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Online Vs Offline: Comparison of Effectiveness of PhET Simulation and Science KIT in Junior High School

Firda Nikmah[1], Maison[2], Syamsurizal[3]
[1,2,3]Department of Science Education, Pascasarjana, Universitas Jambi, Jambi, Indonesia

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ABSTRACT

Purpose of the study: This study aims to determine the comparison of the effectiveness of online and offline simulation media. Especially during the transition period from the new normal, hybridlearning and back to the new normal.

Methodology: The research design used was quasi-experimental. The study sample was taken using random sampling technique. The data collection techniques used are observation and tests. Observation is carried out to find out more about the subject of research. A test is conducted to determine the condition of students before and after receiving treatment. There are two test instruments used, namely pretest and posttest. The treatment given to the control class is learning using Science KIT and the experimental class will use PhET Simulation. The results of the study will be processed using SPSS.

Main Findings: The use of PhET media and science KIT based on the N-gain test proved to increase on average after treatment. In the control class, the gain value was 0.7, while in the experimental class, the gain value was 0.8. According to the criteria, both classes are in the high category. but in contrast to the percentage of effectiveness, the use of PhET is effective with a percentage of 86% while KIT science is quite effective with a percentage of 71%.

Novelty/Originality of this study: PhET simulation media and science KIT are able to explain abstract material to improve cognitive understanding. The use of this simulation media can be adjusted to learning conditions. if offline use KIT and if online use PhET.

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Corresponding Author:
Firda Nikmah,
Department of Science and Education, Pascasarjana, Universitas Jambi,
Raden Mattaher Street No.21, Kota Jambi, Jambi 36123, Indonesia
Email: nikmahfirda888@gmail.com

1. INTRODUCTION

Education has a very important role in advancing a country. The quality of education is an asset for the future of the country. So it is important for us to advance human resources through education. Technology that is increasingly sophisticated and continues to grow and the needs of the community that continue to increase need to be balanced with improving the quality of education[1], [2]. The government has made various efforts to improve the quality of education, one example is through upgrading teachers on how the teaching and learning process, teacher certification and curriculum improvement.

The teaching and learning process is the implementation of the curriculum in educational institutions so that students can achieve the learning goals that have been set. The purpose of education is basically to lead students to behavioral changes in the form of intellectual, moral, and ethical as well as socio-cultural[3], [4]. Every improvement of the curriculum to the independent curriculum requires educators to be more creative in

the learning process, especially in science subjects. Science learning materials contain a lot of learning that is theoretical[5], conceptual[6] and abstract[7] so that it is difficult for students to understand, especially if the learning contains several formulas that are integrated with each other, researchers even reveal if science learning is a frightening scourge for students to understand a material. Research of Kartina and Subani shows that science subjects are subjects that many students dislike, various reasons can be stated by students, one of which is "science is difficult to understand"[8]. Science lessons are arguably the most difficult among other exact lessons. In addition, Amaliyah, Suardana and Slamet revealed that science learning in schools tends to emphasize understanding concepts in learning so that some students choose shortcuts by memorizing concepts and formulas to overcome science learning difficulties[9]. Learners who have the ability to memorize and long-term memory prefer to memorize rather than understand the concept itself.

Basically, students do have a certain amount of knowledge, but knowledge is only obtained from teachers without them being able to find their own concepts from their knowledge. In the curriculum for primary and secondary education, it is stated that science serves to develop skills, insight and awareness of technology in relation to its use in everyday life[10]. This means, through science learning in schools should be used to improve student competence. Government Regulation number 19 of 2005 article 25 (4) concerning national standards of education explains that the competence of graduates includes attitudes, knowledge and skills[11]. This means that learning and assessment must be able to develop student competencies related to affective (attitude), cognitive (knowledge), and psychomotor (skills) domains.

