JISE 12 (1) (2023): 93-96

Journal of Innovative Science Education

http://journal.unnes.ac.id/sju/index.php/jise

Development of Virtual Laboratory Media for Virus Materials to Improve Students' Higher Order Thinking Skills in Senior High School

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Article Info

Article History :
November 2022
Accepted
January 2023
Published
April 2023

Keywords:
virtual laboratory, virus material, learning media

Abstract

This study aims to (1) describe the validity of under-development virtual laboratory media of virus material, (2) describe practicality of under-development virtual laboratory media of virus material, (3) describe effectiveness of under-development virtual laboratory media of virus material. This study is research and development using the ADDIE model (analyze, design, develop, implement, and evaluate). The study instruments are compiled including virtual laboratory media validation sheets for experts, virtual laboratory media practicality sheets for biology teachers and student, critical thinking questions and procedural skills. The application of virtual laboratory media includes limited trials and field trials. The field trial subjects are students of class X at State Senior High School 1 Wonosobo. The field trial design for this research is a pretest-posttest control group design. The practicality of virtual laboratory media is analyzed from data on filling out the eligibility sheet by media and material experts by managing the average score and categorizing the data into ideal ratings. The practicality of virtual laboratory media is analyzed from the data of filling in the practicality sheet by the biology teacher by managing the average score by categorizing the data as an ideal assessment. The effectiveness of virtual laboratory media is analyzed from n-gain data on critical thinking and procedural skills using the Mann-Whitney U test. The results showed that (1) the under-development virtual laboratory media is valid for use in teaching biology on viruses based on expert validation (2) the under-development virtual laboratory media is practically used in learning biology material on viruses based on the biology teacher's assessment. Thus, it becomes a solution for laboratory tools and materials for State Senior High School 1 Wonosobo which can facilitate their students in improving HOTS skill (3) the under-development virtual laboratory media effectively improves students' higher-order thinking skills based on Mann Withey U analysis on trial data.

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p-ISSN 2252-6412
e-ISSN 2502-4523

INTRODUCTION

The 2013 curriculum is designed to produce students who are equipped to face the future and proactively respond to the challenges of the times. Higher-order thinking skills (HOTS) in schools, as explained by Thomas & Thorne (2009) require students to be able to understand, analyze, categorize, manipulate, create, and apply in finding solutions to new problems. According to Bloom's taxonomy which has been revised, cognitive processes are divided into two, namely high order thinking skills (HOTS) and lower order thinking skills (LOTS). Low-level thinking skills involve the ability to remember (C1), understand (C2) and apply (C3) while high-order thinking skills involve synthesizing analysis (C4), evaluating (C5), and creating (C6) (Anderson & Krathworl, 2001) .

HOTS is a thinking process in receiving new knowledge and then processing it to be used in problem solving. HOTS requires students to do something about facts such as understanding, concluding, relating facts and other concepts, categorizing, manipulating, putting facts together in new ways and applying them in finding solutions to a problem (Nugroho, 2019). Successful mastery of a concept is obtained when students are able to think at a higher level, students are not only able to remember and understand a concept, but also analyze and synthesize, evaluate, and create a concept well. Concepts that have been understood can be embedded in students' memories for a long time, so it is essential for students to have higher-order thinking skills (HOTS) (Lailly, 2015).

One of the biology learning sub-materials in high school is Viruses. This material is contained in basic competency 3.4 which analyzes the structure, replication and role of viruses in life. From basic competency after being analyzed, requires activities in the form of experiments. Experimental learning in the laboratory is believed to be a key factor in learning biology because it can understand natural phenomena and develop a scientific way of thinking. However, real laboratory activities are felt to be more time-consuming by some teachers, including in terms of preparing equipments and materials, and having to provide proper and correct instructions for experimental activities. With the development of information technology, the virtual laboratory set as an alternative to overcome this problem by simulating experimental activities in the laboratory.

Virtual laboratory is a series of laboratory tools in the form of interactive multimedia-based computer software, which is operated with hardware and can simulate activities in the laboratory (Santoso, 2009). According to Oetomo in (Razi, 2013) there are several advantages to using a virtual laboratory, 1) it does not require expensive laboratory equipment and materials, so that it can be an alternative to overcome the limitations or lack of laboratory equipment and material facilities. 2) reduce time constraints, when there is limited of time to teach in the laboratory. 3) the ability of the computer to broadcast back the information needed by the user (computer patience) can help students who have a slow learning speed (slow learner), 4) it is more interactive, so that students can do practicum as in an attractive physical and visual laboratory, 5) students can use it independently or in groups and it doesn't have to be in the laboratory room, 6) increases security and safety, because it doesn't really interact with tools and chemicals.

Based on the previous explanation, in learning biology, an interactive multimedia learning is needed which can facilitate students to improve HOTS. This research focuses on the development of virus material virtual laboratory media to improve high-order thinking skills of high school students.

