



Effectiveness of Virtual Laboratory Utilization in Improving Students' Science Process Skills

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Abstract: The aim of this study is to determine the effectiveness of using a virtual laboratory. This research was carried out at SMAN 1 and MAN 1 Kolaka for 3 (three) months. The type of research is quantitative with an experimental method with a pretest-posttest control group design. The research population was students of class The instrument is a test of students' science process skills. Data analysis techniques were carried out descriptively and inferentially. The research results reported that there was an increase in student learning outcomes and a positive impact on the science process skills of students at SMAN 1 Kolaka and MAN 1 Kolaka after implementing a PhET-based virtual laboratory. Thus, the application of the Science-Physics learning model through a PhET-based virtual laboratory is effective in improving the science process skills of students at SMAN 1 Kolaka and MAN 1 Kolaka. This research gives the impression that laboratory use is not actually the only equipment used to carry out experiments. However, laboratories have developed so that students and teachers can carry out experiments through virtual laboratories at affordable costs.

Abstrak: Tujuan penelitian ini adalah untuk mengetahui efektivitas penggunaan virtual laboratory. Penelitian ini dilaksanakan di SMAN 1 dan MAN 1 Kolaka selama 3 (tiga) bulan. Jenis penelitian adalah kuantitatif dengan metode eksperimen dengan rancangan pretest-posttest control group design. Populasi penelitian adalah siswa kelas X IPA, sampel ditetapkan dengan teknik Purposive Sampling, yaitu memilih dua kelas secara sengaja, masing-masing kelas X IPA SMAN 1 dan kelas X IPA MAN 1 Kolaka. Instrumennya adalah tes keterampilan proses sains siswa. Teknik analisis data dilakukan secara deskriptif dan inferensial. Hasil penelitian melaporkan bahwa terdapat peningkatan hasil belajar siswa dan dampak positif keterampilan proses sains siswa SMAN 1 Kolaka dan MAN 1 Kolaka setelah diterapkan virtual laboratory berbasis PhET. Dengan demikian, penerapan model pembelajaran IPA-Fisika melalui virtual laboratory berbasis PhET efektif untuk meningkatkan keterampilan proses sains siswa SMAN 1 Kolaka dan MAN 1 Kolaka. Penelitian ini memberikan implikasi bahwa penggunaan laboratorium nyata bukanlah satu-satunya peralatan yang digunakan untuk mengadakan percobaan. Tetapi, laboratorium sudah mengalami perkembangan sehingga siswa dan guru bisa melakukan percobaan-percobaan melalui

Keywords: Science Process Skills, Virtual Laboratory, Physics Learning

INTRODUCTION

In today's society, the use of information and communication technology (ICT) has become part of daily practice (Hinojo Lucena et al., 2019), including in education that can improve the learning process (Nikolić et al., 2019). For example, laboratories in physics learning that have an important role (Serrano-Perez et al., 2023; Vahdatikhaki et al., 2023) not only use real laboratories (Radianti et al., 2020), but also use virtual laboratories (VL) (Budai & Kuczmann, 2018).

The important role of the laboratory is as a vehicle to develop basic skills to observe or measure an object, prove concepts or natural laws so that it can further clarify the concepts learned (Hurtado-Bermúdez & Romero-Abrio, 2023), and develop thinking skills through the problem-solving process for students to find their own concepts. Through this role, the laboratory has been used as a vehicle for learning how to learn (Wiyanto, 2008).

One form of utilization of computer technology in physics learning is the development of a VL (Billah & Widiyatmoko, 2018; Fadhilah et al., 2021; Masril et al., 2018; Rahmi et al., 2022). A virtual laboratory is defined as a form of interactive multimedia object. Interactive multimedia objects consist of various heterogeneous formats, including text, hypertext, sound, images, animation, video, and graphics. A virtual laboratory is a complex interactive multimedia object and a new digital form with implicit or explicit learning objectives (Gabdullina et al., 2021). Learning in a virtual laboratory allows students to be more independent and can

improve their thinking skills and the ability to communicate ideas (Wiyanto, 2008).

