Jurnal Pendidikan Fisika dan Keilmuan (JPFK)
Vol. 7, No 2., September 2021, pp. 59-76
P-ISSN: 2549-4996, E-ISSN: 2548-5806, DOI: http://doi.org/10.25273/jpfk.v7i2.10783

Students' Scientific Problem Solving Skills in 3T Region: Using PhET Simulation to Enhance the Matter

[1*]Indah Slamet Budiarti, [1]Bonefasius Yanwar Boy, [1]Albert Lumbu
[1] Department of Physics Education Universitas Cenderawasih, Papua, Indonesia
e-mail: [*]indah_budiarti@yahoo.com; boniyanwar@gmail.com; albertlumbu9@gmail.com

Abstrak

Keterampilan pemecahan masalah secara ilmiah sangat dibutuhkan ketika kita menghadapi masalah kontekstual dalam kehidupan sehari-hari. Siswa harus dipersiapkan untuk memiliki keterampilan pemecahan masalah secara komprehensif. Penelitian ini bertujuan untuk menganalisis kemampuan pemecahan masalah saintifik siswa dalam pembelajaran menggunakan simulasi PhET pada wilayah 3T. Wilayah 3T merupakan wilayah terluar di wilayah Indonesia yang membutuhkan tiga parameter kondisional yaitu terdepan *(frontier),* terpencil *(remote),* dan tertinggal *(disadvantaged).* Terdapat 122 daerah di Indonesia yang masuk dalam kawasan 3T dan salah satunya adalah wilayah Nimboran, Papua. Tempat penelitian ini adalah SMAN 1 Nimboran, Papua, Indonesia. Metode deskriptif kualitatif dipilih sebagai pendekatan penelitian. Partisipan yang diambil dalam penelitian ini adalah 51 siswa dan dipilih dengan teknik *purposive random sampling* dari seluruh siswa kelas XI-IPA SMAN 1 Nimboran. Pengumpulan data dilakukan melalui triangulasi dengan menggunakan wawancara, observasi, dan dokumentasi (tes) pada kelas XI-IPA semester II. Hasil penelitian ini menunjukkan bahwa 10,20% siswa mampu mendefinisikan masalah, 3,27% siswa mampu mengeksplorasi masalah, 10,98% siswa mampu merencanakan solusi, 6,54% siswa mampu mengimplementasikan rencana, 1,70% siswa mampu memeriksa solusi, dan 4,44% siswa mampu mengevaluasi data. Rerata hasil teknik tes menunjukkan bahwa kemampuan pemecahan masalah saintifik siswa adalah 38,46. Siswa di SMAN 1 Nimboran memiliki keterampilan pemecahan masalah ilmiah yang rendah.
Kata Kunci: Fisika, Keterampilan Pemecahan Masalah Saintifik, Getaran dan Gelombang, PhET, Wilayah 3T.

Abstract

Contextual problems in daily life are related closely with scientific problem solving skills. It is necessary to prepared when students study science comprehensively. The aim of this study was analyzing students' scientific problem solving skills during the learning process by simulation of PhET located in 3T region. The outermost area in the territory of Indonesia is referred as 3T region. There are three conditional aspects of 3T region; terdepan *(frontier),* terpencil *(remote), and* tertinggal *(disadvantaged). A number of 122 regions in Indonesia are included in the 3T region, one of which is Nimboran, Papua. SMAN 1 Nimboran, Papua, Indonesia, was chosen as research subject. We comprehended the analysis by using descriptive qualitative method. Participants were 51 students chosen from purposive random sampling technique above all students in XI-IPA grade of SMAN 1 Nimboran. Data collecting was done through triangulation using interview, observation, and documentation (test). The research was conducted during the second term. The obtained results were as follows: students can define the problem (10.20%), students can explore the problem (3.27%), students can plan the solution (10.98%), students can implement the plan (6.54%), students can check the solution (1.70%), and students can evaluate the data (4.44%). The mean result was 38.46. It was interpreted that showed students' scientific problem solving skills in SMAN 1 Nimboran was low. Thus, the need to improve the skills is demanded.*
Keywords*: 3T, PhET, Physics, Scientific Problem Solving Skills, Vibration and Wave.*

How to Cite: Budiarti, I. S., Boy, B. Y., & Lumbu, A. (2021). Analysis of Students' Scientific Problem Solving Skills in Learning Using PhET Simulation in 3T Region. *Jurnal Pendidikan Fisika dan Keilmuan (JPFK)*, 7(2), 59-76. http://doi.org/10.25273/jpfk.v7i2.10783

Received August 11, 2021; Revised August 25, 2021; Accepted September 7, 2021

INTRODUCTION

In the new days of teaching and leanring, scientific problem solving skills are skills that must be nurtured since elementary levels (Darmawan et al., 2020). It is one of the competencies that students need to face everyday problems. This skill is closely related to being able to experiment, asking literate questions, persuading hypothesis, identifying limitations, controlling variables, operationally defining those variables, and interpreting and inferring the experiment's results (Nanditasari, 2019). Students with good scientific problem solving skills are expected to be able to define the problem related to science, to explore the problem given, to plan the solution to the problem, to implement the solution plan, to check the solution, and to evaluate the results (Mourtos et al., 2004). Learning science, one of which is physics, can be used to hone students' scientific problem solving skills so that they can solve contextual problems (Trianggono, 2017). Besides, scientific problem solving skills are very close to the learning outcomes when students must apply their knowledge to the daily life in the mean of challenges and problems.

One literate way to stimulate students' scientific problem solving skills is learning media (Kurniawan et al., 2019). Learning media is very important to make students involved in active learning physically and cognitively in the right way (Wieman et al., 2010). The learning process is currently still dominated by teachers, so it has not provided students to develop independently in discovery and thought processes (Forum, 2015). Broadcast media in active learning has the potential to play an active role in activating cognitive activity in students to understand concepts (Rideout, 2014). Learning with appropriate media can improve the competency aspects that educators want to achieve as the outputs students get when learning a concept (Kholiq, 2020; Nurhidayati et al., 2019). One of these competencies is students' scientific problem solving skills (Novia & Riandi, 2017).

Most of the teachers are still interested in using learning media in the form of presentation slides that are displayed in the form of writing, pictures, and non-animation. This can be seen from several studies on the development of presentation slide-based learning media (Kholiq, 2020). The latest research results, related to instructional media, examine the implementation of instructional media in active learning with a new approach as a form of teacher professionalism in the global era (Alpaslan et al., 2016). This shows that the learning media must be able to activate the cognitive aspects of students so that the learning media for presentation slides need to contain questions before the statement shows (Saputra et al., 2017). The goal is to stimulate the cognitive activity of students during the learning process (Viyanti et al., 2020).