In teaching and learning activities do not always run smoothly, there are problems or difficulties encountered, as well as in achieving learning objectives, not always competencies can develop as expected, there are many factors that can affect the development of student competencies ranging from suboptimal school environment conditions[12], unattractive learning models[13], decreased student abilities[14], and many other factors. This situation is often a common problem that occurs in the teaching and learning process. However, along with the development of the times, these factors began to be overcome and new problems emerged related to technological developments that over time continued to emerge. One of them is the limitations of teachers in using technology in the form of learning media.

Based on the results of interviews with students at Junior high school 17 Tanjung Jabung Timur, students said that during science learning they rarely use learning media. Learning is often done only based on guidebooks without additional media. This happened because of limited facilities at the school and the prohibition for students to bring smartphones.So it is difficult for students to understand abstract material. Moreover, they are classified as a transition period from online learning to offline learning. Based on student information, during the two years they experienced online learning, they rarely used learning media and even carried out teaching and learning activities and were often only given assignments to be collected at school. Based on information obtained by researchers from students conducted through short interviews at Junior high school 17 Tanjung Jabung Timur, especially grade IX B and grade IX C students, as many as 72% of students said teachers did not use online learning media in the teaching and learning process, especially in science materials.

This makes it difficult for students to develop their way of learning. Based on the curriculum applied at Junior high school 17 Tanjung Jabung Timur, science material in class IX tends to be more abstract materials such as static electricity, dynamic electricity and magnetism which according to students are very difficult to imagine about the movement of the charge, how electric current flows and how the energy is. So that learning media is needed as a support and foundation for students' thinking to develop their way of thinking. But that does not mean that teachers do not know about simulation media to support this abstract material such as PhET Colorado.

This research will focus on the subject of dynamic electricity, electrical circuit material needs to be explained in advance about electric current, electric voltage, electrical resistance, electrical measuring instruments and how to use electrical measuring instruments. In order for this material to be explained easily, it is necessary to use learning media. In this study, the media used was in the form of virtual simulation media, namely PhET Simulation. PhET is a simulation created by the University of Colorado that contains simulations of learning physics, biology, chemistry and mathematics for the benefit of classroom teaching or individual learning. Real-life phenomena with underlying science support interactive and constructivist approaches, provide feedback and provide a creative workplace.

Research results from Muzana, Lubis and Wirda show that the use of PhET simulation media is feasible to use[15]. Puspitasari, Subiki And Supriadi research, shows that the use of PhET Simulation media can improve learners' understanding and learning motivation[16]. All students completed after participating in science learning using PhET Simulation learning media, the results of limited trials of science learning using PhET Simulation learning media on Newton's Law material showed that teachers had managed science learning very well, with a score of 35.5 at the first meeting and 39.5 at the second meeting. The difference in the researcher's research above lies in the understanding of students, learning motivation and the material, while this study saw an improvement in the science process using PhET Simulation media.

The PhET simulation that researchers will use is the DC Construction Kit. The advantages of PhET simulation can determine the direction of electron flow and also electric current, which is considered too abstract for students to imagine. In addition, through PhET, students are also safer in practicing electrical circuits so as to avoid laboratory accidents related to electricity. In addition to using PhET simulation, students' understanding can also be trained using a simple kit. KIT is an integrated instrument box which contains tools that can be assembled and used to carry out various experiments according to a predetermined theme/topic. A simple KIT is a box that contains components used in electrical circuit practicum consisting of lights, jumpers, resistances, voltage sources, circuit boards and multimeters. A simple kit is a medium to instill and strengthen the understanding of physics concepts in science learning, showing how the relationship between theory and concept so that students are able to apply the concept in everyday life.

The success of the learning process in the field is measured based on learning outcomes in this case cognitive abilities. Research studies say that the ability of students is influenced by the learning atmosphere and teaching methods of teachers. One of the factors that affect the atmosphere and teaching methods of teachers is the learning media used. Student interest in learning media can build student motivation in learning. Good media is media that is able to influence students' focus on the material so that the attraction of participants is chosen to follow learning carefully.