Over the past decade and a half, there has been a lot of research on VL. For example, first, research related to the application of virtual laboratories in civil engineering and electrical engineering (Chan & Fok, 2009; Vahdatikhaki et al., 2023). They studied VL in terms of the effectiveness of its use for both civil and electrical engineering students. Second, VL research was conducted in the field of Biology (Dyrberg et al., 2017; Špernjak & Šorgo, 2018; Swan & O'Donnell, 2009). Basically, these three studies have differences; Dyrberg et al. (2017) looked more at the level of student motivation in the use of VL; Špernjak & Šorgo (2018) looked at the differences in knowledge and attitudes gained through traditional laboratories, computer-assisted laboratories, and virtual laboratories; and Swan & O'Donnell (2009) sought to explore further the contribution of virtual biology laboratories. Third, VL research with the aim of improving students' concept understanding (Fadhilah et al., 2021; Gorai et al., 2016; Gunawan et al., 2018; Hurtado-Bermúdez & Romero-Abrio, 2023). Fourth, comparative research between VR and VL (Serrano-Perez et al., 2023; Toth, 2016) or a comparison of VL and VL (Stark et al., 2017). Fifth, integrated modern VL research (Budai & Kuczmann, 2018). Meanwhile, VL research in the field of science, especially physics, is still limited to the STEM approach (Rahmi et al., 2022).

To fill the gap, this study aims to explore the effectiveness of Virtual Laboratory

implementation using PhET Simulation at SMAN 1 Kolaka and MAN 1 Kolaka. Physics Education Technology (PhET) is a simulation made by the University of Colorado that contains simulations of physics, biology, and chemistry learning for the benefit of classroom learning and individual learning. According to Yuafi, as cited by Saputra (2020), Physics Education Technology (PhET) is an interactive physics simulation software available on a site that can be run online or offline. In PhET, theoretical and experimental simulations actively involve users. Users can manipulate activities related to experiments. PhET was developed to help students understand visual concepts (Zulkifli et al., 2022).

The exploration of the effectiveness of the use of the Virtual Laboratory above is expected to contribute both practically, empirically, and in policy. This research is experimental research, so teachers can know the effectiveness of the application of Virtual Laboratory. Empirically, this research contributes to students' understanding of abstract science concepts. In terms of policy, principals and supervisors can take more effective policies in overcoming the limited availability of real laboratory equipment that requires a large cost.

METHOD

An experimental design using a pretest-posttest control group design (Zain & Jumadi, 2018) was adopted for this study. The study population was X IPA class students. The sample was determined by purposive sampling technique, namely choosing two classes intentionally, each X IPA class of SMAN 1 and X IPA class of MAN 1 Kolaka. Data was collected using tests to measure student knowledge in the form of pre-test and post-

test. The pre-test and post-test were given before and after treatment. Next, the data was analyzed using descriptive data analysis by looking at the average absorption capacity, learning effectiveness, and Normal Gain Test, as well as using inferential analysis with the t-test.

RESULTS AND DISCUSSION

The Description of Result Data

Data description was conducted in order to obtain a clear picture of the research results. The data displayed in the study came from the variables of science process skills of students of SMAN 1 Kolaka. These data are presented in accordance with the chronology of the research, which includes the value of the results of the implementation of physics learning using virtual laboratories in class X with Hooke's Law material.

1) Description of students' science process skills value before treatment

The value of the initial test (pretest) of students' science process skills before being given a virtual laboratory-based learning treatment on the concept of Hooke's Law. Students' science process skills through the initial test (pretest) are given before the learning process. The initial score of the test results is a reference or standard for grouping students in a class setting that uses virtual laboratory-based physics learning. The initial score is processed with the help of the SPSS-21 program, which is briefly presented as follows.

Table 1. Students' science process skills value before virtual laboratory-based

<i>Statistics Descriptive</i>		SMAN I Kolaka	MAN 1 Kolaka
N	Valid	28	28
	Missing	0	0
Mean		25.29	26.14

Median	27.00	27.00
Mode	23 ^a	23
Std. Deviation	7.174	6.193
Variance	51.471	38.349
Range	28	20
Minimum	11	15
Maximum	39	35
Sum	708	702

Table 1 above shows that the average value of science process skills of SMAN 1 Kolaka students before learning physics based on virtual laboratory obtained a value of 25.29 while the average value of MAN 1 Kolaka students amounted to 26.14. The data looks slightly different (meaningless difference), so it can be explained that the level of knowledge possessed by students before being given a virtual laboratory-based physics learning treatment does not show a significant difference (the same).