The educational field has an urge in activating students in learning besides active learning strategies is active learning media (Milner-Bolotin et al., 2013). Learning media, especially those based on technology and informatics, are also demands in the 2013 Curriculum Permendikbud Number 24 of 2016 Number 22 C.E. (Nomor, 22 C.E.). However, what is professional in this global era is not merely fulfilling these demands. It is essential that teachers need to pick a detail of instructional media's accuracy to maximize the thought process in processing this information (Price et al., 2019). Had barely known that the thinking process facilitated by instructional media are matters regarding the design and use of instructional media. Otherwise, the media needs to be revised (Briggs, 1967). The role of learners in active learning using media is to emphasize the importance of the student learning process in addition to the learning outcomes achieved at the end of the learning process (Rohani, 2019; Samal, 2018).

The teacher's ability to choose learning media that is by the objectives to be achieved is another important consideration in the learning process (Putranta & Wilujeng, 2019). Selection of learning media that is not appropriate, even completely irrelevant (as long as you choose), can reduce interest in learning and finding a concept of the teaching material being studied (Adams, 2010). Physics learning is full of scientific concepts that students must find through a process of searching and scientific attitudes (Ince, 2018). Improper learning media can hinder the process of understanding the concept (Argaw et al., 2016). The selection of learning media that is by the concept of physics—in this case, there are two, namely abstract and concrete—will bring out the ease of learning for students. It will lead to better understanding of the material being studied (Diani & Syarlisjiswan, 2018). Furthermore, students can have applicable physics concepts in contextual problems.

PhET Simulation media is a technology-based and informatics-based learning media that is also required in 2013 Curriculum Permendikbud Number 24 of 2016 (Nomor, 22 C.E.). The appropriate learning media and the current curriculum can activate students during the process. Learning will become meaningful and stored in memory for a long time (Naimah et al., 2019). One of the demands of 21st-century learning is technology-based learning (Abou Faour & Ayoubi, 2017; A. M. Price et al., 2018). The virtual laboratory contained in the PhET simulation can help physical laboratory activities, which are related to the limitations of laboratory equipment in schools (Adams, 2010). The 21st-century learning also requires students to think at higher levels (Bagarukayo et al., 2012). This can be stimulated through learning media that can activate students (Yusuf & Widyaningsih, 2019). PhET Simulation is a learning medium that can answer the demands of 21st-century learning in the industrial era 4.0 (Adams & Wieman, 2015).

In addition, the PhET Simulation media is an interesting medium to use in the learning process, especially in physics (Correia et al., 2019). PhET Simulation can be a virtual laboratory, where students can play an active role in conducting virtual experiments and discovering physics concepts (Wieman et al., 2010). It is a learning media based on a Javascript software program that has interactive characteristics so that students can interact with the parameters of the quantities in the learning shows (Moore et al., 2014). Media PhET Simulation has been widely used in learning in advanced and developing schools, such as schools on the island of Java (Putranta & Wilujeng, 2019; Yuliati et al., 2018). However, based on the findings, the use of this media has never been used in the physics learning process in schools in the 3T area in Papua.

SMAN 1 Nimboran, Jayapura Regency is the only public school in the Nimboran district that is included in the 3T area in Jayapura Regency. The outermost area in the territory of Indonesia is referred as 3T region. There are three conditional aspects of 3T region; *terdepan* (frontier), *terpencil* (remote), and *tertinggal* (disadvantaged) (Dike, 2017; Syafii, 2018). A number of 122 regions in Indonesia are included in the 3T region, one of which is Nimboran, Papua (Sanoto et al., 2021). Prior study was conducted by observation and interview. The participants of the pilot study were 2 physics teachers and 10 students of SMAN 1 Nimboran Jayapura Regency, the resource person stated that the school had never used PhET Simulation media in the learning process. The teacher teaches vibration and wave material through the lecture method. The teacher has never used learning media in conveying vibration and wave material. Thus, the PhET

Simulation media is expected to facilitate physics learning on vibration and wave material and stimulate students' scientific problem solving skills.

Based on the findings that we got in the preliminary study, we applied the PhET Simulation media to vibration and wave learning to increase cognitive activity and scientific problem solving skills during active learning for teachers and students at SMAN 1 Nimboran, Jayapura Regency. The research question in this study is how to describe the cognitive activities and scientific problem solving skills of students after the use of the PhET Simulation learning media in the physics subject matter of vibrations and waves. The novelty in our research is a description of the scientific problem solving skills of students and the application of the PhET Simulation learning media in Nimboran, which is a 3T area in Jayapura, Papua. The findings from our research are expected to be a reference for conducting further research related to interactive learning media and the achievement of student competencies in physics subjects in other 3T regions.

METHOD

The aim of this study was analyzing students' scientific problem solving skills during the learning process by simulation of PhET located in 3T region. SMAN 1 Nimboran is included in 3T region of Indonesia. The type of this research was descriptive qualitative intended to identify and describe trends using participants of research samples and identifying causal effects to determine critical role in the scientific process due to educational research in particular scheme and framework (Dịnçer, 2018). We describes regarding five fundamental questions to answer the current phenomenon by effectively approach, conduct, and communicate quantitative descriptive analysis (Asadollahi Kheirabadi & Mirzaei, 2019).

This research place was SMAN 1 Nimboran, Jayapura, Papua, Indonesia. The objects of this research were all students of class XI-IPA SMAN 1 Nimboran. The participant selection used the purposive sampling technique because we intended to choose the classes that have not experienced any innovative or interactive learning model. We chose purposive sampling to select and include only certain people with grand specific criteria (Patton, 2014). All of the students being participants are XI-IPA grade students. There were 51 students being respondents of this study. Students who were involved in this study were given tests and interviews. Of the recorded results, students were given a consent form to take part in this study. The research was conducted for approximately three months with three stages, namely: the preliminary study stage, the data collection stage, and the data analysis stage to obtain research conclusions. The main objective matter was students' scientific problem solving skills by using PhET simulation during the learning process in SMAN 1 Nimboran. The applied PhET Simulation was done through students' worksheet in four meetings. Test was conducted after the implementation of simulation in learning physics.

