



## Comparison of Virtual Experiment Methods and Real Experiments Using Real World Problems in Improving Science Process Skills

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### Abstract

Science Process Skills must be owned by a junior high school student, but the SPS owned by junior high school students is still relatively low. In an effort to develop the SPS owned by students, it is necessary to carry out experimental or observation activities. The experimental method itself is divided into virtual and real experimental methods, both of which have their own advantages and disadvantages in increasing students' basic SPS. Efforts to improve SPS can also link experimental learning with an existing problem. Therefore, a combination is needed using a problem, namely a real world problem. so that it becomes more effective in increasing SPS. The purpose of this study was to determine the comparison of the effectiveness of virtual and real experimental methods using real world problems in increasing the SPS of junior high school students. A quantitative approach was used in this study with a true experimental research type, a research design in the form of a pretest and posttest control group design was carried out in two classes VIII. Based on the independent t-test, a sig. value of 0.216 was obtained, indicating that there was no difference in the increase in basic SPS in the two classes. However, based on N-Gain (0.61 for virtual experiments and 0.52 for real experiments), it was found that both experimental classes were equally able to increase students' SPS with values that were not much different.

## 1. INTRODUCTION

In a learning process, science will always develop and teachers as educators are not able to teach all concepts and facts to students so that a skill is needed by students. The required skills must be able to involve cognitive skills, manual and social skills where these skills are Science Process Skills (SPS) (Agustina et al., 2018). SPS is important for students in learning because if these skills are not possessed, students will face difficulties in learning, especially in interpreting the knowledge they gain because knowledge will always develop and continue in life so that every human being will always interpret in their life (Agustina et al., 2018).

One of the SPS consists of basic SPS. Firdaus & Subekti (2021) argue that students, especially those at the junior high school (SMP) level, must have basic SPS because it will serve as a foundation for studying science and conducting scientific research, while integrated

SPS will be further trained at the next level. Furthermore, the choice of basic SPS is because it will provide a foundation for students' skills in carrying out tasks according to applicable scientific methods. Students who have and are able to master basic SPS sufficiently well can improve their SPS to a higher level.

SPS must be owned by a student, but the SPS owned by junior high school students is still relatively low, which is in line with the results of research conducted by Rahmasiwi, Santosari and Sari (2015) who obtained results from students' SPS which is relatively low because the percentage of each aspect studied is included in the poor category. Research conducted by Sukarno et al. (2013) shows that almost 50% of students in one junior high school in Jambi have a low or low level of SPS. SPS in other low categories was also found in Padang City Junior High Schools, which are below average or in the low category (Alberida et al., 2018). In addition to Indonesia, the low level of SPS owned by students is also felt by several countries in the Asian continent, where both elementary and junior high school students have a level of mastery of SPS in the low category (Özgelen, 2012). From the data that has been mentioned, it can be concluded that junior high school students in Indonesia and several countries in Asia have SPS that is in the low category.

In an effort to develop students' SPS, it is necessary to conduct experimental activities or observation activities that can be carried out in a practicum (Najemah, 2020). The experimental method itself is divided into virtual experiments and real experiments. Virtual experiments are a form of practicum or experimental activities that will be carried out with the help of technology that uses a laboratory in a virtual or non-real form that displays various simulations called virtual experiments (Hermansyah et al., 2015). Real experiments will utilize real tools and materials. Previous research conducted by Tukan (2015) found that between virtual experiments and real experiments, the average learning outcomes were not much different or there was no significant difference so that in general both experimental methods were able to improve SPS.

Efforts to improve SPS, in addition to using experimental learning methods, can link experimental learning to an existing problem because SPS itself is a useful ability and competency as a tool in science learning such as solving a problem (Agustina et al., 2018). Where a problem can make students more active because it causes students to become the center of learning and with experimental learning, students can provide proof and find their own solutions to the problem (Nurqomariah et al., 2015). Therefore, a combination of using a problem is needed so that it becomes more effective in improving SPS. The problems that will be used must be relevant and related to students' daily lives so that real-world problems are needed because real-world problems can make students see the relationship between the material being studied and the problem.

