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DEVELOPMENT OF SCIENCE VIRTUAL LABORATORY (SCIVLAB) TO DEVELOP CRITICAL THINKING SKILLS IN ELEMENTARY SCHOOLS ON THE TOPIC OF CHANGES IN THE STATE OF SUBSTANCES

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Abstract

This study aims to describe the use of Scivlab in developing critical thinking skills of elementary school students on the material of changes in the state of matter. The method used in this study is design-based research. The stages discussed in this study are the development stages. The results of the validity of the science virtual laboratory media developed in the very good category from the aspects of language, software engineering, and visual display. The validity of the material with aspects of material relevance, material organization, evaluation, and language obtained an average value of very good. In this study, a limited trial was also conducted in the Laboratory elementary school, the results showed that the Scivlab developed could be used well in learning in elementary schools. Suggestions for subsequent researchers include a virtual laboratory with other materials and a more interactive menu related to the addition of a children's game menu so that in the learning process students will be more interactive.

Keywords: Changes in the state of matter, Critical thinking skills, Elementary school, Scivlab, Virtual laboratory.

1. Introduction

Critical thinking is one of the abilities that is valued and made a goal in the educational system. Critical thinking skills in elementary schools are still low [1]. Critical thinking skills can be developed through scientific work activities [2]. Based on the results of observations, the number and facilities of laboratories in elementary schools are very small [3]. The limitations of the laboratory underlie the development of the science virtual laboratory (Scivlab) which is an alternative to conducting scientific work. The Scivlab that was developed is the material on changes in the state of matter which is one of the basic concepts that is very important and relevant in everyday life [4]. Table 1 presents several research that demonstrates how virtual laboratories might enhance students' conceptual knowledge. Additionally, students can achieve notable improvements in learning outcomes when they use virtual laboratories [5-9].

Table 1. Literature review of virtual laboratory research.

No.	Title	Ref.
1	Virtual laboratory in the role of dynamic visualisation for better understanding of chemistry in primary school	[5]
2	A gender matching effect in learning with pedagogical agents in an immersive virtual reality science simulation	[6]
3	The use of augmented reality to foster conceptual knowledge acquisition in STEM laboratory courses—Theoretical background and empirical results	[7]
4	Using hands-on and virtual laboratories alone or together—Which works better for acquiring knowledge and skills?	[8]
5	Virtual laboratories in science education: students' motivation and experiences in two tertiary biology courses	[9]

The purpose of this study is to develop Scivlab in fostering critical thinking skills in elementary school students on the material of changes in the state of matter. The novelty of this research is: (i) Scivlab adventure which is equipped with a story with a scout theme, (ii) Market laboratory, where students can choose tools and materials independently, and (iii) Analysis, as a deepening of the material.

2. Literature Review

One of the most important abilities and capabilities that kids need to acquire is critical thinking [10]. From primary school onward, critical thinking abilities including analysis, synthesis, and assessment can be cultivated [11]. Six critical thinking skill indicators are engaged in its interpretation, analysis, evaluation, inference, and explanation of self-control [12]. In science learning in elementary schools, critical thinking skills can be developed through scientific work activities in real laboratories. Facts in the field show that there are still many schools that do not have laboratories. To overcome this, a virtual laboratory is needed.

A virtual laboratory is a computer-operated simulation in the form of interactive computer software that can try laboratory activities as if it were a school laboratory. Science Virtual Laboratory (Scivlab) is a website designed for virtual practicum-based science learning. Scivlab is committed to answering this challenge by providing a critical platform [13]. Through Scivlab, students can carry out various

scientific work activities directly from computers and mobile phones, allowing them to better understand scientific work concepts [14].

Changes in the state of matter are one of the most important basic concepts in natural science. Based on Fig. 1, changes in the state of matter are one form symptom of a change in an object to a different form from before, whether the size, shape, colour, and aroma change. Changes in the state of matter occur because an object is affected by heat or heat, temperature, humidity, and so on. A deep understanding of processes such as melting, freezing, evaporating, condensing, sublimating, and crystallizing is not only essential for mastering the subject matter but is also relevant in everyday life [15].