Data collection techniques in qualitative research are used to obtain relevant and appropriate data according to research objectives (Fernandez-Rio et al., 2017). Data collecting was done through triangulation using interview, observation, and documentation (test) during the second term of XI-IPA class. Observation in this study was done during the pilot study. Test was taken after the observation. The purpose of the data obtained from this instrument was to identify students' scientific problem solving skills. We used free guided interview; kind of unstructured interview bringing guidelines with particular outline questions to be asked. The samples of teachers were all physics teachers teaching at SMAN 1 Nimboran,

Papua, Indonesia. Interviews were done to have qualitative data from participants. This interview instrument was used to explore the learning process and the correctness of the concepts obtained by students (Gao et al., 2017). Data were analyzed after collection using triangulation (Moleong, 2019). We intended to find the compatibility in data from the three instruments. The results of the students' cognitive tests score range were 0-100. The indicators of scientific problem solving skills in this study were to define the problem related to science, to explore the problem given, to plan the solution to the problem, to implement the solution plan, to check the solution, and to evaluate the results (Mourtos et al., 2004).

RESULTS AND DISCUSSION

Description of SMAN 1 Nimboran as 3T Region in Indonesia

SMAN 1 Nimboran is located at Jalan Icim Pobaim, Pobaim, Nimboran District, Jayapura Regency, Papua Province. The number of teachers is 25, the number of male students is 218, the number of female students is 206, and the study group is 14. The curriculum applied in SMAN 1 Nimboran is the 2013 Science curriculum. The implementation of learning is five full days a week. Even though they already have electricity from PLN, these senior high schools do not yet have adequate internet access, so most of the learning process are mainly using lecture method by teacher-centered learning approach. Standing on an area of 1 km2, SMAN 1 Nimboran has 17 classrooms, four laboratories, one library, and two sanitation facilities. This school is accredited B.

SMAN 1 Nimboran is one of the schools in Papua, Indonesia, which is included in the 3T region category. Therefore, the obstacles that often occur during learning at school are the absence of an internet connection or an internet network disconnection. It makes internet-based learning, for example, virtual media, cannot be done optimally. Physics learning at SMAN 1 Nimboran uses more conventional lecture methods or direct instruction than other methods. The learning model that is more widely used in this school is the teacher-centered learning model so that students do not take much part in two-way or interactive learning. It is in line with the findings of a previous study that also researched schools in the 3T area. Several previous studies stated that the obstacle in schools in the region was the availability of internet access so that the methods and learning media used were also limited (Amin et al., 2020; Maskhuliah & Bungkang, 2017; Putra et al., 2019; Syafii, 2018; Yulianti et al., 2016). The results are in forms of graphics, tables, and description. Analysis and interpretation of the results are needed before discussion.

Interview with Teachers and Students from SMAN 1 Nimboran

Researchers conducted interviews with educators from SMAN 1 Nimboran, namely Mrs. Nofriana as a resource person. The informant stated that physics learning at SMAN 1 Nimboran only used the lecture method with a teacher-centered learning approach. Based on interview method, we collected data that learning in schools has not used interactive learning media such as simulations and virtual laboratories. The application of learning media is still foreign and the first in schools. The teacher also stated that the application of this media is expected to make learning more interesting because there are visuals seen by students during the learning process and not just listening to the teacher explaining abstract and concrete physics theories.

> "Physics learning based on problem solving or scientific problem solving skills in our school has never used PhET Simulation media. So, the application of

> the media is a new thing in our school. Maybe students become more enthusiastic about learning because there is a more interesting simulation." – Physics Teacher from SMAN 1 Nimboran

To students' scientific problem solving skills on vibration and wave material, the resource person stated that modern learning media with visual displays can help stimulate students' scientific problem solving skills. The application of PhET Simulation learning media equipped with students' worksheets makes physics learning on vibrations and waves more efficient and effective. The enthusiasm of students increases and the success of competency achievement also increases.

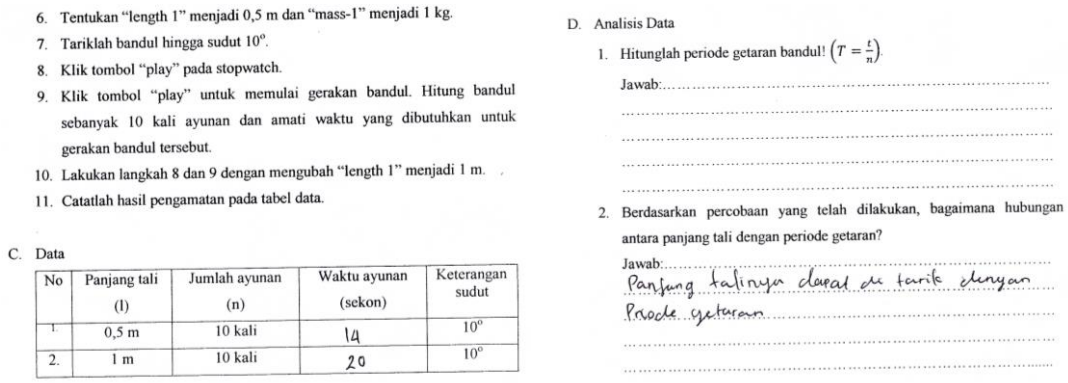
> "PhET Simulation may be easier as a means of learning for students for problem solving skills. If only given material through lectures, many students do not understand. However, the existence of PhET Simulation learning media can improve problem solving skills in vibration and wave material." – Physics Teacher from SMAN 1 Nimboran

In addition, the teacher also mentioned that the PhET Simulation learning media can help to stimulate students to solve scientific problems contextually or that are related to the daily lives of students. Everyday phenomena related to vibrations and waves are playing guitar, ocean waves, and jumping rope. The findings in this study are in line with previous research related to learning using PhET Simulation media (Batuyong & Antonio, 2018; Ndihokubwayo et al., 2020; Putranta & Wilujeng, 2019). When interviewed, educators said that the enthusiasm and learning activities of students increased. However, the problem faced in learning with virtual media is that the internet network at SMAN 1 Nimboran sometimes disconnect during the lesson. Previous research related to physics learning in Papua also found that the main problem was internet connection (Budiarti & Tanta, 2021). Thus, the learning method mainly used the environment (Budiarti et al., 2018).