Based on field observations, researchers conducted an interview with a teacher who teaches science subjects at Junior high school 17 Tanjung Jabung Timur. The teacher said that the use of Phet Simulation is not a new thing used by the teacher, during the pandemic all teachers are required to use interesting media to deliver material in class so as not to cause boredom in learning, including science lessons which are famous for difficult subjects among students. According to the teacher, during the use of simulation media, even in online conditions students are very motivated and students' interest in learning increases along with the use of various media.

Based on the background that has been described, the question of this research is which is more effective between online simulation media (using simulated PhET) and offline media (using science KIT)?. Relevant research states that when learning is carried out using PhET and KIT science. Science KIT is able to improve students' skills compared to simulated PhET [17]. but in practice the use of PhET is better and more practical than science KIT[18]. Furthermore, a simple and attractive PhET display can increase student motivation compared to KIT Sains[19].

2. RESEARCH METHOD

This research was conducted at Junior high school 17 Tanjung Jabung Timur. The study was conducted using a quasi-experimental design. Quasi-experiments were conducted to determine the effect of a treatment on the characteristics of the subjects studied [20]. The goal is to determine the effectiveness of using PhET-based and KIT-based simulation learning media. This experimental research design is the non-equivalent pretest-posttest group design [20]. The experimental class will use learning using PhET Simulation while the control class will learn using KIT. Both groups of both control classes and experimental classes will be given a pretest first which serves as initial knowledge before being given treatment while after being given treatment students will be given a post test to find out the condition of students after being given treatment, here is an overview of the research design used [21]

Table 1. Research Design

Class	Pretest	Treatment	Posttest
Control	O_1	X_1	O_2
Experiment	O_3	X_2	O_4

Where:
O_1 : Control Class Pretest Scores
O_2 : Control Class Posttest Scores
O_3 : Experiment Class Pretest Scores
O_4 : Experiment Class Posttest Scores
X_1 : treatment using science KIT used directly by students
X_2 : treatment using PhET Simulation media used directly by students

The sample used in this study was grade IX Junior high school 17 Tanjung Jabung Timur. The study will be conducted in February 2023. Samples were taken using a simple random sampling technique[22] by randomly assigning numbers to students. The data techniques used in this study were observations and tests. Observation is used to determine problems and also conditions that exist in schools. Tests are used to determine the results of increasing students' understanding of concepts. In this study are two tests that will be given, the first is a pretest to find out students' understanding of concepts before using simulation media and the second is a post test to find out students' understanding of concepts after using simulation media.

The data processing techniques used in this study are validity and raliability tests to determine the validity and validity of the instrumentals used, prerequisite tests and N-gain tests. We can see based on figure 1.

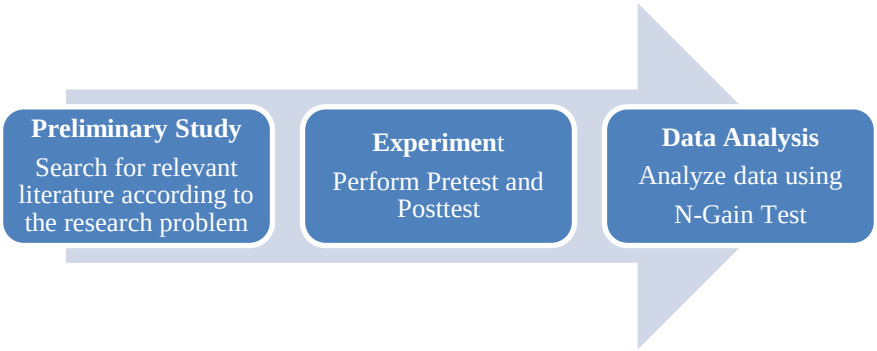

Figure 1. Data collection procedure

Data collection techniques for the N-gain test measured based on pretest scores and posttest scores of class students and N-gain criteria experiments can be seen in table 2 as follows:

Table 2. N-gain criteria

No	Value <g>	Category
1	0.3 < g	Low
2	0.3 ≤ g < 0.7	Keep
3	0.7 ≤ g	Tall

Based on data collection techniques using ng tests, the category of interpretation of the effectiveness of simulation media can be seen in table 3 regarding the category of interpretation of N-gain effectiveness.

