Analysis of physics parameters on aerophone musical instruments from Minangkabau as context meaningful learning

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Abstract. The scientific context as part of scientific literacy becomes the need to apply 21st century skills in learning physics according to the 2013 curriculum. The fundamental problem in this study is the ability of prospective teacher students to design scientific context in the physics material for senior high school grade XI is not optimal despite using a variety of literature and media. This has an impact on student mastery of all physics material of grade XI is still low. The solution offered is the provision of learning resources sourced from local wisdom. The Minangkabau musical instruments are one of the tangible local wisdom related with the physics material for senior high school grade XI, namely sound waves. The purpose of this study was to analyze of physics parameters for aerophone musical instruments from Minangkabau as context of meaningful learning. The type of research to be conducted is qualitative research. This research just arrived at the stage of data analysis Visual Analyser. The aerophone musical instruments from Minangkabau analyzed for physics parameters are "pupuik batang padi", "bansi", "sampelong", and "saluang". Data collection in this study uses the analysis of the results of the Visual Analyzer simulation and Focus Group of Discussion (FGD). The data analysis technique used is qualitative with three components, namely: data reduction, data presentation, conclusions and verification. The results of the analysis showed that "pupuik batang padi", "bansi", "sampelong", and "saluang" can be categorized into open ended pipes but bansi can be categorized into closed ended pipes according fundamental frequency detected by VA. The conclusion of the research shows that parameters of physics on aerophone musical instruments from Minangkabau fulfill one of the attributes of meaningful learning, namely learning is a process of experiencing because it is related to the natural context and the ability to adapt to the surrounding environment.

1. Introduction
The scientific context as part of scientific literacy becomes the need to apply 21st century skills in learning physics according to the 2013 curriculum. Learning of physics in schools and in universities is emphasized in efforts to understand the concept of physics through the process of internalization in students to be able to solve the problems they face [1]. Physics education students as teacher candidates must be able to relate physics material and problems from natural phenomena that occur. Physics for High School Physics Grade XI as compulsory subjects supporting educational competencies have a learning outcome in which students are able to study physics materials according to their characteristics, implement them in digital technology-based learning, and communicate them
easily, effectively, and efficiently. The learning outcome achievement can be seen from the results of the following questionnaire analysis. First, only 21.54% of students had mastered all physics material in class XI correctly before presenting the material. Second, more than 84% of students have been able to design and implement learning scenarios with models that are recommended by the 2013 curriculum. Third, only 43.08% of students are able to design real problems for all physics materials in class XI when starting the application of learning models recommended by the 2013 curriculum. Fourth, 61.54% of students are able to study the material of physics in accordance with their characteristics from a variety of literature and media.

Facts on the ground show that the fundamental problem is the ability of prospective teacher students to design real problems in physics for high school grade XI not optimal despite using a variety of literature and media. This has an impact on student mastery of all physics material class XI is still low. The solution offered is the provision of learning resources sourced from local wisdom. The manifestation of local wisdom can be categorized into two aspects, namely local wisdom tangible and intangible [2]. Traditional musical instruments are one of the local wisdoms associated with Class XI physics material, namely sound waves. Physics parameter analysis is limited to traditional aerophone minangkabau musical instruments using Visual Analyzer (VA).

VA is software designed by A. Accattatis and can be downloaded freely on the website (http://www.sillanumsoft.org). The results of the analysis of physics parameters of a traditional Minangkabau type of aerophone can be used as a reference for prospective teachers to involve students in meaningful learning. Active, constructive, cooperative, authentic, and intentional learning of students in meaningful complex problems is a representation of 21st century skills [3]. Ausabel and Novak suggest the goodness of meaningful learning, namely: (a) information that is learned meaningfully takes longer to remember than rote learning, (b) facilitates subsequent learning processes for similar things due to assimilation of new knowledge [4]. This study aims to analyze the physics parameters of a traditional Minangkabau type of aerophone as a meaningful learning context.

2. Research Methods
This type of research is qualitative research. The traditional musical instruments used as objects in this study were pupuik batang padi, bansi, sampelong, and saluang. The study was carried out during July 2019 using the preparation phase, the stage of collecting and analyzing VA data as the research stage. The preparation phase begins by identifying musical instruments, VA software, and audio recording. Meanwhile, the VA data collection stage is carried out in the form of simulating VA data and reducing wave physics parameter data. Data analysis techniques in qualitative research consist of three components, namely data reduction, data presentation, conclusions and verification [5]. Reducing data means summarizing, choosing the main points, focusing on the things that are important, looking for themes and patterns and removing unnecessary. Presentation of data is a collection of structured information that gives the possibility of drawing conclusions. Conclusion or verification is the final stage in the data analysis process.