Analysis of Students' Worksheet Based on PhET Simulation Learning Media

The application of the PhET Simulation learning media is carried out by compiling students' worksheets or *Lembar Kerja Peserta Didik* (LKPD). Students' worksheets of vibration and wave material consist of titles, student identities, learning objectives, tools, and materials, general instructions for filling in students' worksheets, virtual practicum procedures, data tabulation, analysis and discussion, and conclusions. There are four students' worksheets for vibration and wave material, namely: 1) students' worksheet on pendulum vibration concept (LKPD 1 of vibration on a pendulum); 2) students' worksheet on spring vibration concept (LKPD 2 of vibration on spring); 3) students' worksheet on the stationary wave (LKPD 3 of stationary waves); and 4) students' worksheet on traveling wave (LKPD 4 of traveling wave). Researchers compiled four students' worksheets and prepared PhET Simulation learning media suitable for virtual lab work assisted by a laptop or computer. Learning for vibration and wave material is divided into four meetings according to the media and students' worksheets that have been prepared before the lesson. The researcher did the observation through the learning process using PhET Simulation by observing the students when they used the application and filled the worksheets. From the observation during the PhET Simulation implementation, we divided the results and discussion in four parts based on the number of worksheets and meetings.

At the first meeting, students did a virtual practicum on the vibration concept of the pendulum. Students hold the worksheet and the PhET Simulation learning media to find the concept of vibration of the pendulum. Figure 1 shows an example of students' answers in worksheet 1 for the concept of vibration of the pendulum.



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 bandul sebanyak 10 kali ayunan dan amati waktu yang dibutuhkan untuk gerakan bandul tersebut.
10. Lakukan langkah 8 dan 9 dengan mengubah "length 1" menjadi 1 m.
11. Catatlah hasil pengamatan pada tabel data.

C. Data

No	Panjang tali (l)	Jumlah ayunan (n)	Waktu ayunan (sekon)	Keterangan sudut
1.	0,5 m	10 kali	14	10°
2.	1 m	10 kali	20	10°

D. Analisis Data

1. Hitunglah periode getaran bandul! $\left(T = \frac{t}{n}\right)$

Jawab:.....

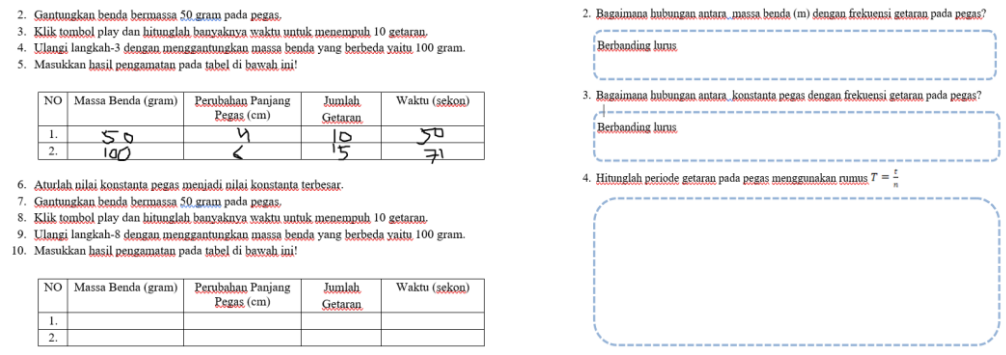
2. Berdasarkan percobaan yang telah dilakukan, bagaimana hubungan antara panjang tali dengan periode getaran?

Jawab: Panjang talinya dapat di tarik dengan Procle getaran

Figure 1. Example of Answer on Students' Worksheet 1 of Pendulum Vibration Concept

Students are asked to tick (√) in the "Stopwatch" section to observe the time to be used. Students determine "Length 1" to be 0.5 m and "Mass-1" to be 1 kg and pull the pendulum to an angle of 10° with the help of the mouse. Then, students press the "Play" button on the stopwatch to start the pendulum movement. Ten movements or swings of the pendulum and the time required to do so are recorded in the table. In Figure 1, students fill in the data table section with two types of rope lengths, namely 0.5 meters, and 1 meter. In the data analysis section, students did not answer question number one but answered question number two. Students answer that the relationship between the length of the rope and the period of vibration. They write that the rope's length can be pulled by changing the period of vibration.

At the second meeting, students did a virtual practicum on the concept of vibration on a spring. Students already hold the worksheet and the PhET Simulation learning media to find the concept of vibration on spring. Figure 2 shows an example of students' answers to students' worksheet 1 for the concept of vibration on springs.



2. Gantungkan benda bermassa 50 gram pada pegas.
3. Klik tombol play dan hitunglah banyaknya waktu untuk menempuh 10 getaran.
4. Ulangi langkah-3 dengan menggantungkan massa benda yang berbeda yaitu 100 gram.
5. Masukkan hasil pengamatan pada tabel di bawah ini!

NO	Massa Benda (gram)	Perubahan Panjang Pegas (cm)	Jumlah Getaran	Waktu (sekon)
1.	50	4	10	50
2.	100	6	15	71

6. Aturlah nilai konstanta pegas menjadi nilai konstanta terbesar.
7. Gantungkan benda bermassa 50 gram pada pegas.
8. Klik tombol play dan hitunglah banyaknya waktu untuk menempuh 10 getaran.
9. Ulangi langkah-8 dengan menggantungkan massa benda yang berbeda yaitu 100 gram.
10. Masukkan hasil pengamatan pada tabel di bawah ini!

NO	Massa Benda (gram)	Perubahan Panjang Pegas (cm)	Jumlah Getaran	Waktu (sekon)
1.				
2.				

2. Bagaimana hubungan antara massa benda (m) dengan frekuensi getaran pada pegas?

Berbanding lurus

3. Bagaimana hubungan antara konstanta pegas dengan frekuensi getaran pada pegas?

Berbanding lurus

4. Hitunglah periode getaran pada pegas menggunakan rumus $T = \frac{t}{n}$

Figure 2. Example of Answer on Students' Worksheet 2 of Spring Vibration Concept

Students choose the “Masses and Springs” simulation on the PhET Simulation learning media and play the program. Students put a checkmark in the “Natural Length” box as a reference for the starting point of the spring. Then, they mark the “Equilibrium Position” as a reference for the spring’s equilibrium point, “Movable line” as a reference for the farthest deviation of the spring, and issue a “Ruler” tool. It can measure changes in spring length. After that, students used “Stopwatch” tool for counting time. Then students are asked to set the value of the spring constant to be the smallest constant value, hang an object with a mass of 50 grams on the spring, and record the time. The data obtained were recorded in the table and analyzed. In Figure 2, students write down the data and analyze the relationship between the mass of the object and the spring constant with the frequency of the spring vibration.

