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The Effectiveness Of Using A Frequency Generator Application In Enhancing Students' Conceptual Understanding Of Determining The Speed Of Sound

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ABSTRACT

This research utilizes a frequency generator application on smartphones to enhance students' understanding of the concept of sound resonance in closed organ pipes. The study employs a pre-test-post-test design with a control group that was not selected randomly. The method used is non-probabilistic sampling (convenience sampling). The sample used in this study consists of fourth-semester students in the Elementary Teacher Education (PGSD) program who are enrolled in the science-learning course. Data collection was conducted using a Concept Understanding Instrument Sheet. The percentage of students' concept understanding above the average increased from 40.1% to 63.4%. This indicates that the concept understanding attained improved after receiving treatment in the form of the frequency generator application. The N-Gain test results yielded an average score of 0.68.

INTRODUCTION

The study of science, particularly in the field of physics, emphasises the importance of understanding fundamental concepts. Each student must understand the basic concepts in each branch of physics. To understand this, students need to examine the basic concepts in the lessons or texts available in the field of physics (Arifin et al., 2021). The ability of students to understand concepts makes physics learning more meaningful. (Capriconia & Mufit, 2022). The ability to understand physical concepts can also help students succeed in learning physics. (Puspitasari et al., 2021). In addition, students' ability to understand concepts can help them develop the skills that exist within themselves (Delvia et al., 2021). Therefore, accuracy in choosing instructional devices is very important for the absorption of concepts present in physics learning.

In physics, there are many fundamental topics at advanced levels, especially in quantum physics, physical optics, and geometric optics. (Şengören, Tanel, 2009). The matter requires special devices to help students understand. In addition, the understanding of concepts in wave material is still considered a concept that is rarely researched by physicists, so further research is necessary (Sutopo, 2015). Although further research on wave materials is rarely conducted, the reality in the field is that learners still often have trouble in understanding concepts, such as the difficulty in understanding wave propagation. (Imiati et al., 2016; Tanel et al., 2008; Wittmann et al., 1999). Students in the PGSD program who are taking the

science-learning course experience the same thing; most of them encounter difficulties in understanding the basic concepts of sound waves, especially in closed and open pipes. The basic concepts present in wave materials consist of various quantities such as wavelength (λ), frequency (f), velocity (v), and Amplitude along with other quantities as a basis that is often used in the material of sound waves (Imiati et al., 2016; Wittmann et al., 1999).

The role of teaching aids is very important in determining the success of the learning process, thus the role of learning media, whether in visual or virtual form, is needed during the learning process. The use of media is especially necessary when conducting practical work. In addition to media that can attract the interest of students, the role of practical work can create an engaging learning atmosphere. (Widiastuti et al., 2022). Thus, combining the roles of both visual and virtual media will have a positive impact on the learning development of students. The appropriate media that serves as the main tool in the lives of students is the smartphone. This is because smartphones are a part of technological development that plays a multifunctional role similar to that of computers (Al-Imam, 2019). The use of smartphones in physics learning by utilizing various easy-to-install applications, one of which is the frequency generator application that is easy to use, especially for wave materials. The frequency generator is useful as a digital tuning fork aid to test and measure the speed of sound in a closed pipe. Based on the experience of previous experiment activities using an analogue tuning fork, the speed of sound found was far from the standard (v = 340 m/s). Additionally, the practitioners also still seemed hesitant to quickly place the tuning fork on the glass tube. Their concern is caused by the possibility of the tuning fork colliding with the glass tube because if a collision occurs, it could cause the resonant glass to break. The frequency generator application is an application available on smartphones that produces sound accompanied by frequency and is equipped with wave propagation direction; the frequency of the sound produced is relatively stable. The stability of the frequency during observation can facilitate the determination of the speed of sound in the air. This research aims to determine the effectiveness of using audio frequency on students' understanding of the concept regarding the resonance of closed organ pipes by conducting experiments on a scaled glass tube. The results of the actions are expected to build students' concepts through the experiments.

