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Enhancing Students' Scientific Literacy Using Virtual Lab Activity with Inquiry-Based Learning

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ABSTRACT

Laboratory activity is closely related and yet is important in the process of science teaching-learning. The hands-on laboratory experiment is the one normally used in school. Particularly with the state of online schooling, it is quite challenging to perform a hands-on laboratory activity. The combination of inquiry-based learning with virtual lab activity can be one of the alternatives to develop a more alluring yet meaningful learning process within online learning. The objective of this research is to analyze the effect of virtual lab activity with inquiry-based learning on students' scientific literacy in light and optics topics. Participants were taken from junior high school students in the 8th-grade in Bandung, Indonesia. It includes 40 students with 14 males and 26 females with age range 13-14 years old who have not yet studied light and optics. Pre-experimental research method with a one-group pre- the post-test design was used. The finding indicates that there students' scientific literacy was significantly increased with a medium category (N-Gain score 0.441). Based on this research, virtual-lab activity with inquiry-based learning could be considered as an alternative to conducting a meaningful online learning activity, especially in science education.

Keywords

Science Education, Light and Optics, Virtual Laboratory, Inquiry-Based Learning, Scientific Literacy

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1. Introduction

The students considered physics as a hard subject to be comprehended (Lee, 2018). Other than that, there is also a lack of urgency for studying physics by the students where they are not playing an active role during the learning process (Afriani, 2019). As a consequence, in the Program for International Student Assessment (PISA) 2018, which was held by the Organization for Economic Co-operation and Development (OECD), Indonesia shows a low result in science. Where Indonesia earned 396 points in which it is far lower than the average score from the participating countries (OECD, 2018). PISA was being used as global, comparable data of schools performance in the standard of the quality in the education sector, whereby countries with better PISA score average results have better school performance (Agasisti, T. et al., 2018). This condition indicates the low achievement in science education. Besides that, the global Covid-19 pandemic may have an impact on the performance of science teaching-learning activities to be held through online learning.

One of the aspects measured in science achievement in PISA is students' scientific literacy. Scientific literacy is a thoughtful citizen that has the capacity to deal with science-related concerns and the concepts of science (OECD, 2018). Thus, the scientifically literate person is able to understand the main conceptualization and theories that shape the foundation of science and technical thinking, the derivation process of the knowledge, and the extent of how evidence or theoretical explanations can justify such knowledge (OECD, 2017). Fives et al. (2014) describe scientific literacy as the capacity to grasp and work with scientific information in a practical way on a regular basis. The low score that Indonesia gained in PISA 2018 can be one of the indicators that there is a problem in science teaching in Indonesia. Hurd (2000) stated that science education needs to pursue students to fit the living in the 21st-century. Furthermore, Turiman et al. (2012) state that scientific literacy and comprehension of science concepts are needed to face the digital era. Physics, as shown by Halliday et al. (2008), can enrich students' 21st-century skills by relying on experimental observations and quantitative measurements.

Laboratory activity is closely related and yet is important in the process of science teaching-learning. Practicum activity contributes to emphasize the students to acquire new experience, anticipation, curiosity, motivation, confidence, and the greatest significant aspect is that the student has a deeper learning understanding (Lee & Sulaiman, 2018). The hands-on laboratory experiment is the one normally used in school. But unfortunately, the conventional hands-on laboratory needs high costs in the procurement of the equipment, room, and maintenance staff. Particularly with the state of online schooling, it is quite challenging to perform a hands-on laboratory activity. Here, as a result, students cannot continue to undertake hands-on laboratory activity. Attempting to implement an appropriate learning activity in which students are able to study science wherever they can access internet connection to take part in this situation is indeed very essential. In which they may also do self-guided learning and allows them to work at their place.

In order to address these obstacles, the cycle of science teaching and learning must require a number of approaches, strategies, and models to accomplish the learning objective. However, there is a shortage of practical facilities and resources for hands-on laboratory experiment, and also a concern which still limits the full realization of long-distance learning, in online learning, the virtual laboratory might be helpful (Daineko et al., 2016 and Potkonjak et al., 2016). The virtual lab has been used widely in science teaching because of its ability to that permits students to obtain expertise in modifying variables and studying the scientific phenomena that exist. We may also carry out laboratory experiments in the context of online schooling (Daineko et al., 2016 and

Potkonjak et al., 2016). However, in Indonesia, the teacher has not been used computer technology such as virtual lab as a learning tool maximally (Ismail et al., 2016).

Furthermore, the usefulness of the virtual laboratory in teaching relies on the expertise of the teachers' pedagogic skills, the ability to design the learning process, and the ability to apply the curricula during the learning process (Daineko et al., 2016). A virtual laboratory activity can also be used as a piece of inquiry-based learning (Ifthinan, D, 2019). Wolf and Fraser (2007) describe inquiry-based learning as a student-centered, focused on discovering how to learn, and immersive learning approach. A virtual laboratory activity that is integrated with inquiry-based learning poses students construct their own experiment rather than trying to follow predefined experiment procedure, so that they can formulate their own explanation of the scientific phenomena happened, which establish their higher-order cognitive skills (Ural, 2016). Besides, the research done by Wolf and Fraser (2008) has shown that inquiry-based laboratory activity strengthens the cohesion amongst students and has felt the inquiry-based laboratory activity is efficient for the learning activity. Nevertheless, the incorporation of virtual lab activity with inquiry-based learning is seldom performed in Indonesia (Prima et al., 2018). Hence, combining virtual laboratory activity with inquiry-based learning to be implemented in the science teaching-learning process is anticipated to have beneficial impacts on students' scientific literacy.