2) Description of students' science process skills values after treatment

Students' science process skills were obtained through the final test (post-test) on a sample of 28 people in each data group. Furthermore, measurements were made to students through a student science process skills assessment sheet test given after the virtual laboratory-based physics learning treatment.

Students' science process skills obtained after the application of Virtual Laboratory-based physics learning on the Concept of Hooke's Law in Class X SMAN 1 and MAN 1 Kolaka can be presented as follows:

Table 2. Description of students' science process skills values after the implementation of virtual laboratory-based Physics learning

Statistics Descriptive		SMAN I Kolaka	MAN 1 Kolaka
N	Valid	28	28
	Missing	0	0
Mean		32,86	33,67

Median	34,00	30,00
Mode	34,00	26,00 ^a
Std. Deviation	6,786	5,922
Variance	46,053	35,073
Range	24,00	24,00
Minimum	18,00	18,00
Maximum	42,00	42,00
Sum	920,00	943,00

Table 2 above shows that the average value of science process skills of SMAN 1 Kolaka students after being given the treatment of virtual laboratory-based physics learning obtained a value of 32.86 while the average value of MAN 1 Kolaka students amounted to 33.67. The data showed a slight difference between the mean scores of science process skills of students of SMAN 1 Kolaka and MAN 1 Kolaka (the difference is not significant). Nevertheless, there was an increase in the mean score of students' science process skills both in SMAN 1 Kolaka and MAN 1 Kolaka significantly from 25.29 to 32.86 (SMAN 1 Kolaka) and 26.24 to 33.67 (MAN 1 Kolaka). This illustrates that the implementation of physics science learning using PhET virtual lab at SMAN 1 and MAN 1 Kolaka was effective so as to cause descriptive improvement.

3) Hypothesis testing

Based on the description of the research data and data analysis above, after going through the analysis requirements test. Hypothesis testing in this study was carried out by paying attention to the characteristics of the data in the sample group under study. Based on the results of the analysis requirements test both normality test and homogeneity test in each data group above, then the appropriate test tool can be determined for testing the research hypothesis. To test the hypothesis proposed, the mean test (t-test) was used through the SPSS version 21 program. The results of testing the hypothesis of this study are successively presented as follows:

1. Analysis of difference in students' science process skills of SMAN 1 and MAN 1 Kolaka before learning

Testing the average (t-test) of students' science process skills before the application of virtual laboratory in Physics learning with the aim of knowing which group has a greater influence. The average value of the two sample groups can be seen as follows:

Table 3. The average score of students' science process skills of SMAN 1 and MAN 1 Kolaka before learning

Statistic	Class	N	Mean	Std. Deviation
Science Process Skills Pretest	SMAN 1 Kolaka	28	25,29	7,174
	MAN 1 Kolaka	28	26,14	6,193

The table above shows that there are 28 subjects observed, it can be seen that the average value of students' science process skills pretest before the application of Virtual Laboratory at SMAN 1 is 25.29, and 28 subjects of MAN 1 Kolaka obtained an average value of 26.14, meaning that the value of students' science process skills before the application of Virtual Laboratory is the same. Furthermore, for hypothesis testing, the output used to test the hypothesis is a t-test, which is displayed in the Independent Samples Test table as follows:

Table 4. Summary of mean test results of students' science process skills of SMAN 1 and MAN 1 Kolaka before learning

Statistic	Levene's Test for Equality of Variances			t-test for Equality of Means			
	F	Sig.		t	Df	Sig. (2-tailed)	Mean Difference
Students' Science Process	Equal variances assumed	.424	.518	1.479	54	.634	-.857

Skills Pretest of SMAN 1 and MAN 1	Equal variances not assumed			1.479	52.872	.634	-.857
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In the table above, the significance value of Levene's test is 0.407 greater than $\alpha = 0.05$, meaning that the variants of the two groups are equal or homogeneous, the t-test results obtained t-count value = 1.479 < t-table = 2.000 at the level of $\alpha = 0.05$, and the probability value (ρ) Sig. = 0.634 > $\alpha = 0.05$, then the null hypothesis (H_0) is accepted, meaning that there is no difference between the average value of science process skills of SMAN 1 and MAN 1 Kolaka students before the application of Virtual Laboratory in Physics learning. It can be explained that before being given treatment, the average value of students' science process skills in Physics subject is the same.

