The Use of Virtual Measuring Toolkit toward Students' Cognitive and Procedural Knowledge Achievements

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Abstract. Virtual laboratory known as VMT (Virtual Measuring Toolkit) has been developed to succeed in the learning objection in a Junior High School level. This VMT was used in measurement on a natural science subject to involve the active participation in measuring process in an unavailable real laboratory facility. This media contains various measurement tool (caliper, three-arm balance, stopwatch, measuring glass for volume and grid for the area) to use for measuring process with the real using approach. Besides, VMT applies in a complete instruction process, integrate to worksheet and assessment sheet. Furthermore, this particular study aimed to measure the students' cognitive and procedural knowledge achievement with the support of VMT and describe its attainment level on that knowledge based on certain criteria. The variables measured in an examination setting on 49 students. Besides, the students' responds to relating media uses are discussed. As a result, the students' achievement on cognitive and procedural knowledge after the Virtual Measuring Toolkit (VMT) using in learning setting on classroom state in a good with percentage of 69 %. While the students’ positive responds percentage on 85 %.

1. Introduction

One part of science is physics, which is a systematic attempt to organize knowledge through observation of natural phenomena. The truth is obtained empirically through the five senses. Therefore, in developing physics concepts, measurement is an important aspect that is needed [1]. In physics learning, measurements are taught including to find out how to use measuring instruments. Skills in using measuring instruments can be achieved if students have prior knowledge. One domain of knowledge in accordance with what is intended is procedural knowledge. It means the knowledge of how to do something. The something might range from completing fairly routine exercise to solving novel problems [2]. Supported by Hernando’s opinion, procedural knowledge is an acquisition of skills in solving problem context related to step-by-step actions [3]. During teaching procedural knowledge, that involves showing the relationship between the concepts. In other words, procedural learning alone would not be adequate without conceptual knowledge [4]. Conceptual knowledge includes mental models, schemas, explicit or implicit theories in different cognitive psychological models [2]. In learning, they should be harmonized well [4].

But in fact, Indonesian students have less understanding in procedural knowledge [5]. This knowledge will be a bridge between conceptual knowledge and skill. However, students needed are
doing some experiments to get better concept. But, in specific area, SMP Al Izzah Batu shows that there are no enough gauges available for every student. So that students get real experience, then a virtual simulation is made. It is also needed in current learning. In a 21st century learning environment, digital electronic communication technology is the key factor. Teaching and learning have to centers around the innovative use of existing and emerging technologies [6]. In teaching physics, varieties of computer applications have been developed and used. Computer simulations offer a great variety of opportunities for modelling concepts and processes [7,8,9]. Concur with Ranjan who stated that virtual laboratory presents important concepts, process, and principle. It provides students with meaningful experiences in virtual. Students have the opportunity of repeating any incorrect experiment or to deepen the experiences by means of virtual laboratories. Research studies have indicated that visualization of phenomena through computer simulations can contribute to students’ understanding of physics concepts at the molecular [8,9,10]. The research result that has been done by Sudarmani et al, physics media improves conceptual and procedural knowledge of the student [11]. Because the problems that exist in that school and virtual simulations have a good impact on learning, a simulation has been created called VMT (Virtual Measuring Toolkit).

![Figure 1. VMT Screen for Measuring Length by Vernier Caliper](image)

VMT consist of six simulations to measure objects. They are ruler, vernier caliper, triple-beam balance, stopwatch, measuring glass (measuring volume of an irregular object) and grid (measuring area). VMT is made with similarities to the actual measuring instrument. For example, in the calipers the parts are fitted in accordance with the originals. There is a lock so that the calipers do not move when used. From some of the above explanations, this research aims to determine the achievement of procedural and conceptual knowledge of students and their responses in using VMT.

2. Method
2.1. Participants
The subject of this research is the 7th grade junior high school students. The number of students used is 49 from junior high school Al Izzah, Batu, East Java based on the sample formulation [12]. The assessment of the attainment of conceptual and procedural knowledge is done after the teacher conducts learning with VMT using an assessment sheet. In addition, students are also given a response sheet to find out their responses to the simulation media used.
2.2. Data Analysis
This article is the part of quantitative method with the explanation in every score gained [13,14]. The data obtained from this study are the attainment of conceptual and procedural knowledge and students' responses to the VMT media. Knowledge assessment consists of four questions, namely caliper use, mass measurement, measuring volume using a measuring glass and time measurement by a stopwatch. The minimum completeness score is 75 based on national regulations [15]. Furthermore, 75 score and up called as the upper score and less than 75 score called as lower score. The number of students who meet these grades will be changed to percent. While for the response of students consists of 4 categories namely content, language, media and learning aspect. The number of students giving a 'yes' response will be changed to percent. All final data will be categorized according to Table 1.

| Percentage  | Category   |
|-------------|------------|
| 0 % - 20 %  | very less  |
| 21 % - 40 % | less       |
| 41 % - 60 % | middle     |
| 61 % - 80 % | good       |
| 81 % - 100 %| very good  |

3. Results and Discussion
This section consists of two parts as the score result, cognitive and procedural knowledge attainment and the students' response of the VMT. Both of the parts complete with the discussion based on the findings.