The topic chosen in this research is light and optics topic, where students can engage with scientific phenomena in daily life in which it is one of the requirements of scientifically literate students. The topic is directly-linked to day-to-day events, such as the usage of light, mirrors, camera, and also the use of eyes. Generally, for both student and teacher, the light and optics teaching and learning process is challenging (Tural, 2015). Students consider this topic is abstract and have difficulties in understanding the concept. A research conducted by Kroothkaew, S., & Srisawasdi, N. (2013) revealed that the students' poses a greater conceptual comprehension after completing the class. Chiu et al. (2015) also find that a virtual science laboratory can permit students to formulate an explanation of abstract science subjects as well as light and optics topic.

Previous research on virtual laboratory activity with inquiry-based learning was undertaken. Beck et al. (2014) have done research that highlighted a positive effect on students' learning gains after applying inquiry-based teaching in biology laboratory courses. Wang et al. (2015) examined the learning efficacy of scientific inquiry skills in high school students by utilizing the Virtual Physics Lab (VPL). The result shows that Model-Based Inquiry-VPL were far more significant in comprehensive skills and process skills. Blumer (2019) further analyzed whether students with varying degrees of previous experience have reacted differently to laboratory courses where a guided-inquiry module was implemented. Former research by Galan et al. (2017) reported that inquiry-based learning had been shown to enhance students' enthusiasm and interest, allowing higher-level cognitive skills to be established. Ifthinan, D. N. M., and Atun, A. (2019) presented that students' confidence, creativity, and critical thinking can be promoted by implementing inquiry-based virtual laboratories. In accordance with Hermansyah, H. et al. (2019), substantial influence on students' conceptual comprehension was noticed after the implementation of virtual laboratories in guided inquiry learning.

Such research introduces the benefits of virtual laboratory activity and focuses mainly on conceptual comprehension. Besides that, most of the previous results were emphasizing on senior high school students. In contrast to these studies, this research was prompted to analyze the impact of virtual laboratory activity with inquiry-based learning toward junior high school students. This research also focuses on students' scientific literacy, which is highlighted as the problem in science education. Therefore, this research is contemplated to carry out a study titled 'Enhancing Students' Scientific Literacy Using Virtual Lab Activity with Inquiry-Based Learning in Light and Optic Topic'.

2. Method

a. Research Design

This study utilizes the pre-experimental method with one group pre-test and post-test design. It helps the researchers with an ability to analyze the impact of a treatment on a specific group (Cresswell, 2012). There is only one class that was treated by using virtual lab activity with inquiry-based learning. Table 1 defined the research design.

b. Participant

In this research, the population consisted of 8th-grade students attending an International Junior High School in Bandung, Indonesia. This school is using Indonesia Curriculum 2013 (*Kurtilas*). Convenience sampling technique was used as the sampling technique, in which the sample taken are the groups or individuals that were (conveniently) eligible for the study (Fraenkel, J., 2012). The sample is 40 students that consists of 26 female and 14 male with the age average are 12-13 years old who have not yet learned the topic of light and optics.

c. Research Instrument

The instrument utilized to assess the scientific literacy of the students either in the pre and post-test was made referred to PISA's Assessment on students' scientific literacy that focuses on light and optics topics. The Scientific Literacy test was also adjusted to fit Kurikulum 2013. The initial test consisted of 30 questions. After the construction process, the test was analyzed and judged by the expert. After revising the test based on the expert's suggestion, the test was given to 9^{th}-grade students who have learned the topic. There are 49 students from a different school. The validity, reliability, difficulty level, discriminating power, and the distractor of the test was analyzed by using SPSS ver.25. The most qualified questions were then sorted out. There are 15 questions on the final scientific literacy test. The pre-test is conducted before the treatment to assess students' initial scientific literacy, and after the treatment, a post-test is conducted to assess final students' scientific literacy.

d. Data analysis

The data gained was then analyzed by utilizing Ms. Excel for calculation and SPSS IBM ver.25 for statistical analyses. The first data analysis was calculating the students' score with the maximum score is 100. After that, the average from the pre and post-test data was also calculated. After the average was calculated, the normality test, homogeneity test, and the N-Gain score were done. Lastly, either if the data were normally distributed and homogeneous, a paired sample t-test will be used. Meanwhile, if one of the data was not normally distributed or not homogeneous, a non-parametric Wilcoxon signed-rank test would be carried out.

e. Research Procedure

The treatment given in this research is virtual lab activity with inquiry-based learning. The phases of the learning method are the ones defined by Joyce, Weil, and Calhoun (2004). There are five phases of inquiry-based learning. It consists of confrontation with the problem, data gathering (verification, data gathering (experimentation), formulating an explanation, and analysis of the inquiry process. Meanwhile, for the virtual laboratory, there are two virtual labs used with a different function. The first one is 'Ray Optics Simulation,' in which the layout can be seen in Figure 1. This virtual lab offers geometric optics simulation such as the reflection, refraction, and convergent and divergent of mirror and lens. The second one is 'Lens and Mirrors Lab' that the layout can be seen in Figure 2. Differ with the first virtual lab, and it stimulates the forming of image concave mirror, and concave and convex lens. All of the virtual labs are available online on the website and can be accessed without paying any penny. The treatment was done in 7 meetings within online learning. In the first and the last meeting, the pre-test and post-test were conducted. And the remaining meeting was used to give the treatment.