Experimental methods using real-world problems are generally able to improve students' SPS, but as is known, the experimental method itself is divided into real experiments and virtual experiments which are a result of the development of science and technology in the current era. Seeing the problems that have been explained, the purpose of this study is to determine the comparison of the effectiveness of virtual experiments and real experiments using real-world problems in improving the science process skills of junior high school students.

## **2. METHOD**

This study used a quantitative approach with a true experimental research type. The research design consisted of a pretest and posttest control group design conducted in two eighth grade classes at SMPN 2 Mertoyudan in the even semester. The two classes used were class VIII B (virtual experiment class) and class VIII C (real experiment class). The number of students in each class was 28 students.

The data collection instrument used was a basic science process skills question totaling 19 valid multiple choice questions with 6 main indicators, namely observing, classifying, predicting, measuring, concluding and communicating. The existing data collection instrument has been validated by 3 teachers at the school where the research was conducted and 2 lecturers at Tidar University and then a reliability test will be carried out using KR-20. The data collection technique uses a test. Where the test carried out is a pretest-posttest. The pretest is used by researchers as a description of the initial state of student knowledge and the posttest is used by researchers to determine the final state of student knowledge after being given treatment.

Next, after the pretest-posttest values are obtained, they are processed into gain values (the difference between pretest and posttest). This gain value will then be used for prerequisite tests and hypothesis tests. The prerequisite tests consist of normality and homogeneity tests. The normality test uses the Kolmogorov-Smirnov method, while the homogeneity test uses the Levene method. The hypothesis test uses an independent t-test. N-Gain is used to determine whether there are differences between the treatments.

### 3. RESULT AND DISCUSSION

The research was conducted at SMP Negeri 2 Mertoyudan in two different experimental classes, namely virtual experiments (VIII B) and real experiments (VIII C) where both classes will use the same real-world problem but with different types of experiments adapted to the experimental methods of each class. From both classes, a pretest and posttest were conducted with a multiple-choice test instrument totaling 19 questions. Based on the scores obtained by both classes, the gain value of the virtual experiment class was 31.32 and the real experiment class got a gain value of 27.92. This gain value will be used as basic data for prerequisite and hypothesis testing.

The prerequisite test carried out was a normality test using the Kolmogorov-Smirnov method with the assistance of the SPSS Statistics 25 application. The following results were obtained.

**Table 1.** Normality Test Results

Sample	Kolmogorov-Smirnov Method Normality Test	Description
VIII B (Virtual Experiment)	0,128	Normal
VIII C (Real Experiment)	0,200	Normal

From Table 1, it is known that the results of the normality test for both classes conclude that the gain data obtained are normally distributed because both classes have sig. values that are much greater than 0.05 (normality test for the virtual experimental class and the real experimental class  $> 0.05$ ). The homogeneity test was carried out using the Levene method with the following results.

**Table 2.** Results of Homogeneity Test

Sample	Homogeneity Test	Description
VIII B (Virtual Experiment) VIII C (Real Experiment)	0,684	Homogeneous

Based on Table 2., it is known that the gain data from both virtual experiment classes (VIII B) and real experiments (VIII C) are stated to be homogeneous or the same.

The independent t-test is a type of hypothesis testing that uses gain data from each student in the virtual and real experimental classes. The results of the independent t-test can be seen in Table 3.