METHODS

This research is an R&D (Research & Development) research conducted in September-November 2022. The research subjects were students of class X A and I of State Senior High School 1 Wonosobo, with a total of 49 students. This study used the ADDIE model. The following is the ADDIE development cycle which will be used in research:

1. Analysis

This stage is carried out in 2 stages, (1) needs analysis, this analysis is carried out by interviewing biology teachers at State Senior High School 1 Wonosobo. Furthermore, an initial-end analysis is carried out which included student analysis, technology analysis, important event analysis, analysis of learning objectives, media analysis. This stage aims to obtain data that is used as a consideration in developing the media.

2. Design

The virtual laboratory media design stage includes material planning, display design, flowchart creation and overall design (storyboard) development. Media content charts, material content charts, display designs, and flowcharts are in the methods section.

3. Development

This development stage aims to produce a virtual laboratory product consisting of three, they are the development of virtual laboratory media, virtual laboratory media validation and material validation.

4. Implementation

This stage is a limited trial stage to find out the practicality of media for biology teachers and students. A limited trial is conducted on 9 students of Senior High School 1 Wonosobo, particularly 3 students with low cognition, 3 students with moderate cognition and 3 students with high cognition

5. Evaluation

This stage is the field trial and the media analysis stage. The field trial phase is carried out at Senior High School 1 Wonosobo class XA and XI with a total of 49 students.

RESULTS AND DISCUSSION

Media validity

The results of the research are in the form of media virtual laboratory of virus material to improve higher-order thinking skills. This media has been validated by experts. In this case, the media is validated by material and media experts, the validation results are presented in the table below:

Table 1. Media Validation Results

No.	Validator	Member Validator Values	Criteria
1.	Material expert validator	0.8	Very good
2.	Media member validator	0.8	Very Good

Media validated by material and media experts get the result 0.8, this score indicates that the mediavirtual laboratory developed has very good and valid criteria. Media virtual laboratory facilitated by students being able to analyze, evaluate, create which is summarized in HOTS skills. Advice from experts will then be used for improvement including (1) in this competency, using Indonesian standard, (2) in the material it is necessary to add structural images of various viruses (corona, retro and adeno), and (3) complete the material with a replication mechanism .

Related to the validity of the media virtual laboratory according to research conducted by Felintina (2012) which states that the mediavirtual laboratory is said to be eligible/valid when it meets the criteria very good based on the assessment of material experts and media experts.

Media Practicality

After media virtual laboratory valid then a limited trial will be carried out on 9 students consisting of 3 students with low cognition, 3 students with moderate cognition, 3 students with high cognition. Besides, an assessment is carried out by the biology teacher and students. After conducting limited trials, the following results were obtained:

Table 2. Media Practicality Results

Assessment	Score	Criteria
Biology teacher	0.8	Very good
Student	0.8	Very good

The media assessed by the biology teacher based on table 2 shows results with very good criteria with a score of 0.8. Then a field trial will be carried out at Senior High School 1 Wonosobo. Learning media also needs to be measured for its practicality. Practicality is the convenience that exists in the product both in preparing, using, interpreting and in storage (Arikunto, 2010).

Media Effectiveness

After the limited trials, field trials were conducted which at Senior High School 1 Wonosobo class X-A and X-I which were the experimental class and the control class. Field trials obtained the results of media effectiveness data *virtual laboratory* after being given the pretest and posttest are as follows:

Table 3. Media Effectiveness Results

No.	Class	HOTS Skill	*n-gain*	Information
1.	Experiment class	Critical thinking	0.836	Very effective
		Procedural knowledge	0.583	Very effective
2.	control class	Critical thinking	0.575	Less effective
		Procedural knowledge	0.255	Less effective

Based on the table, the effectiveness of the media *virtual laboratory* analyzed using test *Mann Whitney U* to n-gain in the experimental class resulted in a critical thinking score of 0.836 and a procedural knowledge value of 0.583. Therefore, it can be conculded that learning using a media *virtual laboratory* is very effective to improve students' HOTS skill. In the control class, the n-gain value of critical thinking is 0.575 and procedural knowledge is 0.255. Therefore, it can be summarized that learning using video media itself is quite effective to develop students' HOTS skill.

Based on this description, in the use of media virtual laboratory of virus material from the aspects of critical thinking and procedural knowledge of students can be used as a tool to improve students' HOTS skill. Finally, this will have implications for optimizing aforementioned skill achieved by students.

From the description above in accordance with the research that was done (Siahaan,*et.al,* 2017) media consumption virtual laboratory on experimental learning to prove to increase student understanding. This is also in accordance with (Barbour et al*.,* 2009) which states that the use of technology in learning is effective in increasing understanding of science.

CONCLUSION

According to the findings of the research and development of virtual laboratory media, the following conclusions can be formulated: (1) the under-development media is valid and suitable for use in learning biology material on viruses, according to expert validation. (2) the under-development media is practical, according to the assessment of the biology teacher. (3) the media effectively improves students' HOTS skills from the aspect of critical thinking and procedural knowledge based on the results of the Mann-Whitney U analysis on the trial data.

Suggestions from the results of research that has been done is the need for media virtual laboratory developed for other biology materials, so that high school students are more accustomed to using technology virtual laboratory. Need to develop various other features in the media*virtual laboratory* in order to create more effective learning.

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