3. Result and Discussion

After the pre-test and post-test by using the Scientific Literacy test was conducted, the data obtained was then calculated and analyzed. The answer to the 40 students is calculated, to sum up, the correct answer. Figure 3 shows the comparative data of the pre and post-test average scores. The initial scientific literacy average score of the students obtained from the pre-test was 63.27. Then we can pose an enhancement since the post-test gain 81.25 scores.

After the average score was calculated, the normality test, homogeneity test, N-Gain, and non-parametric Wilcoxon signed-rank test was then carried out to further investigate the data more deeply by using SPSS ver.25. The result is described in Table 2.

Starting from the normality test, the pre-test gets sig. 0.181 and the post-test get 0.001. Therefore, since the prerequisite of a normally distributed data is sig. Value> 0.005, the pre-test is considered as normally distributed; meanwhile, the post-test was not normally distributed. After that, the homogeneity test displayed a sig. value 0.903, showing sig. value > 0.005 and characterized as homogeneous. Despite this, a non-parametric test was carried out. To test the hypothesis, the Wilcoxon signed-rank test was implemented. Asymp. sig. (2-tailed) gained was 0.000 (Asymp. sig. (2-tailed) <0.005), it suggests that students' scientific literacy were having a significant effect after implementing the virtual lab activity with inquiry-based learning. Inevitably, the N-Gain was calculated. The N-Gain score was 0.441, that further classified into medium efficiency on students' scientific literacy (Hake, 1998).

The learning process was conducted throughout 7 meetings. In which every meeting has 2x30 minutes allocated. Because of the global COVID-19 pandemic, the topic was addressed by online learning in which utilizing some online learning portal. Zoom conference was used as the meeting site, Edmodo to organize the assignment, learning material, and launching the announcement, and lastly, is Google Form to conduct gain the data. Meanwhile, the treatment itself was conducted by the use of virtual lab activity with inquiry-based learning. There are two virtual labs utilized in this research, Ray Optics Simulation and Lens and Mirrors Lab, that are available online on the website and can be freely accessed.

Ural (2016) observed that executing a guided inquiry laboratory experiment trigger a substantial enhancement on students' academic achievement and attitude toward chemistry laboratory and decreased laboratory anxiety. Galan et al. (2017) further researched that inquiry-based learning has been shown to increase students' curiosity and interest, allowing higher-level thinking skills to be established. Along with Kroothkaew (2013), who outlined a significantly increased students' conceptual understanding after the implementation of simulation-based inquiry learning.

As mentioned by OECD (2018) that scientifically literate person is able to understand the main conceptualization and theories that form the foundation of science and technical thinking, the derivation of the knowledge, and the extent of how evidence or theoretical explanations can justify such knowledge (OECD, 2017). Fives et al. (2014) describe scientific literacy as the capacity to grasp and work with scientific information in a practical way on a regular basis. Furthermore, students with high scientific literacy have the ability to perceive questions of scientific investigation that foster an individual's understanding of the nature of science, scientific methods, and what stands as evidence in science. These skills will involve students' knowledge and scientific conceptual comprehension and procedures necessary for individual decision making, participation in political and cultural sector, and economic development (NRC, 1996).

The teacher will improve the aspects required for the students to be scientifically literate by utilizing virtual lab activity with inquiry-based learning. The usage of a virtual lab encourages students to learn about how to modify variables in order to get the data to seek as evidence of their conclusion in the end. Integrating virtual lab activity with inquiry-based learning brings more meaningful learning. Where the students may develop their own knowledge and understanding by actively engaged in the learning process through posing and answering questions scientifically, that was so essential to boost their critical thinking. Over the same way, the students are allowed to investigate any potential result by deciding their own experiment procedure along with the guidance from the teacher. They will, therefore, assess whether the data can be counted as credible evidence or not.

Two virtual labs were used in this research. The first one is Ray optics simulation. It was established by Rick Tu and can be accessed freely from the following link https://ricktu288.github.io/ray-optics/simulator/. In operating this virtual lab, the user was encompassed to create the components needed, including such mirrors, lens, and the ray or beams. The user can also decide the location, size, and the focal point of the elements where they could learn by inquiry learning by consulting to the teacher for the right arrangement. The elements provided in this virtual lab can be seen in Figure 4, which includes the ray, beam, point source, mirrors, glasses, blocker, a ruler, and a protractor. This virtual lab can perform any variety of optical geometry experiments. For this research, the virtual lab was utilized to perform refraction of light, the reflection of light, and convergent and divergent from mirror and lens.