2. Analysis of differences in students' science process skills of SMAN 1 Kolaka before and after learning

Testing the average (t-test) of students' science process skills before and after the virtual laboratory application in Physics learning to know which group has a greater influence. The average value of the two sample groups can be seen as follows:

Table 5. The average value of students' science process skills of SMAN 1 Kolaka before and after learning

Statistic	Class	N	Mean	Std. Deviation
Science process skills of SMAN 1 Kolaka	Pretest	28	25,29	7,174
	Posttest	28	32,86	6,786

The table above shows that there are 28 subjects observed. It can be seen that the average value of students' science process skills pretest before learning is 25.29, and after the application of Virtual Laboratory at SMAN 1 Kolaka obtained an average value of 32.86,

meaning that the value of students' science process skills before the application of Virtual Laboratory is increased after treatment. Furthermore, for hypothesis testing the output

used to test the hypothesis is the t-test, which is displayed in the Independent Samples Test table as follows:

Table 6. Summary of mean test results of students' science process skills of SMAN 1 Kolaka before and after learning

Paired Samples Test								
Statistic	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Pretest-Postes SMA N	7.571	9.720	1.837	11.340	3.802	4.122	27	.000

In the table above, the significance value of the Paired Samples Test is the result of the t-test obtained t-count value = 4.122 > t-table = 2.000 at the level of $\alpha = 0.05$, and the probability value (ρ) Sig. = 0.000 > $\alpha = 0.05$, then the null hypothesis (H_0) is rejected, meaning that there is a difference between the average value of science process skills of students of SMAN 1 Kolaka before and after the application of Virtual Laboratory in Physics learning. It can be explained that

before being given treatment, the average value of students' science process skills increased after learning.

3. Analysis of differences in students' science process skills of MAN 1 Kolaka before and after learning

Testing the average (t-test) of students' science process skills before and after the virtual laboratory application in Physics learning to know which group has a greater influence. The average value of the two sample groups can be seen as follows:

Table 7. The average value of students' science process skills of MAN 1 Kolaka before and after learning

Statistic	Kelas	N	Mean	Std. Deviation
Keterampilan Proses Sains MAN 1 Kolaka	Pretest	28	26,14	6,193
	Posttest	28	30,46	5,922

The table above shows that there are 28 subjects observed; it can be seen that the average value of students' science process skills pretest before learning is 26.14, and after the application of Virtual Laboratory at MAN 1 Kolaka obtained an average value of 30.46, meaning that the value of students' science

process skills before the application of Virtual Laboratory is increased after treatment. Furthermore, for hypothesis testing, the output used to test the hypothesis is the t-test, which is displayed in the Independent Samples Test table as follows:

Table 8. Summary of mean results of students' science process skills of MAN 1 Kolaka before and after learning

Paired Samples Test

Statistic	Paired Differences					T	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Pretes-SMAN – Postes-SMAN	4.321	8.538	1.613	7.632	1.011	2.678	27	.012

In the table above, the significance value of the Paired Samples Test is the result of the t-test obtained t-count value = 2.678 > t-table = 2.000 at the level $\alpha = 0.05$, and the probability value (ρ) Sig. = 0.012 > $\alpha = 0.05$, then the null hypothesis (H_0) is rejected, meaning that there is a difference between the average value of science process skills of MAN 1 Kolaka students before and after the application of Virtual Laboratory in Physics learning. It can be explained that before being given the treatment, the average value of

students' science process skills increased after learning.

4. Analysis of differences in students' science process skills of SMAN 1 and MAN 1 Kolaka after learning

Testing the average (t-test) value of students' science process skills after the application of virtual laboratory in Physics learning with the aim of knowing which group has a greater influence. The average value of the two sample groups can be seen as follows:

Table 9. The average value of science process skills of students of SMAN 1 and MAN 1 Kolaka after learning

Statistic	Kelas	N	Mean	Std. Deviation
Postes Keterampilan Proses Sains	SMAN 1 Kolaka	28	32,75	6,813
	MAN 1 Kolaka	28	33,67	5,967

The table above shows that there are 28 subjects observed. It can be seen that the average value of students' science process skills pretest after the application of Virtual Laboratory at SMAN 1 is 32.75, and 28 subjects of MAN 1 Kolaka obtained an average value of 33.67, meaning that the value

of students' science process skills before the application of Virtual Laboratory is the same. Furthermore, for hypothesis testing, the output used to test the hypothesis is a t-test, which is displayed in the Independent Samples Test table as follows:

