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Using Sundanese Musical Instrument and Audacity Software to Learn About Sound Waves

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Abstract.
Integrating local culture into classes can build meaningful experiences for the students. Suling is a musical instrument originating from West Java's dominant Sundanese culture and can be an alternative learning medium for teaching sound wave subjects. Using technology can facilitate understanding concepts for students. The Audacity software can help students analyze the spectrum and frequency of the sound produced by Suling. This study aimed to investigate the measurement of the frequency and spectrum of Suling with four and six holes and to analyze the potential for integrating local culture and technology in science learning. The type of research was descriptive to provide an overview of a symptom, event, and actual situation. We used a microphone and Audacity on the computer and each musical instrument in Suling. The study's results showed that spectrum analysis has a similar pattern in Suling four and six holes and almost had similar frequencies. Local culture has the potential to be implemented in science learning, and technology facilitates students' understanding of concepts. Suling and Audacity can be used as a learning media for a junior high school practicum on a sound wave subject.

Keywords: Sundanese Musical, Instrument and Audacity Software, Sound Waves

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1. INTRODUCTION

Physics as part of natural science is often considered difficult for many students. Some literature states that students think physics is conceptually complex and abstract [1, 2]. Appropriate teaching strategies are needed so that students assume that physics is easy to understand and can achieve higher academic achievement. Previous research found that students' experiences related to concrete such as the application of physics concepts in daily application can create meaningful learning [3, 4]. Meaningful learning can improve students' thinking skills [5]. Creating fun learning activities by applying physics concepts in the environment around students can attract students' interest in the learning process [6]. The local culture in the student environment can build a meaningful learning process [7].

Indonesia is a big country consisting of many ethnic groups and has various local cultures that have the potential to be integrated into science learning. Previous studies explain the concept of thermal physics by showing the process of making *Batik* [8]. Traditional games have also described the concept of mechanics [9, 10]. Also, dance and traditional performances can explain mechanics concepts to students [9].

West Java is a province in Indonesia with Sundanese culture dominant and unique works of art, culture, and subculture. One of the famous works of art is *Karawitan* which requires a set of musical instruments known as *Gamelan* [10]. *Suling* is one of the gamelan instruments as a wind instrument, similar to the flute. *Suling* has five scales, which include the following numbered instruments such as *da* (1), *mi* (2), *na* (3), *ti* (4), and *la* (5)[11]. Traditional musical instruments can facilitate students' conceptual understanding of sound waves [12]. *Suling,* as a musical instrument, can be used as an example of applying the concept of sound waves. *Suling* is based on physics principles [13] and can be adapted as a learning media to teach sound waves and resonance in open pipes [14].

Rapid technological developments have affected the learning process. The use of technology can make students more interested in the learning process [15]. Using technology is essential to bring students closer to the sound produced by traditional musical instruments. *Audacity* is an advanced tool that can be adapted because the software is suitable for teaching and helping students understand the signal of voice and noise [16]. *Audacity* software has measured the frequency of *Gamelan* and *Bonang* [17] as Central Java musical instruments.

This study uses learning activities that combine science and technology with local culture. Local culture of *Suling* as Sundanese musical instruments and *Audacity* software as an advanced tool can analyze the sound waves generated from the *Suling*. This study aims to investigate the measurement of the frequency and spectrum of *Suling* with four and six holes and to analyze the potential for integrating local culture and technology in science learning.

2. RESEARCH METHOD

The research design of this study is descriptive research. This study's descriptive research aims to observe, describe, and document actual situations and determine the relationship between variables based on events that occur when the *Suling* is blown and produces sound. [18]. The study measured the frequency and analyzed the waveform of each number of instruments from *Suling*. The place of the research is in *Ade Suparman's Studio*. Furthermore, this study's research objects are *Suling* with four and six holes. Learning activities use *Audacity* software as an advanced tool to analyze spectrum and frequency. The implementation process is shown in Figure 1.

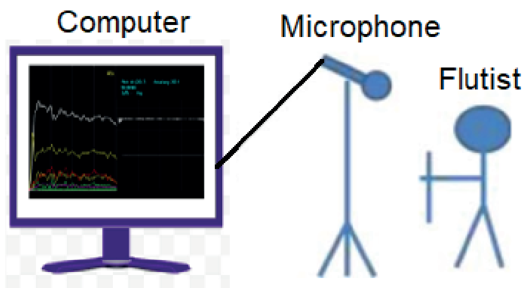


Figure 1: The implementation process.

Figure 1 provides an overview of the experimental design in the implementation process. A microphone to capture sound is placed near a musical instrument and connected to a computer with sound processing software [19]. Prosedur of this experiment, First, Turn on the computer, install Audacity Software, and connect a microphone to the computer. When the flutist plays the *Suling*, the microphone picks up the sound and connects it to software that records and measures frequencies and waveforms. The software used is Audacity.