The next virtual lab utilized was Lens and Mirrors Lab. This virtual lab was developed by simbucket.com and can be freely accessed in the link provided https://simbucket.com/lensesandmirrors/. The contrast from Ray Optics Simulation that encompassed the user to create the elements by themselves, the element has already provided. To use this virtual lab, the user can just drag the object back and forth to observe the image formed by the mirror or the lens. The element consists of concave mirrors and a concave and convex lens. In comparison, the image formation of the convex mirror cannot be observed through this virtual lab. However, the functionality of this virtual lab may be viewed as a complete kit. Because besides we can visualize the image formation by the mirrors and lens, we can also see the special ray, which allows a simpler way to visualize the image formation process. There is a feature where we can switch the special ray to be on and off such we can see which special ray it is. We may even alter the gap between the object and image, and even modify the focus of the mirror and the lens. Candle, arrow, and alphabet are available as the object. The design of the Lens and Mirrors Lab is shown in Figure 5.

Even if the students have not been faced with the real equipment, the use of such virtual labs really managed to help students to visualize the phenomena that occur when the light ray strikes the mirror or the lens, by which enhance students' conceptual understanding of the light and optics topic. By using those virtual labs, they could improve their scientific literacy.

Furthermore, in this research, it is considered that there is a significant effect of the treatment on students' scientific literacy with the N-Gain score 0.441 and categorized into a medium improvement on students' scientific literacy. In accordance with Zhang L. (2016), which notes that inquiry-based learning models ''do in fact'' encourage students to improve their science content knowledge as well as investigative activities. Students' scientific literacy was not quite as high as anticipated. One of several factors that can affect this situation would be that the learning process has been entirely done through online learning, in which the teacher was unable to verify that the five phases of inquiry-based learning were executed properly by the students.

The five phases of inquiry-based learning by Joyce, Weil, and Calhoun (2004) are adopted in conducting the learning process. The first phase is a confrontation with the problem. The teacher delivers the procedures of inquiry learning to acquainting students to the concept of inquiry-based learning. The students were provided text about everyday phenomena relevant to the studied subject. Based on the text, students are asked to deliver a scientific questions in the worksheet. Such questions were then discussed together to point out the subject that will be learned. By this point, students are supposed to be acquainted with science-related topics surrounding them. Yet when this phase undergoes, some students are not willing to read the text given. In the term of delivering questions, just a few students counted. There are still some students who have not taken part in the conference for a variety of reasons. The solution to this issue is placing the text on the worksheet and allow students to pose a question. As seen in Figure 6, one of the text in the worksheet was shown.

The next phase is data gathering (verification). After reading the text and asking questions centered on the text, they ought to compose the basic theory of the subject. Websites and books can be used as the source to construct the basic theory. It could allow them to be aware of the basic concept that they must apply to the experiment. Figure 7 shows the example of student-made the basic theory.

The third phase is data gathering (experimentation). The virtual lab activity with inquiry-based learning forces students to construct their self-made procedure with the teacher hint in the form of questions. The example is the question, 'What should you do if you want to measure the incident angle of the ray? What element do you use?' this will help them consider what they are going in the experiment yet still on the right guidance. We must not compel them to obey a rigid procedure to establish students' scientific inquiry—one sample of students' data The Figure 8.

However, while a number of evidential studies have shown that virtual lab may establish students' conceptual understanding, certain students still have difficulty in learning when utilizing virtual lab (Chiu et al., 2015). The virtual lab utilized in this study can be freely accessed via the website, but then there was a shortage of exposure to such virtual labs by the usage of a PC. Having that in mind, certain students who cannot access the virtual lab since they do not have laptops were excluded from the sample. But they still can join the class by watching the video of the experiment on the youtube.

The fourth phase is formulating an explanation. After the data was obtained by conducting the experiment, it is evaluated to formulate an explanation. Again, the teacher-guided the students by questioning. In this phase, they may openly state their understanding of the phenomena that occur. Since the discussion was taken at an online meeting, unfortunately, there have been several of the students absent. The meeting process is illustrated in Figure 9.

The final phase is the analysis of the inquiry process. The whole learning process was assessed by verifying the conclusions of the students. If there are still misconceptions found in conclusion, clarification should be carried out by the teacher and deliver more explanation of the concept to prevent more misconceptions. Here, the teacher ought to make sure each of the students comprehends the basic idea of the topic. Eventually, the finished worksheet was compiled through Edmodo. Sadly, copying a friend's work was often found, and even some students did not submit the worksheet right on time.

Both the students and the teacher ought to carry out the whole phases properly. Although the researcher has indeed performed the phase right, it is difficult to make sure whether the students follow precisely the right phases owing to online learning. Furthermore, in order to mitigate the risk of a missed phase, it would be better to collaborate with the parents of the students in order to ensure that the students carry out all of the phases. Additional analyses were carried out by the researcher by asking the students on their impression of using virtual lab activity with inquiry-based learning in the learning process. The virtual lab used in this research was found to be easy to use, but many students often find it challenging to operate the virtual lab at first because this is the first time they have encountered a virtual lab through online courses. The researcher notes that the video tutorial was very useful to help the students understand the procedure to use the virtual lab, but the students admit they did not face any further problems in the next trial.

There are 7 meetings with 2x30 minutes of time allocation in every meeting. This situation has been modified to suit the school's regulation. The short time requires the teacher to teach the entire content in such a compressed time. This situation might exacerbate the difficulties for the students. They said that they had to attempt to do a lot of assignments other than science in school, which made it much tougher to learn the subject. It may contribute to outcomes that are not as good as anticipated, where students still low on conceptual comprehension so that the N-Gain value was classified into the medium. In addition, the results of the pre-test were also considered high, despite that they have not known much about this topic. It may have arisen because the test was administered through Google Form, so the teacher could not be sure that the students were truthful. They might access the internet, books, or asking people around them to search for the answer.