Table 10. Summary of Mean Test Results of Science Process Skills of Students of SMAN 1 and MAN 1 Kolaka After Learning
Independent Samples Test

Statistic		Levene's Test for Equality of Variances		t-test for Equality of Means			
		F	Sig.	t	Df	Sig. (2-tailed)	Mean Difference
Postes	Equal variances	.701	.407	1.420	49	.162	2.576

Keterampilan Proses Sains Siswa SMAN 1 & MAN 1	assumed						
	Equal variances not assumed			1.439	48.77	.157	2.576

In the table above, the significance value of Levene's test is 0.407 greater than $\alpha = 0.05$, meaning that the variants of the two groups are equal or homogeneous, the t-test results obtained t-count value = 1.420 < t-table = 2.000 at the level of $\alpha = 0.05$, and the probability value (ρ) Sig. = 0.162 > $\alpha = 0.05$, then the null hypothesis (H_0) is accepted, meaning that there is no difference between the average value of science process skills of SMAN 1 and MAN 1 Kolaka students after the application of Virtual Laboratory in Physics learning. It can be explained that after being given treatment, the average value of students' science process skills in Physics subject is the same. Both samples have increased science process skill scores after the application of Virtual Laboratory in Physics learning at SMAN 1 and MAN 1 Kolaka.

5. N-Gain analysis of students' science process skills values of SMAN and MAN 1 Kolaka

Based on the results of research on students of SMAN 1 Kolaka that the value of science process skills of students before and after being given treatment is as follows:

$$N - Gain = \frac{Skor Postes - Skor Pretes}{Skor Ideal - Skor Pretes}$$

$$= \frac{920 - 708}{1120 - 708} = \frac{212}{524} = 0,515$$

While the results of research on MAN 1 Kolaka students that the value of students' science process skills before and after being given treatment are as follows:

$$N - Gain = \frac{Skor Postes - Skor Pretes}{Skor Ideal - Skor Pretes}$$

$$= \frac{953 - 702}{1120 - 702} = \frac{251}{418} = 0,601$$

N-Gain criteria (Melzer in Syafitri, 2008)

$G > 0.7$ = Very Effective

$0.51 \leq G \leq 0.7$ = Effective

$0.3 \leq G \leq 0.50$ = Moderately effective

$G < 0.3$ = Not effective

Based on the results of the N-Gain calculation above, it can be explained that the Application/utilization of Virtual Laboratory at SMAN 1 Kolaka obtained an N-Gain value of 0.409, while at MAN 1 Kolaka obtained an N-Gain of 0.474, so it can be concluded that the Utilization of Virtual Laboratory is Effective in improving students' science process skills at SMAN 1 and MAN 1 Kolaka.

The value of science process skills of students before being given the treatment of Virtual Laboratory application at SMAN 1 Kolaka obtained an average value of 25.29, with a standard deviation of 7.174 while the science process skills of students at MAN 1 Kolaka obtained an average value of 26.14, standard deviation 6.193. Then tested the difference in the average value obtained that the t-count value of 1.479 is smaller than the t-table value of 2.055 and or sig (ρ) value of 0.634 > α 0.05. So it can be explained that the science process skills of students before being given treatment at SMAN 1 and MAN 1 Kolaka are no different; that is, they have the same ability (homogeneous), meaning that both test classes experience the same level of understanding.

Based on the above, it is known that students' science process skills are still low. This is indicated by students not being able to

understand the work steps when doing laboratory activities, students still have difficulty when processing data and concluding experimental results, and still feel awkward using tools in laboratory activities. Not much different from the results of Kusuma's research that the tendency of students who have low science skills in five indicators: 1) graphing and interpreting data; 2) designing experiments; 3) making operational definitions; 4) identifying and controlling variables; and 5) hypothesizing (Kusuma & Rusmansyah, 2021). Whereas the demands of the curriculum require students to master science comprehensively through science process skills (Nursalam et al., 2022). On the other hand, students' low science process skills can also have an impact on students' low critical thinking skills (Darmaji et al., 2020; Firmansyah & Suhandi, 2021).