The intensity and time of the signal were measured using Audacity software. Then, analyze the dominant frequency of each number instrument using The *Fast Fourier Transform* (FFT). The measurements repeat to determine the mean and standard deviation of the frequencies. The notes obtained from the *Suling* are pentatonic, which means the instrument has five notes, they are *da* (1), *mi* (2), *na* (3), *ti* (4), and *la* (5).

3. RESULTS AND DISCUSSION

Data collected are spectrum analysis and frequency based on the implementation process results. This study uses two types of Suling that have four and six holes. Suling with 4-holes is a simplification of 6-holes [13]. The representation of the condition finger when playing Suling in each number instrument is shown in Table 1.

The microphone receives the sound from each instrument. Sound waves produced from Suling are analog signals that a device like a microphone can measure. A microphone converts the acoustic vibrations to electrical signals [20]. An analog-to-digital converter (ADC) converts an analog signal into a digital representation on a computer.

A digital signal of each instrument is shown in Figure 2. Changing the analog signal into a digital representation can be used in a computer.

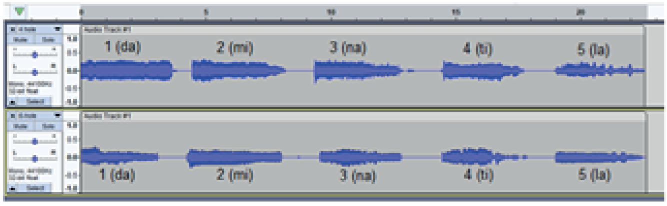
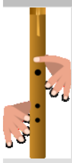
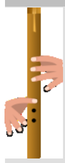
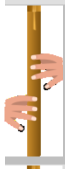
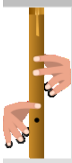
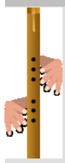
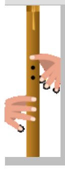


Figure 2: Input signal in a computer.

Table 1: Condition of finger holes in each instrument number.

Instrument Number	Position Finger	
	4-holes	6-holes
da (1)		
mi (2)		
na (3)		
ti (4)		
la (5)		

A digital signal consists of discrete values sampled at fixed time intervals. The representation is in the time domain [21]. You can convert a digital signal to the frequency domain to display the spectrum or spectrum analysis. An approach to spectrum analysis that can use is *Fourier* analysis. The implemented of analysis approach by an algorithm known as *Fourier Transform* (FT). Applying the FT that converts the music signal from the time domain to the frequency domain can also show the musical tone's harmonics.

The input signal shown in Figure 2 can be extracted based on the segment to be analyzed, as shown in Figure 3.