Promoting the enhancement of scientific literacy is one of the requirements of the learning process is required in a science curriculum (Fives et al., 2014). The usage of virtual lab activity with inquiry-based learning will also be one of the forms in which students improve their scientific literacy. The students stated that it is challenging to grasp the abstract theories of the subject through an online explanation by using video and online meetings, but the usage of virtual lab greatly allows the students to improve their own understanding by observing the phenomena that arise after the experiment has been carried out. The combination of inquiry-based learning with the virtual lab activity provides the learning process to be more active, where students will ask questions and deliver their own thought to generate their own knowledge.

4.2.1 Students' Scientific Literacy on Each Aspect

In this research, there are two scientific literacy aspects that were measured, which are scientific competency and scientific knowledge. The data analyses gained for each aspect can be seen in Table 3. From table 3, we can point out the average score of both aspects were increasing.

For scientific competency, the average score for the pre-test is 66.50, while the post-test is 83.00. We can highlight the difference of 16.50 points, where the post-test average score results is higher than the pre-test. The comparison of each scientific literacy aspect average score in pre-test and post-test can be seen in Figure 10.

Furthermore, the data gained was calculated to measure its Normalized Gain. As we can see from Table 3, the N-Gain value of scientific competency was 0.42 and 0.314 for scientific knowledge. The N-Gain score for scientific competency is higher by 0.106 points. Figure 11 draws the comparison of the N-Gain of each scientific literacy aspect.

A. Students' scientific competency

Scientific competency is one of the scientific literacy aspects evaluated in this research. Out of 15 questions, there are 10 questions that assess students' scientific competency. The average score of pre-test and post-test were calculated in order to evaluate students' enhancement in scientific competency. As shown in Table 4, the normality test reveals the pre-test is not normally distributed with score 0.013, and the post-test is normally distributed with the score 0.061. The homogeneity test shows a result of 0.061 and is categorized as homogeneous. A non-parametric test was done by using the Wilcoxon signed-rank test, and the results are Asymp. sig. (2-tailed) 0.000. Where it can be concluded students' scientific competency is having a significant difference after the implementation of virtual lab activity with inquiry-based learning (H_1 accepted, H_0 rejected).

B. Students' scientific knowledge

The following scientific literacy aspects assessed is scientific knowledge. There are 5 from 15 questions to measure students' scientific knowledge from the objective test. The pre-test and post-test average scores were calculated to evaluate students' scientific knowledge enhancement. The data indicates that the average pre-test score is 60.00, whereas the post-test average score is 74.46. We can note that the post-test is greater than the pre-test. As seen in Table 5, the normality for the pre-test scored 0.014 and 0.000 for the post-test, which makes both of the data categorized as not normally distributed. The next test is the homogeneity test that resulted in sig. 0.061 and categorized as homogeneous. A non-parametric test was done by using the Wilcoxon signed-rank test, and the results is Asymp. sig. (2-tailed) 0.000. Where it can be drawn that students' scientific knowledge poses a significant difference after the implementation of virtual lab activity with inquiry-based learning.

In the objective test, the question format is that there is a passage that consists of the daily phenomena that happen related to the sub-topic. Where the students can get indirect information to answer the questions given, then several questions related to the passage will be given. One of the examples of the passage can be seen in Figure 12. Following the passage, the questions were constructed to measure whether students' scientific knowledge or scientific competency. There are three sub-aspects of scientific competency, which are interpreting data scientifically, evaluate and designing scientific inquiry, and explain phenomena scientifically. Scientific knowledge also has three sub-aspects, which are epistemic, content, and procedural knowledge. The example of the question that measures students' scientific competency and scientific knowledge can be seen in Figure 13 and Figure 14.

The two aspects of scientific literacy that were measured in this research include scientific knowledge and scientific competency. In the objective test, the question that measures students' scientific competency requires the students to think not only about the theory but also the implementation of the content itself. They have to think scientifically. Meanwhile, scientific knowledge questions can be answered directly by knowing the theory behind the passage itself. Further analysis of each aspect shows that the average score gained in the pre-test and the post-test for both of the aspects were increasing. But, students' scientific competency increased slightly higher than students' scientific knowledge. The implementation of virtual lab activity with inquiry-based learning that emphasizes students' ability to conduct an experiment and making an explanation on their own may be the cause of this condition. Where students' ability to explain scientific phenomena, design and evaluate scientific inquiry, and interpreting data and evidence scientifically increase higher than students' ability in procedural, epistemic, and content knowledge.

Hermansyah (2019) revealed that students' understanding of the concept of heat enhanced significantly in both cognitive aspect and subtopic of heat by the use of guided inquiry model with virtual laboratories in the research titled "Guided inquiry model with virtual labs to improve students' understanding of heat concept,". In the research entitled "Laboratory courses with guided-inquiry modules improve scientific reasoning and experimental design skills for the least-prepared undergraduate students," Blumer (2019) observed that the integration of the courses with guided-inquiry laboratory activities shows a promising outcome on students' basic scientific reasoning and experimental design skill. Then, Chiu et al., (2015) with the research "The effects of augmented virtual science laboratories on middle school students' understanding of gas properties" possess that students are able to construct complex scientific explanations by connecting molecular-level visualizations to observable, macroscopic phenomena in which the augmented virtual science laboratories have high potential in helping them. The students are able to explain the molecular-level explanation of gas behavior after conducting the treatment. Lastly, the research conducted by (Wardani, T. B., et al., 2017) also found a positive enhancement on students' understanding of Nature of Science (NOS) in light and optic topics after implementing inquiry-based laboratory activity.