Table 3. Categories Interpretation of N-Gain Effectiveness

Percentage (%)	Interpretation
< 40	Ineffective
40 – 55	Less Effective
56 – 75	Quite Effective
> 76	Effective

The tested hypothesis is formulated in the form of the following statistical hypothesis:

H_0: $\mu_1 < \mu_2$

H_1: $\mu_1 \geq \mu_2$

Information:

H_0 : The average dynamic electrical learning outcomes of students using PhET Simulation are no better than using science KIT

H_1 : The average dynamic electrical learning outcomes of students using PhET Simulation are better than using science KIT

3. RESULTS AND DISCUSSION

Based on the problems that arose during the observation related to the transition from hybrid class to new normal class, researchers are interested in making research on the effectiveness of simulation media used during the new normal transition period. Research has been conducted at Junior high school 17 Tanjung Jabung Timur for classes IX B and IX C on dynamic electrical materials. The type of research carried out is quasi-experimental. The research was conducted in early February by delivering material for three meetings. Learning focuses on using media to explain abstract concepts in dynamic electrical matter. There are two types of media used during the study. The first media used is online simulation media, namely PhET simulation. PhET is used in experimental classes. The second media used is KIT which will be used in the control class.

This study used test instruments in the form of pretest questions and posttest questions as a measure of cognitive competence. The pretest and posttest questions have met the standards and passed the validity test using SPSS and ten questions were declared vailid and suitable for use with a cronbach alpha value of 0.857. A value of 0.857 was good explains that the test given is appropriate to measure this study to determine the comparison of the effectiveness of the media given. Before conducting research using PhET and KIT Science simulation media and also carrying out pretests, students were already familiar with dynamic electrical material through face-to-face learning conducted in semester 1 which focused on theories, concepts and formulas. So that when doing the pretest, the pretest results obtained are the initial knowledge of students during classroom learning. The pretest results of students for the experimental class and the control class can be seen in table 4 as follows.

Table 4. Pretest results of experimental class and control class

Data	Experiment	Control
Number of students	29	25
Top marks	60	50
Lowest score	20	0
Mean	39.65	33.60
Standard deviation	9.44	10.75

Based on table 4, it can be concluded that the average pretest scores of the experimental class and the control class before treatment have almost the same value. This is because previously they had received material using the lecture method through face-to-face learning in class during odd semesters. In table 4 it can be seen that the highest value for the experimental class is 60 while the highest value for the control class is 50, then for the lowest value for the experimental class is 20 and for the control class the lowest value is 0. This difference is very dependent on the initial knowledge of each student that students have gained based on classroom learning in the previous semester.

To support learning to be more interesting and more effective in the classroom, one of them is using simulation media, especially dynamic electrical learning is abstract learning. In this study, the simulation media carried out in the experimental class used pet simulation media while the simulation media used for the science KIT control class. Before conducting research, students will be divided into groups. Each student gets his or her group of researchers will give a science KIT to each group for a control class. As for the experimental class, they will be welcome to use one gadget per each group. Before conducting learning and practicum, researchers have first explained the material as well as practicum using PhET simulation media and also science KIT. During practicum activities, researchers will provide worksheets for students to each group. Ask students to record each measurement result based on the practicum that has been done then the researcher will ask students to calculate the measurement results based on the material that has been taught. After finishing processing the data, researchers will ask representatives of each group to present the measurement results in front of the class.

After completing learning and practicum, both classes will be given a post test to determine the difference between the experimental class and the control class after being given treatment, the test results can be seen in table 5.