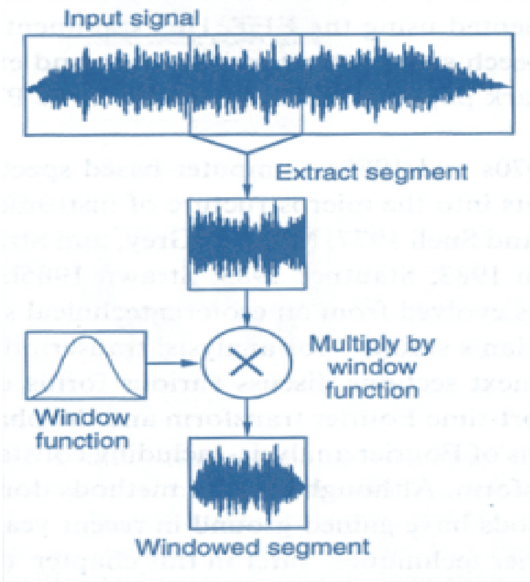


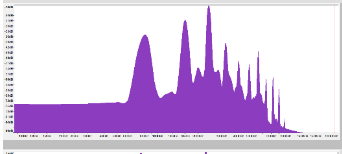
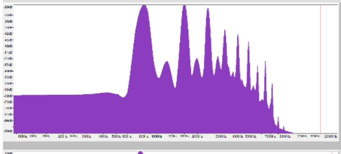
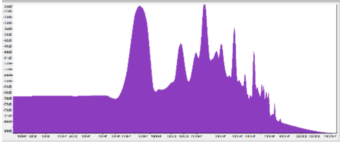
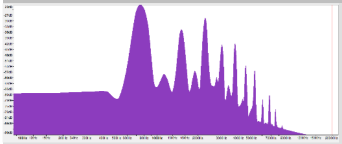
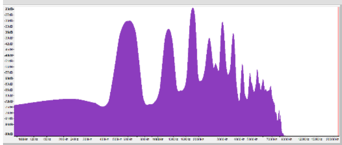
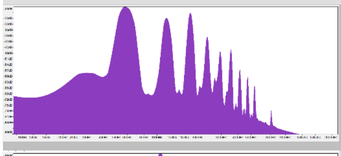
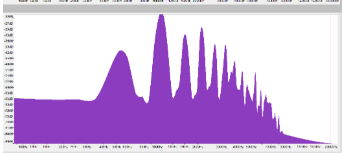
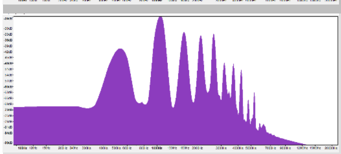
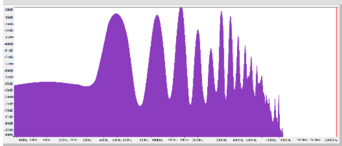
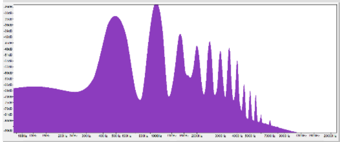
Figure 3: Process input signal into windowed segment.

3.1. Spectrum Analysis

One type of FT is The *Fast Fourier Transform* (FFT). The FFT is more efficient and is often used to implement the FT on digitized signals [22]. The basic premise of the FFT algorithm is that the signal is periodic and indefinite. However, the frame discontinues if the signal in a particular analysis window does not have the exact period [23]. Using the windowed function to minimize these discontinuities. *Hamming*, *Gauss*, and *Blackman* are the type of windowed functions [24]. The windowed functions used in this study are the *Hamming,* as shown in Table 2.

Data processing is carried out from spectrum analysis with *Hamming* function to facilitate analysis in this study. The result spectrum analysis is shown in Figure 4. The result in Figure 4(a) shows that the Suling with 4-hole has the highest intensity at a frequency in the range of 2.0-3.0 x 10^3 Hz, which is *da* (1). The frequency is increased, causing the intensity to decrease. The analysis did not find a trend pattern for each instrument number on the *Suling* with 4-hole. And result study for *Suling* with 6-hole in Figure 4(b) has the highest intensity in the frequency range of 0.0-1.0 x 10^3 Hz with the number instrument is *da* (1). The spectrum analysis result can be interpreted that the FFT for Suling 4 and 6-holes almost have a similar pattern. Increasing frequency affected intensity decreases.

TABLE 2: The *Fast Fourier Transform* (FFT) of each instrument number.

Instruments Number	Sundanese Flute	
	4-holes	6-holes
da (1)		
mi (2)		
na (3)		
ti (4)		
la (5)		

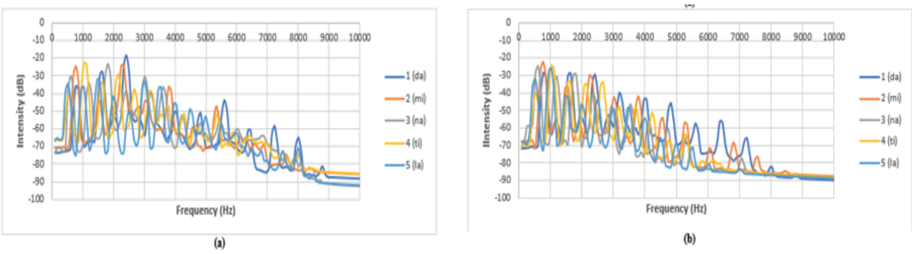


Figure 4: *Fourier Transform* (FT) of the spectrum (a) 4 holes and (b) 6 holes.

Figure 4 shows that the 4-hole and 6-hole have a similar pattern, with no trend for each number instrument in the *Suling* with 6-hole. The pattern in *Suling* with four-hole and six-hole found that the number instrument *da* (1) had a higher intensity than the other instrument number. The results show similarities between each instrument in *Suling* with 4 and 6-holes and have little difference. The differences can be assumed due to the characteristics of instrument changes caused by different times of measurement [19].

3.2. Frequency Analysis

The FFT analysis selected the dominant frequency of *Suling* as the highest intensity frequency. In the screen, a red cursor is a tool for displaying the dominant frequency. Sound frequency measurement is the number of sound vibrations occurring during a time. *Suling* is a learning media to facilitate understanding of open cylindrical column of air concepts. The blown air vibrates in the column, causing resonance in the *Suling* column [25]. The frequency of *Suling* in each instrument is different, as shown in Table 3. In table also shows the result study comparing *Suling* measurements with different methods.

TABLE 3: Result of fundamental frequency.

