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Assessment Inside Assessment: Developing Course Embedded Assessment to Measure Science Process Skills and Scientific Reasoning in Simple Harmonic Motion Labwork

Jerry Hall [a)] Muslim [b)] and Andhy Setiawan

Master Program of Postgraduate School, University of Indonesian Education

[a)]Corresponding author: hall.jerry91@gmail.com
[b)]muslim@upi.edu

Abstract. The idea to embed an assessment into another assessment could help student's flow of thought. When students are concentrating on an activity, teacher had the opportunity to assessed student's activity along with another assessment. Just like an engine, when student's brain cooled down, they will lose their tempo and it will be difficult for teacher to start another assessment. Educational curriculum requires teachers to be able to effectively assess students, while the students are required to have a variety of skills. This statement gave birth to an idea to embed an assessment into another assessment and hoped that these ideas can be an effective way for teachers to assess. This article describes the development of the assessment of scientific reasoning that is attached to the other assessment, which is assessment of observation-inference. Intensive analysis conducted on the nature and form of these two assessments. The analysis carried out to see a match between the two assessments, as it is known that the assessment of scientific reasoning is embedded on the assessment of observation-inference should be able to continue the flow of student thinking. Validation of this assessment carried out by five experts in order to achieves the critical content validity ratio ($CVR_{critical}$). Five from five experts already agree to this assessment (by revision). Finally, this assessment already tested in real learning instruction and revised three times by suggestion of advisor, expert panel members and field testing.

INTRODUCTION

Over the past few years, the educational curriculum demanded that the individual output of education must have the skills [1]. Education curriculum also requires that teachers be more creative in developing assessments to assess students' skills more effectively [2]. This demands an impact on changes in teaching methods and assessment. The learning model will be more oriented to the skills of students to construct knowledge and assessment will be more focused on gathering information about students' skills [3].

Assessment is an instrument used to collect specific information of individual/group [4]. The information is used by assessors or other authorities to make a policy [5]. Students skilled in constructing knowledge, based on what? It based on assessment, because assessment is a tool to gather evidence that proves students being skilled in constructing knowledge.

Embedding an assessment into another assessment can be an effective way to facilitate an activity to gather information of the different types of skills. Philosophically, the brain can be put on a same term as a machine. Machine will take a time to efficiently work again after it cooled down, so it will be difficult to restore students' concentration if students have lost their concentration. Embedded assessment enables students to carry on their activities without realizing that some of the skills have been assessed. The idea is to make two series of assessments with different objectives but both of it will integrate with each other. The first assessment is independent while the second assessment is relies on the first assessment.

Embedded assessment needs planning, designing and developing, like an assessment in general. This article will describe the planning stages that implemented in the form of intensive analysis of the respective skill, then designing the assessment as well as the format and nature of the assessment in assessing skills.

Analysis of Nature and Form Each Assessments

Imagine if a teacher wants to assess two different kinds of skills, for example the science process skills and scientific reasoning. By definition, both these skills are a different skill. Science process skills are skills that researchers use to find and develop concepts [7–9], while scientific reasoning used to justify the concept that has been found [10]. The difference of these two skills is analogous: if the science process skills answers "what" and "how" question, meanwhile the scientific reasoning answers "why" question. Note TABLE 1 to make it easier to distinguish these two skills.

TABLE 1: General Differences Between Science Process Skills and Scientific Reasoning

Skills	Kind of skill	For…	When use it…
Science Process Skills	Hands on & Minds on	Collecting & Using Empirical Information	Before Concept Formed
Scientific Reasoning	Minds on	Using Empirical Information	Before & After Concept Formed

Based on Table 1, it can be inferred that science process skills and scientific reasoning are anatomically different. The conclusion of Table 1 is these two skills are different, but let's analyze the properties of both of these skills more deeply.

The first analysis, it has been known that scientific reasoning answers "why" question and it is used before and after the concept was formed. Science process skills used before the concept was formed due to form concepts [11]. Based on these two statements, the scientific reasoning can be executed while running science process skills, as what? Phase to use scientific reasoning when running science process skills can be considered as a phase of reflection. Phase reflection means a moment when each statement produced by the science process skills (eg, inference, prediction) justified. Simple questions can be posed to every statement, such as: why these events happen? Or, why the event will not occur as predicted?[12]. This simple question can be the essence of the reflection phase.

Second analysis, scientific reasoning uses empirical information to make “backing”, so it can support the statement. From Table 1, it known that scientific reasoning does not collect information, while the science process skills to gather information. These two statements make it clear that scientific reasoning can integrate commensalism with science process skills. Although it is known that scientific reasoning using conceptual information [13] and information collected by the science process skills are free content, but there is a level of scientific reasoning which forms the backing only by using empirical evidence [10]. The level of scientific reasoning is evidence-based reasoning.

The both of analysis produces an inference, that scientific reasoning can be carried out when the science process skills implemented. It is not impossible that the activities of scientific reasoning assessment can be carried out with course-embedded assessment, so this integration to be a breakthrough an assessment is embedded in the course-embedded assessment.

