

THE USE OF PHET SIMULATION ON PHYSICS CHAPTER WAVE AND VIBRATION IN 3T REGION

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ABSTRAK

Pembelajaran menggunakan *PhET* sebagai *virtual laboratory* dapat meningkatkan pemahaman peserta didik tentang konsep abstrak atau materi yang sulit dieksperimentasikan di laboratorium nyata. Tujuan dari kegiatan pengabdian lokal ini adalah untuk melakukan pelatihan bagi guru dan peserta didik di SMAN 1 Nimboran Kabupaten Jayapura. Hal ini untuk mengetahui bagaimana implementasi media pembelajaran *PhET Simulation* di wilayah 3T yang merupakan singkatan dari *terdepan* (frontier), *terpencil* (remote), and *tertinggal* (disadvantaged) yang ada di Indonesia. Kegiatan pengabdian ini diikuti oleh guru fisika dan peserta didik kelas XI-IPA di SMAN 1 Nimboran Kabupaten Jayapura. Metode dari kegiatan ini dilakukan dalam bentuk pelatihan *virtual laboratory* melalui *PhET Simulation*, secara tatap muka/luring di SMAN 1 Nimboran. Keberhasilan dalam program pelatihan ini pada guru dan siswa terlihat dari antusiasme dan pencapaian keterampilan untuk menggunakan *PhET Simulation* dengan lancar. Siswa lebih memahami konsep getaran dan gelombang melalui simulasi. Guru fisika meminta kesediaan waktu dari Tim Pelaksana pengabdian untuk tetap membimbing dalam penggunaan aplikasi sebagai sarana laboratorium virtual dalam pembelajaran fisika. Rencana tahapan berikutnya dari kegiatan pengabdian ini adalah *follow up* untuk pokok bahasan yang lain dan wilayah 3T yang lain.

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ABSTRACT

Learning to use PhET as a virtual laboratory can improve students' understanding of abstract concepts or material that is difficult to experiment in a real laboratory. The purpose of this local service activity is to conduct training for teachers and students at SMAN 1 Nimboran, Jayapura Regency. This is to find out how the implementation of the PhET Simulation learning media in the 3T region which stands for terdepan (frontier), terpencil (remote), and tertinggal (disadvantaged) in Indonesia. This service activity was attended by physics teachers and students of class XI-IPA at SMAN 1 Nimboran, Jayapura Regency. The method of this activity is carried out in the form of virtual laboratory training through PhET Simulation, face-to-face/offline at SMAN 1 Nimboran. The success of this training program for teachers and students can be seen from the enthusiasm and attainment of skills to use PhET Simulation smoothly. Students better understand the concepts of vibration and waves through simulation. The plan for the next stage of this service activity is to follow up for other subjects and 3T area.

1. INTRODUCTION

Learning media plays an important role in getting students involved in physically and cognitively active learning in the right way (Wieman et al., 2010). Broadcast media in active learning has the potential to play an active role in activating cognitive activity in students to understand concepts (Kholiq, 2020). Most teachers are still interested in using learning media in the form of presentation slides that are displayed in the form of writing, images and non-animation (Rideout, 2014). This can be seen from several studies on the development of presentation slide-based learning media (Alpaslan et al., 2016; Chahal & Bakshi, 2014).

Active learning includes listening, watching, discussing, doing, teaching others, helping students find concepts, and mastering the skills they learn (Bernard et al., 2019). What is also urgent in activating students in learning apart from active learning strategies is active learning media (Kharub & Sharma, 2017). The most important thing is that teachers need to pay attention to the accuracy of using learning media to maximize the thought process in processing the information (Alsmadi et al., 2021). Based on the results of research on the thinking process facilitated by learning media, there are things regarding the design and use of learning media that need to be revised (Kristiyanto, 2016). The role of the learner in active learning is to emphasize the importance of the student's learning process in addition to the learning outcomes (Rohani, 2019; Samal, 2018).

In general, the use of learning media is to facilitate interaction between teachers and students so that teaching and learning activities are more optimal, effective, and efficient in terms of both theoretical and practical which are ultimately applied in action. Media can be used in the teaching and learning process in two ways, namely as teaching aids and as learning media that can be used by students themselves (Kholiq, 2020). The media used as teaching aids are called dependent media (Mustafá & Trubel, 2013). As a tool, the effectiveness of the media really depends on the way and ability of the teacher who uses it. For example, a photograph or a transparency used by the teacher to explain a concept (Sukma et al., 2019).

