Students worksheet with augmented reality media: scaffolding higher order thinking skills of high school students on uniform accelerated motion topic

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Abstract. Higher-Order Thinking Skills (HOTS) are needed to enhance the characters of students. The scaffolding is required to train student’s HOTS. This article will describe the development of the student’s worksheet with augmented reality (AR) media as a scaffolding to train student’s HOTS. The method used for this research is the research and development with Dick and Carey's model approach. AR student worksheet media had been produced on the uniformly accelerated motion topic. There are three stages in the student worksheet; introduction, main-stage, and post-stage, which consist of AR media in all stages. The AR student worksheet has been validated with the percentage of achievement of 94.6 % according to the learning media expert, 86.1 % according to the material expert. These results clarify that development of the student worksheet with AR technology as scaffolding to trains HOTS has fulfilled the requirement as physics teaching materials.

1. Introduction

Scientific learning directs students to critical-thinking habits, conducts them, and changes the self-character as in Figure 1. Figure 2 shows that through scientific learning, nine characteristics of students have increased [1]. Critical thinking directs students to Higher-Order Thinking Skills (HOTS). Based on Bloom's taxonomy, HOTS indicators include the ability to analyze, evaluate, and create [2]. To improve characteristics [3] and train HOTS students [4], Laboratory Activity (LA) based learning is needed. LA can provide learning experience, increase participation and problem-solving skills, and train students to think and act scientifically [5]. The teacher as a facilitator is required to be smart in designing learning media and learning strategies in LA in order to support the formation of HOTS students[6].

Learning environment with technology enrichment using multimedia combination can develop scientific process skills and improve students' high level thinking skills [7]. Learning media with images and videos [8], as well as virtual labs [9] are proven to increase students' motivation and learning outcomes. AR is a new 3D technology that combines the physical and digital worlds in real time and is the right choice for packaging media such as images and videos in LA-based learning. AR allows visualization of objects, including videos on smart phone devices through the scanning process [10]. The use of AR media on books proved to be able to help the learning process of science, especially physics [11], as well as increasing the active role and thinking abilities of students [12].
LA needs the tool that functions as activity guides, namely Student Worksheets (SW). SW is a learning tool that is used to guide students to form knowledge, skills, and attitudes and improves science process skills in scientific learning based on learning by doing [13]. Well-designed SW can help teachers overcome time constraints, confusion of students, and improve students’ conceptual understanding and critical-thinking skills [14,15]. The SW has various types, including printed SW and online SW that is made in various designs, and learning models. AR can be used as a new virtual media integrated with SW. Therefore, this study developed SW accompanied by AR media as an innovation in science learning to train HOTS students. The material is limited to Uniformly Accelerated Motion (UAM) topics with the consideration that the UAM topic requires more visual media assistance in learning with compare topics in Kinematics. [16].

2. Methods
The method used for this study is the research and development method with the Dick & Carey model approach. This selection is in accordance with the statement of Borg & Gall that the educational development model that can be used is the development model of Dick & Carey The Dick and Carey model consists of 10 steps, but this research is limited up to the eighth step. The steps of this research are: analyzing the need to identify general objectives, analyze learning, analyze characteristics of students, formulate specific learning goals, developing assessment instruments, developing learning strategies, develop products in the form of SW and AR applications, and carry out validation [17].
Product development is carried out in digital media laboratories, Universitas Negeri Jakarta. Product validation is carried out by three experts; media experts, material experts, and learning experts.

