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Effect of ICARE Model Assisted by Virtual Practicum on Students' Science Process Skills in Traveling and Stationary Wave Materials

Nisa Nuraeni*, Aripin, Yanti Sofi Makiyah

Siliwangi University, Tasikmalaya, Indonesia

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ABSTRACT

Objective: *This study aimed to analyze the effect of the ICARE model assisted by virtual labs on students' science process skills.* ***Method:*** *This research was a quasi-experiment using a posttest-only control group design. The sample consisted of 35 students of XI MIPA 4 and 35 students XI MIPA 6 MAN 2 Tasikmalaya Regency. Data collection was carried out through an essay-shaped science process skills test consisting of 6 questions which were analyzed using the t test.* ***Results:*** *Hypothesis test using a t-test at the significance level ($\alpha = 0.05$) obtained tcount > ttable where 3.35 > 1.67 so that H_a was accepted and H_0 was rejection. Therefore, the research findings show that the ICARE model assisted by virtual practicum has an effect on students' science process skills on the material of traveling waves and stationary waves.* ***Novelty:*** *Innovation in this study was that students applied the material learned with the help of virtual practicum to train science process skills.*

INTRODUCTION

Physics is one of the branches of Natural Sciences that learns various natural phenomena and all interactions that happen in them. Natural phenomena studied in physics can increase scientific facts (Hanum, 2023). Physics is a subject included in the 2013 Curriculum to be equipped with concepts, principles, and skills to develop scientific knowledge across various disciplines (Kemendikbud, 2014). Curriculum 2013 prioritizes individual experience through observation, questioning, association, communicating and concluding (Sulistiyono, 2020). Along with the fast growth in Science, Technology, and Art (Science and Technology), which increasingly extends to various aspects of life, the competencies developed refer to 21st-century skills. 21st century trains students' ability to acquire and improve skills that will be useful in the future. Science process skills are essential in the 21st century (Mardianti et al., 2020). Acquiring knowledge requires science process skills, utilized in the learning activity.

The science process skill is one skill that all students must have when learning physics. Hardiyanti (2020) explains that science process skills involve students' capability to implement scientific approaches to comprehend, discover, and advance science. Students can apply their thinking skills to solve problems by employing science process skills, which involve cognitive processes. Students not only know the material but will also understand how the concept will be learned from it. Scientific thinking can be facilitated through practicum activities that provide direct experience to measure students' skills more effectively (Hardiyanti, 2020). Every student in education should have the necessary knowledge and actively participate in the learning process to realize their full potential (Putri et al., 2021). Science process skills are essential in learning activities to realize student participation.

Based on the preliminary study, information was obtained that students rarely carried out practicum activities due to limited learning time, so learning was only the delivery of material from the teacher without involving students in conducting experiments. Thus, students' science process skills still need to be classified very little, with an average percentage of 33.4%. Another problem is that students do not understand how to resolve the problem. Some students still have difficulty determining the right formula to solve physics problems, so many errors occur in the operation of the problem when answering questions. Based on observation of physics learning activities in the classroom, information was obtained that the teacher still uses the old lecture method. However, at the beginning of each lesson, stimulation is always given in images by linking physics material to daily life applications to provide interactive learning conditions and explore learning materials. Students have not yet developed confidence in the learning process when answering and solving practice problems. As a result, students cannot express their ideas when solving the problems given.

The solution to overcoming the lack of science process skills is to implement a student-focused learning model. One of the solutions applied is to use the ICARE model. This model allow students to apply skills and knowledge to increase science process skills in mastering learning materials. The ICARE learning model allows each stage of learning activities to hone students' ability to understand the material (Mahdian et al., 2019). The ICARE model consists of five learning process stages: introduction, connect, apply, reflect, and extend (Wahyudin, 2010). This ICARE model can create more innovative learning that helps students develop KPS to be more active, creative, and skilled in acquiring knowledge by involving experience as a source of knowledge. Accordance to Destari et al. (2021), the ICARE model, in learning activities, students are more active in asking questions in class. They are more courageous in expressing their opinions, so learning time is more effective because they can provide scientific views according to the problem (Destari et al., 2021). Learning activities using this model can overcome the lack of confidence when answering and solving problems. The advantage of the ICARE model is its ability to allow students to apply the lessons to train, build knowledge, and increase curiosity (Abdan, 2019).

