Teaching sound waves using *gamelan* and smartphones

To cite this article: D P Anggraeni *et al* 2019 *J. Phys.: Conf. Ser.* **1153** 012123

View the [article online](https://doi.org/10.1088/1742-6596/1153/1/012123) for updates and enhancements.
Teaching sound waves using *gamelan* and smartphones

D P Anggraeni¹, Sukarmin², F Nurosyid³

¹²Department of Physics Education, Postgraduate Studies, Sebelas Maret University
³Physics Department of Post Graduate Program Sebelas Maret University
Jalan Ir. Sutami 36 Keningtang, Jebres, Surakarta, Indonesia, 57126
E-mail: dyaneputri@student.uns.ac.id

Abstract. Sound is an example of a mechanical waves, especially longitudinal wave. Using simple experiments involving musical instrument of Gamelan family and Oscope apps in a couple of smartphones, it is useful and possible for students to “see” characteristics of sound waves. This study aimed to: (1) illustrate the nodes-antinodes of standing acoustic waves in musical instrument of the Gamelan; (2) see the forms of sound waves for each Gamelan’s instrument; (3) explain relationship between frequency and length; and (4) know about student’s response after that learning. This study used experimental method. From this study can be concluded that: (1) the nodes-antinodes standing acoustic waves in musical instrument of the Gamelan can be drawn based on the results of video recording; (2) the form of sound waves for each Gamelan’s instrument can be see using the Oscope apps; (3) relationship between frequency and length is inversely proportional; and (4) very good student’s response with that learning.

1. Introduction

Physics is called the most basic science. Understanding science begins with the understanding of physics through learning. Physical learning is a process of investigating, product (a body to knowledge) and attitude (a way of thinking) [1]. In essence as a product and process, the study of physics primarily for abstract material begins with scientific activities such as observation and investigation of a phenomenon, where such activities require mental processes and attitudes derived from thought. Sound waves as part of mechanical waves are one of the most difficult physics material because they are classified as abstract so it is suitable for learning through observation and investigation activities [2].

Less attention to the potential of the environment as a source of learning (media) is suspected to be the cause of the difficulty of a physics concept can be accepted by students [3]. If local media is incorporated into scientific activities will be able to improve the quality of physics learning so that it becomes meaningful for students and students to receive full lessons [4]. Other researchers affirm that by linking the content of learning with something that has been known will make students motivated to learn [5]. Related to the role of the surrounding environment as a medium in learning, it should be realized that neither the physical environment of the map nor the sociocultural environment owned by Indonesian society especially Sukoharjo has various potentials that can be explored and developed as a supporter of physics learning. One of the local social culture that can be used as a medium of learning is Gamelan. Although local value but it seems Gamelan also been known in some schools in the world. Through Gamelan, students will observe, experience themselves and ultimately in addition to the concept of physics, students will also become more acquainted and proud of the local potential in their area. Besides the utilization of local media, to overcome the 21st century global competition with the
requirements of digital technology, it is proper that the field of education, especially physics is supported by technology. Integrating technology into learning must be precise and appropriate to the material character [6]. One of them is the use of applications from smartphones. Today, there have been many physics experiments with regard to sound waves that use smartphones [7]. Based on the background, the idea to teaching sound wave using gamelan and smartphone was realized. This experiment is very simple for student to learning sound wave. Through this research students can observe illustrations of nodes-antinodes from standing acoustic waves, able to describe the form of sound waves for each Gamelan’s instruments and can know the relationship between frequency and length instrument music.

2. Experimental Methods
This research is an experimental research which is explained by quantitative and qualitative analysis. Intake of data for research purposes 1 and 2 is to know the illustration of nodes-antinodes and see the waveform of each instrument gamelan obtained through experiments by observing the waves formed from each instrument gamelan. For research purpose 3 is to know the relationship of frequency and length obtained through the experiment by observing the frequency from the rebab string. While for the purpose of the 4th research is to know the response of students obtained using observation, documentation and interviews and questionnaires before and after learning.

Free variable used for research purposes 1 and 2 is a type of gamelan instrument (consisting of kendhang, saron, flute, rebab and bonang barung). Meanwhile, for the purpose of research to 3 which is used as a free variable is the change in the position of friction rebab string on 5 a different point, the first point of the string is a control variable. The instruments used for research purposes 1,2 and 3 include gamelan, Oscope apps installed in smartphones as audio recording devices and waveforms. For the purposes of the fourth study, the research instruments used include observation sheets, interview lists and questionnaires.