At the third meeting, students did a virtual practicum on the concept of stationary waves. Students already hold the worksheet and the PhET Simulation learning media to find the concept of stationary waves. Figure 3 shows an example of students’ answers to the students’ worksheet 3 for the concept of stationary waves.

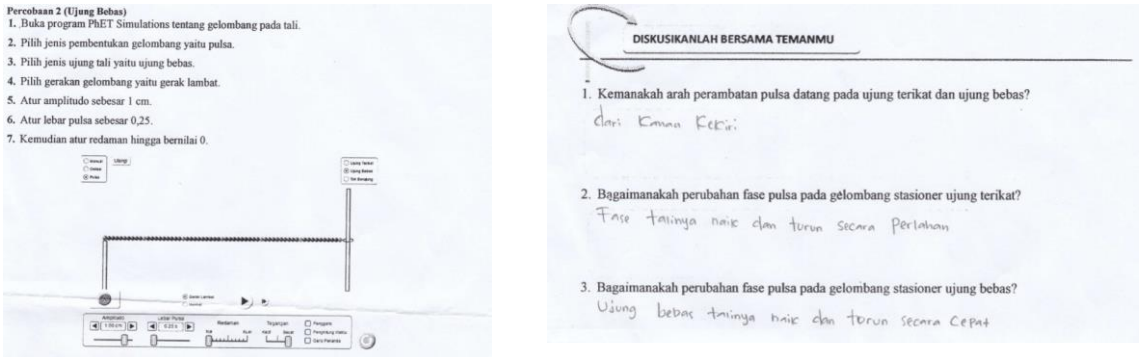
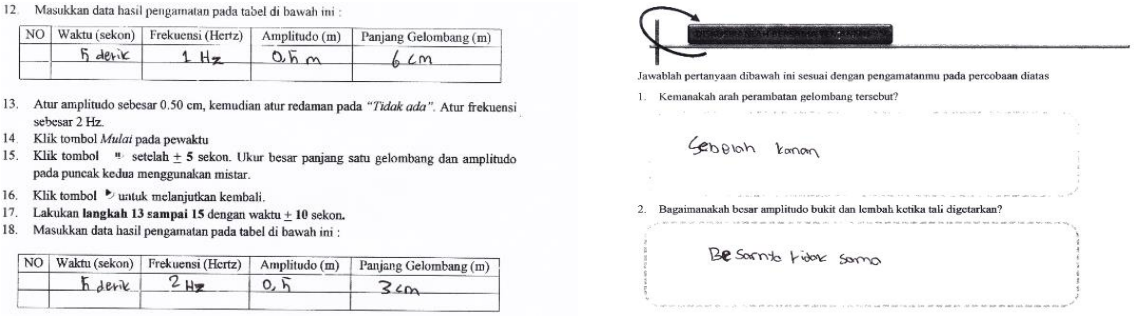


Figure 3. Example of Answer on Students’ Worksheet 3 of Stationary Wave Concept

Students open the PhET Simulation program on waves in a rope and conduct two experiments on waves in a rope with free and tied ends. When experimenting with waves in a rope with tied ends, students choose a slow wave motion, set the amplitude to 1 cm, set the pulse width to 0.25, and set the damping to a value of 0. When experimenting with waves on a rope with a free end, students choose the free end, choose the slow-wave motion, set the amplitude of 1 cm, set the pulse width to 0.25, and set the attenuation to 0 and free. Figure 3 shows that students answered three discussion questions on the students’ worksheet. Students answer that the direction of the pulse propagation comes from the right to the left. It occurs in tied and free-end ropes. They also replied that the wave phase of the tied end rope was slower than the free end.

At the fourth meeting, students did a virtual practicum on the concept of a walking wave. Students already hold worksheets and PhET Simulation learning media to discover the concept of a traveling wave. Figure 4 shows an example of students’ answers on students’ worksheet 4 for the concept of a traveling wave.



12. Masukkan data hasil pengamatan pada tabel di bawah ini :

NO	Waktu (sekon)	Frekuensi (Hertz)	Amplitudo (m)	Panjang Gelombang (m)
	5 detik	1 Hz	0,5 m	6 cm

13. Atur amplitudo sebesar 0.50 cm, kemudian atur redaman pada *"Tidak ada"*. Atur frekuensi sebesar 2 Hz.
14. Klik tombol *Mulai* pada pewaktu
15. Klik tombol ⏸ setelah ± **5** sekon. Ukur besar panjang satu gelombang dan amplitudo pada puncak kedua menggunakan mistar.
16. Klik tombol ▶ untuk melanjutkan kembali.
17. Lakukan **langkah 13 sampai 15** dengan waktu ± **10** sekon.
18. Masukkan data hasil pengamatan pada tabel di bawah ini :

NO	Waktu (sekon)	Frekuensi (Hertz)	Amplitudo (m)	Panjang Gelombang (m)
	5 detik	2 Hz	0,5	3 cm

Jawablah pertanyaan dibawah ini sesuai dengan pengamatanmu pada percobaan diatas

1. Kemanakah arah perambatan gelombang tersebut?

Sebelah kanan

2. Bagaimanakah besar amplitudo bukit dan lembah ketika tali digetarkan?

Besarnya tidak sama

Figure 4. Example of Answer on Students' Worksheet 4 of Traveling Wave Concept

Students choose the type of wave formation, namely, oscillation, the type of rope end that is endless, a ruler on additional items so that the ruler appears on the display, and select the time on additional items so that the timer appears on the display. Then, students click the button to make the wave stop and repeat the process by setting the amplitude to 0.50 cm and the attenuation on the "None" option. The frequency is set at 1 Hz and the timing starts. After 5 seconds, students measure the length of one wave and the amplitude at the second peak using a ruler. Figure 4 shows that students have filled out the students' worksheet with observational data in the form of time, frequency, amplitude, and wavelength. Students also answer the discussion section for questions number one and two. The direction of wave propagation is answered to the right and the amplitude is not the same between one wave and another. Students can distinguish the peak of pulse correctly.

