show better learning outcomes than students who used feedback in the context of cognitivism learning theory in their learning with only correction feedback.

Table 3. Descriptive Data and ANCOVA on Pre-test Score

Group	N	Mean	Standard Deviation	Adjusted mean	Standard error	F	P
Experiment	18	53,89	10,97	51,83	2,16	5,42	0,026**
Control	19	74,78	8,85	75,61	2,05		

** $p < 0,05$

The findings of this study indicate that the feedback process in ongoing assessment with soft scaffolding was able to improve students' learning performance significantly. Ongoing assessment with feedback activity encourages students to be more motivated in solving physics problems systematically and improving cognitive processes,

facilitating information processing, and transforming knowledge presented in the learning process. The students primary concern for feedback is generally on correcting errors in resolving or defining solutions to a given problem. Nevertheless, they were very enthusiastic on the reinforcement feedback.

Some of the feedback utilization made by the majority of students was activeness in finding new learning resources. To ensure the lecturers' feedback, they searched for appropriate online literature through Smartphone. The more frequently given assessment and feedback have been proven to be able to increase the accommodation ability toward new learning resources so that they gain new solutions in overcoming the problems of physics. The impact was that the students began to recognize and apply effective ways to reduce the gap between learning achievement and formulated competencies. This is in line with the meta-theory of cognitivism and social constructivism, that feedback supports and plays a role in familiarizing learners with learning outcomes, recognizing the gap between their true achievement and desired performance, and then attempting to close this gap through feedback responses (Nicol & Macfarlane-Dick, 2006; Pokorny & Pickford, 2010). (Espasa & Meneses, 2010) also revealed that effective feedback should be able to encourage students to gain further information and confidence needed to complete tasks.

In addition, feedback also inspires lecturers to perform a number of sequence improvements (stages) of learning, especially in providing assistance or cognitive scaffolding for students in performing information processing dynamically (Xun & Land, 2004). Optimizing the principle of collaboration in small groups is easier after feedback is received by students (Jayanti et al., 2016; Saregar et al., 2016). Students realize the importance of peer-coaching in understanding abstract quantum concepts by discussing and exploring the academic motivation of the feedback given by lecturers in improving their learning performance. Conditioning this feedback process provides students with opportunities to respond the feedback content and engage in constructive dialogue with lecturers as a provider of the feedback. In other words, feedback will be more effective in the context of collaboration between the lecturers and students and among the students themselves (Auld et al., 2010; Landry et al., 2009; Nicol & Macfarlane-Dick, 2006).

There are a number of rational arguments for why collaboration among learners is very effective in determining the success of inquiry-based learning or discovery along with its assessment. According to socio-constructivist learning theory (Duit & Treagust, 1998) learners' competencies will grow through the process of problem-solving activity done collaboratively among learners. In addition, some studies suggest that one of the obstacles in mastering quantum physics

concepts is the use of high-level mathematics, causing a constraint for students in understanding the lectures in Quantum Physics classes (Singh, 2008; Wuttiptom et al., 2009; Zhu & Singh, 2011). The application of feedback in the form of reinforcement in a logical mathematical explanation along with a number of very contextual physical meanings is a supporting factor for students in improving motivation and creativity in physics problem-solving. This is in line with the theory of social constructivism learning, that the fully rewarded and honest (open) feedback done by lecturers/teachers will imprint on students' memories permanently (Li, Liu, & Steckelberg, 2010) and will encourage positive motivational beliefs in achieving learning objectives (Martens et al., 2010).

In addition, the key to successful feedback by lecturers/teachers as a provider of feedback is to maintain mutual relationships with receivers/students (Pokorny & Pickford, 2010). Besides, the students' learning performance is sustained by frequent feedbacks conducted in the experimental class, which greatly assist the students in improving their thinking skills. The correctness and reinforcement process in the form of soft scaffolding will create students' natural state in thinking activity, and easily accommodate the next information stimulated by the teachers or other learning resources. Orsmond & Merry (2011) revealed that effective feedback should engage students in thinking, so explicit feedback activity will improve alternative strategies for better learning. The content of Quantum Physics seems to be difficult, complicated, and abstract because it uses a high level of mathematical approach that can be overcome by improving analytical thinking skills and strategies scaffolded by the lecturers in the process of physics problem-solving strategy as part of the feedback reinforcement activity based on the students' response toward ongoing assessment issues. This is in line with the results of the study (Fund, 2010; Nahadi et al., 2015) which revealed that students' performance, enthusiasm, and thinking habits in learning heavily depend on the strength of feedback that supports students' involvement in practicing correct thinking strategies in problem-solving.

CONCLUSION

The potential of formative assessment as an ongoing assessment in the context of assessment for learning is instrumental in encouraging the active involvement of the prospective teachers in the learning process, including a challenging

and abstract subjects such as Quantum Physics. Such active and dynamic involvement relies heavily on content feedback as the core of ongoing assessment. The combination of content feedback between correction that involve students collaboratively and lecturers' reinforcement in the context of soft scaffolding with the help of flashcards greatly determines the level of competency achievement of the prospective teachers as the students in the subjects of Quantum Physics.

Students' interaction through feedback (individual or group correction and reinforcement during ongoing assessment), lecturers, and lecture materials are an integral part in determining the success of the students as prospective teachers in mastering the subjects of Quantum Physics. Some of the difficulties in the use of high-level mathematics to explain quantum phenomena are gradually eliminated during the ongoing assessment cycle process in the context of metacognitive learning theory and social constructivism. The use of tools such as flashcards encourages students to do some self-corrections and prepare physics problem-solving strategies after constructive reinforcements were done by lecturers and peers.

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