The ordering of the experimental apparatus for the purposes of studies 1, 2 and 3 as shown in Figures 1.

As in Figure 1, the data for research purposes 1 and 2 are obtained by sounding each gamelan instrument and recording it using the Oscope apps found on the smartphone. From the record will be seen waveform and can be analyzed how nodes-antinodes each instrument Gamelan. Meanwhile, the data for research purpose 3 was obtained by rubbing the rebab strings at 5 positions from the near
srenten rebab to the end of the neck as Figure 1 (b). Recorded data were analyzed to determine the frequency and degree of intensity of each position.

3. Results and Discussion

3.1 Analysis Node-antinodes and Standing Wave Forms for Each Gamelan’s instrument of Video Recording Image by Oscope apps

Figure 2. (a) Illustration of node-antinodes on kendhang; (b) Form of vertical sound wave at kendhang

Figure 2 is a sound recording of kendhang. Through Oscope apps can be analyzed illustration nodes-antinodes and sound waveforms for gamelan instruments. The resonant frequency recorded in Oscope apps is 1263 Hz. Through Figure 2 (a) it appears that the node is formed on a relatively high pitch. When viewed from the waveform through Figure 2 (b) the sound waveform on the kendhang instrument tends to be regular.

Figure 3. (a) Illustration of node-antinodes on saron; (b) Form of vertical sound wave at saron

Figure 3 is a sound recording of a saron. Through Oscope apps can be analyzed illustration nodes-antinodes and sound waveforms for gamelan instruments. The resonant frequency recorded in the Oscope apps is 1040 Hz. Through Figure 3 (a) it appears that the node is formed on a pitch that is also relatively high. When viewed from the waveform through Figure 3 (b) the sound waveform in the instrument saron up and down but still regular.
Figure 4. (a) Illustration of node-antinodes on suling; (b) Form of vertical sound wave at suling

Figure 4 is a sound recording of a suling. Through Oscop apps can be analyzed illustration nodes-antinodes and sound waveforms for gamelan instruments. The resonant frequency recorded in Oscop apps is 740 Hz. Through Figure 4 (a) it appears that the node is formed on a relatively low pitch. When viewed from the waveform through Figure 4 (b) the sound waveform in the suling instrument is regularly from low to slightly high.

Figure 5. (a) Illustration of node-antinodes on rebab; (b) Form of vertical sound wave at rebab

Figure 5 is a sound recording of a rebab. Through Oscop apps can be analyzed illustration nodes-antinodes and sound waveforms for gamelan instruments. The resonant frequency recorded in the Oscop apps is 349 Hz. Through Figure 5 (a) it appears that the node is formed on a relatively low pitch. When viewed from the waveform through Figure 5 (b) the sound waveform in the rebab instrument is regularly low.

Figure 6. (a) Illustration of node-antinodes on bonang barung; (b) Form of vertical sound wave at bonang barung
Figure 6 is a sound recording of bonang barung. Through Oscope apps can be analyzed illustration nodes-antinodes and sound waveforms for gamelan instruments. The resonance frequency recorded in Oscope apps is 998 Hz. Through Figure 6 (a) it appears that the vertices are formed on low and high pitches. When viewed from the waveforms through Figure 6 (b) the sound waveforms on the bonang barung instrument are tended to be regular.

Figure 2 through Figure 6 shows how a combination of pitches forms a certain sound color [8]. Therefore, when some gamelan instruments are sounded simultaneously, we can still distinguish between the sound of the flute and the sound of the rebab due to the color of the distilled sound and the different rebab [9].

### 3.2 Relationship between Frequency and Length

The research data to find the relationship between frequency (f) and length (L) of instrument strings was obtained by recording the sound of the rebab being swiped on the rebab string with 5 different friction positions. Sound recording via Oscope apps is analyzed to determine the frequency of each friction. Table 1 is the result data of research using rebab at 5 different friction position.