The selection of learning media must be adjusted to the characteristics of students (Naimah et al., 2019). In teaching and learning activities, media is basically used to help students learn objects, sounds, processes, events or environments that are difficult to bring into the classroom (Chahal & Bakshi, 2014; Rusydiyah et al., 2021). Furthermore, the use of teaching media can help educators a lot, so the selection must pay attention to: (1) the suitability of teaching media with the intended purpose. to be achieved, (2) the suitability of the characteristics of the lesson, (3) the sophistication of the media teaching media compared to the level of development of students, (4) the suitability of the teaching media with the interests, abilities and interests of students, (5) the suitability of the characteristics of the media with the socio-cultural background, (6) academic factors, and (7) students' learning conditions, therefore efforts to know students' self or student characteristics are expected steps, so that the use of teaching media can be effective (McLuhan, 1994). This is in line with the cone theory of Edgar Dale's experience of the learning process that occurs in students.

The cone of experience based on Edgar Dale's thinking, which is also known as the Cone of Experience, provides an overview for educators to choose learning media according to the characteristics of the learning concept and the characteristics of students (Dale, 1969). This is an initial effort to provide a reason or basis for the relationship between learning theory and audiovisual communication in learning media, both conventional and modern technology-based media (Van Ryzin et al., 2020). The percentage numbers on the left side of the pyramid indicate how much people generally remember and understand something according to the level of the type of activity they do (Dale, 1969; Moore et al., 2014; Perkins et al., 2006). Rudi Bretz classifies media on the main characteristics, namely sound, visual form (images, lines and symbols), and motion. Bretz (1971) classifies all media into 7 classes, namely (1) motion audio-visual media, (2) silent audio-visual media, (3) semi-motion audio media, (4) motion visual media, (5) silent visual media, (6) audio media, and (7) print media. In the early stages of learning or early teaching and learning activities

(pre-instructional) teachers often have difficulty in directing, interest or motivation to the subject matter, so that learning media is needed to stimulate students' curiosity and interest in the subject to be studied (Schunk, 2012).

The development of Information and Communication Technology (ICT), namely open source (free) software, which is specifically designed for learning is becoming increasingly rapid—especially because of the demands of distance learning/in the network (online). PhET (Physics Educational Technology) is an open source application software for science learning that contains several interactive shows to discover science concepts in physics, chemistry, biology, earth, and mathematics. PhET Simulation is freely accessible and available at <https://phet.colorado.edu> (Wieman et al., 2010). PhET is an interactive simulation with a research-based approach, which connects real-life phenomena with the underlying science, so as to increase students' understanding and interest. This gives teachers the opportunity to use PhET as a virtual laboratory in learning activities or *kegiatan belajar mengajar* (KBM). This simulation is open source, so anyone who wants to use it can download and access it for free. However, the use of PhET Simulation must be supported by some Java-based software player to be used (Adams, 2010).

Learning to use PhET as a virtual laboratory can increase students' understanding of abstract material concepts (Moore et al., 2014). The PhET virtual laboratory gives students the opportunity to conduct experiments to identify and develop the relationship of experimental variables, students are free to work manipulating experimental object variables and are safe in carrying out activities (Mustafá & Trubel, 2013). This gives students the opportunity to build (construct) their own knowledge from various information (learning experiences) through activities to create hypotheses, analyze data, and make conclusions, so that they can improve higher-order thinking skills (HOTS) (Price et al., 2018). Though the role of PhET cannot substitute the real experiment, it can still elevate students' conceptual understanding in learning physics (Perkins et al., 2006; Price et al., 2018; Wieman et al., 2010).

Based on the observations and interviews with physics teachers at Yapis Nimboran High School, Jayapura Regency, the resource person stated that the school had never used PhET Simulation media in the learning process, so that the implementation of local service activities proposed to conduct training for teachers and students at SMAN 1 Nimboran, Jayapura Regency. This is to find out how the implementation of the PhET Simulation learning media in the 3T region which stands for *terdepan* (frontier), *terpencil* (remote), and *tertinggal* (disadvantaged) in Indonesia. This also alludes to the problems in schools located in the 3T area with the absence of stable internet access and a variety of learning media. In the future, this research will be a follow-up study for the implementation of PhET Simulation learning media in other 3T areas in Indonesia.