4. Conclusion

The implementation of virtual lab activity with inquiry-based learning on light and optics topic was done with the sample that consists of 40 8th grade Junior High School students. After the calculation and analyses on the data, students' scientific literacy was increased by the pre-test score was 68.27, while the post-test was 81.25. Furthermore, the N-Gain value that scored 0.441 indicated the medium improvement on students' scientific literacy. There are two aspects of scientific literacy that were measured in this research. The first one is scientific competency that scores 66.50 for the pre-test and 83 for the post-test. Meanwhile, the N-Gain score is 0.420. The second aspect is scientific knowledge with pre-test score 60 and post-test score 74. The N-Gain value is calculated to be 0.314. This data indicates that the implementation of virtual lab activity with inquiry-based learning emphasizes more on scientific competency that involves more on the way students think and act like a scientist.

Furthermore, this research is perhaps one of the references to conduct online learning, particularly in science education. Other than that, the implementation of virtual lab activity with inquiry-based learning can enrich the variety of learning methods that may be used in science teaching and learning. For future research, it is suggested to combine physical and virtual laboratories to underlines students' conceptual comprehension.

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Table List

Table 1 One Group Pretest-Posttest Design.

One class	Pre-test	Inquiry Virtual Lab Activity	Post-test

Table 2 The Summary of students' scientific literacy

Component	Signification	Description
Normality		
Pre-test	0.181	Normally distributed
Post-test	0.001	Not Normally distributed
Homogeneity	0.517	Homogeneous
Hypothesis (Wilcoxon signed-rank test)	0.000 Asymp. sig. (2-tailed)	There is a significant difference (H_1 accepted, H_0 rejected)
N-Gain	0.441	Medium

Table 3 N-Gain for Each Scientific Literacy Aspect

Component	The Aspect of Scientific Literacy	
	Scientific Competency	Scientific Knowledge
Pre-test	66.50	60
Post-test	83	74
N-Gain	0.420	0.314
Category	Medium	Medium

Table 4 The Summary of students' scientific competency

Component	Signification	Description
Normality		
Pre-test	0.013	Not Normally distributed
Post-test	0.061	Normally distributed
Homogeneity	0.061	Homogeneous
Hypothesis (Wilcoxon signed-rank test)	0.000 Asymp. sig. (2-tailed)	There is a significant difference (H_1 accepted, H_0 rejected)

Table 5 The Summary of students' scientific knowledge

Component	Signification	Description
Normality		
Pre-test	0.014	Not Normally distributed
Post-test	0.000	Not Normally distributed

Component	Signification	Description
Homogeneity	0.822	Homogeneous
Hypothesis (Wilcoxon signed-rank test)	0.000 Asymp. sig. (2-tailed)	There is a significant difference (H_1 accepted, H_0 rejected)

Figure List

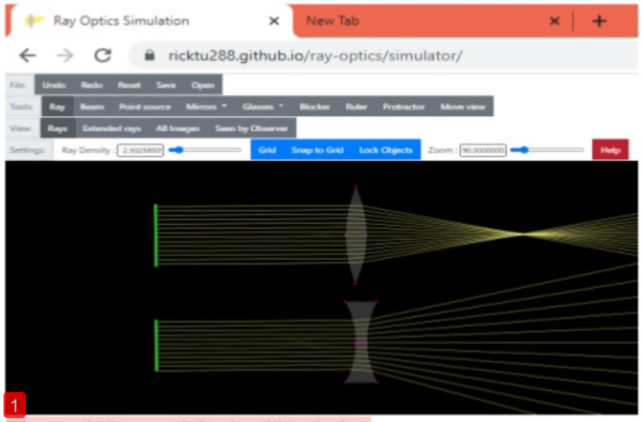


Figure 1. Ray and Optics Simulation

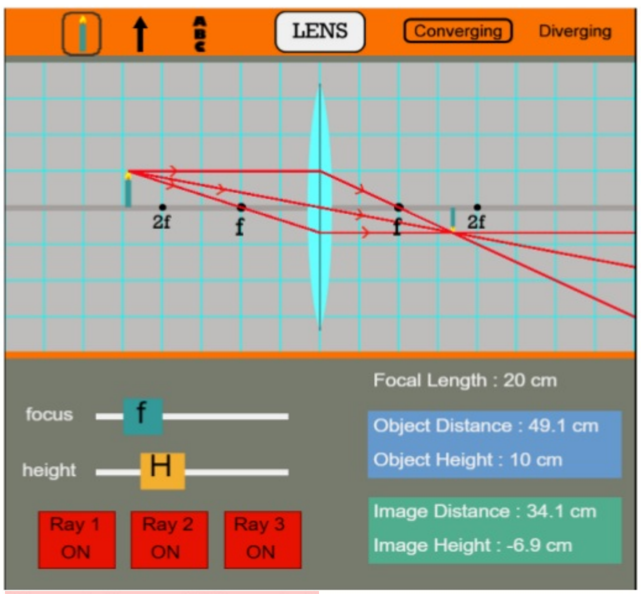


Figure 2. Lens and Mirrors Lab

Figure 3 The average score of pre-test and post-test for students' scientific competency