Determining the Purpose of Each Assessments

Course-embedded assessment is an assessment that has clear purpose. This assessment serves as assessment for learning. Assessment for learning occurs during learning activities take place [14]. By contrast, the assessment of learning that acts as summative assessment, assessment for learning is a formative assessment. This assessment is the assessment that support students learning, where information on the strengths and weaknesses of students towards learning are collected and analyzed [4]. The information obtained by the formative assessment disclosed to students in the form of feedback, so students can learn to use his strength and overcome weaknesses [15].

It is necessary to analyze the specific purpose of course-embedded assessment and also the specific purpose of assessment inside course-embedded assessment. Based on this statement it is known that there are two assessment, they are assessment of science process skills and assessment of scientific reasoning. It should be emphasized that the both of assessment are not equivalent even though both represent two similar skills, it can be analogized that the assessment of science process skills is “host” and assessment of scientific reasoning is attached to the “host”.

The objective of assessment of science process skills is to obtain information about the strengths and weaknesses of students based on aspects of science process skills. Assessment of science process skills as assessment for learning has a special purpose for teaching students about each skill. Note the aspects of science process skills that make up an experiment in Figure 1.

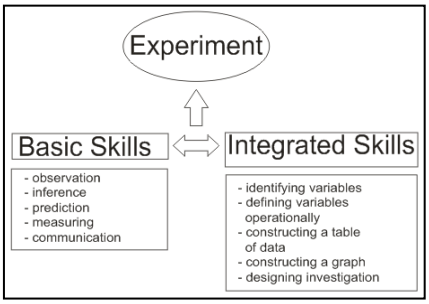

FIGURE 1: Skills that represents science process skills in experiment

Specifically, the objective of assessment of science process skills developed in this study is to assess every aspect of skills as in Figure 1.

The objective of assessment of scientific reasoning is to get information about the strengths and weaknesses of students in scientific reasoning based on aspect of evidence-based reasoning. In particular, the assessment to measure scientific reasoning is in the form of response or it is also called by constructed response [12]. This assessment seeks to assess the students' response of the object or event, so the information about the object or event should have been held first. The empirical information will facilitate students to construct their reasoning, so the formation of students' scientific reasoning will processed as in FIGURE 2.

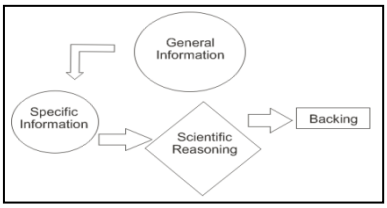

FIGURE 2. Flow when students construct backing by scientific reasoning

Assessment of scientific reasoning that developed has specific goals to measure how much the relationship between students “backing” and the concept.

METHOD

The method used for this study is research and develop. The steps used for this method are designing, first design revision, first field test, second design revision and second field test

Embedded assessment is an assessment that embedded into instructional activities. Embedded assessment can be grouped as assessment for learning. The idea is assessment activities can be carried out during the learning takes place, this is called course-embedded assessment [6]. Learning materials are selected to be the "course" on the course-embedded assessment is simple harmonic motion. This material is selected, because the curriculum advised on this course need to be conducted by lab, demonstration and analysis activity. This article will explain that embedded assessment not only assessment that is included in learning activities, but also the assessment that included when assessment’s activities take place.

Designing

The design of the assessment in this study is worksheet. Originally, worksheet used in inquiry instruction as instrument that guide students to do practicum, but worksheet in this study not only used as instrument that guide students but also as instrument that can collect information of student’s science process skills and scientific reasoning.

In physic education, the best time for students to do inquiry is when they immersed themselves into practicum. As explained before learning material for practicum is simple harmonic motion. This learning material divided into three kind of practicum. The purpose of this treatment is to make the assessment remembered the development of student's skills. The first practicum's purpose is to determine the relation between pendulum's string length and period in certain amplitude and time. The second practicum's purpose is to determine the relation between pendulum's string length and acceleration of gravitation in certain amplitude and time. The third practicum's purpose is to determine the relation between mass that load in spring and spring period, and also to determine the relation between mass that load in spring and spring's constant in certain amplitude and time.

Each question in this worksheet has been designed to assess student's science process skills and scientific reasoning. The format of each question are adopted and adapted from several previous studies [8,12].

First Revision

The design's revision of this worksheet is based from advice of five expert panels. The five experts are functioning as validator. This is done to fulfilling critical validation rate (CVR). To achieve CVR, every member of panels must agree with every aspect that questioned[16].

The problem that had been revised:

1. Making the research question in worksheet more specific.
2. Make sure every aspect of science process skills that used in experiment are questioned in worksheet.
3. Rearranging the aspect of science process skills are questioned in worksheet.
4. Revising the scoring indicator for each aspect of skills that questioned in worksheet.
5. Revising the scoring technique for each aspect of skills that questioned in worksheet.
6. Adjusting the assessing technique for each aspect of skills.