2. METHOD

The implementation of this service activity has been carried out in the XI-IPA class room of SMAN 1 Nimboran, Jayapura Regency. This service activity is carried out in the form of training. This service activity was attended by physics teachers and students of class XI-IPA at SMAN 1 Nimboran, Jayapura Regency. The method of this activity is carried out in the form of virtual laboratory training through PhET Simulation, face-to-face/offline at SMAN 1 Nimboran. The forms of virtual laboratory through PhET Simulation that will be implemented are: 1) The basic characteristics of the spring, 2) The direction of the vector and the amount of energy acting on the spring, and 3) The amount of energy on the swing pendulum. The purpose of the first competency is to explain the concept of vibration, amplitude, frequency, and period of a spring by manipulating the load. The purpose of the second competency is to explain the direction and magnitude of the force, as well as the amount of energy acting on the spring when the spring is given a load, and is pulled with a certain deviation. The purpose of the third competency is to explain the amount of energy acting on the spring when the spring is given a load, and is pulled with a certain deviation. The stages of service activities are shown in Table 1.

Table 1. Stages in Research and Community Service in SMAN 1 Nimboran

No.	Schedule	Activity	Description
1	March-April	Preparation of Workshop and Training in SMAN 1 Nimboran	a. Setting up the PhET Simulation application by downloading the simulation application from the PhET Colorado website and preparing vibration and wave materials. b. Making 4 Student Worksheets (LKPD) consisting of vibrations on springs and swing pendulums as well as traveling and stationary waves. c. Checking the PhET Simulation application on vibration and wave materials and making an evaluation tool to measure the success of the training.
2	April-May	The Invitation Making and Information to SMAN 1 Nimboran	a. Regarding the invitation, it is a notification of the implementation of service to the principal of SMA Negeri 1 Nimboran, Jayapura Regency to inform physics teachers and students of class XI-IPA to take part in the training. b. The distribution of invitations is addressed to the principal and physics teacher.
3	May	Workshop and Training of PhET Simulations	a. Registration of training participants. b. Checking the phet simulation application link and LKPD on vibration and wave material by the Implementation Team. c. Materials are prepared or created by the Team based on needs analysis. d. The training is carried out after the delivery of the material and students are divided into groups to practice through PhET simulation of vibration and wave material.
4	May-September	Evaluation and Follow Up	a. Evaluation tools are distributed to training participants. b. The collection of evaluation tools is carried out by the training participants to the Implementation Team. c. Preparation of service activity reports.

Based on the method of implementing the activities described above, there are several evaluations carried out. Making an invitation to the principal of SMAN 1 Nimboran Jayapura district for the place of service implementation, the implementation of activities with the approval of the physics teacher is carried out in

the XI-IPA IPA classroom. The response from the school and physics teachers was to provide Class XI-IPA1 and Class XI-IPA2 for the training place with a total of 52 students.

Submission of material by the Implementation Team was carried out for 40 minutes. The material includes important points

contained in the material and LKPD that have been distributed. In the training session, the delivery of material and the use of a classical virtual laboratory PhET simulation, while during the practicum, students use Android smartphones or practice in front of the class which is displayed on the screen via Infocus on screen. Participants are divided into small groups of 3-4 people. The Implementation Team also provides guidance for participants/groups who need assistance from the team.

At the end of the training session, several participants/training groups were given the opportunity to show what they had done during the practicum activities. And the results are satisfying because the participants can quickly display what has been taught/delivered by the Implementation Team. Reporting is carried out based on the systematics determined by LPPM-UNCEN and is based on the entire series of activities that have been shown in the matrix on the implementation method.

3. RESULTS AND DISCUSSION

In general, the use of learning media is to facilitate interaction between teachers and students, so that teaching and learning activities are more optimal, effective, and efficient in terms of both theoretical and practical which are ultimately applied in action. Media can be used in the teaching and learning process in two ways, namely as teaching aids and as learning media that can be used by students themselves. Interactive simulation can be positioned as virtual laboratory and substitute—or even strengthen—the direct experiment. The problem is not all physics concept is practical. We elaborated this issue in 3T region to enhance the appliance of technology using PhET Simulations so that students and teachers at SMAN 1 Nimboran can ease the limited access of abstract physics concept and the lack of practicum amenities.

3.1. Results

Based on the dedication that has been carried out, the results show that there is a desire for students and teachers of SMAN 1 Nimboran Jayapura Regency to use PhET as a virtual laboratory in learning activities (KBM) on the subject of vibrations and waves. Students and

teachers feel happy and interested in this service activity. In addition, there are other factors that support and hinder the implementation of this service. The supporting factor is the level of willingness to learn of the students of SMAN 1 Nimboran, Jayapura Regency in participating in a very large training using PhET as a virtual laboratory in learning activities (KBM) on the subject of vibrations and waves. The level of motivation of students and teachers is also very large. The inhibiting factor is the lack of basic knowledge of students, both physical science knowledge in junior high school and in high school class X. The process of training the PhET Simulations media by the Implementation Team is shown in Figure 1.



