Teaching wave concepts using traditional musical instruments and free software to prepare prospective skillful millennial physics teachers

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Abstract. This study aims to show the basic concepts of wave through traditional musical instruments integrated with computer-based software and smartphones, as well as to find out the profile and improvement of students' science process skills. The design of inquiry-oriented learning activities is guided by science process skill worksheets that involve the exploration of traditional musical instruments and software. Traditional musical instruments used are stringed instruments (Gambo Mbojo), wind instruments (Sundanese flute), and membrane instruments (Rebab), while the software used is Adobe Audition, Zelscope, MacScope II, LiteChromatic, Spectrum Advenced, and Spear. The students studied were 32 prospective physics teacher students enrolled in the wave course. Data collection was carried out by means of literature study and tests. The test kits use multiple choice science process skills (SPS-tests). The data was statistically analyzed using the mean difference test (paired sample t-test) with normalized gain determined by the hake factor (\( N_{gain} \)). Based on the results of the research, it was concluded that the learning design of the traditional musical instrument and free software can increase the quality of the process of physics learning which is indicated by the achievement of students science process skills which significantly increase between before and after learning activities.

1. Introduction
Prospective millennial physics teacher are required to be able to follow the development of science and technology while upholding the national character, so they need to have adequate skills and cognitive abilities. Teaching and learning of science (physics) according to its nature can be used as a forum to develop the domain of attitudes, knowledge, and skills [1]. Therefore it is very much needed an innovative teaching that accordance with the demands of the development of science and technology without leaving a character that reflects identity or national identity.

Most physics teacher candidates already have and use technology products such as smartphones and computers/laptops, but their implementation in physics learning activities is not optimal. On the other hand, local resources are increasingly being eroded [2,3]. Therefore, physics teacher candidates
are expected to have the competence to utilize, empower, and manage technology products, as well as the local wisdom as a source/learning material as well as an effort to preserve local culture.

The design of physics learning and teaching strategies based on technology and local wisdom is one of the concepts deemed suitable to make a physics teacher candidates in the millennial era. Through this concept, prospective physics teachers will be able to gain learning experience and the ability to design and implementing technology-based learning, local wisdom-based, and innovative strategies/methods of active learning in classrooms or laboratories, so that they can eventually develop competencies to build new paradigms about learning design innovative technology-based and local wisdom.

One of the important principles in teaching physics should provide opportunities for students to gain hands-on experience through investigate/experimentation with the inquiry process [1] so that students can form their science process skills. This is also supported by the results of research [4] that a guided inquiry approach with a practicum model can improve science process skills and the ability of students to think critically.

Some basic and integrated science process skills that need to be developed for students at least in the aspects of infering, predicting, determining variables and its defining, classifying, designing experiments, designing tables and graphs, up to communicate [5]. In reality the science process skills of students are still very low, this is expressed by [6]. Likewise also [7] revealed that the average ability of science process skills students in the City of Jambi, Indonesia is still relatively low. Meanwhile [8] shows that the science process skills of Senior Secondary School students in West African-Negeria in the period of 10 years (1998-2007) are also still low.

In teaching physics the subject of wave, students still rarely experience direct learning through experiments in investigating the phenomenon of waves that occurred in traditional musical instruments and using a computer or smartphone as a learning media, whereas [9] said that examples of musical instruments and computers can be used as material physics learning. Similarly [2] studies and states that Sundanese flute as a traditional wind instrument can be used as a tool of physics learning about the system of open pipes organa. Meanwhile [10] revealed that computer and mobile devices can be used to help visualize wave characteristics. The traditional musical instruments raised in this article are Gambo, Sundanese Flute, and Rebab.

Based on the background of the problems above, the purpose of this study is to show the basic concepts of wave material physics that can be learned through traditional musical instruments integrated with computer-based and smartphone-based software, and to find out the profile and improvement of students science process skills.

2. Methods
The subjects in this study were 32 physics teacher candidates who were enrolled in the wave course at the Muhammadiyah University of Mataram in West Nusa Tenggara Province-Indonesia. This type of research is a case study and quasi-experimental one group pretest-posttest design. Data collection is done by means of documentation and tests. Measurement of the achievement of science process skills using multiple choice test questions (SPS-tests) that have met valid and reliable requirements. The data of subject response is shown in percentages and analyzed in descriptive quantitative. SPS pretest and posttest data were analyzed statistically using a paired t-test with significant criteria in Sig. (2-tailed) \(< \alpha: 0.05\) or \(t_{\text{count}} > t_{\text{table}} (\alpha, \text{df} = n-1)\) and normalized gain with criteria \(\geq 0.70\) (high), \(0.70 > \text{N-gain} \geq 0.30\) (moderate), and \(< 0.30\) (low) [11].

3. Result and Discussion
3.1. Exploration of the concept of physics in traditional musical instruments.
The basic concepts of waves that can be learned through the phenomenon of traditional musical instruments consist of the concept of waves in the string system, the air column system, and the membrane system. The shape of a traditional musical instrument is shown in Figure 1.
Meanwhile free applications and free software used to acquire data of phenomena in traditional musical instruments include Zelscope (http://www.Zelscope.com), MacScope II (https://physics2000.com/Pages/MacScope.html), Adobe Audition (https://www.Adobe-Audition.shtml), Advanced Spectrum[pro] (www.vuche.com), Spear (http://www.klingbeil.com/spear/), and LiteChromatic (https://store/apps/LiteChromatic= en).