3. Result and Discussion

3.1 Product

3.1.1 Student Worksheet (SW) This SW is structured with discovery learning models with stages: identifying problems, developing possible solutions (hypotheses), collecting data, analyzing and interpreting data, and testing conclusions [18]. This SW contains three stages that guide students in building their own concepts and practice high-level thinking skills, namely: introduction, main-stage, and post-stage. 1) Introduction, this stage consists of: LA titles, basic competencies, learning objectives to be achieved, basic theory of LA, and initial questions to measure the initial abilities of students. AR media at this stage contains the concept video application as an introduction to LA. Students are asked to criticize the AR video and explain it to the initial question part. 2) Main-stage, at this stage, a list of tools and materials will be presented, practical work steps, and observation tables. The integrated video AR work step section that displays instructions for designing a LA. 3) Post-stage, at this stage, students interpret data into a graph and construct concepts related to UAM through the data analysis stage. Furthermore, students are directed to apply the application concepts in everyday life delivered by AR videos. This step is at the core of developing students' high level thinking skills.

3.1.2 AR application In previous studies, AR book have been produced as physics learning aids. This study produced an SW integrated with the AR applications called "SmART (Science Experiment with AR Technology)" which is shown in Figure 3. In SW, there are several images that will be used as markers (shown in Figure 4) that will display AR information in the form of videos through a scanning process at a certain distance. Scanning can be done offline or without an Internet connection using a phone camera with a minimum Android operating system of v4.1 (Jelly Bean) in the SMART application.

![Figure 3. Interface of AR application](image1)

![Figure 4. Marker images](image2)
3.1.3 Student Worksheet grouping based on HOTS indicators

**Table 1.** SW grouping based on HOTS indicators according to Bloom stage analysing (C4)

| No | Part of the SW | Information |
|----|----------------|-------------|
| 1. | Main-stage     | - Students are able to examine the series of tools and steps of laboratory activity appropriately with the help of AR video displayed. |
|    | Post-stage     | - Students are able to analyze the table of observation data into a meaningful graph. - Students are able to interpret pattern of graphics in accordance with the concept of physics. |

**Table 2.** SW grouping based on HOTS indicators according to Bloom stage evaluating (C5)

| No | Part of the SW | Information |
|----|----------------|-------------|
| 1  | Introduction   | - Students are asked to criticize the AR in videos related to the concepts that will be relate to knowledge about the previous topic |
|    | Post-stage     | - Students can specify all concepts obtained from practical activities (table observation and data analysis) |
Table 3. SW grouping based on HOTS indicators according to Bloom stage creating (C6)

| No | Part of the SW | Information |
|----|----------------|-------------|
| 1  | Main-stage     | - In the part of data collection:  
|    |                |   - Students learn to plan the placement of reference points and time intervals used in the type ribbon to be used as experimental data. |
| 2  | Post-stage     | - In the part of data analysis:  
|    |                |   - Students are given the freedom to determine the interval of data and put variables into the graph to declare the results of lab data. |
| 3  | Post-stage     | - In the part of data analysis and discussion section:  
|    |                |   - Based on questions, students are able to find concepts that are learn based on processed data and graphics  
|    |                |   - Students are able to make mathematical equations based on the concepts obtained. |
| 4  | Post-stage     | - In the part of application concept:  
|    |                |   - After understanding the material concepts, students are able to solve problems that shown in the video by combining the concepts obtained through LA. |

3.2 Validation Test Results

The results of this SW development have passed validation tests by media expert and material expert. The following is the results of validation of the SW with AR of UAM topic.

Table 4. SW validation test by media expert

| No | Aspect Measured       | Presentation Scale | Interpretation |
|----|-----------------------|--------------------|----------------|
| 1  | SW size               | 100%               | Very Good      |
| 2  | The layout of the SW cover | 88.6%            | Very Good      |
| 3  | Typography of SW cover | 96%               | Very Good      |
| 4  | Component of SW       | 95%                | Very Good      |
| 5  | The layout of SW content | 100%              | Very Good      |
| 6  | Typography of SW content | 92%               | Very Good      |
| 7  | Illustration of SW content | 100%             | Very Good      |
| 8  | Interface AR          | 93.3%              | Very Good      |
| 9  | The content of AR     | 86.7%              | Very Good      |
|    | **Average of all aspect** | **94.6%**        | **Very Good**  |
Table 5. SW validation test by materials expert

| No | Aspect Measured            | Presentation Scale | Interpretation |
|----|----------------------------|--------------------|----------------|
| 1  | Material conformity        | 80%                | Good           |
| 2  | Material consistency       | 93.3%              | Very Good      |
| 3  | Material writing language  | 85%                | Good           |