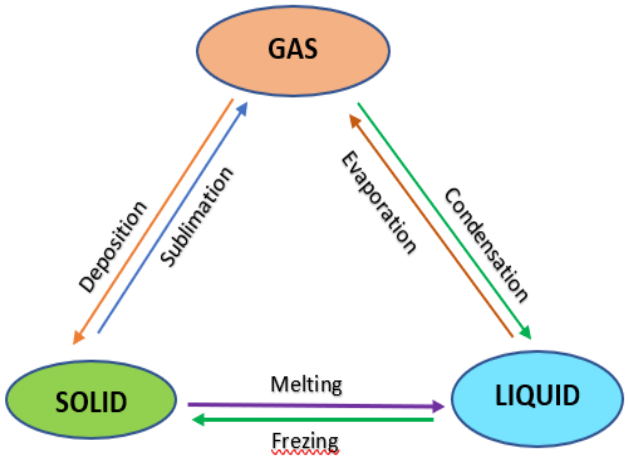

Fig. 1. Changes in the state of matter.

3.Method

This study uses a DBR design-based research method. There are 4 steps in this study, namely: analysis, design, development, and evaluation. The analysis is carried out to record the needs of the application to be developed. Then the design is carried out in the form of a website-based application science virtual laboratory related to fostering critical thinking skills in the material of changes in the state of matter. This is done as a development stage, and a validation test is carried out by media experts. In addition to the validation test, a limited trial was carried out on 25 students who used the Scivlab application.

4.Results and Discussion

The analysis carried out in this study revealed that Surabaya region elementary school children have poor critical thinking abilities [16]. Then the researcher identified the existence of elementary school laboratories in the Surabaya area. Based on the results of the observations made, the condition and number of laboratories are still not sufficient. This will certainly have an impact on the imbalance in educational accommodation. One way that is considered appropriate by the character of the concept of 21st-century education, namely related to technology skills and information media, is to include technology in the laboratory. Therefore, other learning media are needed to support scientific work activities.

The creation of a science virtual laboratory, an alternate method for carrying out scientific research, is based on the deficiencies of the physical laboratory. The results of the study showed that virtual laboratories were able to improve scientific attitudes and scientific work skills [17].

Drawing from a range of sources and conversations with developers, the application is tailored to meet specific requirements. The design of the virtual laboratory science media application can be seen in Fig. 2. First, by logging in, then entering the Scivlab user manual, and selecting the material menu for changes in the state of matter. Enter the pretest menu to find out students' initial knowledge. Then enter the Scivlab adventure which contains adventure stories by combining the concept of scientific experiments with scouting activities. Through an interesting narrative, students are invited to explore the application of scientific methods in an interesting and educational real-life context. Continue to the material, instructions for using the experiment, enter the experimental room/place to do scientific work, the Analysis room, and finally the posttest.

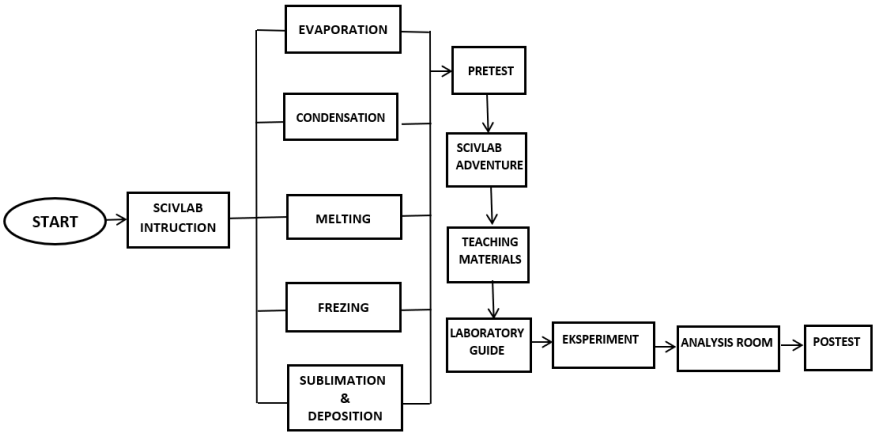

Fig. 2. Flow chart science virtual laboratory.