**Table 3.** Results of the Independent T-test

Sample	Independent T-test Results	Decision
VIII B (Virtual Experiment) VIII C (Real Experiment)	0,216	No Significant Difference

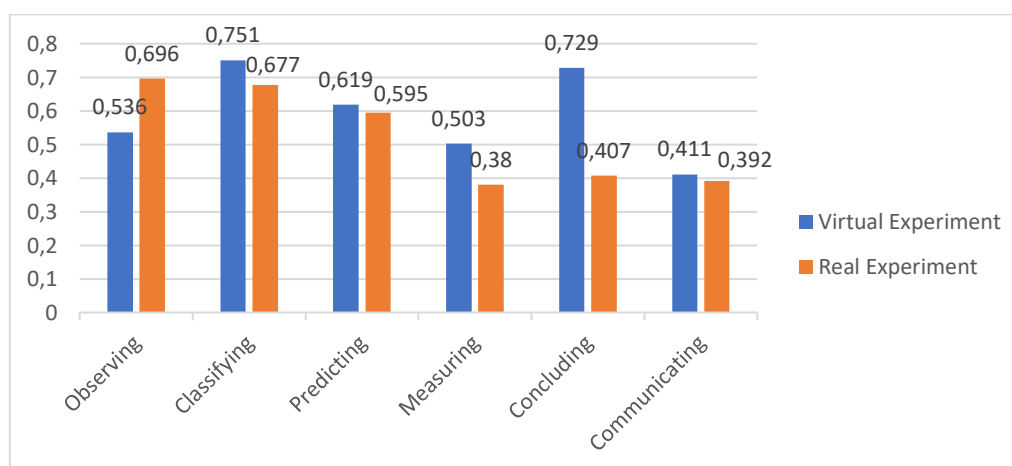
From Table 3, it is known that the results of the independent t-test obtained a sig. value by the experimental class of 0.216. The results have a sig. value  $> 0.05$  so that  $H_0$  will be accepted and  $H_a$  will be rejected. Therefore, it can be concluded that the two experimental classes stated that there was no difference in the increase in SPS of students who used the virtual experiment method and students who used real experiments in learning based on the results of the gain of each student in both classes.

The N-Gain test is used to determine whether there is a difference after being given different treatments in the virtual and real experimental classes. In other words, it is used to see the magnitude of the improvement obtained by students, which can be calculated using the Pretest and Posttest scores of each student in each class. The following is the average N-Gain for each class shown in Table 4.

**Table 4.** Average N-Gain Value of Each Class

Sample	N-Gain	Description
VIII B (Virtual Experiment) VIII C (Real Experiment)	0,61 0,52	Moderate

Based on the N-Gain value obtained by each class, it is known that both experimental classes have N-Gain values that are included in the medium category, where the N-Gain value of the virtual experimental class (VIII B) has a larger N-Gain value, namely 0.61 when compared to the N-Gain value obtained by the real experimental class, which is 0.52. Meanwhile, the N-gain value obtained by each indicator is as follows.



**Figure 1.** Improvement of Each Basic SPS Indicator Studied

From the N-Gain value, it is known that in the observation indicator, the real experimental class has a greater N-Gain value compared to the virtual experimental class. This is because

when conducting virtual experiments, students get less observation activities. PhET Simulation used for virtual experiments for students is quite unfamiliar because so far students have always used real experiments with the help of tools in the school laboratory so that students will play a direct role in operating the existing tools and materials so that all the senses owned by students can work because real experiments require real tools and materials unlike virtual experiments that only require a cellphone so that students do not optimize their psychomotor skills in real. The same thing was also said in Hamida's (2013) study where virtual experiments caused students to lack psychomotor skills. Based on the N-Gain value obtained, it is known that both experimental classes have increased, this is caused by one of the main factors, namely the use of real-world problems. Real-world problems are real-world problems that are applied in learning to develop several student skills (Kua et al., 2018). The use of real world problems can improve students' observation skills because it can cause students to be more focused in observing activities in an experiment and arouse students' curiosity about the problems they face so that students become more focused in observing something that will happen in their experiment, especially students who carry out experiments directly which can optimize students' psychomotor skills.