An innovation to support learning activities is a virtual practicum. Virtual practicum is one of the technology-based learning processes with practicum methods that can be used as an alternative learning solution (Pratiwi et al., 2021). Virtual practicum provides an interactive simulation like a real practicum using tools and materials provided in an application. Virtual practicum can overcome obstacles in conducting experiments due to several factors: limited laboratory space, limited tools and materials, and a lot of experiment time (Nursafitri et al., 2023). Teachers must have a strong understanding of science to assist and accommodate students' goals during their engagement in the learning process (Juniati et al., 2020). Practicum is strongly associated with science process skills because it helps students become accustomed to the process and make observations. The virtual practicum used in this study includes PhET Simulations to conduct a traveling wave experiment and apply Melde's experiment using Amrita Lab.

The materials chosen for this research are traveling waves and stationary waves. The data from the preliminary study of a science process skills test support this, showing that the material still needs to be improved. In addition, students' daily test scores are still relatively low because they still have difficulty determining the right formula to solve physics problems. Wave material is very relevant to everyday life, so it is essential for students to learn it. According to this background, researchers are interested in applying

ICARE models to the material of traveling and stationary waves assisted by virtual practicum on students' science process skills.

RESEARCH METHOD

Research Design

The research method utilized was a quasi-experiment with a posttest-only control group design. This design selected two groups, the experimental group and the control group (Creswell, 2012). The research design shown on Table 1.

Table 1. Research Design

Group	Treatment	Post-test
Experiment	X	$\mathbf{O_1}$
Control	-	$\mathbf{O_2}$

Instrument and Procedures

The data collection technique was given via a science process skills test in an essay shape of 6 questions. The six questions represent six indicators of science process skills, namely observing, classifying, communicating, measuring, predicting, and concluding. Three validators have validated the instrument, which has been tested with an average validity of 0.90. Validity is determined using expert agreement by giving validity values through Aiken's V formula (Retnawati, 2016). Furthermore, the validity test was computed using product moment correlation to examine the validity of research instruments. The instrument is said to be valid if $\mathrm{r_{count}} > \mathrm{r_{table}}$ and invalid value if $\mathrm{r_{count}} < \mathrm{r_{table}}$. As for knowing the consistency of the instrument to be used, instrument reliabilities are tested with a Cronbach Alpha equation (Arikunto, 2014).

Data Analysis

Data analysis techniques to determine students' science process skills were carried out by calculating the total percentage of each indicator using the equation (1).

$$\text{value} = \frac{\text{score answered correctly}}{\text{maximum score of the question}} \times 100\% \tag{1}$$

The post-test scores obtained were then interpreted using the guidelines in Table 2.

Table 2. Percentage Criteria for Science Process Skills

Percentage (%)	Criteria
> 85	Very good (A)
70 – 85	Good (B)
56 – 69	Enough (C)
41 – 55	Less (D)
≤ 40	Very less (E)

(Oktofika et al., 2018)

The prerequisite tests in this study include a normality test conducted with the Chi-Square test and a homogeneity test conducted with the Fisher test. The normality test purpose to find out whether the samples are normally or not distributed, while a homogeneity test is used to compare two or more groups that have the same characteristics, namely whether the groups to be compared are homogeneous (Sugiyono, 2020).

According to the prerequisite test results, the normal distribution of data and homogeneous variance. Therefore, hypothesis test was conducted using t-test. This test purpose to know the two mean parameter differences in experimental and control classes after being treated with the dependent variable using equation (2) below (Sudjana, 2005).

$$t = \frac{\bar{x}_1 - \bar{x}_2}{s\sqrt{\frac{1}{n_1} + \frac{1}{n_2}}} \tag{2}$$

RESULTS AND DISCUSSION

Results

Based on research conducted by applying the ICARE model to an experimental class and direct instruction model to a control class, posttest data is found as follows in Table 3.

Table 3. Posttest Statistics Data of Science Process Skills

	N	Minimum	Maximum	Mean	Standard Deviation	Variance
Experiment Class	35	42	69	60.86	6.01	36.07
Control Class	35	39	67	55.94	6.29	39.53

The ideal score students can achieve if they correctly answer all post-test questions is 72. The mean value of the experimental class, surpasses that of the control class, suggesting that students in the experimental class possess superior science prosess skills. In addition, the variance and standard deviation values of the control are larger than those of the experimental class. The post-test data for the control group showed various, and wider data distribution when contrast to the experimental class. Researchers conducted prerequisite tests which inclusive normality tests and homogeneity tests before proposing hypotheses. The normality test utilize the Chi-Square equation was utilized to evaluate the data normally distributed or not with Microsoft Excel assistance. The following are the normality test results in Table 4.