METHODS

Data collection for the research was carried out in the PGSD study program at PGRI Kanjuruhan University of Malang during the science-learning course. The research was conducted in mid-March with a sample size of 60 students. Sampling was done using the cluster random sampling method. The selected samples were Class A and Class B of the 2023 batch.

The variables in this study consist of independent variables and dependent variables. The independent variable is in the form of a frequency generator application that acts as a learning medium. The dependent variable is conceptual understanding (post-test) after the students receive treatment.

The method in this research is Pre-Experimental with a Group Pre-test-Post-test Design. The data collection process was carried out by giving a pre-test to the students while they conducted experiments using an analogue tuning fork, in other words, it was the same as the previous practical activities. After the pre-test, the same students received treatment by providing them with a practical guidebook that was supplemented with the use of a frequency generator (digital tuning fork) during the demonstration of the rapid propagation of light in the material of sound resonance in closed organ pipes. With the presence of a pre-test-post-test, the results of

the treatment can be assessed for accuracy between before and after the action (sugiono, 2018). The research design used in this study is:

Table 1. Research Design

Class	Before Study (Pretest)	Treatment	After Study (post-test)
Science Learning CLASS A	O1	X	O2

The types of instruments used in this study are multiple-choice tests before the treatment (pre-test) and multiple-choice tests after the treatment. In addition to the multiple-choice tests, the researcher also conducts performance assessments using an observation sheet of students' performance during practical activities.

The data obtained is analyzed using the N-Gain test to determine the benchmark for the effectiveness of using the frequency generator application on students' understanding of the concept of sound propagation in the air during the resonance of sound in a closed organ pipe. The N-gain test is conducted using the formula:

$$\text{N-Gain} = \frac{(FG) - (Garputala\ Analog)}{Ideal\ Score - Score\ before\ study} \quad (1)$$

Interpretation of the N-Gain results quoted from Hake's opinion in 1998 is written in the table below:

Table 2. Score Interpretation N-Gain.

Score Interval N-Gain	Grades
g > 7	High
0,3 ≤ g ≤ 0,7	Medium
g<0,3	Low

RESULTS AND DISCUSSION

The results of this study were obtained through three stages. In the first stage, students conducted a resonance experiment following the same procedure as in previous years, namely by performing a practicum using an analogue tuning fork. After completing the experiment, students were given a conceptual understanding test consisting of 16 multiple-choice questions on the topic of sound resonance in closed organ pipes. The results of the student's conceptual understanding test are as follows:

Table 3. Score Result Before Study(pre-test)

Statistic	Before Study
Total (N)	30
Mean ($\bar{x}$)	10,20
Standard Deviation (SD)	1,5177
The lowest score (minimum)	7
The highest score (maximum)	13
Variant	2,303
Precentage of scores above the Mean	40,1%
Precentage of scores below the Mean	59,9%

Table 3 shows the scores before the intervention (pre-test). The average score obtained was 10.20, with the lowest score being 7 and the highest score being 13. The number of students who scored above the class average was 12, or 40.1% of the total sample, while the students who scored below the class average amounted to 18, or 59.9% of the total.

Table 4. Score Result after Study (pos-test)

Statistic	After Study
Total (N)	30
Mean ($\bar{x}$)	13,933
Standard Deviation (SD)	1,5391
The lowest score (minimum)	10
The highest score (maximum)	16
Variant	2,369
Precentage of scores above the Mean	63,4%
Precentage of scores below the Mean	36,6%

Table 4 shows the values after the actions taken (post-test). The average score of conceptual understanding obtained is 13.933, with the lowest score being 10 and the highest score being 16. The percentage of scores above average is 63.4%, which is higher than the scores before the actions were taken. Meanwhile, the scores of students who scored below average are 36.6%, which is lower than the scores before the actions were taken.