The validation test by media expert generates some suggestions and inputs to revise the SW with AR. The appearance of the back cover needs to be arranged according to the standard, the sound effects in the AR video need to be raised, and the SW needs to be packaged attractively. The average score of learning media validation is 94.6%. This value obtained cause the AR video in SW can show good visualization of concept of LA on UAM topic appropriate with Wong Yip J’s research. On the other hand, AR video on SW can increase the active role and thinking abilities of students in LA learning.

The validation test by material expert gives some suggestions that in the AR video the introduction section should include a graph of speed vs. time that is being highlighted so that UAM phenomenon appears, information in the image must be completed, and the qualities of the AR video must be ensured so that the concept can be raised. The average score of learning material validation is 86.1%. It causes by well designing of SW and AR videos, so can help the learning process of science.

4. Conclusion

SW with AR to be developed through three stages, namely the introduction, main-stage, and post-stage to train high-level thinking skills. AR media developed into the form of videos that function as to train HOTS of students. The AR videos are placed at each stage in the SW, which is at the introduction to the form of a physical phenomenon related with the concept to be practiced, at the main-stage in the form of sequencing instructions and the use of tools, and in the post-stage in the form of applying the concept. Based on the results of product validation, the percentage of eligibility is 94.6% for the media, and 86.1% for the material.

5. References

[1] Rubini B, Permanasari A and Permana I 2018 IOP Conf. Ser. Mater. Sci. Eng 288 012030
[2] Ghani I B A, Ibrahim N H, Yahaya N and Surif J 2017 Chem. Educ. Res. Pract 18 849–874
[3] Malik A, Setiawan A, Suhandi A, Permanasari A and Sulasman S 2018 IOP Conf. Ser. Mater. Sci. Eng 288 012027
[4] Riyadi B, Ertikanto C and Suyatna A 2018 Inter. J. Res. Granthaalayah 6 223–233
[5] Usmeldi 2016 J. Pendidik. IPA Indones 5 134–139
[6] Kirschner P A 2015 Instr. Sci 43 309–322
[7] Nachimuthu K 2016 Int. J. Recent Trends English Lang. Teach. (ELT), Educ. Psychol. Arts Allied Res 3
[8] Delen E, Liew J and Willson V 2014 Comput. Educ 78 312–320
[9] Radhmanani R, Sasidharakurup H, Sujatha G, Nair B, Achuthan K and Diwakar S 2014 Conf. Proc. eLEOT 2014, Lect. Notes Inst. Comput. Sci. Soc. Telecommun. Eng. LNICST 138 138-146
[10] Yip J, Wong S H, Yick K L, Chan K and Wong K H 2019 Comput. Educ 128 88–101
[11] Permana A H, Muliayati D, Bakri F, Dewi B P and Ambarwulan D 2019 J. Phys. Conf. Ser 1157 032027
[12] Sabara E and Suhhaeb S 2017 Int. J. Sci. Dev. Res. 2 78–81
[13] Nugraha M G, Utari S, Saepuzaman D and Nugraha F 2018 J. Phys. Conf. Ser 1013 012038
[14] Lee C-D 2014 Int. J. Educ. Math. Sci. Technol 2 96–106
[15] Putra A, Lufri, Festiyed and Ellizar 2019 J. Phys. Conf. Ser 1185 012045
[16] Siahaan P, Suryani A, Kaniawati I, Suhendi E and Samsudin A 2017 *J. Phys. Conf. Ser.* **812** 012017

[17] Dick W Carey L and Carey J O 2015 *The Systematic Design Of Instruction (Eight Edition)* Pearson, Boston

[18] Azizah S N, Dafik D and Susanto S 2018 *Int. J. Adv. Eng. Res. Sci* **5** 74–82

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