3. Result and Discussion
The VA can produce the measurement frequency of fundamental on aerophone musical instruments so that harmonic series of sound wave are the following.

3.1. Harmonic Series of Sound Waves in an Pupuik Batang Padi
The result of measurement fundamental of frequencies on Pupuik Batang Padi use VA display multiple peak of frequency spectrum on the VA window as shown in Figure 1 and analysis result on its fundamental frequency shown in Table 1.
Figure 1. Example of Frequency Spectrum on VA window for harmonic series experiment in Pupuik Batang Padi with fundamental frequencies is 940 Hz, 1420 Hz, 1890 Hz, and 2360 Hz

Table 1. Analysis Result on Fundamental Frequency Sample from the VA Snapshots for Pupuik Batang Padi

| Length of Musical Instruments | Analysis Result on Fundamental Frequency | Overtones in Pipe |
|------------------------------|------------------------------------------|------------------|
| $f_0 = 2360\,\text{Hz}$     |                                          |                  |
|                              | $\lambda = \frac{v}{f} = \frac{340\,\text{m/s}}{2360\,\text{Hz}} = 0,144\,\text{m} = 14,4\,\text{cm}$ |                  |
|                              | $\ell = \frac{\lambda}{2} = \frac{14,4\,\text{cm}}{2} = 7,2\,\text{cm}$ |                  |
| *) opened organ pipe         |                                          |                  |
|                              | from sound generated analysis result = SUITABLE with measurement length |                  |
| *) closed organ pipe         |                                          |                  |
| $\ell = \frac{\lambda}{4} = \frac{14,4\,\text{cm}}{4} = 3,6\,\text{cm}$ |                  |
|                              | from closed end                          |                  |
|                              | analysis result = NOT SUITABLE with measurement length |                  |

Table 1 shows that the distance of the knot formation from the sound source is 7 cm based on the calculation results and 7 cm based on the measurement results for the 2360 Hz base pitch frequency of pupuik batang padi. Pupuik batang padi has the same characteristics as an open organ pipe.

3.2. Harmonic Series of Sound Waves in an Bansi

The result of measurement fundamental of frequencies on Bansi use VA display multiple peak of frequency spectrum on the VA window as shown in Figure 2 and analysis result on its fundamental frequency shown in Table 2.
Figure 2. Example of Frequency Spectrum on VA window for harmonic series experiment in Bansi with fundamental frequencies is 650 Hz, 1280 Hz, 1930 Hz, 3210 Hz and 4500 Hz

Table 2. Analysis Result on Fundamental Frequency Sample from the VA Snapshots for Bansi

| Length of Musical Instruments | Analysis Result on Fundamental Frequency | Overtones in Pipe |
|-----------------------------|------------------------------------------|------------------|
| $f_0 = 4500\text{Hz}$     | $\lambda = \frac{v}{f} = \frac{340\text{m/s}}{4500\text{Hz}} = 0,075\text{m} = 7,5\text{cm}$ | *) opened organ pipe |
|                             | $\ell = \frac{\lambda}{2} = \frac{7,5\text{cm}}{2} = 3,75\text{cm}$ | from sound generated analysis result = NOT SUITABLE with measurement length |
|                             |                                          | *) closed organ pipe |
|                             | $\ell = \frac{\lambda}{4} = \frac{7,5\text{cm}}{4} = 1,875\text{cm}$ | from closed end analysis result = SUITABLE with measurement length |

Table 2 shows that the distance of the knot formation from the closed end is 1,875 cm based on the calculation results and 1.5 cm based on the measurement results for the 4500 Hz base tone frequency of bansi. Bansi has the same characteristics as a closed organ pipe.

3.3. Harmonic Series of Sound Waves in an Sampelong

The result of measurement fundamental of frequencies on Sampelong use VA display multiple peak of frequency spectrum on the VA window as shown in Figure 3 and analysis result on its fundamental frequency shown in Table 3.
The 2nd International Conference on Research and Learning of Physics
IOP Conf. Series: Journal of Physics: Conf. Series 1481 (2020) 012109
doi:10.1088/1742-6596/1481/1/012109

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Figure 3. Example of Frequency Spectrum on VA window for harmonic series experiment in Sampelong with fundamental frequencies is 540 Hz, 840 Hz, 1090 Hz, and 1180 Hz