Table 5. Students' Performance Observation Results

No	Practicum Performance Assessment Aspect	Result Percentage (pre-test)	Result Percentage (post-test)
1.	Preparation (3 indicators)	75 %	91,67 %
2.	Implementation (6 indicators)	70,83 %	87,5 %
3.	Post-activity (3 indicators)	58,33%	91,6 %
4.	Discussion of Results (4 indicators)	62,5%	87,5%

Table 5 shows the results of the performance assessment indicators of students during the sound resonance experiment on closed organ pipes before and after using the audio frequency application. In the preparation stage, there are 3 indicators including the use of laboratory coats, bringing tools according to the working steps, and preparing tools and materials according to procedures. The implementation stage of the practical includes the use of tools and materials, performing experimental steps, grouping observation results, writing results, collaboration among groups, and active roles. The stage after conducting the practicum (post-activity) includes the process of calculating and analysing, summarizing the results, cleaning up, and concluding the results. The final assessment stage of student performance is the discussion stage. This stage includes four assessment indicators that cover presenting practicum results systematically, respecting group members' opinions, communicating politely, and giving friends the opportunity to express their opinions.

The results of student performance evaluation during practical activities consist of four aspects. The first aspect is the preparation stage with a pre-test score of 75% and a post-test score of 91.67%. The second aspect is the implementation stage with a pre-test score of 70.83% and a post-test score of 87.5%. The third aspect is the post-practical activity stage with a pre-test score of 58.33% and a post-test score of 91.6%. The final aspect of this research is the discussion activity after the practical, with a pre-test score of 62.5% and a post-test score of 87.5%.

Table 6. Results of the Paired Sample t-Test

Paired Samples Test

		Paired Differences					t		Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	pre-test - post-test	-3.733	.44978	.08212	-3.90128	-3.56538	-45.46	29	.000

Based on the results of the Paired Samples Test, the t-value calculated is -45.46 with a significance level of 0.000, or in other words, the p-value is less than 0.05 (0.000 < 0.05). This indicates that H0 is rejected, thus it can be said that there is a significant difference between the pre-test and post-test scores. It can be concluded that there is a difference in the average concept understanding score between students before and after using the audio frequency application during the practical session.

Table 7. The Result of N-Gain

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Ngain	30	.38	1.00	.6857	.18233
Valid N (listwise)	30				

Table 7 shows the average N-Gain value of 30 students is 0.6857. The score falls within the medium criterion ranging from 0.3 to 0.7. This indicates that the use of a frequency generator is quite effective in improving conceptual understanding of sound resonance in closed organ pipes.

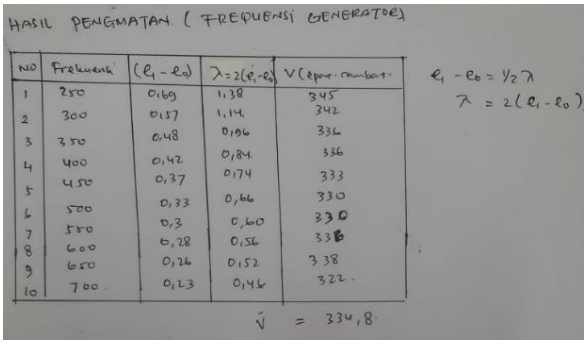
Discussion: The research was conducted on fourth-semester students of the PGSD study program who had taken the science education course. In this science education course, students applied experimental methods to the material of sound waves. The results obtained from the experimental method have met the learning objectives. This is evidenced by the increase in the average concept understanding score of students from 10.20 to 13.933. Before the interventions were implemented, the

percentage of students scoring above the class average was below 50%, specifically 40.1%. After the interventions, the percentage of students achieving above the class average increased to 63.4%. The data presented shows the impact caused by audio frequency media in the sound resonance experiment in determining the speed of sound propagation in air.

The results of the concept comprehension analysis show a significant difference between the pre-test and post-test with a significance level of 0.000, or in other words, a p-value less than 0.05 (0.000 < 0.05). It can be concluded that there is a difference in the average scores of students' concept comprehension who received media in the form of audio frequency during the proof compared to before receiving additional media.