The development team and supervisor listed were consulted during the application's development. Starting by logging in via the page https://scivlab.com/ then entering the menu: (a) virtual laboratory consisting of 5 materials melting, evaporating, condensing, freezing, and sublimating and crystallizing. Then enter Scivlab adventure, (b) which is an adventure story that combines the concept of scientific experiments with scouting activities. Through an interesting narrative, students are invited to explore the application of scientific methods in a real-life context that is exciting and educational. Reading teaching materials(c). Market The laboratory is a place to choose tools and materials that suit your needs (d). After all the necessary tools and materials have been selected, you can continue by selecting the "next" button to enter the next stage in the scientific work activity process. Carrying out practical activities according to laboratory instructions (e). After completing scientific work activities, the next stage is to analyse the scientific work activity process that has been carried out by answering several questions provided. (f) This analysis can comprehensively evaluate how scientific work activities are carried out. Figure 3 shows the development of Scivlab from the beginning until analysis.

Fig. 3. Scivlab development results: (a) Menu of material on changes in the state of matter, (b) Scivlab adventure, (c) Teaching materials, (d) Market laboratory, (e) Experiment room, and (f) Analysis room.

In developing the science virtual laboratory, the developer's revision of the selection of the substance change menu added an interesting image according to the title. The Scivlab adventure stage is not only a dialogue in written form, it needs to be added with sound. In the teaching material menu, the material expert validator asked the researcher to review the material so that it is more by the learning concept that has been created, namely the material on changes in the state of matter in condensed material. In the market laboratory menu, there are several revisions, including the images of tools and materials that still do not resemble their original form. When choosing the tools and materials needed, there is an indicator that appears, namely a cross. When the tools and materials are finished, there is an indicator that shows the writing is successful so that it can enter the experimental room.

For revisions to the experimental room menu, several aspects need to be fixed, including the scales not working yet, then the stove having no flame, and the stopwatch numbers cannot show the length of time needed. For the analysis menu, the answer cannot be saved in the science virtual laboratory system. Thus, improvements are needed. In each menu, an arrow needs to be added that points to the menu before and after, in addition, a home icon is added to the top right of each Scivlab menu to make it easier for users to operate it. Validation of the Science virtual laboratory media was carried out by 3 material experts and media experts. By using a material expert validation sheet instrument consisting of 14 questions and using 4 alternative answer choices referring to a Likert scale of 1-4. Based on the calculation results obtained, it can be seen that the level of material validity obtained a category value of "very valid". Thus, "Scivlab" can be said to be worthy of being tested on students. For media validity, it consists of 10 questions with a Likert scale of 1-4. Based on the calculation results obtained, the level of material validity is in the category of "very valid". Thus, the material contained in the "Scivlabs" media is worthy of being tested on students.

This virtual laboratory science application media is made according to the characteristics and needs of students [18, 19]. In Scivlab, a practical menu is available which can make it easier for students to practice virtually. Thus, students

do not have to bring tools and materials from home to make practical changes in the state of matter [19]. The advantage of Scivlab is that students not only learn about scientific concepts but also develop strong analytical skills in processing data and interpreting the results of scientific work activities [20]. The advantages of Scivlab are its interactive features and the ability to collaborate so that Scivlab can add to the learning experience [21]. Apart from that, students can carry out scientific work activities by analysing various changes in variables and observing the results directly [22]. Finally, this study adds new information in virtual laboratory as reported elsewhere [23-29].

5. Conclusion

The purpose of this study is to ascertain how science virtual laboratories might be utilized in primary schools to enhance student's critical thinking abilities on the subject of changes in the state of matter. The method used in this study is design-based. The stages discussed in this study are the development stages. The results of the validity of the science virtual laboratory media developed in the very good category from the aspects of language, software engineering, and visual appearance. The validity of the material with the aspects of material relevance, material organization, evaluation, and language obtained an average value of very good. In this study, a limited trial was also conducted at the Laboratory elementary school, the results of the study showed that the Scivlab developed could be used well in learning in elementary schools. The application developed by the researcher only covers the material of changes in the state of matter for grade IV of elementary school. Therefore, it is hoped that there will be the development of similar products with broader material. Further researchers can develop website-based media for subject matter, education levels, and other needs that are more relevant with more attractive media designs.

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