Table 3. Analysis Result on Fundamental Frequency Sample from the VA Snapshots for Sampelong

| Length of Musical Instruments | Analysis Result on Fundamental Frequency | Overtones in Pipe |
|-------------------------------|------------------------------------------|------------------|
| $f_0 = 540Hz$                | $\lambda = \frac{v}{f} = \frac{340m/s}{540Hz} = 0,6296m = 62,96cm$ |                  |
|                               | $\ell = \frac{\lambda}{2} = \frac{62,96cm}{2} = 31,48cm$ |                  |
|                               | ) opened organ pipe                      |                  |
|                               | $\ell = \frac{\lambda}{4} = \frac{62,96cm}{4} = 15,74cm$ |                  |
|                               | ) closed organ pipe                      |                  |

Table 3 shows that the distance of the node formation from the sound source is 31.48 cm based on the calculation results and 31 cm based on the measurement results for the basic tone frequency of 540 Hz from the sampelong. Sampelong has the same characteristics as an open organa pipe.

3.4. Harmonic Series of Sound Waves in an Saluang

The result of measurement fundamental of frequencies on Saluang use VA display multiple peak of frequency spectrum on the VA window as shown in Figure 4 and analysis result on its fundamental frequency shown in Table 4.
Figure 4. Example of Frequency Spectrum on VA window for harmonic series experiment in Saluang with fundamental frequencies is 130 Hz, 200 Hz, 410 Hz, and 510 Hz

Table 4. Analysis Result on Fundamental Frequency Sample from the VA Snapshots for Saluang

| Length of Musical Instruments | Analysis Result on Fundamental Frequency | Overtones in Pipe |
|------------------------------|------------------------------------------|-------------------|
| $f_0 = 410\text{Hz}$         | $\lambda = \frac{v}{f} = \frac{340\text{m/s}}{410\text{Hz}} = 0.8292m = 82.92\text{cm}$ |          |
|                               | *) opened organ pipe                      |          |
|                               | $\ell = \frac{\lambda}{2} = \frac{82.92\text{cm}}{2} = 41.46\text{cm}$ from sound generated |          |
|                               | *) closed organ pipe                      |          |
|                               | $\ell = \frac{\lambda}{4} = \frac{82.92\text{cm}}{4} = 20.73\text{cm}$ from closed end |          |
|                               | analysis result = **NOT SUITABLE** with measurement length |          |

Table 4 shows that the distance of the node formation from the sound source is 41.46 cm based on the calculation results and 40 cm based on the measurement results for the 410 Hz base tone frequency from saluang. Saluang has the same characteristics as an open organa pipe.

The results showed that the basic tone frequency of traditional aerophone musical instruments changes with the location of the knot. Of the four musical instruments used as research objects where the comparison of the results of calculations and measurements through VA software is appropriate. VA software is effectively used to reveal the physics parameters of sound waves in tubes and gamelan instruments. Demonstration of physics parameters of sound waves on plastic tubes using VA software shows that the speed and frequency have met the standard [6]. the frequency of the sound wave series in PVC resonance tubes with three variations, namely both ends of the open tube, one end open, and both ends closed have shown accurate results for $v$ with an error percentage of 1.91% when compared to the standard value [7]. In addition, VA software is well used to measure sound intensity due to the intensity (dB) displayed in this device with the accuracy of two digits behind the comma so that the level of accuracy of the software is high in measuring intensity (dB) [8].

The results also showed that pupuk batang padi, sampelong, and saluang can be categorized into open organa pipes while bansi is categorized into closed organa pipes. The traditional type of
aerophone is tangible local wisdom. Exploration of the sublime richness of the nation's culture that contains local wisdom is very necessary to be done in order to remain sustainable. This traditional musical instrument can be used as a scientific context of physics learning so that it becomes more meaningful. This is because of the ability to learn and adapt to the environment. Wisdom integration into subjects will foster an environmentally friendly character that can be transmitted to prospective teachers and students [8]. In addition, active involvement of students in manipulating objects and environments and observing the results can produce a meaningful learning experience [9].

4. Conclusion
Physics parameters of the traditional Minangkabau musical instrument analyzed were the frequency of the basic notes of the instrument. The frequency of the basic tone is varied by varying the location of the vertices through the addition of holes in each of these tools. Parameters of physics on aerophone musical instruments from Minangkabau fulfill one of the attributes of meaningful learning, namely learning is a process of experiencing because it is related to the natural context and the ability to adapt to the surrounding environment.

Acknowledgement
This article is the result of a research by novice lecturers funded by the Universitas Negeri Padang in 2019. The authors also thank's to the musicians of traditional Minangkabau.

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