Table 4. Data Normality Test Results

Data	χ^2_{count}	χ^2_{table}	Conclusion
Post-test Experiment Class	3.47	12.8	Normally Distributed Data
Post-test Control Class	1.17	12.8	Normally Distributed Data

Any χ^2_{count} value obtained is less than the value of χ^2_{table}. In accordance with the decision-making requirements of $\chi^2_{\text{count}} < \chi^2_{\text{table}}$, it can be inferred that all groups of data are normally distributed. The following prerequisite test is the homogeneity test. To determine if the data groups studied are homogeneous or not so that they know the similarity of their variances, a homogeneity test using the Fisher test was conducted. The following are the analysis results of the homogeneity test in Table 5.

Table 5. Homogeneity Test Results

Data	α	F_{count}	F_{table}	Conclusion
Post-test scores (Experiment and Control)	0.05	1.10	1.77	Both data are homogeneous

Both variances are said to be homogeneous if the value of $\mathbf{F_{count}} < \mathbf{F_{table}}$. Because the value of $\mathbf{F_{count}} < \mathbf{F_{table}}$ the research data has the same or homogeneous variance. After finding out that the data is normally distributed and homogeneous, the following step is to conduct hypothesis test. The hypothesis test applied is the t-test in Table 6.

Table 6. Results of the t-test

Data	α	t_{count}	t_{table}	Conclusion
Posttest scores (Experiment and Control)	0.05	3.35	1.67	$\mathbf{H_0}$ is rejected and $\mathbf{H_a}$ is accepted

The results of hypothesis test by applying t-test at the level of significance (α = 0.05) acquire $t_{count} > t_{table}$, so that H_0 is rejected and H_a is accepted. Therefore, at the 95% confidence level, it can be concluded that there is an effect of the ICARE model aided by virtual practicum on students' science process skills in the material of traveling waves and stationary waves in the XI MIPA class of MAN 2 Tasikmalaya Regency in the 2023/2024 academic year. The results of the data analysis indicated that there were different mean scores of students' science process skills, where the mean posttest of skills that receive treatment is higher compared to those that are not given treatment. More details are shown in Figure 1.

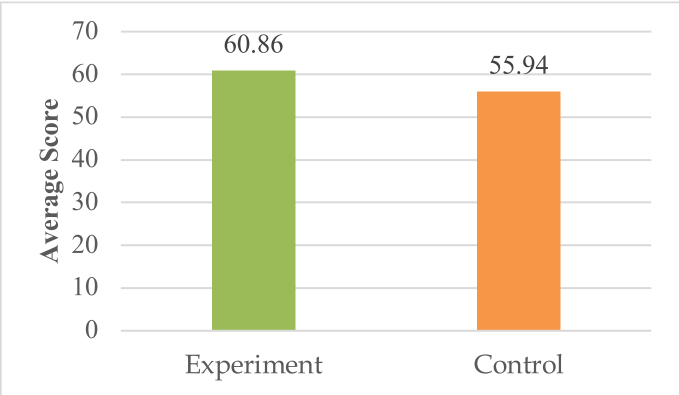

Figure 1. Average posttest score of KPS in sample class

Student skills assessment was carried out using percentage averages on posttest scores from six essay items that measured indicators for science process skills, in accordance with the method described by (Dimyati & Mudjiono, 2015). The categories of obtained science process skills were identified according to the classification explained by (Oktofika et al., 2018). The assessment results are presented in Table 7.

Table 7. Average posttest score per indicator of science process skills

No.	Indicator	Experiment Class		Control Class	
		Percentage (%)	Category	Percentage (%)	Category
1	Observe	83.57	Good	75.48	Good
2	Classify	87.62	Very good	77.86	Good
3	Communicate	84.29	Good	76.90	Good
4	Measure	79.05	Good	70.71	Good
5	Predict	85.95	Very good	82.38	Good
6	Conclude	86.67	Very good	82.86	Good
Average		**84.52**	**Good**	**77.70**	**Good**