Figure 1. PhET Simulation Media Training Process by the Implementation Team

Figure 1 shows the training process in class XI-IPA 1. Students participate in learning training using interactive simulation media while still complying with health protocols. Students wear masks and maintain a safe distance from each other. In the learning process, students looked very enthusiastic in undergoing training on the use of interactive simulation learning media which is a virtual laboratory. This is a new experience for them. Figure 2 shows one of the LKPD competencies that have been carried out by students after the training on the use of PhET Simulations was carried out.

6. Tentukan "length 1" menjadi 0,5 m dan "mass-1" menjadi 1 kg.
7. Tariklah bandul hingga sudut 10°.
8. Klik tombol "play" pada stopwatch.
9. Klik tombol "play" untuk memulai gerakan bandul. Hitung sebanyak 10 kali ayunan dan amati waktu yang dibutuhkan gerakan bandul tersebut.
10. Lakukan langkah 8 dan 9 dengan mengubah "length 1" menjadi 1.
11. Catatlah hasil pengamatan pada tabel data.

C. Data

No	Panjang tali (l) (m)	Jumlah ayunan (n)	Waktu ayunan (s)	Ket. sa
1	0,5 m	10 kali	14	1
2	1 m	10 kali	20	1

Figure 2. Example of Filling LKPD by Students in the First Competence

While one competency training is being conducted, students will be asked to fill out the LKPD sheet they have received. Students do practicum with the help of the hardware they hold (in this activity using a laptop) and follow the practicum instructions that have been written in the LKPD. Students fill out the LKPD according to the data they get from the virtual practicum results.

The success of the service and training activities for teachers and students at SMAN 1 Nimboran can be seen from the sustainability of the program. When the training participants register, the Implementation Team will verify the data according to the student data proposed by the physics teacher. Submission of material by the Implementation Team was carried out for 40 minutes. The material includes important points contained in the material and LKPD that have been distributed. In the training session, the delivery of material and the use of the virtual laboratory PhET Simulations are classical, while during the practicum students use Android-based smartphones or practice in front of the class which is displayed on the screen via Infocus. Participants are divided into small groups of 3-4 people. The Implementation Team also provides guidance for participants/groups who need assistance.

In the training session, the enthusiasm of the class XI-IPA1 and class XI-IPA2 participants was seen because they have never done practical activities. At the end of the training session, several participants/training groups were given the opportunity to show what they had done during the practicum activities. The results were satisfactory because participants were able to quickly display what was taught/delivered by the Implementation Team. Then, the evaluation tools distributed to the trainee students were analyzed as an indicator of an increase in the

ability to master the use of practical teaching aids. Finally, the report is made based on the systematics determined by LPPM-UNCEN and is based on the entire series of activities that have been shown in the matrix on the implementation method.

3.2. Discussion

SMAN 1 Nimboran is one of the educational units with high school level in Pobaim, Kec. Nimboran, Kab. Jayapura, Papua. In carrying out its activities, SMAN 1 Nimboran is under the auspices of the Ministry of Education and Culture. SMAN 1 Nimboran is located at Jl. Icim Pobaim, Pobaim, Kec. Nimboran, Kab. Jayapura, Papua, with postal code 99361. SMAN 1 Nimboran provides electricity to assist teaching and learning activities. The source of electricity used by SMAN 1 Nimboran comes from PLN. Learning at SMAN 1 Nimboran is carried out from morning to evening. In a week, learning is carried out for 6 days. SMAN 1 Nimboran has accreditation B, based on certificate 458/BAN-SM/SK/2020. SMAN 1 Nimboran is included in the category of being in the 3T region. Learning at SMAN 1 Nimboran is still centered on teacher orientation (teacher centered learning) with lecture and demonstration methods. The lecture method is carried out because of the limitations of other learning media, especially those related to technology and information-based learning media. The demonstration method is mostly done because of the limitations of practical teaching aids. Per subject, there are only one or two practical tools. This shows that SMAN 1 Nimboran has not received the proper equality of school facilities and infrastructure. This indicator is one of the determinants of a school included in the 3T region category (Dike, 2017).