The classification indicator is contained in questions 3-5 with an N-Gain value of 0.751 in the virtual experimental class and 0.677 in the real experimental class. The N-Gain value of the virtual experimental class is in the high category while that of the real experimental class is in the medium category. It is seen that the virtual experimental class has a greater N-Gain value than the real experimental class. This can occur because the virtual experimental class uses PhET Simulation which has sophisticated features that can accurately display research data ranging from numbers and other information so that students can easily record, group them and later be processed and able to answer existing questions. In contrast to the real experiment found many students do not understand what they get so that students are a little confused and always ask the teacher about whether what they get is correct or not because it is different from other groups. This is in line with research conducted by Fauziah (2016) where using PhET simulation can improve classification indicators because students are able to clearly and concretely understand the shadows formed in the PhET Simulation application.

The predicting indicator is contained in questions 6-10. Both experimental classes received N-Gain scores with the same category, namely both are in the medium category. Based on the N-Gain value on the predicting indicator obtained, both have N-Gain values that are not too different, so that students in the virtual and real experimental classes have abilities that are not much different in estimating or predicting according to existing trends that have occurred. However, the virtual experimental class received slightly higher scores than the real experimental class. This occurs because virtual experiments have the advantage of being able to display something that cannot be displayed in real experiments. Where in the practicum of light properties when the laser in PhET Simulation is turned on from air to water, the direction of the laser beam is seen to change due to refraction. In the real experiment, refraction is proven by part of the pencil body being inserted into water causing the pencil in the water to break when viewed from the side, but this has not clearly explained that this can happen because of refraction so that students in the real experimental class experience a little confusion. This is supported by research conducted by Iffati (2023) which states that PhET simulation media displays images of an event clearly because it is able to display phenomena or events that are difficult to observe directly.

Questions 11-14 are questions that contain measuring indicators. Both experimental classes have N-Gain values that are in the same category, but the difference between the two classes is quite large. The virtual experimental class gets a greater N-Gain value than the N-Gain value of the real experimental class. This can happen because in the virtual experimental class, the numbers obtained during the practicum process are stated clearly and definitely,

which is in accordance with research conducted by Iffati (2023) found that by using PhET simulation media, a definite result value will be obtained because the numbers will be stated on the PhET simulation media, with the constancy of the results obtained, it can prevent students from experiencing confusion, misunderstandings and errors in conducting experiments. In the real experimental class, many students get different numbers due to many influencing factors. In addition, another factor that causes differences in the N-Gain values of the two classes is the use of measuring tools such as rulers. Many students in the real experiment class did not bring rulers, so they had to borrow them from other groups and wait for them to finish measuring, which could distract students. Furthermore, some students brought rulers measuring only 10 to 15 cm, which forced students to connect the rulers and potentially lead to human error. However, the virtual experiment in the PhET application included a ruler feature, allowing students to get used to measuring. This is consistent with research conducted by Nurulwati (2021) which states that getting used to measuring in an experiment using measuring tools can improve students' measuring skills. The use of real-world problems in both experimental classes contributed to the improvement in both classes in the measuring indicator because problem-based learning motivated students to find solutions or answers to these problems, including taking measurements.

The concluding indicator is contained in questions 15-17. Based on the N-Gain value, it is known that the value obtained by the virtual experimental class is greater when compared to the real experimental class. This can occur because virtual experiment-based learning is better able to visualize information using an existing simulation because virtual experiments using PhET simulation have various features that can help students understand existing information because they can display something that cannot be seen directly by the eye when using real experiments. This is in accordance with research conducted by Iffati (2023) which states that using PhET simulation media can display animations that can help students understand abstract things that cannot be observed directly by their senses. Problem-based learning can help students to open their minds to a learning which is in accordance with research conducted by Ngadinem (2019). The use of real-world problems can link problems in the real world with the learning process, this is based on research from Kua et al. (2018) where learning is linked to real-world problems, students are able to develop their skills by seeing a clear connection between real-world problems and learning materials and are able to draw conclusions from what they find.