Discussion

Based on the analysis of post-test results in Figure 1, the science skills of the experimental group that applied the ICARE model assisted by virtual practicum were superior to the science skills of the control class, which utilized the direct instruction model. Post-test score differences are influenced by the level of student involvement or activeness during learning activities. In the experiment class, student-centered learning methods encourage students to investigate problems and obtain information so that students play a role an active part in teaching and learning activities. In the control class, the learning method was teacher-centered, which made students less actively involved in the learning. In addition, in both classes, some factors influence the study's result, such as maturation, diffusion or imitation of treatment, which aims to balance the results (Hastjarjo, 2008). The mean score of science process skills in the experimental and control classes is not much different due to the imitation of treatment which is physically close to the classroom so that it allows communication and delivery of information about learning. In addition, the equalization of treatment as an offset occurs because researchers provide the same treatment at the apply stage in the experimental class, and control class the guiding training stage. In both stages, researchers applied the same experimental activities with the help of virtual practicum. Based on Table 7, the average skills in experimental and control classes are categorized as good. Although both classes have the same good category, every indicator for science process skills in the experimental class shows a percentage that is higher than the control class. This means each indicator of students' skills in the experimental class is better than the control class.

The average percentage post-test score of the six science process skill indicators obtained the three most significant indicators: classifying, predicting, and concluding. The classifying indicator in the experimental class was categorized as very good because it was supported by the connected syntax so that students could connect students' initial understanding with new material. In science process skills, students will be required to know how to get new knowledge from the initial knowledge they have previously obtained (Uliya & Muchlis, 2022). In the control class, the indicator of classifying was in a suitable category because students only remembered the material conveyed by the teacher. The predicting indicator in the experimental class was categorized as very good because the connected syntax supported it, so students were trained to explore information about the material being discussed. Learners must be active and creative in their skills to get important information from a lesson (Nurliani et al., 2018). In the control class, the predicting indicator was categorized as good because students only received information from the teacher's explanation. The conclude indicator in the experimental class was categorized as very good because it was supported by the extended syntax so that students could expand what had been learned by looking for information related to everyday phenomena related to the material. In the control class, the conclude indicator was in a good category because students were not given reinforcement of the material, so in working on the questions, students only answered brief conclusions from the experimental data.

The cause of observing indicators in the experimental and control classes is included in the good category because the experimental students provide a simple explanation of the phenomena displayed, and in the control class, students are not given a stimulus at the beginning of learning. They immediately focus on learning the material presented by the teacher. The communication indicator in both classes was good because students had difficulty analyzing the researcher's graph. In addition, the measuring indicator in both experimental and control classes was in a suitable category because in the experimental process, the virtual simulation application for students had difficulty when interpreting the graph displaying the results for wavelength, and some students in the control class did not know the materials and tools used in the application. The practicum activities at the first meeting were waves on a rope through the PhET Simulations application, and the second meeting was the Melde experiment. This activity aims to connect various physical quantities of traveling wave and stationary waves. Science process skills are abilities used to understand scientific phenomena (Nurtang et al., 2019). Using virtual lab media can improve the spirit of learning so that students are attracted in learning (Nursafitri et al., 2023). Students' participation in practicum activities can stimulate them to explore and develop their science process skills, significantly improving cognitive, affective, and psychomotor aspects (Siswono, 2017).