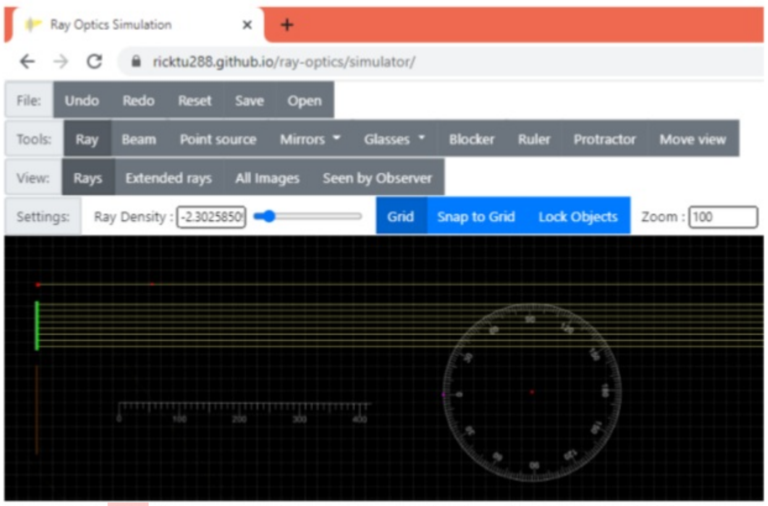


Figure 4 The Element that can be used in Ray Optics Simulation

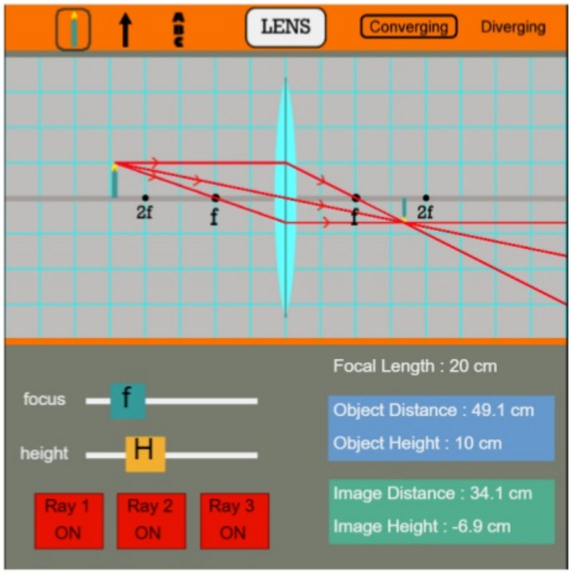


Figure 5 The Layout of Lens and Mirrors Lab

1. Sifat Konvergen dan Divergen

Gambar 1. Senter

Senter dikenal sebagai alat yang digunakan untuk menerangi ruangan. Senter umumnya berbentuk tabung dengan bola lampu kecil di ujungnya.

Tahukah kamu bahwa cermin cekung digunakan dalam sebuah senter? Mengapa demikian?

Jawabannya dapat kamu temukan pada percobaan berikut ini.

Figure 6 The passage stated in the worksheet

B. Dasar Teori

Carilah informasi mengenai hal yang ingin kalian ketahui atau buktikan. Kalian dapat melihat berbagai sumber seperti buku dan internet. Kemudian tulis pada kolom di bawah ini!

Cermin lengkung adalah cermin yang permukaannya lengkung seperti permukaan bola. Cermin ini dibedakan atas cermin cekung (konkaf) dan cermin cembung (konveks). Sinar datang pada cermin cekung berhadapan dengan permukaan pantul yang bentuknya seperti permukaan dalam bola, sedangkan pada cermin cembung sinar datang berhadapan dengan permukaan pantul yang merupakan permukaan luar bola. Cermin cekung memiliki sifat konvergen, yaitu mengumpulkan sumber-sumber cahaya menjadi satu titik fokal (memfokuskan cahaya). Cermin cembung memiliki sifat divergen, yaitu memecah sumber-sumber cahaya dari satu titik fokal.

Figure 7 Student’s answer on basic theory

E. Hasil Pengamatan

Isilah tabel di bawah ini sesuai dengan pengamatanmu!

- Berilah tanda silang (x) pada kolom konvergen atau divergen sesuai dengan sifat bayangan yang dihasilkan oleh masing-masing cermin!
- Atur panjang foto menjadi 5 cm sebelum dimasukkan dalam tabel

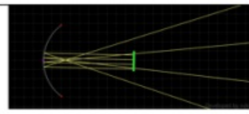
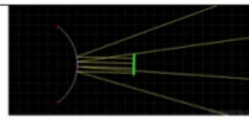
Cermin	Foto	Konvergen	Divergen
Cekung		x	
Cembung			x

Figure 8 Students' result after conducting the experiment by using the virtual lab