**Table 1.** Frame frequency friction rebab on 5 different positions

| Position | Experiments |
|----------|-------------|
|          | 1 | 2 | 3 | 4 | 5 |
| 1 (8 cm) | 2706 | 2525 | 2525 | 2708 | 2610 |
| 2 (16 cm) | 1934 | 1772 | 1936 | 1888 | 1754 |
| 3 (24 cm) | 986 | 969 | 973 | 970 | 899 |
| 4 (32 cm) | 589 | 593 | 581 | 590 | 590 |
| 5 (40 cm) | 349 | 393 | 349 | 294 | 388 |

**Figure 7.** Relationship between length and frequency

Through Table 1 it appears that each frictional position of the string produces different sound frequencies. When the wooden bend is rubbed on the rebab string at 5 different positions from the shortest to the long, the effective length of the vibrating string is extended. Thus the frequency and pitch becomes lower due to the longer wavelength. In this experiment, the strings on the rebab produce different sounds due to different friction positions [10]. The shorter the length of the string, the shorter the wavelength of the sound, the higher the sound frequency [11]. That is, the wavelength is inversely proportional to the frequency of sound produced. Therefore, the frequency of sound depends on the position of the string friction.

The results of this study correspond to the physics concept in which to determine the frequency \( f \) of each vibration, use \( f = \frac{v}{\lambda} \) and seen
\[ f_n = \frac{V}{\lambda_n} = n \frac{V}{2L} \text{ where } n = 1, 2, 3, \ldots \]

where \( f_1 = \frac{v}{\lambda} = \frac{v}{2L} = nf_1 \) is fundamental frequency. It can be seen that each resonant frequency depends on the fundamental frequency and the length of the vibrating string [12].

3.3 Student’s Responses

Based on student participation observation and student comments through interview, there are some responses during physics learning using Gamelan and smartphone, among others:

1) When the first time researchers start learning with this method, students are very enthusiastic and want to know how to use the gamelan in learning.
2) Initially many students who do not know various kinds of gamelan instruments, but after learning, all students become know and even understand how to play every instrument Gamelan.
3) Before learning, students cannot imagine how the waveform, but with this learning, students are no longer difficult to imagine.

From the description formed means learning by using Gamelan and smartphones not only give good response for students, but also make learning more meaningful.

4. Conclusion

From this study can be concluded that: (1) the nodes-antinodes standing acoustic waves in musical instrument of the Gamelan can be drawn based on the results of video recording; (2) the form of sound waves for each Gamelan’s instrument can be see using the Oscope apps; (3) relationship between frequency and length is inversely proportional; and (4) very good student’s response with that learning.

5. Acknowledgements

The authors would like to thank the students, physics teachers and headmaster of senior high school in SMAN 1 Mojolaban, Sukoharjo, Central Java, Indonesia. We also would like to thank Mr Sarwanto who has guided the use of gamelan instruments. Finally, we thank to the Physics Education of Graduate Program, Sebelas Maret University, Indonesia.

6. References

[1] Sutrisno 2016 Fisika dan Pembelajarannya UPI
[2] Gredler 2013 Learning and Teaching Ohio Merril Prentice Hall
[3] Park S.J 2004 Physics Education in Cultural Context: Issues, Approaches, and Perspectives Phys. Educ. 101 252407
[4] Baker et al. 1995 The Effect of Culture on the Learning of Science in non-Western Countries: The Results of a Integrated Research Review Scie.Educ 17 123
[5] Gilbert J. K 2008 Visualization: An Emergent Field of Practice and Enquiry in Science Education Scie. Educ. 95 3-24
[6] Mishra, P. Koehler 2006 Technological pedagogical content knowledge: a framework for teacher knowledge Teach. Colledge Record. 108 6 1017-1054
[7] Kuhn J and Vogt P 2013 Analyzing acoustic phenomena with a smartphone microphone Phy. Teach. 51 118
[8] Douglas C, Giancoli 2001 Physics 55 3049
[9] Sumarsam 2003 Gamelan Interaksi budaya dan perkembangan musikal di Jawa Yogyskarta Pustaka Pelajar
[10] Egeland 2009 An investigation on the influence of the position and method of plucking a guitar string for the sidtribution of energuu between fundamental tone and overtones Phys. Teach. 504 04 2-7
[11] Gunther 2012 *The physics of music and color* New york Springer
[12] Serway A. Raymond 2004 *Physics for scientists and engineer* California Thomson Brooks