Table 5. Posttest results of experimental class and control class

Data	Experiment	Control
Number of students	29	25
Top marks	100	80
Lowest score	50	20
Mean	74.83	59.20
Standard deviation	12.99	15.25

Table 5 shows the results of students' post-test scores an average increase after being given treatment. The increase in average scores occurred because the treatment given using simulation media turned out to make students more active in the classroom while providing real learning experiences to students to increase learning motivation and also increase students' understanding of concepts. This is in line with research Lacka which revealed that the use of simulated media can improve students' cognitive outcomes [23].

The comparison that can be seen in table 4 and table 5 does increase the average score of student understanding in dynamic electrical learning using PhET simulation and also KIT Science, but if viewed based on the lowest score there is no significant increase, there are several factors that cause this to occur based on the observations of researchers during practicum. First, one tool is used in a group where a group consists of 3 to 4 students, this is certainly a factor influencing whether or not student understanding increases because students divide tasks into measurements so that one student only understands one subject matter. Secondly, there are some students who are less active working in groups so that these students experience limitations in understanding the material. third, students are very unfamiliar with the use of PhET simulation media and also science KIT so that they do not understand using these media during practicum which results in students' understanding being hampered.

Based on the results of interviews with teachers, it was revealed that teachers rarely use simulation media because students need to demonstrate in advance about the procedures for using simulations, be it PhET or Science KIT. To carry it out, it is necessary to do a zoom meeting first. Unfortunately, based on parent meetings, often many parents express objections to quota fees for zoom meetings. Conditions like this must be corrected immediately. One of them is through increasing learning activities by adding learning media used with the hope that this media can be applied so that it can improve student competence. It is proven that based on the

average score of students there is a significant increase after using simulation media. This means that simulation media can improve students' cognitive understanding.

Alannasir revealed that the lack of use of media during learning can result in students who are less active and also less motivated so that student learning outcomes only depend on the learning explained by the teacher [24]. Furthermore, Pamungkas research explained, based on the results of interviews obtained by Pamungkas, students stated that learning in class without learning media became less enjoyable, but after Pamungkas provided media in the form of learning videos, students stated that learning became interesting and easier to understand than just looking at pictures based on teacher lighting [25], in his research Pamungkas also explained that the use of media he used was very effective to improve student understanding [25].

After conducting an assumption test, the researcher first conducts a prerequisite test with the display in Table 6.

Table 6. Pretest and Posttest Normality Test Using Kolmogorov-Smirnov Test Sample

Instrument	Experiment	Control	Decision
Pretest	0.063	0.055	Normal
Posttest	0.169	0.537	Normal

Table 7. Pretest and Posttest Homogeneous Test Results

Class	P	Decision
Pretest	0.490	Homogeneous
Postest	0.706	Homogeneous

After confirming that the data is normally distributed and homogeneous, an assumption test will be carried out using an independent sample t-test to see if there is an average difference between the two groups.

Table 8. Independent Sample T-Test

Instrument	Class	Mean	T_{value}	P	Decision
Pretest	Experiment	36.65	2.203	0.032	There is a difference
	Control	33.60			
Postest	Experiment	78.83	4.067	0.000	There is a difference
	Control	59.20			

After data processing, the results can be seen in the 8-point table based on table 8 calculated T values on the pretest instrument, which is 2.203 with a probability value of 0.032 then H_0 is rejected. Based on the test results, it can be said that there is an average difference in dynamic electrical learning outcomes between learning using PhET simulation media and dynamic electric KIT. There is a difference in the average learning outcomes before and after the implementation of PhET simulation and KIT Science because through these visual media students get a representation of the material presented. In dynamic electrical material, the information that students must obtain is how systematics of current flows in two different circuit arrangements, namely in series and in parallel. PhET simulation media is superior because students can directly observe the occurrence of differences in the direction of electric current and also the direction of electrons that occur when the circuit is arranged in series and also in parallel. Whereas when students use science KIT, students cannot see abstract things such as the direction of current flow and also the direction of electrons

This statement is supported by the research of Sylviani, Permana and Utomo that PhET Simulation provides interactivity, making the originally invisible intovisible, includes multiple representations (Movement of objects, graphs, numbers, etc.), using connections with the real world, providing implicit guidance to the user (e.g., by limiting controls) in productive exploration, and create simulations that can be used flexibly in many education situation[26]. In addition, when using PhET simulation media, there is no fear of getting electric shock due to virtual activities, while when using electric KIT, there is a fear for students to get electric shock so that these activities spend different times, the point of using pet media is considered more efficient than using point electric KIT, but the use of simulated PhET cannot replace KIT that students can use in real time, so that students who use KIT will understand more about the real components they encounter during the practicum process using KIT.