The observation in this stage concluded that students have attended four face-to-face lessons for PhET Simulation-assisted physics learning on vibration and wave material. Four students' worksheets are pendulum vibration concept, spring vibration concept, stationary wave, and traveling wave. Students at SMAN 1 Nimboran are very enthusiastic about the applied interactive learning media in the form of virtual lab uisng PhET Simulation. Learning feels more alive and active, especially when students begin to play with simulation applications. The enthusiasm that appears is higher than conventional learning using the lecture method and the teacher-centered learning approach. However, we also found some shortcomings in physics learning assisted by PhET Simulation at SMAN 1 Nimboran. Students are too busy using simulation media and do not fill out worksheets with analysis based on detailed physics theory. There were even some students who did not fill in the data observation table and discussion section because their time had run out.

It is in line with the findings positive effect of using PhET Simulation media. Hereby the advantage lies in the accuracy of the observation results that are close to physical theory, unlike real practicums that have error analysis, virtual practicums assisted by PhET Simulation tend to be successful and get results that are by theoretical physics according to previous scientists (Abou Faour & Ayoubi, 2017; Batuyong & Antonio, 2018; A. M. Price et al., 2018; Ryan et al., 2016). PhET Simulation media can also make students more active in participating in physics learning (Ndihokubwayo et al., 2020; Putranta & Wilujeng, 2019). This media can also stimulate students' scientific problem solving skills because students can see virtually what springs and pendulums look likes (Batuyong & Antonio, 2018; Correia et al., 2019; Putranta & Wilujeng, 2019). They can relate the springform to the

mattress and the pendulum that is on the children's swing around them because the illustration of the PhET Simulation media simulation is close to real. On the other hand, the PhET Simulation media does not require students to get alternative concepts, so students only accept the results of the simulation findings (Abou Faour & Ayoubi, 2017; Reddy & Panacharoensawad, 2017). Students also get distractions, such as playing games, so they don't focus on discussing and filling out the students' worksheets on material vibration and wave.

The Test Results on Students' Scientific Problem Solving Skills

SMAN 1 Nimboran, as a part of 3T region, held only 1.70% especially in the indicator of check the solution. It also showed low percentage outcome for each indicator. The results for each indicator of the percentage of problem solving skills are shown in Table 1.

Table 1. *Scientific Problem Solving Skills Indicator*

Scientific Problem Solving Skills Indicator	Percentage (%)
Define the problem related to science	10.20
Explore the problem given	3.27
Plan the solution to the problem	10.98
Implement the solution plan	6.54
Check the solution	1.70
Evaluate the results	4.44

We found that in the first category, students must've to define the problem. They need to develop certain activity using deep analysis out of the picture that is presented. By doing this, the learning outcome expected were to: (1) determine contextual problems related to images prsented and certain discourse; (2) upbring the comprehensive process during the lesson; (3) validate the information of discourse; and (4) examine the definition of the problem. Figure 5 shows the relevant explanation of first indicator.

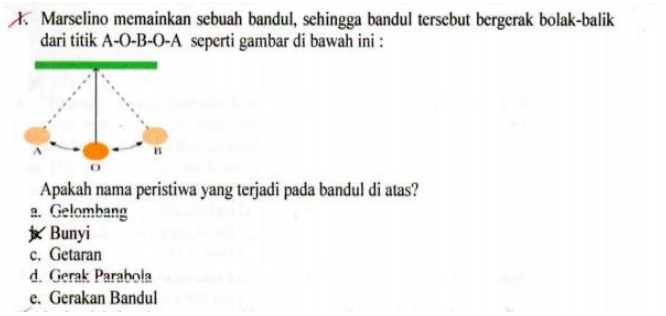


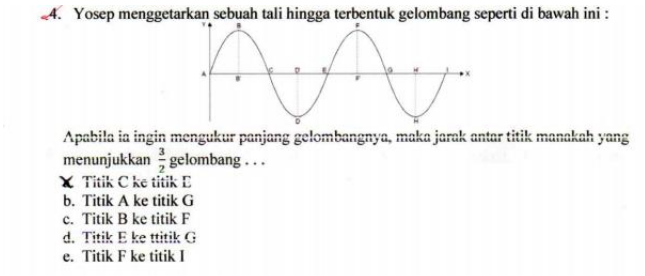
Figure 5. The Example of Students' Answer in to Define the Problem Indicator

The question is "Marselino plays a pendulum, so that the pendulum moves back and forth from the point A-O-B-O-A as shown below. What happened to the pendulum above?". The answer choices or options are: A) Wave, B) Sound, C) Vibration, D) Parabolic Motion, and E) Pendulum Motion.

The students' answers show that a pendulum swing is a sound event. Figure 5 shows that students cannot identify the scientific issues indicated by the events on the swing pendulum. The swing pendulum moves back and forth past the equilibrium point, which is called vibration. The answer based on Figure 5 was incorrect. Interview was drawn to recheck the background understanding. Student was not able to define the problem by only looking at the pictures. We knew that

students did not understand the concepts of vibration in a swing pendulum. A swing pendulum is said to be vibrating if it moves back and forth through the equilibrium point (Serway & Jewett, 1998).

To explore the problem was the second indicator we needed to illiterate after the first question. This indicator required that students must've to: (1) object of the problem; (2) address the defined problems and its related theory; (3) engage to determined assumptions; and (4) build answers to predetermined checks.


4. Yosep menggetarkan sebuah tali hingga terbentuk gelombang seperti di bawah ini :

Apabila ia ingin mengukur panjang gelombangnya, maka jarak antar titik manakah yang menunjukkan $\frac{3}{2}$ gelombang . . .

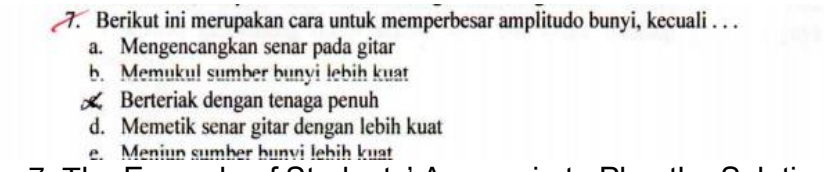
X. Titik C ke titik E
b. Titik A ke titik G
c. Titik B ke titik F
d. Titik E ke ttitik G
e. Titik F ke titik I

Figure 6. The Example of Students' Answer in to Explore the Problem Indicator

The question is "Joseph vibrates a rope to form a wave like the one below. If he wanted to measure the wavelength, what distance between points would represent 3/2 waves?". The answer choices or options are: A) Point C to E, B) Point A to G, C) Point B to F, D) Point E to G, and E) Point F to I.

