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The application of virtual laboratory as an effort to improve 10th grade students' learning outcomes on environmental change topic

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ABSTRACT

The purpose of this research was to identify the effect of a virtual laboratory application on the student results in the environmental changes topic at SMAN 16 Bandung. A virtual laboratory is an activity of learning with the use of software as a simulator containing all necessary equipment in preparation, tools, working step demonstration, and practicum observation. During learning process, the teacher guided the students to understand the concept of environmental changes topic (pollution and climate changes). The method used in this research was pre-experimental with a one-group pretest-posttest design. The sample in the research consisted of 34 students in one class experiment. Instruments used in this research consisted of 30 multiple choices questions with six options and a questionnaire about the attitude cases to the learning process. Supported research results showed that there was an effective effect in the application of virtual laboratory, with an N-gain value of 0.72 with the category of high effect. The average learning mastery of students after implementing a virtual laboratory was 88%. Learning outcomes about students' attitudes when learning using virtual laboratory showed a very good category with an average of 81%, with the highest attitude on indicators of collaboration and critical thinking.

INTRODUCTION

Environmental education is considered a major factor in the learning process that can improve knowledge and skills towards environmental change (Otto & Pensini, 2017; Jose et al., 2017). Environmental education in Indonesia is starting to be applied to learning programs and is listed in the Basic Competencies. In learning during this pandemic, material about the environment is found in the emergency curriculum KD 3.6 and 4.6. Environmental education that is taught is related to knowledge, skills, and attitudes and has the goal of environmentally responsible behavior (Bodzin et al., 2014). This makes the teacher as a guide must determine the right learning method to deliver learning.

Environmental change requires methods that clearly apply how things actually happen. It aims to generate awareness, knowledge, skills, values and opportunities for participation. It is expected to result in effective learning and behaviour to adopt a sustainable lifestyle. Learning during a pandemic like this can utilise technological advances, one of which is through virtual laboratories. Virtual laboratory is a system that can be used to support conventional practicum (Zaturrahmi et al., 2020). A virtual laboratory is a computer technology that supports conventional practicums by simulating laboratory experiments into a computer (Ravista et al., 2021). This virtual laboratory is not done in a separate room but uses software in carrying out practicum. Some studies highlight virtual laboratories as an alternative to live tourorials and represent an exciting new way of preparing learners for hands-on exercises such as laboratory work (Makransky et al., 2016).

Virtual laboratories are currently an alternative to face-to-face tutorials that can provide adaptive guidance and help learners to explore scientific phenomena safely and in a short time. Learning using virtual laboratories, in general, has benefits that will be obtained such as a more interesting learning process, more interactive, efficient time in learning, quality in learning can be increased, improving safety and security because there is no interaction with dangerous tools and materials and the learning process can be done anywhere and anytime (Ferreira et al., 2009; Gamage et al., 2020). This makes learning effective, learners gain a deeper and physically rooted understanding of the content, which can support learning in scientific fields especially on environmental change material (Makransky et al., 2016). However, virtual laboratories also have disadvantages such as lack of problem-solving experience, lack of direct supervision by teachers, servers that sometimes have problems that hamper and students lack experience assembling tools (Kapilan et al., 2021; Nirwana, 2016; Trúchly et al., 2019;).

A number of studies have revealed that virtual laboratories are beneficial for improving student learning outcomes in cognitive, affective and psychomotor aspects (Kapici et al., 2019; Maksum & Saragih, 2020; Siswanto et al., 2021; Udin & Ramli, 2021). The results of the study found that the effects of using virtual laboratories in learning can be beneficial for conceptual understanding and attitudes (Bogusevschi et al., 2020; Dyrberg et al., 2017; Hurtado-Bermúdez & Romero-Abrio, 2020). However, research related to the effect of virtual laboratories on learning outcomes both cognitive and affective on environmental change material is still limited. Therefore, researchers have the intention to further identify the effect of the application of virtual laboratories on learning outcomes on environmental change material. Researchers also examined the learning outcomes of cognitive knowledge and attitudes (affective) of students in carrying out practicum.

METHODS

The method used in this research is a pre-experiment research method with a quantitative approach. This method was chosen because in the research conducted, no control group was used. The sampling method is purposive sampling. Considerations in determining the

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experimental group are students majoring in MIPA, have not received material on environmental change and global warming, and students who have electronic devices such as mobile phones/laptops and the internet to support this research.