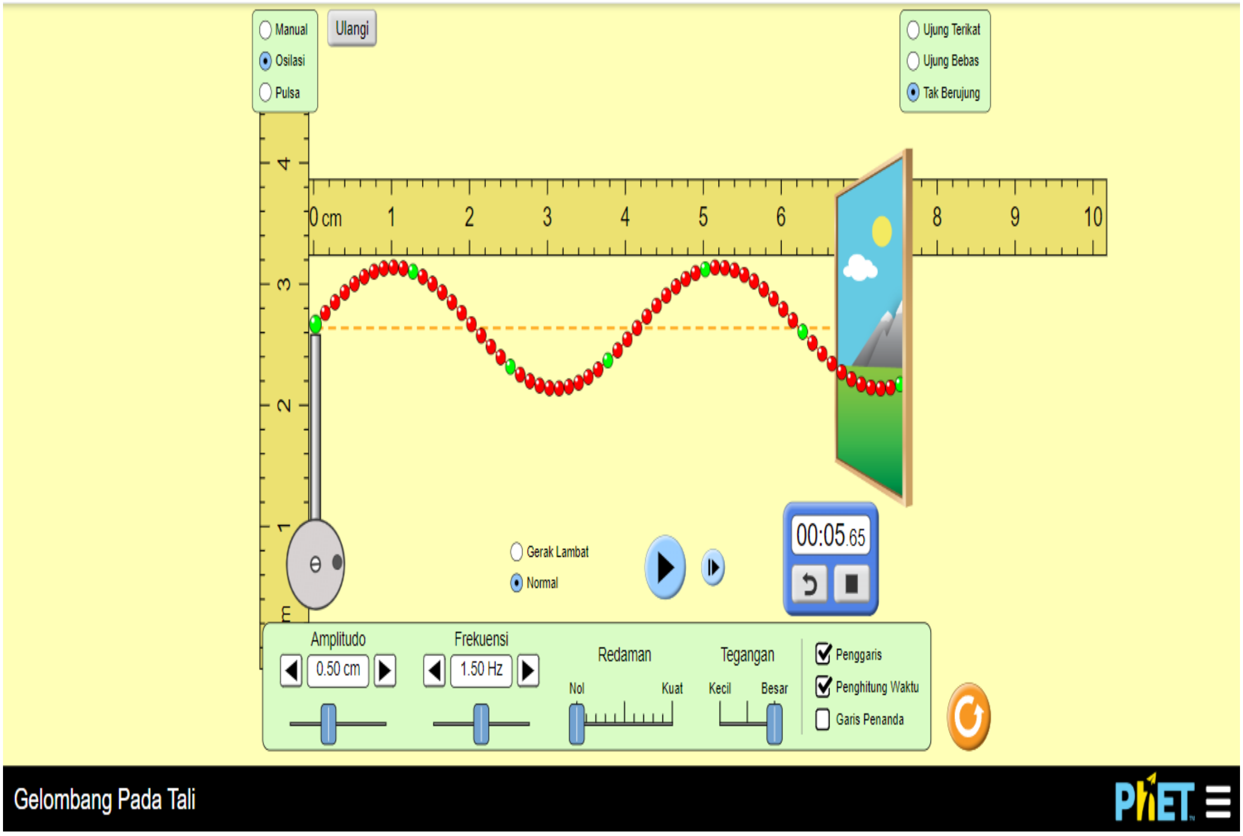

Figure 2. PhET Simulations virtual practicum display of traveling waves

Figure 2 is a virtual practicum activity using PhET Simulations. The practicum aims to determine the relationship between wave frequency and wavelength. The experiment varied the amplitude and frequency values to obtain wavelength data. PhET Simulations in learning aim to clarify concepts, easy the delivery of lessons by teachers, and increase time efficiency. In addition, this method aims to build meaningful and fun learning by providing opportunities for students to actively participate (Alfiah & Dwikoranto, 2022).