By looking into Figure 6, we can point the is an example second indicator which is to explore the problem. It can be seen that students cannot explore a problem shown by a picture. Students should understand the concept of wavelength first. Figure 6 shows that students do not understand the concept of wavelength in a rope, where the waves that occur in the rope are transverse waves. The distance traveled by one full wave is called the wavelength. After conducting the interview, students were not capable in relating concept of wavelengths that occurred in transverse waves because students were unable to explain the definition of wavelengths. Students' answers indicate that students are not able to explore a problem shown by a picture. Students should understand the concept of wavelength first. Figure 6 shows that students do not understand the concept of wavelength in a rope, where the waves that occur in the rope are transverse waves. The distance traveled by one full wave is called the wavelength (Halliday et al., 2013). After conducting the interview, we enhanced the case that student did not understand the concept of wavelengths that occurred in transverse waves because students were unable to explain the definition of wavelengths.

The next indicator was to plan the solution. In this indicator, students are expected to select the theory that has connection between one case to another. Using the designed of predestined solution, students need to design or proceed the assumptions that have been made in the form of a map or chart (Figure 7).


7. Berikut ini merupakan cara untuk memperbesar amplitudo bunyi, kecuali . . .

a. Mengencangkan senar pada gitar
b. Memukul sumber bunyi lebih kuat
c. Berteriak dengan tenaga penuh
d. Memetik senar gitar dengan lebih kuat
e. Meniup sumber bunyi lebih kuat

Figure 7. The Example of Students' Answer in to Plan the Solution Indicator

The question is “All of the following are ways to increase the amplitude of sound, except...”. The answer choices or options are: A) Tighten the strings on the guitar, B) Hit the sound source harder, C) Scream with full force, D) Strum the guitar strings harder, and E) Blow louder at the sound source.

Students’ answers show that students do not understand the concept of amplitude applied to sound waves that occur in everyday life. After conducting interviews with these students, we intended to infer that student could not distinguish the application of the concept between frequency and amplitude in daily life. This shows that students are not able to make a plan for the solution.

We leaped to the fourth indicator: to implement the plan. Students must’ve to apply the determined theories, priciples, and concepts they have already known to create the analysis process by using embodied chart or available data. Figure 8 shows the example of the fourth indicator.

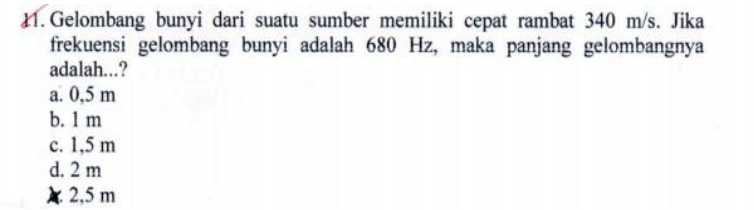
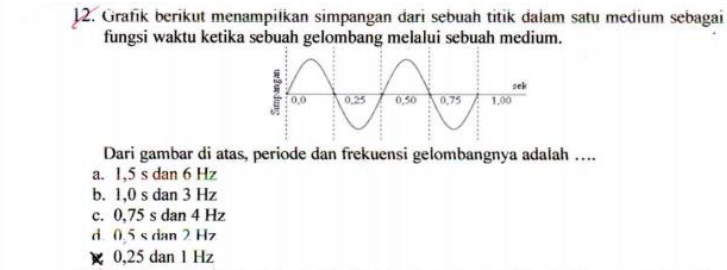

11. Gelombang bunyi dari suatu sumber memiliki cepat rambat 340 m/s. Jika frekuensi gelombang bunyi adalah 680 Hz, maka panjang gelombangnya adalah...?
a. 0,5 m
b. 1 m
c. 1,5 m
d. 2 m
✗ 2,5 m

Figure 8. The Example of Students’ Answer in to Implement the Plan Indicator

The question is “Sound waves from a sound source have a speed of 340 m/s. If the frequency of a sound wave is 680 Hz, what is its wavelength?”. The answer choices or options are: A) 0.5 m, B) 1 m, C) 1.5 m, D) 2 m, and E) 2.5 m.

The example of students’ answer in this indicator was delivered in Figure 8. We’ve seen that students cannot apply the concept of waves. Wavelength is the ratio of the speed of the wave to the frequency of the wave (Serway & Jewett, 1998). After going through in-depth interviews, students stated that they did not understand the concept of the relationship between wavelength, wave speed, and wave frequency. It can be concluded that students cannot apply the equation of the relationship between wave velocity, wavelength, and wave frequency.

Checking the solution is the fifth indicator of problem solving skills. Students at this stage need to verify the exact method they analyze using prior data. Then proving the preassumptions were deployed. Figure 9 shows the example.


12. Grafik berikut menampilkan simpangan dari sebuah titik dalam satu medium sebagai fungsi waktu ketika sebuah gelombang melalui sebuah medium.

Dari gambar di atas, periode dan frekuensi gelombangnya adalah ....
a. 1,5 s dan 6 Hz
b. 1,0 s dan 3 Hz
c. 0,75 s dan 4 Hz
d. 0,5 s dan 2 Hz
✗ 0,25 dan 1 Hz

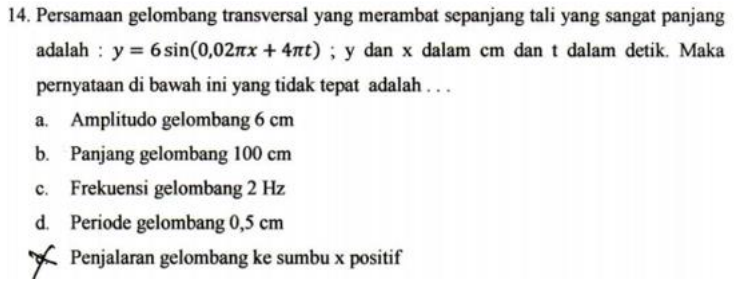
Figure 9. The Example of Students’ Answer in to Check the Solution Indicator

The question is “The following graph shows the deviation of a point in a medium as a function of time when a wave passes through a medium. From the figure above, the period and frequency of the wave are...”. The answer choices or

options are: A) 1.5 s and 6 Hz, B) 1.0 s and 3 Hz, C) 0.75 s and 4 Hz, D) 0.5 s and 2 Hz, and E) 0.25 s and 1 Hz.

Students gave incorrect answers in the example in Figure 9. Students are not able to solve problems through the illustration of a traveling wave. Learning physics through a PhET simulation has seen the period taken by a traveling wave. After conducting in-depth interviews, information was obtained that student forgot the concept of periods and frequencies when presented in a walking wave illustration. Based on students' answers, it can be concluded that students are not able to solve problems in the aspect of check the solution.