The research design used a one-group pretest-posttest design involving one experimental class. The participants in this study were students of class X MIPA 3 at SMA Negeri 16 Bandung with a total of 34 people. Before learning, students were given a pretest and after treatment was given a posttest. The instrument used for testing cognitive knowledge in the form of multiple-choice questions total 30 questions with five options. The questions tested used a proportion of difficulty levels with a ratio of 30% easy category questions, 50% medium item categories, and 20% difficult category items (Haniyah & Ibrahim, 2020).

$$\text{Score} = \frac{\text{Scores obtained by students}}{\text{Total scores}} \times 100$$

The reference criteria for categorize scores can be seen in Table 1.

Table 1. Cognitive assessment categories

Rate	Criteria
81-100	Very high
61-80	High
41-60	Fair
21-40	Low
1-20	Very low

(Sarwoto et al., 2020)

After converting the scores into grades, the posttest scores were then averaged to determine the learning outcomes of students' understanding of the concept of environmental change and pollution material. The improvement of students' learning outcomes skills after learning using a virtual laboratory is calculated and interpreted according to the N-gain formula. Classical completeness is achieved if 85% of all students at least get a score above 70. The formula used to determine classical completeness is:

$$\text{KK} = \frac{\text{JT}}{\text{Js}} \text{x} 100\%$$

Description:
KK = Classical Completeness
JT = Number of students who are complete
JS = Total number of students

The instrument to measure learners' affective or attitude is an attitude scale consisting of 25 question items covering seven indicators, namely learning effectiveness, the ability to connect new information with new information with pre-existing information, being sceptical, application of material in life, accepting differences and respecting different views, cooperation, and critical thinking skills. The attitude assessment uses a five-level Likert scale with the conditions as outlined in Table 2.

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Table 2. Likert scale questionnaire scoring

Description	Score for Positive Questions	Score for Negative Questions
Strongly Disagree	1	5
Disagree	2	4
Neutral	3	3
Agree	4	2
Strongly Agree	5	1

(Pranatawijaya et al., 2019)

Attitude data was analyzed descriptively using percentages. Furthermore, the percentage score of the questionnaire statement was interpreted based on Table 3.

Table 3. Affective attitude score range category

Rate	Criteria
81%-100%	Very good
61%-80%	Good
41%-60%	Good enough
21%-40%	Not good
1%-20%	Less

(Sarwoto et al., 2020)

RESULTS AND DISCUSSION

During the learning process, there are two sub-chapters of environmental changes used for the application of virtual laboratories, namely environmental pollution and climate change material. All materials refer to the emergency curriculum KD 3.6 and 4.6. In environmental pollution material, students work on virtual laboratories individually while climate change material, students work on virtual laboratories in groups. Learning activities for each meeting vary, such as providing videos/pictures of several phenomena and LKPD to guide virtual laboratory work.

The results showed that the average pretest score of experimental class students on the material of environmental change and pollution was 41 and the posttest score was 83. This amount can also be interpreted as cognitive ability, so that if it is made into a percentage, the pretest value is 41% and the posttest value is 83%. From the results of these values, it will then be interpreted and discussed based on the category, namely the pretest is not good and the posttest is very good.

Comparison of learning outcomes that have been categorized is presented in Figure 1.

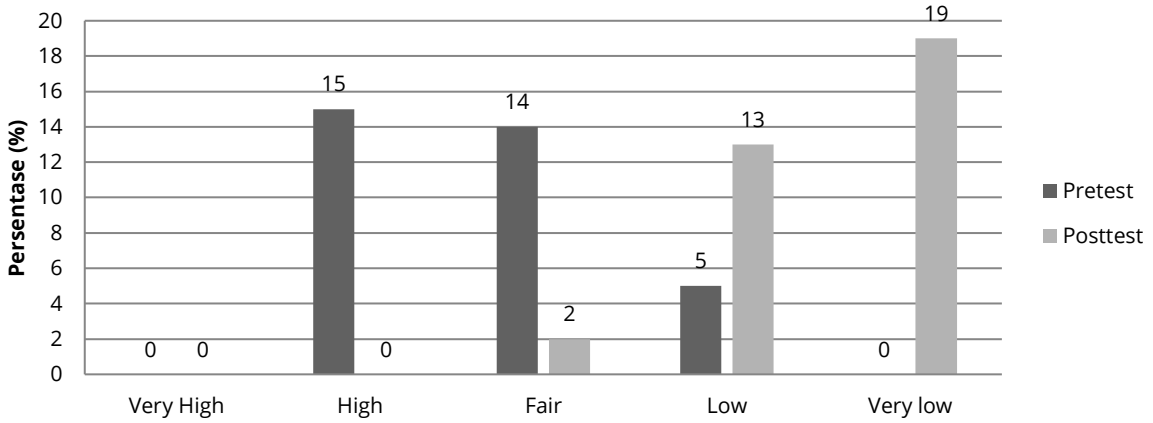

Figure 1. Comparison of pretest and posttest scores of cognitive learning outcomes