Furthermore, the researchers conducted an N-gain test to see the magnitude of the increase in students' understanding of concepts in the experimental class and control class that had been tested using students' pretest scores and post test scores, the test results can be seen in table 9.

Table 9. N-gain Test Results

Class	Mean Pretest	Mean Posttest	Gain	Percentage (%)
Experiment	36.65	78.83	0.8	86
Control	33.60	59.20	0.7	71

Table 9 shows that in the experimental class there was an average increase from the pretest which originally got an average of 36.65, increased quite rapidly in the post test and got an average of 78.83. The rapid increase occurred due to treatment by providing learning using simulated media. The increase in students' average scores was measured from students' pretest and posttest results, the increase resulted in a gain value of 0.8. Based on table 2, the gain value of 0.8 is included in the high category produced for the experimental class, so it can be concluded that the treatment given to science learning dynamic electrical material using PhET simulation media can improve students' cognitive aspects.

In the control class, there was also an increase in the average pretest score which originally got an average score of 33.60 increased in the post test to 59.20. Of course, the resulting increase in the control class also occurred due to the treatment given to the control class, namely simulation media using science KIT. Based on table 6, the average increase in students measured from tape to posttest resulted in a gain value of 0.7. In table 2 the gain value of 0.7 is also included in the high category for the control class, so it can be concluded that the treatment given to science learning dynamic electrical material using science KIT simulation media can improve students' cognitive aspects.

Based on the results of the N-gain test, it has been proven that both media using PhET simulation media and also using science KIT media are proven to improve students' cognitive aspects. however, based on table 3 the percentage of experiments is 86%, which states that PhET simulation media is effectively used to improve students' cognitive aspects but in contrast to the percentage of control classes of 71% based on table 3 the percentage value of 71% is stated to be quite effective. This means that the use of simulation media using PhET is more effective to explain dynamic electrical matter which is known to be abstract in the theory section so that electrical theories, especially dynamic electricity, are more suitable and more effective if explained using simulated PhET media. Evidenced by the results of research from Simamora, Safitri and Syiarah that learning media can arouse student learning motivation [27], especially for simulation-based media such as PhET and also Science KIT [28]–[30]. While according to Saurdeli, honing students' skills based on students' own experiences through practicum activities can attract students' learning interest [31], Akdemir and Robelo also said the same thing [32].

4. CONCLUSION

Based on the results of the study, it can be concluded that the use of PhET media and science KIT based on the N-gain test proved to increase on average after treatment. In the control class, the gain value was 0.7, while in the experimental class, the gain value was 0.8. According to the criteria, both classes are in the high category. but in contrast to the percentage of effectiveness, the use of PhET is effective with a percentage of 86% while KIT science is quite effective with a percentage of 71%. This research can be used as a benchmark for applying simulation media in schools.

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REFERENCES

[1] P. H. Garland And T. W. Grace, *New Perspectives For Student Affairs Professionals: Evolving Realities, Responsibilities And Roles. Ashe-Eric Higher Education Report No. 7.* Eric, 1993.

[2] D. Rotatori, E. J. Lee, And S. Sleeva, "The evolution of the workforce during the fourth industrial revolution," *Hum. Resour. Dev. Int.*, vol. 24, no. 1, Pp. 92–103, 2021.

