Student worksheet with augmented reality technology: media to construct higher order thinking skills of high school students in elasticity topic

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Abstract. The learning process in high school requires scientific learning to construct Higher-Order Thinking Skills (HOTS). The purpose of this research is to produce student worksheet equipped with Augmented Reality (AR) technology as a media to construct HOTS for high-school students. This research used the Dick and Carey model approach. The worksheet has been produced for physics subject, and it has integrated with AR-technology. This student worksheet consists of three stages: the introduction, main-stage, and post-stage. Each of these stages has been integrated with AR-based video technology. The student worksheet has been validated by learning media expert and material physics expert. According to learning media expert, the percentage of average of all aspects is 96.02% and according to material physics expert, the percentage of average is 79.09%. Based on the results of the validity test, it can be concluded that the student worksheet media added by the AR-technology produced can be used as a physics learning material that constructs HOTS in the elasticity topic.

1. Introduction

Modifications to the development of teaching materials in the form of worksheets have equipped with the virtual lab [1], media digital [2], and Augmented Reality (AR) [3]. From that research, it can be concluded that there is an urgency for teaching materials that should be equipped with technology developments (IT). Related to the development of technology, researchers stated that AR is very potential and able to provide great benefits and opportunities to be applied in learning activities and teaching materials, especially in the field of physics science [4,5,6]. Augmented Reality is a technology that combines real world and virtual world into a real three-dimensional environment then projects virtual objects in real time [7]. The application of AR-technology enables physics material to be simulated and made into 3D objects so that students can directly interact with the AR object [8]. In addition, the use of AR technology can make the learning process more flexible, interesting and interactive so that it can create active learning for students [9]. Active learning is able to help students to construct Higher-Order Thinking Skills (HOTS) [10,11]. This active learning is based on strong interaction between the media and the user [11]. The AR-technology is able to wrap many interactions up created during the learning process. Therefore, the implementation of AR-technology to teaching materials strongly supports active learning strategies and should be a current research’s trend.

Active learning strategy must also be supported by the implementation of laboratory activities [12]. Students can try to build the knowledge and concepts of physics independently through laboratory activities. So that, creative thinking and problem solving skills for students can be trained well [13].
Laboratory activities in the learning process can be successfully implemented because of well planned. One of the plans carried out by the teacher is to design a student worksheet [14]. Student worksheet is a teaching material in the form of sheets of paper, which contains steps to guide students in finding a physics concept with reference to basic competencies [15]. The developed student worksheet is adjusted to the scientific approach so that it can help students to process and acquire knowledge to construct higher order thinking skills (HOTS). HOTS is aspects of the learning process that includes critical and creative thinking skills that oriented to concept building [16].

The category of HOTS is the cognitive domain of Bloom-Anderson’s (revised) Taxonomy, which includes the level of analyzing (C4), evaluating (C5), and creating (C6) [17]. These three categories will be applied to the student worksheet so that students will be trained to think at a higher level. At the C4 level, students are directed to solve a problem and find out how the connection between two things or more can cause problems. At the level C5, students are asked to give an assessment based on existing criteria and standards. At the C6 level, students are directed to generalize an idea and organize parts into new structures. The topic that will be discussed in the student worksheet is elasticity. The selection of this topic is based on the basic competencies that require critical thinking skills in solving each problem [18]. Based on the explanation before, this paper is made to describe the preparation of the student worksheet equipped with AR-technology to construct HOTS of high school students in elasticity topic.

2. Methods
To produce student worksheet models that have been AR-technology in building HOTS, research and development of educational products is carried out. The Dick and Carey research and development model is in accordance with Borg and Gall’s statement [19]. The Dick and Carey model consists of 10 steps, but this research is limited to the ninth step. The steps of this research are: (1) analyzing the need for teaching materials to identify the general objectives of learning based on student worksheets, (2) analyzing the learning process on student worksheets that construct HOTS, (3) analyzing student characteristics in HOTS-based learning, (4) formulate specific goals in student worksheet-based learning to build HOTS, (5) develop HOTS ability assessment instruments and product feasibility instruments for student worksheets, (6) develop learning strategies in student worksheets that are added by AR technology to build HOTS, (7) designing student worksheet products that were added by AR technology to build HOTS capabilities, (8) conducting formative evaluations to test the validity and feasibility of student worksheet products for money added by AR technology to build HOTS capabilities, and (9) revising student worksheet products and AR technology was added to fit the research objectives and product development. The tenth step of Dick & Carey is a formative evaluation that was not conducted in this study. The final decision on whether to use the media in learning is made by external parties, such as teachers in schools or related institutions.

The instrument in this study was a Likert scale questionnaire to test the feasibility of the material and media of student worksheets. The results of this study are student worksheets that were added by AR technology as a medium for building HOTS. Validators are physics material experts and physics learning media experts based on student worksheets. The target user is middle school students in learning physics on the elasticity topic.

3. Result and Discussion
3.1. development of student worksheet with AR-technology
The previous research produced teaching materials in the form of a textbook that equipped with AR media [20]. Meanwhile, this research produced teaching materials in the form of the student worksheet with AR-technology. The developed student worksheet is based on laboratory activity and consists of three stages, namely the introduction stage, the main stage, and the post stage. The three stages consist of various components and questions that are arranged based on the HOTS category and referred to the scientific approach. At each stage, there are pictures that have been integrated with AR media.
3.1.1 the introduction stage.
This stage contains basic competence that must be mastered by students, learning objectives to be achieved, initial questions to measure student’s ability, and brief theories related to the concepts. In addition, at this stage there is an illustration that is integrated with AR video about application of the concepts to be learned in daily life.