Field findings also show that the availability of internet and access devices is very limited. If there is internet, usually the connection is often lost or lost. This makes physics learning at SMAN 1 Nimboran unable to run optimally. This reason also underlies the limitations of the variety of learning carried out in schools. Therefore, our research and service team conducted training in the use of virtual laboratories using interactive two-way simulations from PhET Colorado. After our

research and service activities were carried out, we got several important points to become the forerunner of service at the next 3T school. PhET simulations can be downloaded and installed on hardware such as computers and laptops (Yuliati et al., 2018). This makes it easier to learn physics in class without worrying about internet traffic jams. The simulation can be used offline or off the network. The second positive thing is that the PhET simulation can bridge the limitations of practical teaching aids, so that students can still understand concepts through virtual practicums through good visual experiences (Yusuf & Widyaningsih, 2019). Although PhET simulation cannot replace real experiments with optimal ones, students are still enthusiastic about participating in learning and learning outcomes are more enjoyable and optimal. The third point is abstract material on physics. With PhET simulation media, students get a good visual learning experience for abstract physics materials or concepts. The concept of vibrations and waves sometimes cannot be imagined by imagination because the direction of the vibrational energy is not visible to the naked eye (Ndiokubwayo et al., 2020). However, PhET simulation can describe the phenomenon well.

This training activity was attended by 52 participants consisting of class XI-IPA 1 and class XI-IPA 2 at SMAN 1 Nimboran, Jayapura Regency. This training is very helpful for class XI-IPA1 and class XI-IPA2 SMAN 1 Nimboran Jayapura Regency because students feel that the use of PhET as a virtual laboratory in learning and learning activities that are trained is something they need in understanding the concept of vibration and waves. in physics learning. Learning the concept of vibration and waves through the virtual laboratory Phet Simulation, equipped with 4 worksheets consisting of LKPD vibration on a swing pendulum, vibration on a spring, traveling waves and stationary waves. This training provides new knowledge for students, class XI-IPA. For physics teachers, it gives enthusiasm to do physics practicum activities virtually using the PhET application.

Learning to use PhET as a virtual laboratory can increase students' understanding of abstract material concepts or material that is difficult to experiment in a real laboratory through virtual

laboratory simulations (Adam et al., 2020). The PhET virtual laboratory gives students the opportunity to conduct experiments to identify and develop the relationship of experimental variables, students are free to work manipulating experimental object variables and are safe in carrying out activities (Mustafá & Trubel, 2013). This gives students the opportunity to build (construct) their own knowledge from various information (learning experiences) through activities to create hypotheses, analyze data, and make conclusions, so that they can improve higher-order thinking skills (HOTS) (Nulngafan & Khoiri, 2020).

The training participants, in this case teachers and students, were very enthusiastic not only during the training time but also outside the training time, the physics teacher asked for time from the Service Implementation Team to continue to guide the use of the PhET application as a virtual laboratory facility in physics learning. The plan for the next stage of the Service Implementation Team hopes that service activities can continue for other subjects. The school, in this case the principal, asked for time to carry out service activities in the future. The use of the PhET Simulation application through a virtual laboratory is very important during the current pandemic and 21st century because SMA Negeri 1 Nimboran, Jayapura district, still lacks physics laboratory equipment and stimulates students' higher-order thinking skills, which are in accordance with the demands of the 21st century (Manalu et al., 2021).

Other research in 3T region also found that local wisdom and technology can help to improve students' physics conceptual understanding (Budiarti, 2017; Budiarti et al., 2019). Thus, the combination of certain learning media which in this case is PhET Simulations as virtual laboratory can help to maintain the optimum physics learning at schools during pandemic. It can help to assist students in virtual experiment and understand abstract concept, which in this study is wave and vibration. The research and community service activity by Universitas Cenderawasih is expected to be applied in wider scope and sequence, in other learning subjects and other 3T region in Papua. It can also answer the learning challenge during covid-19 era as we have to be creative to teach

physics using blended learning and virtual gaming (Muanafi, 2021; Rizky, 2020).

4. CONCLUSION AND SUGGESTION

4.1. Conclusion

The trainees for class XI-IPA1 and Class XI-IPA2 were very enthusiastic in using phet simulation applications for virtual laboratory activities on vibration and wave materials. Training activities using phet simulation applications in virtual laboratories improve students' higher order thinking skills (HOTS). This training activity improves the ability of teachers to use phet simulation applications in virtual laboratories during this pandemic.

4.2. Suggestion

Expectations as well as suggestions from the Implementation Team after carrying out this training activity. Advanced training on the use of phet simulation applications in virtual laboratories for Physics teachers and all students majoring in Science Class X, Class XI and class XII at SMA Negeri 1 Nimbora, Jayapura Regency. Physics material training for students so that students' higher-order thinking skills increase.

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