The last indicator was to evaluate. Students must've to deliberate analysis and assessment they performed using scientific statements put forward. The conncetion of dots will lead to inferring stage and raise questions given by other students. Then teacher should compare the different analysis results and conclude the relevance between them.


14. Persamaan gelombang transversal yang merambat sepanjang tali yang sangat panjang adalah : $y = 6\sin(0{,}02\pi x + 4\pi t)$; y dan x dalam cm dan t dalam detik. Maka pernyataan di bawah ini yang tidak tepat adalah . . .

a. Amplitudo gelombang 6 cm
b. Panjang gelombang 100 cm
c. Frekuensi gelombang 2 Hz
d. Periode gelombang 0,5 cm
e. Penjalaran gelombang ke sumbu x positif

Figure 10. The Example of Students' Answer in to Plan the Solution Indicator

The question is "The equation for a transverse wave traveling along a very long string is y = 6 sin (0.02 π x + 4 π t); y and x in cm and t in seconds. So the correct statement below is...". The answer choices or options are: A) The amplitude is 6 cm, B) The wavelength is 100 cm, C) The wave frequency is 2 Hz, D) The wave period is 0.5 cm, and E) Wave travels to positive x axis.

We can see the example in Figure 10s. The correct answer was option A. So that the students' answer was incorrect as the answer was option E. Students are not able to understand the concept of a traveling wave through the traveling wave equation. Students are asked to evaluate the statements related to the wave equation that occurs. Based on in-depth interviews, it was found that students did not understand the general equation of a traveling wave. It shows that students cannot evaluate the traveling wave equation. It can be seen from the answers and the results of in-depth interviews that students cannot analyze the related quantities of the traveling wave equation. The correct answer if students considered about the traveling axis was negative x axis.

Test Mean Score of Students' Scientific Problem Solving Skills

Of the results from students' scientific problem solving skills, we also gathered the data to get the descriptive statistics related to the test score. It can show the data spread and conclude the students' scientific problem solving skills level. Figure 11 shows the average, median, and mode of 51 students in class XI-IPA based on the average science score for class VIII students in SMAN 1 Nimboran, Papua, Indonesia, which describes scientific problem solving skills.

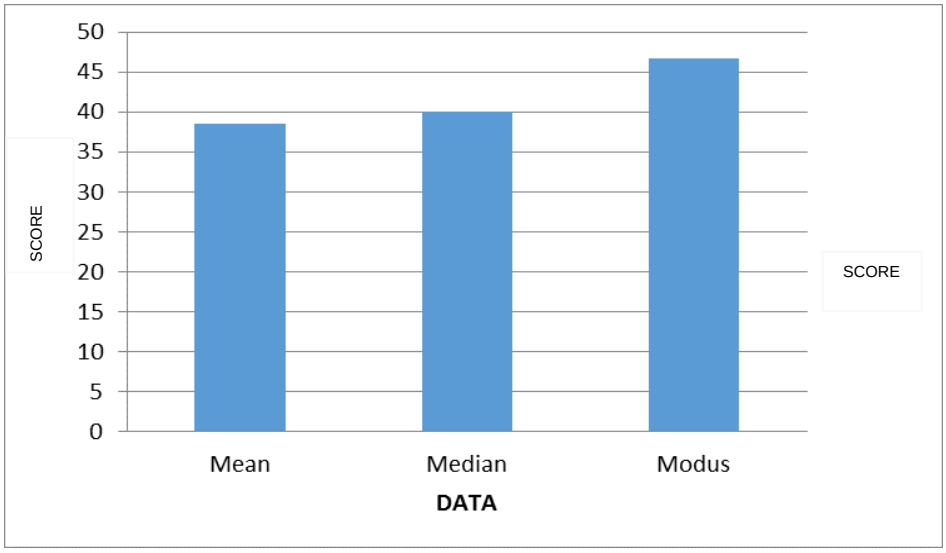


Figure 11. The Mean Score of Students' Scientific Problem Solving Skills

Figure 11 shows the average, median, and mode of 51 students in class XI-IPA. The mean score of science score for class VIII students in SMAN 1 Nimboran, Papua, Indonesia, described the scientific problem solving skills. The mean, median, mode scores are 38.52, 40, and 46.67 respectively. Figure 11 also determined the level of matter discussed related to students' scientific problem solving skills. The mean score showd that the level of skills owned by students in SMAN 1 Nimboran was low. From the pattern of indicators, the first indicators that held by students mostly was first and second stage. Students were able to define the problem and determine whether ihe problem can be solved using their knowledge and experience. The achievement score was reflected to the future comprehensive study to enhance the matter of students' scientific problem solving skills in rural are, one of which is other Papua regions.

CONCLUSION

SMAN 1 Nimboran is one of the schools in Papua, Indonesia, which is included in the 3T region category. Therefore, the obstacles that often occur during learning at school are the absence of an internet connection or an internet network disconnection. It makes internet-based learning, for example, virtual media, cannot be done optimally. The resource person stated that learning physics at SMAN 1 Nimboran only uses the lecture method with a teacher-centered learning approach. Learning in schools has not used interactive learning media such as simulations and virtual laboratories. The application of learning media is still unfamiliar and the first in schools. The positive effect of using PhET Simulation media lies in the accuracy of the observation results that are by physical theory. This media can also stimulate students' scientific problem solving skills because students can see virtually what springs and pendulums look like. On the other hand, the PhET Simulation media does not require students to get alternative concepts and makes students experience distraction, so they do not focus on filling out worksheets. The mean, median, mode scores of respective skills were 38.52, 40, and 46.67. It can be concluded that the mean, median, and mode can be categorized into low categories. Thus, the category of students' scientific roblem solving skills in SMAN 1 Nimboran was low and need to be elevated.

AUTHORS' CONTRIBUTIONS

The first author of this study conducted the interview to collect data from pilot study and data collecting process before the implementation of PhET Simulation in physics learning in SMAN 1 Nimboran and performed data analysis. The second author assisted through research grant and funding to elaborate the study in SMAN 1 Nimboran. The third author had done data analysis and article writing.

ACKNOWLEDGMENTS

The authors want to acknowledge and send the gratitude to the helps, funding, and permission from Universitas Cenderawasih and SMAN 1 Nimboran as this study finished without any convenience.

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