First Field Test

The method for the first field test was one-shot case study. The students that participate in this test are 36 individual. The student's condition when the test being hold was: students not gotten use of inquiry yet and students was not taught simple harmonic motion yet.

The focus of this field test was implementation test for course embedded assessment worksheet, so the test done in form of practicum. Practicum done one time and the instruction's model for this practicum was argument-driven inquiry (ADI). The test was held in order to identify and anticipate problem that occur when the course embedded assessment worksheet implemented. ADI as instruction's model functioned as facilitator for student to invoke their science process skills and scientific reasoning.

The problem occurred during the first field test was: student confused when working their practicum by worksheet's guidance and insufficient time to conduct every phase of ADI.

Second Revision

The results of observation from first test convince that the worksheet needed to revise. The revising of the worksheet focused on worksheet's feature and implementation's technique:

1. The questions in worksheet that can create double meaning to student were revise into more simple language.
2. Combining the activity of observation, inference and scientific reasoning into one worksheet.
3. Adding feature, the field for students to draw graph in worksheet.
4. Practicum must held after students already learned simple harmonic motion.

Second Field Test

The method that used in the second field test was one-shot case study. The instruction's model for second field test was argument-driven inquiry (ADI). The differences between first field test and second field test was the condition of students. The condition of students in second field test was: students not gotten use of inquiry yet and students already learned simple harmonic motion. The participation of this test was 32 individual.

The results of observation on second field test showed that there was no problem. Implementation of course embedded assessment worksheet reached final stage when there were students that confused with practicum and when students did phase argumentation and reflection from ADI.

Finalization

The development in this article focused on worksheet that originally only for guiding students to do their practicum into worksheet that not only guiding but also assess student's science process skills and scientific skills. This development produced worksheet with specification that shown on Table 2.

TABLE 2. Specification Product

Worksheet Course Embedded Assessment	
What is it?	Worksheet
What is it for?	1. Guide for practicum 2. Assessment's instrument for science process skills 3. Assessment's instrument for scientific reasoning
What aspect of science process skill that assessed?	Identification of variable, definition operational of variable, Tools, Investigation's plan, construction of hypotheses, observation, inference, measuring, construction of table, construction of graph, prediction, communication.
What aspect of scientific reasoning that assessed?	Construction of claim, construction of premise, construction of backing
How to score it?	By using rubric with 1-3 scale
Use in :	
Learning material	Simple harmonic motion
Instruction model	Argument-Driven Inquiry (ADI) or another instruction model that facilitate students to invoke their science process skills and scientific reasoning
Instruction method	Inquiry's practicum

RESULTS AND DISCUSSION

First Design

The first design of course embedded assessment worksheet is separate worksheet between observation, inference and scientific reasoning with other skills. The worksheet of observation, inference and scientific reasoning is in pre-experiment and followed by experiment. This design implies that experiment/investigation starts with observation. This design come from rationality that scientist must understand phenomena that happen in order to do experiment/investigation [7].

Second Design

The second design of course embedded assessment worksheet comes after advice from validation expert panel. The advice is to add feature of learning material inside the worksheet. Students needed sufficient knowledge in order to do practicum. To facilitate students to construct knowledge by their own, so learning material added in it.

Final Design

The final design is design resulted from reflection of second design implementation. After second design implemented, we found that even if students given learning material in worksheet, they were not read it at all. Students answer worksheet's question as they like, it shown by their hypotheses. Students were just guessed the hypotheses, they were not known what really could happen to the period of pendulum if pendulum's string made longer than before. At this point, we found that students always take easiest way, they directly asked teacher. To tackle this problem, we deprived learning material to none and holding practicum after students learned simple harmonic motion.

Another finding is about the activity of observation, inference and scientific reasoning. Even if the activity as pre-practicum based by theory, but students never know the simple harmonic motion before. To tackle this problem, we input this activity inside core practicum. Students will do this activity after they know variable.

The final design also added feature drawing field for graph. We added this feature after we found that students needs longer time to measure graph scale and also incomprehensible size of the graph. Sometime their graphs are too small, sometime their graphs are too big.

CONCLUSION

The development in this article is process to develop course embedded assessment. The focus of this study is to develop worksheet that not only to guide students but also to assess their science process skills and scientific reasoning. The sufficient teaching techniques and time needed to implement this worksheet, but it will make great benefit when implemented.

This study was not only developed embedded assessment, but also to design appropriate learning instruction with the demands of the curriculum. The appropriate learning instruction will meet the demands of curriculum to trained the curriculum's desirable skills, so embedded assessment would be appropriate in measuring these skills. Other issues that need to be considered after the development of this assessment is a teachers' in-depth understanding of the assessment, in which the assessment is not a system to increase teachers' job difficulties. Assessment is often considered to be more work for teachers and troublesome, this is because the teachers do not understand that the assessment can be used for students' learning. Assessment would be more beneficial if implemented together rather than separate from learning instruction.

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