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To strengthen the data from the pretest and posttest results, it was continued with the N-gain analysis. The N-gain obtained in this study is 0.72 which is included in the high category. This is thought to be due to the effect of treatment by applying a virtual laboratory in understanding environmental change material (pollution and climate change). This is in accordance with research showing that learning using virtual laboratories can help students learn concepts effectively (Gunawan et al., 2017; Hernández-de-Menéndez et al., 2019; Supurwoko et al., 2017). Research has also found that using simulation-based virtual laboratories can help improve students' understanding of concepts so that it can improve students' scores (Dewi et al., 2020; Kapilan et al., 2021; Peechapol, 2021). The results of this study are also supported by the results of research by Siswanto et al. (2021) which states that the experimental class that implemented learning using a virtual laboratory produced an N-gain of 0,50 (high) while the control class N-gain was only 0,29 (low). The results of this study are in line with the results of Trisnawati & Yetri (2019) research which obtained N-gain results of 0,66 on straight motion material.

Based on the research conducted, virtual laboratories have an effective influence in improving student learning outcomes in environmental change materials, especially in the subchapter of pollution and environmental changes in class X SMA Negeri 16 Bandung. In addition, based on the experience of applying virtual laboratories to environmental change material, virtual laboratories have many benefits and advantages such as the learning process is more interesting, more interactive, saves time, can improve the quality of learning, makes it easier for students to practice abstract concepts such as climate change, can be done repeatedly even until the next semester without having to prepare tools and materials, and can be done anywhere and anytime as long as they have devices and the internet. However, in some research found that virtual laboratories cannot be fully implemented due to the level of experience and practical skills that are still not as good as direct practicum (Maksum & Saragih, 2020; Udin & Ramli, 2021).

The results of the analysis of the completeness of students based on data on the cognitive learning outcomes of students after the application of virtual laboratories on environmental change material show that 30 students or 88% have achieved completeness (KKM 70). These learning results show that learning using virtual laboratories is achieved and students meet the criteria for completeness of learning outcomes. Some learners experienced a significant increase in learning outcomes after using a virtual laboratory because the learning process became more interesting. However, there are still some students who have not completed the learning because they do not understand the knowledge and material about environmental changes even though the researcher has used cognitive learning knowledge.

In this study, the data from the measurement of students' attitudes are presented in Figure 2. The average value of students' attitude assessment score is 81% which is included in the very good category. However, there are factors that can affect the non-optimal achievement of students' attitudes on climate change material. Some factors are that students still tend to choose neutral option answers. Choosing the neutral option results in constant changes or only slight changes between indicators and other factors. One of the things that causes students to choose netrak is because the virtual laboratory is relatively new so that several times students are confused about its operation and somewhat hampers learning.

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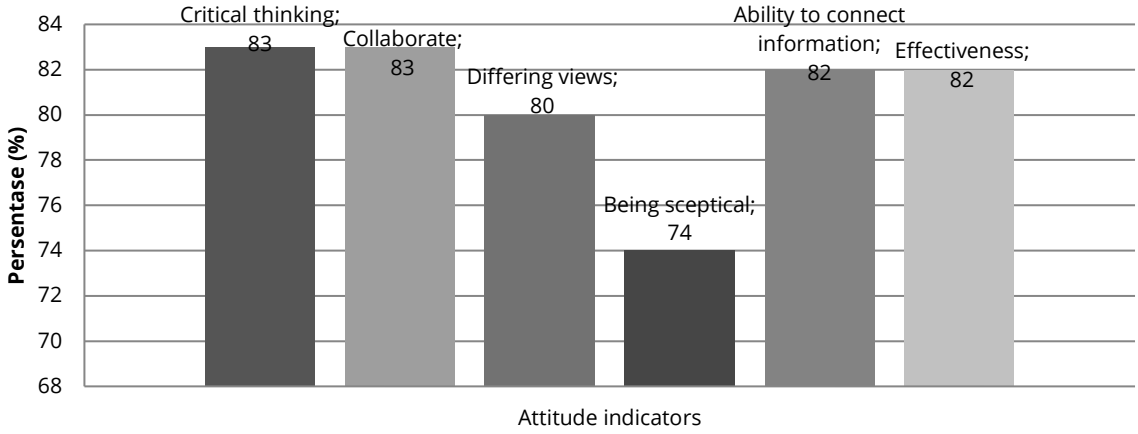

Figure 2. Results of students' attitude assessment

CONCLUSION

The application of virtual laboratories in learning environmental change material has a positive effect on student learning outcomes. The N-gain obtained in this study is 0,72 which is included in the high category. A total of 88% of students reached the minimum completeness (70). Assessment of students' attitudes during learning using virtual laboratories is included in the very good category with an average score of 81%.

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