The low science process skills of students at SMAN 1 Kolaka and MAN 1 Kolaka are allegedly due to the lack of available infrastructure and teachers' ability to innovate. Alternative solutions offered for these problems include the utilization of computer technology in learning. According to Donnelly, learning can be improved by the use of computer simulations (Donnelly et al., 2013). Utilization of computer-based learning media can improve learning because it is learner-oriented and involves high learner interactivity (Sung & Hwang, 2013). The use of computers in the learning process can take many forms depending on the ability of learning designers and developers. Abstract concepts can be taught to be more concrete in the form of audio and visuals that are simulated by movement or animated (Ristina et al., 2020). A virtual laboratory can be an interactive experience where learners observe and manipulate system-generated objects, data, or phenomena in order to fulfill learning objectives (Hikmah et al., 2017). Of course, this will be beneficial for students because interactive multimedia can be accessed

flexibly anywhere and anytime (Muchlis & Putra, 2017). Virtual laboratories provide learners with meaningful virtual experiences and present important concepts, principles, and processes. By using virtual laboratories, learners have the opportunity to repeat experiments that went wrong or to deepen the intended experience (Sapriadil et al., 2019).

Based on the results of data analysis, the significance value of Levene's test is 0.407 greater than $\alpha = 0.05$, meaning that the variants of the two groups are equal or homogeneous, the results of the t-test obtained t-count value = 1.420 < t-table = 2.051 at the level of $\alpha = 0.05$, and the probability value (ρ) Sig. = 0.162 > $\alpha = 0.05$, then the null hypothesis (H_0) is accepted, meaning that there is no difference between the average value of science process skills of SMAN 1 and MAN 1 Kolaka students after the application of Virtual Laboratory in Physics learning. It can be explained that after being given treatment, the average value of students' science process skills in heterogeneous Physics subjects is the same. Both samples have increased science process skill values after the application of Virtual Laboratory in Physics learning at SMAN 1 and MAN 1 Kolaka.

Based on the data above, students' science process skills obtained from the results of the application of Virtual Laboratory in Physics learning provide meaning that in understanding the concept of Physics learning (Hooke's Law) requires students to have high critical thinking and analysis skills and is useful for solving complex problems through the use of virtual laboratories (Fadhilah et al., 2021; Gorai et al., 2016; Gunawan et al., 2018; Hurtado-Bermúdez & Romero-Abrio, 2023). This implies that virtual laboratories can be a solution and contribute to the learning process by providing opportunities for students to learn by doing activities that are more interesting and fun so that they are encouraged to discover and produce an active and fun classroom interaction (Bogusevski et al., 2020);

Estriegana et al., 2019; Jong et al., 2013). This means that information technology-based virtual laboratories are in line with current developments (Potkonjak et al., 2016).

Virtual laboratory as a form of interactive multimedia object consists of various formats, including text, hypertext, sound, images, animation, video, and graphics. Gunawan reported that the advantages of virtual laboratories are that practicum activities become more efficient and cheaper because each stage of the experiment is already available in the learning software, does not require expensive maintenance costs, practicum activities become safer, and there are no worries about damage to laboratory equipment and other disturbances (Gunawan et al., 2015). This allows teachers and principals to improve their competence in technology. Teachers can apply Virtual Laboratory in the classroom with limited real laboratory facilities and infrastructure at a low cost.

The increase in students' science process skills can occur because, with virtual laboratory learning, students can easily do practical activities anywhere without the need to provide props and laboratories so that students can still do practical activities. This learning also simulates the concepts in physics learning and invites students to be active in learning so that students' thinking skills and science process skills can increase (Darmaji et al., 2018; Jaya, 2012).

CONCLUSIONS

Based on the research results, data analysis, and discussion, it can be concluded that there is an increase in physics learning outcomes and a positive impact on the science process skills of students of SMAN 1 Kolaka and MAN 1 Kolaka after applying the PhET-based virtual laboratory. Thus, the application of PhET-based virtual laboratory in science-physics learning is practical in improving learning outcomes and science process skills of students of SMAN 1 Kolaka and MAN 1

Kolaka. This research implies that the use of a real laboratory is not the only equipment used to conduct experiments. However, laboratories have developed so that students and teachers can conduct experiments through virtual laboratories at an affordable cost. This study also has limitations. For example, the research method used is postpositivistic. So that the results of the study are used to test the hypothesis, it is hoped that future studies can explore further and in-depth through other research methods so as to add new findings from a different perspective.

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