Instrument Numbers	**Frequency Flute (Hz)**		
	Four holes	**Six holes**	**Sari (2017)** [26]
1 (da)	805	804	812
2 (mi)	766	758	756
3 (na)	617	594	593
4 (ti)	538	533	522
5 (la)	497	495	493

Table 3 shows that the frequency measurements have similar to the references. This frequency measurement was different, such as the type of *Suling*, flutist, and methods. Generally, the fundamental frequency of the Suling with four holes is higher than that of the *Suling* with six holes. The trends in *Suling* are shown in Figure 5.

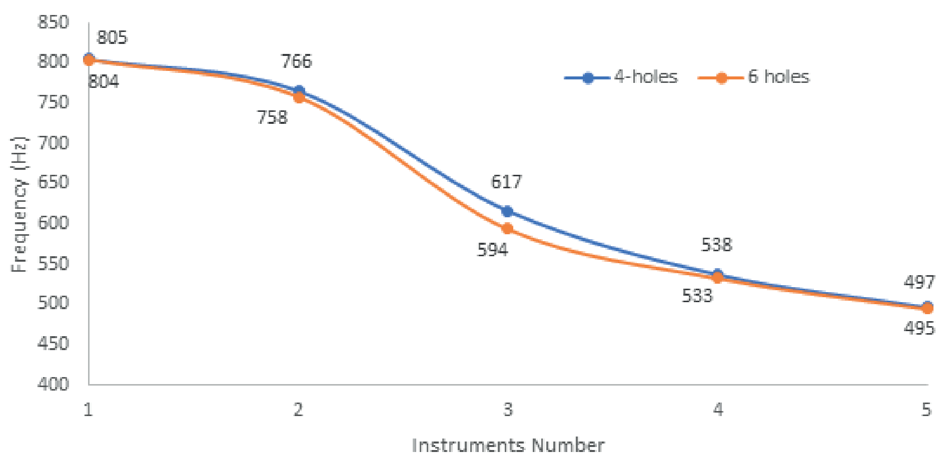


Figure 5: Graph comparison of the fundamental frequency of *Suling* with 4 and 6-holes.

Figure 5 shows that trend of pattern increasing in the *Suling* is almost similar, and the frequency of the *Suling* with four holes is higher than the six holes. The six-hole flute has a length of 55 cm, while the four-hole flute has a length of 35cm, which means that the six-hole flute is longer than the 4 hole flute. The *Suling* with 6-hole has a greater column longer than the 4-hole. The relationship between column length and frequency is inversely proportional. If the column length is longer, it means low frequency. Also, the shorter the column length, the higher the frequency. Therefore, the *Suling* with four-hole has a higher frequency than the six-hole.

3.3. Potential Local Culture and Technology in Science Learning

The local culture as a learning environment can build meaningful learning for students [27]. *Suling* is a traditional musical instrument original to Sundanese culture. The musical instruments are familiar, and students must have seen or played *Suling* in the art subject. *Suling* as a wind musical instrument can be an alternative learning media in science learning [28]. *Suling* can facilitate students' understanding of sound and resonance concepts and wave propagation in open cylindrical column air. The rapid technological progress of the times requires the learning process to be able to integrate technology. *Audacity* software as a technology can help design experimental tools and determine the value of the speed of sound, both frequency and amplitude [29]. The software can facilitate students analyze the frequency properly. *Audacity* can measure the sound-produced frequency and the sound intensity produced by the source [16]. The level of sound intensity produced significantly differs because the air in the environment is not constant, thus affecting the intensity of the sound produced.

Using *Audacity* software as technology in science learning gives the advantage to teachers. This software is suitable for learning media in science learning and encourages students to learn with high motivation because of their interest in multimedia systems capable of presenting animation, sound, graphics and text display [30]. Using technology has a positive impact on students [31]. *Audacity* software is adaptable to help analysis of sound waves. *Audacity* software has been used in science learning, especially physics material [32]. The rapid development of science and technology can help teachers combine local culture and technology in science learning. Local culture has the potential to be implemented in science learning and technology facilitates students' understanding of concepts. Further research can use local culture in certain areas or use other tradisional musical instrument. Then, integrate technology to create meaningful learning.

4. CONCLUSION

Local culture of *Suling* as Sundanese musical instruments and *Audacity* software as an advanced tool can analyze the sound waves generated from the *Suling*. *Audacity* can facilitate the analysis of Suling's spectrum and frequency and can be an alternative to use in practicum sound waves. *Suling* can be an alternative learning media when teaching sound concepts. The study's results show that spectrum analysis has a similar pattern in *Suling* four and six holes and almost has similar frequencies. A combination of science and technology with the local culture can be adapted as a learning media in practicum on sound wave material, especially for Junior high school. Further research can use local culture in certain areas or another traditional musical instrument combined with technology to build meaning learning environment.

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