During the data collection process, the researcher also used an observation sheet to assess student performance in the field. Table 5 shows an increase in the percentage of each aspect. In the first and second aspects, namely the preparation and implementation stages, there was an increase of 16.67% between before and after the actions. This increase occurred because students' activities improved due to their experience in preparing tools and during the experiments, with the difference between before and after actions being the addition of a frequency generator. In the third aspect, which is the post-activity stage, the percentage before the action was still very low at 58.33%, while after the action, the percentage rose to 91.6%. The difference in the percentage of the third stage is 33.27%.

The cause of the low percentage before the action is due to the results of the practical work showing that the speed of sound found by the students still has a significant difference from the established (theory). Because of the mismatch between the findings and the theory, many of them are hesitant about the concepts being studied. At the stage of using the frequency generator application, the value of the speed of sound is 334.8 m/s, which is almost close to the theory. Based on the observational data, students can conclude that, the greater the frequency produced by the sound source (audio frequency), the smaller the wavelength produced. This finding is consistent with what Giancoli (2001) and Tipler (1998) state in their books about the relationship between wavelength and frequency in waves. Below is one of the results of the calculations after the observation.


HASIL PENGAMATAN (FREQUENSI GENERATOR)

NO	Frekuensi	$(\ell_1 - \ell_0)$	$\lambda = 2(\ell_1 - \ell_0)$	V (oper. number)
1	250	0,69	1,38	345
2	300	0,57	1,14	342
3	350	0,48	0,96	336
4	400	0,42	0,84	336
5	450	0,37	0,74	333
6	500	0,33	0,66	330
7	550	0,3	0,60	330
8	600	0,28	0,56	338
9	650	0,26	0,52	338
10	700	0,23	0,46	322

$\bar{v}$ = 334,8

$\ell_1 - \ell_0 = \frac{1}{2}\lambda$

$\lambda = 2(\ell_1 - \ell_0)$

Figure 1. Results of Observation and Calculation of the Speed of Sound in Air Using the Frequency Generator Application

The relative error percentage of the observation results was obtained with a score of 2.3%. This indicates an accuracy level of 97.7%. The accuracy of the observation results obtained can be categorized as very high. In addition, the results of the N-Gain test showed an average score of 0.68. This indicates that the use of frequency generator applications on smartphones in resonance experiments is quite effective in determining the speed of sound in air. This is consistent with previous findings that state that the use of smartphones in physics experiments can bridge the similarities and differences in students' lives with all aspects related to physics experiments. (Svensson, 2017). In addition, when students are able to find the speed of sound waves in the air close to the theory, their facial expressions show enthusiasm and happiness after the laboratory activity. This is in line with previous research that the happy attitude of students in learning science will be visible when they show enthusiasm during learning

both inside and outside the classroom. (Kurniawan et al., 2019).

CONCLUSION AND SUGGESTION

Based on the description of data acquisition and discussion results, the N-Gain test results with an average score of 0.68 indicate that the role of the frequency generator application on smartphones is quite effective in determining the speed of sound in the air. The use of the frequency application can assist students in determining the speed of sound with a very high level of accuracy. Additionally, students can also understand the inverse relationship between frequency and wavelength. The higher the frequency of the sound produced, the smaller the wavelength will be. This indicates that students' understanding has improved after being given treatment. The understanding of the students' concepts is reflected in the percentage increase from 40.1% to 63.4%. This improvement occurs because the rate of acquisition of the wave speed (v) approaches the theory (343 m/s). It can be concluded that the use of frequency generators during the concept discovery process of resonance in closed organ pipes can enhance the skills of educators and learners in using learning technology. The use of technology, such as applications on smartphones, also improves students' understanding of the relationship between wavelength and sound frequency in closed organ pipes.

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AUTHOR CONTRIBUTIONS

All authors were actively involved in writing this article. The first author contributed to the formulation of ideas, research framework, and research objectives. The first author also played a role in analyzing the data from the research. The second author assisted in the data collection process by preparing an application on the smartphone. The second author also helped in the data processing, using both manual calculations with Excel and the SPSS 22 data analysis application. The third author contributed by providing interpretations of the research findings and assisted in the literature review. Additionally, the third author also helped in reviewing the manuscript that was to be submitted.

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