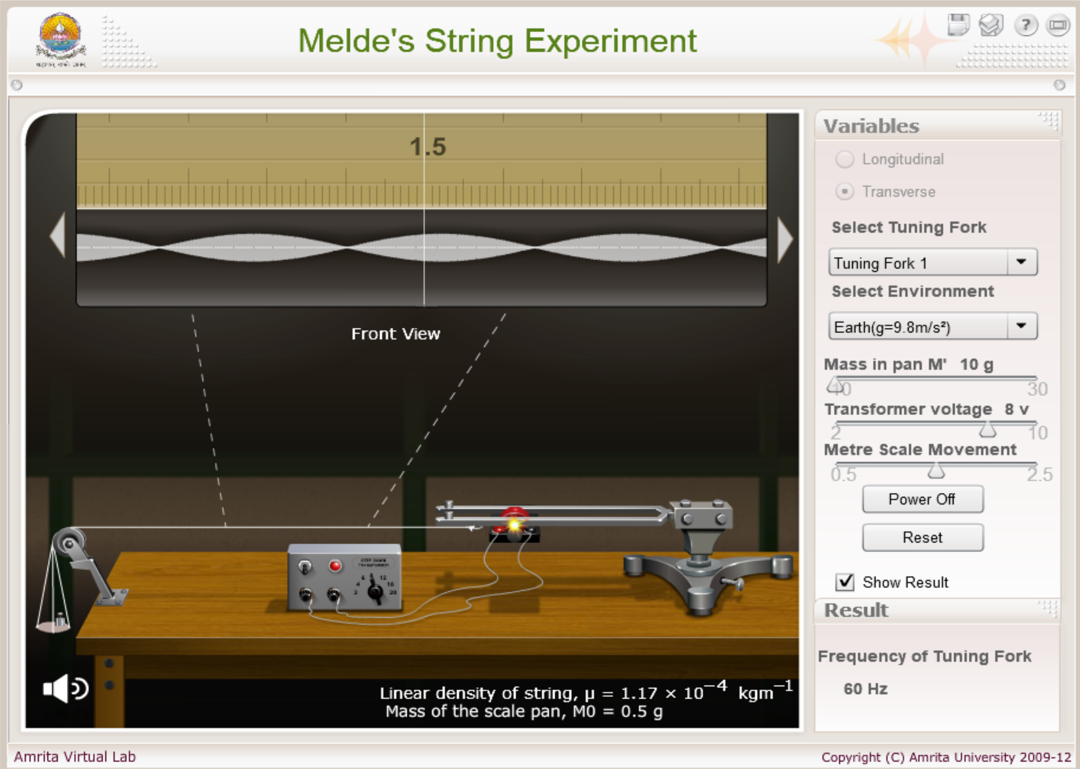

Figure 3. Virtual Practicum Display of Amrita Lab Melde Experiment

Figure 3 is a virtual practicum activity using Amrita Lab. The practicum aims to determine the frequency of a tuning fork. The experiment was carried out by varying the object's mass so that the tuning fork's frequency was obtained. In the stationary wave sub-material, the teacher provides a direct demonstration of how to use the virtual practicum to be discussed. Students carefully pay attention and observe how to use the virtual simulation. The ICARE model assisted by virtual practicum affects student's science process skills on the topic of traveling and stationary waves. This influence is caused by the ICARE model, which involves students actively in the learning process with the help of virtual practicum. The learning process should allow students to solve problems independently (Latifah et al., 2024). The activities in the five syntaxes of the ICARE learning model are easy to implement for learning that can change students' learning experiences (Budi Utami et al., 2017). This is consistent with Mahdian's opinion (2019) which states that ICARE models encourage active discussions between students so that they can directly prove the concepts they learn. Other research states that student are directed to link knowledge and actively construct to discover the meanings of a given issue to comprehend the concept (Yasa et al., 2019). Not only do students listen and read, but they can also utilize the knowledge acquired to solve problems (Latifah et al., 2022).

The ICARE learning model has advantages, including training students in building knowledge independently and providing opportunities to apply the concepts they have learned. Learning models that push students to construct their understanding can increase their science process skills (Azahra, 2023). Science process skills enable students to observe, classify, interpret, predict, apply, and evaluate the results of experiments gained from the learning process (Putri et al., 2022). The implementation of physics learning experienced a change in science process skills resulting from experimental activities undertaken by students (Sinuraya et al., 2019). Science process skills must be cultivated via hands-on learning experiences (Priyani & Nawawi, 2020). Practical activities are an important component of science learning (Hermawan, 2021).

Practical implementation is vital in improving students' skills and customizing the material (Candra & Hidayati, 2020). Through the virtual practicum, students gain experience to increase their knowledge scientifically and rationally. This is because all learning activities, both in class and the laboratory, begin with observation (Darmaji et al., 2018). At each meeting, students do a practicum to apply the studied theory. PhET Simulations and Amrita Lab are used to help apply syntax in conducting virtual practicum in learning. Other research states that practicum activities train students' scientific abilities and support their understanding of physics (Wahyudi & Lestari, 2019). The practicum-assisted ICARE learning model tends to be easy for teachers to implement and positive for learner activities (Triani et al., 2018). Applying a suitable learning model accompanied by practicum activities is fundamental to learning and overcoming student skills problems (Seftriana et al., 2023).

CONCLUSION

Fundamental Finding : Based on research results, data processing, and hypothesis test, it can be inferred that the ICARE model aided by virtual practicum has an impact on students' science process skills on the material of traveling and stationary waves. **Implication** : The use of ICARE model with virtual practicum assistance has a positive impact on student's science process skills. **Limitation** : This research only focuses on traveling waves and stationary waves. **Future Research** : For further research, the ICARE model is collaborated with real practicum activities in the laboratory not only with virtual practicum.

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***Nisa Nuraeni (Corresponding Author)**
Department of Physics Education, Faculty of Teacher Training and Education, Siliwangi University,
Jl. Siliwangi, Tasikmalaya, West Java, 46115, Indonesia
Email: nsnuraeni.02@gmail.com

Aripin
Department of Physics Education, Faculty of Teacher Training and Education, Siliwangi University,
Jl. Siliwangi, Tasikmalaya, West Java, 46115, Indonesia
Email:aripin@unsil.ac.id

Yanti Sofi Makiyah
Department of Physics Education, Faculty of Teacher Training and Education, Siliwangi University,
Jl. Siliwangi, Tasikmalaya, West Java, 46115, Indonesia
Email: yanti.sofi@unsil.ac.id