[3] T. Sharhun And A. Potseluiko, "Linguistic and humanitarian competence of future engineers: the philosophical and anthropological aspect," *Hum. Stud. Ser. Pedagog.*, vol. 0, no. 10/42, pp. 122–132, 2020, Doi: 10.24919/2413-2039.10/42.199852.

[4] A. Fadhil, A. Hakam, M. Effendi, S. Nurpratiwi, And A. Amaliyah, "Socio-Cultural revitalization, as an effort to empower the character of humanism in students," 2022, Doi: 10.4108/Eai.15-9-2021.2315570.

[5] M. Thees, S. Kapp, M. P. Strzys, F. Beil, P. Lukowicz, And J. Kuhn, "Effects of augmented reality on learning and cognitive load in university physics laboratory courses," *Comput. Human Behav.*, vol. 108, pp. 106316, 2020.

[6] B. Fauth *Et Al.*, "The effects of teacher competence on student outcomes in elementary science education: the

mediating role of teaching quality," *Teach. Teach. Educ.*, vol. 86, pp. 102882, 2019.
[7] G. Falloon, "Using simulations to teach young students science concepts: an experiential learning theoretical analysis," *Comput. Educ.*, vol. 135, pp. 138–159, 2019.
[8] L. Kartina And S. Subani, "Analisis kemandirian siswa mts pada mata pelajaran ipa," *Schrödinger J. Phys. Educ.*, vol. 1, no. 1, pp. 30–35, 2020.
[9] M. Amaliyah, I. N. Suardana, And K. Selamet, "Analisis kesulitan belajar dan faktor-faktor penyebab kesulitan belajar ipa siswa smp negeri 4 Singaraja," *J. Pendidik. Dan Pembelajaran Sains Indones.*, vol. 4, no. 1, pp. 90–101, 2021.
[10] P. M. Kurup, X. Li, G. Powell, And M. Brown, "Building future primary teachers' capacity in stem: based on a platform of beliefs, understandings and intentions," *Int. J. Stem Educ.*, vol. 6, no. 1, pp. 1–14, 2019.
[11] Y. N. Rahayu, R. Rosyadi, U. C. Barlian, And S. Sauri, "Analisis standar penilaian pada pendidikan menengah atas: studi literatur review," *Gema Wiralodra*, vol. 12, no. 1, pp. 17–33, 2021.
[12] F. C. Dewi And T. Yuniarsih, "Pengaruh lingkungan sekolah dan peran guru terhadap motivasi belajar siswa," *J. Pendidik. Manaj. Perkantoran*, vol. 5, no. 1, pp. 1–13, 2020.
[13] H. Fauhah And B. Rosy, "Analisis model pembelajaran make a match terhadap hasil belajar siswa," *J. Pendidik. Adm. Perkantoran*, vol. 9, no. 2, pp. 321–334, 2021.
[14] S. Maulidina And Y. B. Bhakti, "Pengaruh media pembelajaran online dalam pemahaman dan minat belajar siswa pada konsep pelajaran fisika," *Orbita J. Kajian, Inov. Dan Apl. Pendidik. Fis.*, vol. 6, no. 2, pp. 248–251, 2020.
[15] S. R. Muzana, S. P. W. Lubis, And W. Wirda, "Penggunaan Simulasi Phet Terhadap Efektifitas Belajar Ipa," *J. Dedik. Pendidik.*, Vol. 5, No. 1, Pp. 227–236, 2021.
[16] L. Puspitasari, S. Subiki, And B. Supriadi, "Pengaruh media phet simulation terhadap motivasi dan hasil belajar fisika siswa smk," *J. Pendidik. Fis*, vol. 11, no. 2, pp. 89–96, 2022.
[17] D. A. Basri, "Implementasi simulasi phet (physics education technology) dan kit ipa terhadap keterampilan proses sains peserta didik sma negeri 6 Pinrang," *J. Sains Dan Pendidik. Fis*, vol. 15, no. 3, pp. 319111, 2020.