3.1.2 the main stage.
At this stage, there is an image of tools and materials that will be used, steps of laboratory activity, observation tables, data analysis, and conclusion. The image of the tool and material is integrated with the AR video about the process of preparing the tools and materials.

3.1.3 the post stage.
In the last stage, students are presented with images that have integrated with AR videos related to the application of the concepts that have been found through practicum.

3.2. development of AR application
In the developed student worksheet, there are illustrations or images that are used as markers. Based on previous research, markers made in textbooks are connected with 3D animation and learning videos [20]. All markers used in this worksheet are integrated with video. The video can be displayed in the help of an application that has been installed on an Android smart phone with a minimum specification of OS 4.1 Jelly Bean. Application designed called WAR (Worksheet-with AR). There are five main menus in the interface of WAR application: elasticity, worksheet, about, a hint, and feedback. Those main menus are shown in Figure 1.

![Figure 1. Interface of WAR application](image)

3.3. development of student worksheet based on HOTS category
Based on previous research, an increase in thinking skills can be achieved through learning that applies aspects of analysis, evaluation, and creation [21]. The three aspects of HOTS are also applied to the developed student worksheet, as shown in Table 1-3.
| Table 1. Worksheet based on HOTS category, stage of analysing (C4) |
|---------------------------------------------------------------|
| **Part of Worksheet**                                      | **Details** |
| ![Worksheet Image]                                           | Main-Practicum stage (tools, materials and procedural steps): |
|                                                             | - Students are able to examine the series of tools and steps of practicum appropriately with the help of AR video displayed. |
|                                                             | Main-Practicum section (data analysis): |
|                                                             | - Students are able to analyze the table of observation data into a meaningful graph. |
|                                                             | - Students are able to interpret graphics in accordance with the concept of physics. |

| Table 2. Worksheet based on HOTS category, stage of evaluating (C5) |
|---------------------------------------------------------------|
| **Part of Worksheet**                                      | **Details** |
| ![Worksheet Image]                                           | Introduction stage (apperception and initial question): |
|                                                             | - Students are expected to be able to criticize AR videos related to the concepts to be studied in the initial question section. |
|                                                             | Main-practicum stage (data analysis): |
|                                                             | - Through questions in data analysis, students are able to assess a situation based on a graph that has been made. |
|                                                             | Main-practicum stage (conclusion): |
|                                                             | - Students are asked to specify all concepts obtained from laboratory activities (table observation, graphs, and data analysis). |

| Table 3. Worksheet based on HOTS category, stage of creating (C6) |
|---------------------------------------------------------------|
| **Part of Worksheet**                                      | **Details** |
| ![Worksheet Image]                                           | Main-practicum stage (data analysis): |
|                                                             | - Students are able to develop concepts that are learned based on observation and graph data. |
|                                                             | - Students are able to make mathematical equations from the concepts learned. |
|                                                             | Post-practicum stage (Implementation of concept): |
|                                                             | - Students are able to solve problems by combining concepts obtained through practicum. |
3.4 Validation Test

The developed student worksheet has been through the feasibility test of media experts and material experts. The following is the result of validation of student worksheet with AR. Feasibility tests from media experts get some suggestions and input to revise this worksheet. The writing of the back cover must be in harmony with the front cover and the writings on the AR application must be set with a larger font size to make it easier to read. As shown in Table 4, the results of the media expert validation for the products of this study gained an average point of 96.02%. This result indicates that the student worksheet with AR technology to construct the HOTS for elasticity subject material is considered very good and feasible to be used as a learning material for physics. The validation test from the material expert also provides input that the writing of mathematical equations must be distinguished from the writing of material. The results of the validation of material experts get an average point of 79.09%. This value indicates that this student worksheet is considered good to be used as teaching material in physics learning.

The previous research explained that the development of an electricity book with AR media had fulfilled the requirements and eligible to be used as supporting teaching materials [20]. This AR Student worksheet also fulfilled the requirements and feasible to be used as physics learning materials for elasticity topic.

| No. | Aspect Measured                          | Presentation Scale | Interpretation |
|-----|-----------------------------------------|--------------------|----------------|
| Media Expert Validation                  |                      |                  |
| 1.  | Worksheet size                          | 100%               | Very Good       |
| 2.  | The layout of worksheet cover           | 80%                | Good           |
| 3.  | Typography of worksheet cover           | 100%               | Very Good       |
| 4.  | Component of worksheet                  | 96.67%             | Very Good       |
| 5.  | The layout of worksheet content         | 100%               | Very Good       |
| 6.  | Typography of worksheet content         | 98%                | Very Good       |
| 7.  | Illustration of worksheet content       | 100%               | Very Good       |
| 8.  | Interface of AR                         | 100%               | Very Good       |
| 9.  | The function of AR                      | 96.67%             | Very Good       |
| 10. | The stages of practicing HOTS           | 88.9%              | Very Good       |
|     | Average of all aspects                  | 96.02%             | Very Good       |
| Material Expert Validation               |                      |                  |
| 1.  | Material conformity                     | 82.27%             | Very Good       |
| 2.  | Material consistency                    | 80%                | Good           |
| 3.  | Writing and language                    | 70%                | Good           |
|     | Average of all aspects                  | 79.09%             | Good           |

4. Conclusion

The teaching material model added by AR technologies has become a learning trend in the 21st century. Some experts have validated the student worksheet model that is equipped with AR to build HOTS high-school students. Based on the results from the validation, this worksheet is feasible according to media experts (96.02%) and material experts (79.09%). This concludes that the student worksheets developed are eligible and are suitable for use as teaching material in learning that builds HOTS abilities.

5. References

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