3.1. Score results: Cognitive and Procedural
Cognitive and procedural score gaining from the students’ answer on four questions was used as the final exam after VMT using in instructional process. All the questions set in high order thinking skill (HOTs) or analyse level. This two-knowledge appropriate in all cognitive level [2] and use the HOTs for make sure that the knowledge stay in students thinking as a good understanding. Commonly, ‘how to use’ knowledge easy to gain memorize some step in using particular measurement tool. The combination between the cognitive-procedural knowledge with HOTs level minimises the possibility of the memorizing thinking process on students.

The final questions include the measurement tools on VMT. It uses the four of six tools in VMT, which are vernier caliper, triple beam balance, measuring glass and stopwatch. The four measuring tools used due to the adjustment on the junior high level and a real using possible of the measurement tools. Ruler and millimetre block didn’t investigate for some reasons; ruler is a basic tool and explained well in elementary level. Besides, the area measurement with millimetre block rarely use in real life. The result of the students’ answer score shows in Figure 2.
Figure 2. The Percentage of Upper and Lower Score in Cognitive and Procedural Knowledge

Based on the Figure 2, all the measurement tools occur on the good and very good category. Vernier caliper, triple beam balance, and measuring tube performed in a good category and stopwatch state in very good category (95.24 %). It indicated that stopwatch easier to use compare to others. Besides, stopwatch is the common measuring tool, available on smartphone or feature phone. Furthermore, operating process on stopwatch is useful as easy as press the button and sees the result directly, but many students still in lower score because of the important step on many measuring tools, calibrating or zeroing. Many students didn’t write that the first process to make sure that the stopwatch start from zero for measuring process. The problem in using a stopwatch at the exam set for the winner determination in a sprint. Students should be applying the stopwatch using as the cognitive knowledge and explain that tool using as the procedural knowledge. If the VMT purposeful in students’ thinking, the whole process of stopwatch using isn’t a problem, VMT should start from zero for gain the similar result to the true result on video.

In another tool, 69.05 % students succeed in vernier caliper using and application in the real-life problem. The question: Mr. Andi has a workshop, engaged in welding and receives the manufacture of iron fences. He gives the price of iron fences to consumers based on the quality and the thickness of the materials. It can be said that ‘the thicker material of iron, the more expensive in price’. Based on that question, the student should explain the appropriate tools for measure the thickness and the steps for use it. As the characteristic of all questions, it contains the cognitive and procedural knowledge. The other 30.95 % students fail to explain clearly about the caliper using or choose the other tool as the answer. Some students answer this question with roll meter using, which is inappropriate tool for measure the material thickness for a fence.

Three beam balance has the lowest percentage of all, 66.67 %. This question combines with mathematical skill for determining the mass of the water in a glass mix with oil if known the mass of the glass and the mass of the oil same with the water. Mostly, the students succeed for determining the mass from the triple beam balance from the scale but in the unit conversion, the known unit different with the standard unit of the triple beam balance.

In volume determination, 76.16 % student success to describe the measuring tube using for irregular object. This is the common problem, similar to the problem in VMT. However, the other fail to describe completely, skip the minus process (the final volume of irregular object and water minus the initial volume of water). They write that the final condition on the scale is the volume of the irregular object.
Observe from the percentage of the cognitive and procedural attainment score, the score is slightly above the minimal score of good categories. As each point, the all point percentage of virtual measurement tools state on 69.05%. It indicates that the VMT using should be complete with supporting learning method, such as the student centre learning, inquiry model. Furthermore, the virtual tool is the future device in technology using for 21st century purpose. The use of virtual setting can minimize the time allocation in learning setting.

3.2. Score results: Students’ responds
The responds percentage score uses to support the achievement percentage. The good attainment in students responds will support the students support on VMT using. The students’ enthusiast is the first step to gain motivation. The responds consist of four aspects: content, language, media and learning. Content aspect contain the interesting level for students of the concept in VMT, language contain the understanding level after reading many button (guidance) in the media, media consist of the user experience on using VMT and the learning aspect is the media support on solution on measurement problem solving.

![Figure 3. The Percentage of Positive Responds in Each Aspect](image)

Based on the Figure 3, all aspects indicated in a very good category. However, three aspects: content, language and learning are under average. Media aspect hold in very good percentage, as the indicator that students in junior high level very interesting in something ‘new’ for them and technology using in every part of life. In this school, the technology using expects use in relating subject as information technology in a part on the craft subject, even though most of students have laptop to use.

SMP Al Izzah Batu or specifically brand as “Al Izzah Leadership School” is the Islamic boarding school with international purpose. This kind of media suitable to use for shortens the duration on learning effectively, due to many activities after school [8-9]. For proficiency, VMT should be complete with another measuring tool, a micrometre screw gauge. Besides, it should be improving with real tool approach in all measuring tools, directly impact pointer after beam moving. In the future, VMT should be combined with appropriate method in learning process for gaining cognitive and procedural knowledge. As the learning setting done in VMT using, do in direct explanation.
4. Conclusion
The students’ achievement on cognitive and procedural knowledge after the Virtual Measuring Toolkit (VMT) using in learning setting on the classroom state in a good and very good criteria. The knowledge performance that in caliper in percentage of 69 %, triple beam balance on 66 %, measuring tube on 76 % and stopwatch on 95 % with all measuring tools concept and procedural achievement of 69 %. It means the VMT is the alternative for train cognitive and procedural achievement combine with high order thinking level. However, for gaining more percentage of its knowledge, it should be optimizing with another interactive method. The students’ responds also describe to support the enthusiast level of the student in media using. The students’ positive responds percentage on 85 %. It means, students interesting on media using and feel better to study the measurement tool with VMT.

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