The basic concepts related to the phenomenon of vibration, waves, and sound that can be built through learning activities on traditional musical instrument components with a data acquisition system using free computer software and smartphone applications are shown in Table 1.

Table 1. The basic concepts of vibration, waves, and sound in the phenomenon of traditional musical instruments

| No. | Types of traditional musical instruments | Learning objectives |
|-----|------------------------------------------|---------------------|
| 1   | Gambo | Learning Objective 1: Describe the definition of vibration-waves and the definition of various physical quantities on the concepts of vibration, waves, and sound. Learning Objective 2: Describe wave properties. Learning Objective 3: Develop the concept of natural resonance in the string system that is bound at both ends. Learning Objective 4: Construction of concepts about the laws of Melde and Mersenne. Learning Objective 5: Develop the concept of wave propagation speed as a function of medium temperature. |
| 2   | Sundanese Flute | Learning Objective 1: Represent and describe waves and various physical quantities as mathematical functions. Learning Objective 2: Describe wave properties. Learning Objective 3: Construction the concept of natural resonance in the air column that is closed or open at both ends. Learning Objective 4: Construct the concept of the functional relationship of the length of the pipe to the frequency or wavelength, and the functional relationship between the diameter of the pipe to the frequency. Learning Objective 5: Construction of the concept of wave propagation speed in the air medium. Learning Objective 6: Construction of the Doppler effect concept. |
| 3   | Fiddle | Learning Objective 1: Establish the concept of the effect of membrane diameter on frequency. Learning Objective 2: Building the concept of natural resonance of membrane vibrations. |
Through laboratory inquiry activities in various phenomena of traditional musical instruments, scientific process skills can be well trained, ranging from observation, inferring, hypotheses, predictions, designing experiments, make a tables and graphs, to communicating findings collaboratively and cooperatively. On the other hand mastery of concepts can be increased because in this activity is a construction concept.

3.2. Profile and improvement of science process skills
Before treatment using Gambo media, free software, and the teaching and learning process, achievement in every aspect of SPS was only at an average achievement of 18.18%, indicating that the SPS domain of prospective Physics Teachers was still relatively low. However, after being taught with strategies that have been designed using traditional musical instruments and free software as well as through inquiry activities the science process skills of students increased to an average of 58.33% classically, and showed the criteria for an increase of "Medium". The achievement of each aspect of the measured science process skills is shown in Figure 2. The acquisition of SPS test data before and after learning is in a normal and homogeneous distribution so that the paired sample t-test mean difference test obtained by the Sig. (2-tailed) < 0.05 or t<sub>count</sub> (3.56) > t<sub>table</sub> (2.04) which shows that there are significant differences in SPS achievement before and after learning activities using traditional musical instruments and free software.

![Figure 2. Comparison of SPS-Skills achievements before and after treatment.](image)

Meanwhile, it is also known that the \( N_{\text{gain}} \) achievements for each aspect of prediction (0.714) and identification of variables (0.702) are in the "high" category, while the other aspects are in the "medium" category. The low initial SPS acquisition was due to the most of students who did not understand the meaning and definition of every aspect of SPS from a scientific point of view. For example in the aspect of inferring the average student defines it as a conclusion without being based on observations on objects or phenomena but only based on the knowledge and experience possessed. In the aspect of building graphs, from the interview results obtained information that many students still do not know the elements of the graph, how the meaning of the data relationship, the meaning of the best lines and curve fittings, even the placement of the right axis is still in the weak category, this is because experience in processing data graphically using computer software like Ms. Excel or LoggerPro is rarely experienced by students, because the basic physics activities I or II drawing graphs are still directed manually. Similarly other aspects, get the same initial problem.

Based on preliminary data information, students are strengthened to understand the meaning and definition of all aspects of SPS that are needed in science activities. Meanwhile, data processing in tables and graphs using computer and smartphone applications is trained outside of lectures. This effort has a significant impact on the students initial abilities, while also increasing student interest and
motivation to learn. Looking at the data in Figure 2, the ability to "identify variables" and "predictions" has increased understanding reaching high categories, this is because students understanding of defining the meaning of variables is good, meanwhile in the LKM sheet (Worksheet) always gets points that lead to identifying various variables in investigation so that students become accustomed. In "predicting" students have gained knowledge that the process of predicting is not based on the knowledge that is in the minds of students, but is based on the patterns of tendencies shown in a phenomenon, besides the ability of students to the concept of unit or dimensional analysis becomes a favorable basis in predicting a phenomenon.

Based on the various findings above, it can be concluded that the science process skills of the prospective physics teacher still need to be improved through a teaching and learning design solution based on guided inquiry activities because students can be directly involved in observing, investigating, collecting data and data analysis, which means can help students build appropriate formulations based on information of tables, graphs, or mathematical formulations of the results of curve fittings.

4. Conclusion
Based on the results of the study, it was concluded that traditional musical instruments and free software could be an alternative source of learning the concepts of vibration, waves, and sounds that multirepresentative. The science process skills of students are still in the moderate category, but can be improved through inquiry learning activities with traditional musical instruments and free software. Teaching and learning design can significantly develop and enhance students science process skills.

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