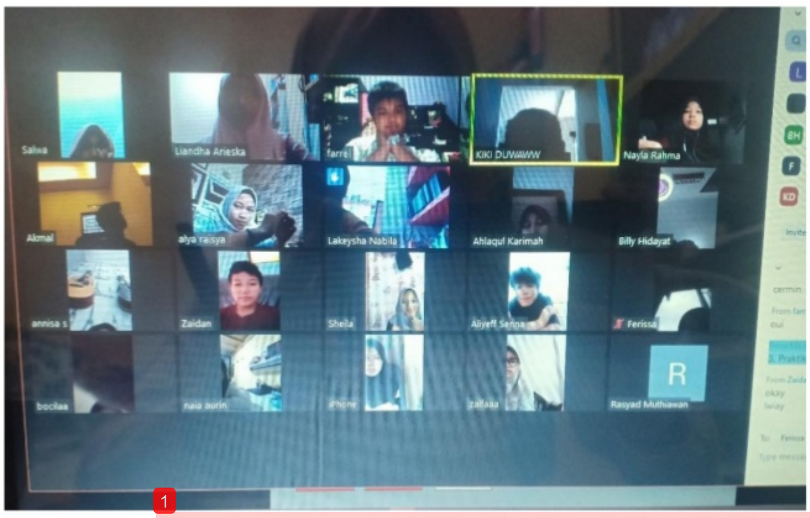


Figure 9 The discussion process was held online through Zoom Conference

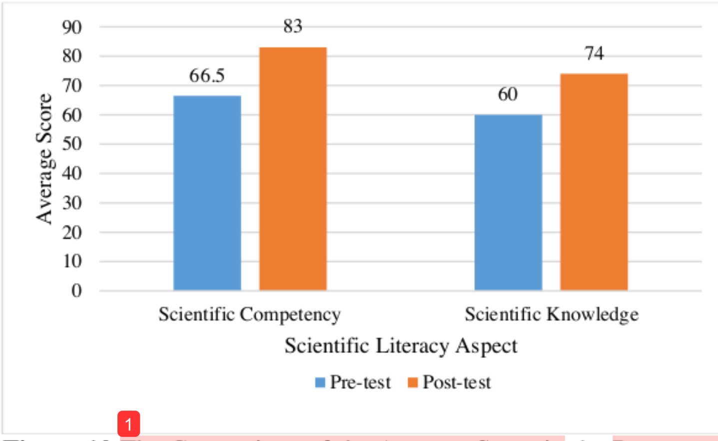


Figure 10 The Comparison of the Average Score in the Pre-test and Post-test on Each Scientific Literacy Aspects

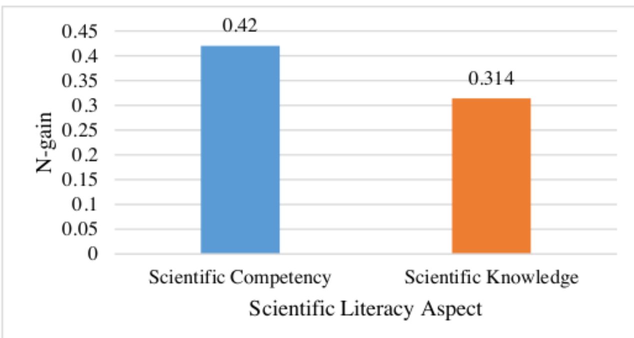


Figure 11 Comparison of N-Gain in Each Scientific Literacy Aspects

Bacalah teks di bawah ini untuk menjawab pertanyaan no. 5-7!

Laghi De Fusine, danau jernih di Italia!

Laghi De Fusine, sebuah glasial yang lokasinya berada satu mil dari perbatasan Italia dan Slovenia. Air di danau ini cukup dalam, namun karena danau ini memiliki air yang jernih, jika dilihat dari permukaan airnya akan terlihat dangkal. Saking beningnya, kamu bisa menyaksikan biota bawah air dengan jelas. Namun jika kamu tidak kuat dingin, jangan sesekali mencoba berenang di sini ya, karena danau ini memiliki suhu air yang sangat dingin.

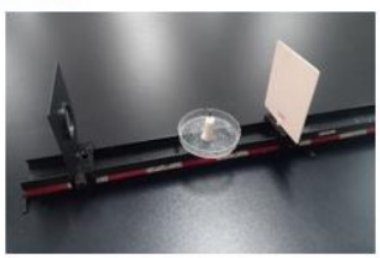
(tripadvisor.com)

Figure 12 The example of the passage on the objective test

Berdasarkan informasi di atas, pernyataan manakah yang paling tepat mendeskripsikan fenomena tersebut?

Figure 13 Example of the question that measures students' scientific competency

Sharon ingin mengetahui sifat bayangan yang dibentuk oleh cermin cekung. Ia melakukan sebuah percobaan dengan menggunakan sebuah cermin cekung, sebuah layar, dan sebuah lilin yang disusun seperti gambar berikut.



Sharon ingin mengetahui perbesaran bayangan yang dihasilkan cermin cekung bila ditempatkan di ruang berbeda. Apa yang harus dilakukan?

Figure 14 Example of the question that measures students' scientific knowledge

Highlight

- Virtual lab activity with inquiry-based learning can be implemented in online learning
- Students' scientific literacy can be established by implementing the Virtual lab activity with inquiry-based learning
- Students found that Virtual lab activity with inquiry-based learning helps them to visualize the abstract concept of light and optics topic

Enhancing Students' Scientific Literacy Using Virtual Lab Activity with Inquiry-Based Learning

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