[18] I. Khoiriyah, U. Rosidin, And W. Suana, "Perbandingan hasil belajar menggunakan phet simulation dan kit optika melalui inkuiri terbimbing," *J. Pembelajaran Fis*, vol. 3, no. 5, 2015.
[19] M. Marlinda, A. Halim, And I. Maulana, "Perbandingan penggunaan media virtual lab simulasi phet (physics education tekhnology) dengan metode eksperimen terhadap motivasi dan aktivitas belajar peserta didik pada materi kelarutan dan hasil kali kelarutan," *J. Pendidik. Sains Indones.*, vol. 4, no. 1, 2016.
[20] J. W. Creswell And J. D. Creswell, *Research Design: Qualitative, Quantitative, And Mixed Methods Approaches*. Sage Publications, 2017.
[21] S. Sugiyono, *Metode Penelitian Pendidikan (Pendekatan Kuantitatif, Kualitatif, Dan R&D).* Bandung: Alfabeta, 2017.
[22] S. Sugiyono, *Metode Penelitian Kombinasi (Mixed Methods)*. Bandung: Alfabeta, 2018.
[23] E. Lacka, T. C. Wong, And M. Y. Haddoud, "Can digital technologies improve students' efficiency? exploring the role of virtual learning environment and social media use in higher education," *Comput. Educ.*, vol. 163, pp. 104099, 2021.
[24] W. Alannasir, "Pengaruh penggunaan media animasi dalam pembelajaran ips terhadap motivasi belajar siswa kelas Iv Sd Negeri Mannuruki," *J. Educ. Sci. Technol.*, vol. 2, no. 2, pp. 81, 2016.
[25] W. A. D. Pamungkas And H. D. Koeswanti, "Pengaruh penggunaan media pembelajaran video terhadap hasil belajar siswa sekolah dasar," *J. Ilm. Pendidik. Profesi Guru*, vol. 4, no. 3, 2021.
[26] S. Sylviani, F. C. Permana, And R. G. Utomo, "Phet simulation sebagai alat bantu siswa sekolah dasar dalam proses belajar mengajar mata pelajaran matematika," *Edsence J. Pendidik. Multimed.*, vol. 2, no. 1, pp. 1–10, 2020, Doi: 10.17509/Edsence.V2i1.25184.
[27] N. N. Simamora, H. Safitri, H. Syiarah, And D. Chen, "Deskripsi motivasi belajar fisika kelas x mipa di sma negeri 4 Kota Jambi," *Integr. Sci. Educ. J.*, vol. 3, no. 1, pp. 1–5, 2022, doi: 10.37251/Isej.V3i1.166.
[28] Z. M. Mardhatilla, "Phet simulation sebagai penunjang pembelajaran ipa secara online selama pandemi covid-19," In *Pisces: Proceeding Of Integrative Science Education Seminar*, 2021, vol. 1, no. 1, pp. 441–448.
[29] H. C. Mahardika, R. Ismawati, And R. Rahayu, "Penerapan lkpd berbantuan simulasi phet untuk meningkatkan motivasi dan hasil belajar kognitif ipa peserta didik smp," *Edu Sains J. Pendidik. Sains Dan Mat.*, vol. 10, no. 1, Pp. 61–70, 2022.
[30] A. Susilawati, Y. Yusrizal, A. Halim, M. Syukri, I. Khaldun, And S. Susanna, "The effect of using physics education technology (phet) simulation media to enhance students' motivation and problem-solving skills in learning physics," *J. Penelit. Pendidik. Ipa*, vol. 8, no. 3, pp. 1166–1170, 2022.
[31] M. G. Saudelli, R. Kleiv, J. Davies, M. Jungmark, And R. Mueller, "Phet simulations in undergraduate physics: constructivist learning theory in practice," *Brock Educ. J.*, vol. 31, no. 1, 2021.
[32] Z. Akdemir And N. S. Rebello, "Door-Alarm lab: Integration of engineering design in a simulation-based learning environment for pre-service elementary teachers," In *2022 Asee Annual Conference & Exposition*, 2022, pp. 1–12.