The last indicator is communicating. Students in the virtual experiment class and the real experiment class get an N-Gain value that is in the medium category. In the virtual experiment class, the N-Gain value is 0.411 and the real experiment class gets an N-Gain value of 0.392. From the N-Gain value, it is known that both are in the same category with values that are not much different so it can be said that both have quite good skills in communicating about what they have done through a graph, picture or scheme, but in the virtual experiment class, the value is slightly higher than the real experiment class because it can clearly visualize the information obtained so that from the visual it makes it easier for students to describe what they see. This is in accordance with research conducted by Prihatiningtyas et al. (2017) that by using PhET on light and optics material, it can show the visualization of the path of light in a lens. Another study was conducted by Iffati (2023) who stated that PhET simulation media is able to display shadow formation clearly and accurately compared to direct practicum so that with clear visualization of information it is able to explain the processes that occur and cause students to be able to easily communicate what they encounter in LKPD or presentations in class.

The improvement in communication indicators in both experimental classes may be due to the use of experimental methods that utilize real-world problems. Using problem-based experimental learning provides students with the opportunity to discover solutions to existing

problems by conducting experiments individually or in groups and then presenting them to other groups (Susanto et al., 2015). Real-world problems can also make students more focused in conducting experiments because they understand what is important for them to know and convey to the audience, which can be useful when they give a presentation. Other research suggests that using problems in learning can make students active in group discussions, which can train students' communication skills (Hasanah and Utami, 2017).

According to Kua et al. (2018), when learning is linked to real-world problems, students are able to develop their skills by seeing a clear connection between real-world problems and the learning material, thus becoming more engaged in the learning process. However, it is necessary to pay more attention to the problems that will be used in the learning process because teachers often make mistakes in selecting real-world problems, where teachers often use conceptual problems. Conceptual problems themselves are problems that require a theory to solve the problem (Devi et al., 2021). In other words, conceptual problems are problems whose answers can be obtained directly without the need for proving activities. This is different from real-world problems, which are problems that are truly based on things in everyday life, where students will encounter these problems in their lives. Furthermore, real-world problems, according to McCormick et al. (2015), found in research that learning based on real-world activities in everyday life can help students transfer the information gained into their own knowledge that is adapted to different situations.

Real world problems as a whole are able to improve students' science process skills when seen from the average N-Gain value obtained by both classes. In the virtual experiment class there was an increase of 0.61 (61%) while in the real experiment class there was an increase of 0.52 (52%). This increase is because real world problems are able to make students participate actively in the learning process (Purba, 2015). In addition, learning based on a real world problem can train students to be independent because they will focus on finding solutions to the problem, one of which is by using experimental activities, this is proven by the research of Susanto et al. (2015) who found that an experimental class combined with problem-based learning is more effective than the control class because with a problem it can train students to be able to solve an existing problem by carrying out a scientific thinking process that can train students' SPS.

The N-Gain scores obtained by each class were not exactly the same. However, virtual experimental learning had a slightly superior score compared to real experiments. This is due to the different types of experiments used. This difference in type significantly affects students because both types of experiments have their own characteristics, advantages, and disadvantages. Not all students have the same level of understanding. Furthermore, this study used random sampling, where no requirements were set for sampling, so the researcher could not limit the available sample. The use of real-world problems, which were considered unfamiliar to students at SMP Negeri 2 Mertoyudan, also affected the research results obtained. The limitations of the tools and materials used in real experiments can also be a reason for the differences in scores because both real and virtual experiments must be able to solve the same problems so that the results obtained can be compared. Other factors can cause differences in research results obtained from the two experimental classes.

#### 4. CONCLUSION

Based on the results of research conducted at SMP Negeri 2 Mertoyudan, both experimental classes stated that there was no difference in the increase in SPS using the virtual experiment method and students who used real experiments in learning the material of Light and Optical Instruments. However, it is known based on the results of the N-Gain test, in both classes that used the virtual experiment method and the real experiment there was an increase in basic SPS,

although both experiments did not show a significant difference in increase. Suggestions that can be conveyed are that in learning experimental methods (virtual and real) using real world problems can be used as a reference for teachers in science learning, especially to improve the basic Science Process Skills of junior high school students and the use of PhET Simulation in the virtual experiment method needs to be reconsidered because not all junior high school learning simulations are included in PhET Simulation.

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