Theremin as teaching aid to improve student understanding of waves

D Ambarwanti1,*, I M Astra1, A A Yaqin2 and I Sugihartono3

1 Program Magister Pendidikan Fisika, FMIPA, Universitas Negeri Jakarta, Jl. Rawamangun muka no. 01, Rawamangun, Jakarta Timur 13220, Indonesia
2 Laboratorium kontrol, FMIPA, Universitas Negeri Jakarta, Jl. Rawamangun muka no. 01, Rawamangun, Jakarta Timur 13220, Indonesia
3 Program Studi Fisika, FMIPA, Universitas Negeri Jakarta, Jl. Rawamangun muka no. 01, Rawamangun, Jakarta Timur 13220, Indonesia

*desyani.ambar@gmail.com

Abstract. Physics learning is taught to equip students with knowledge and understanding of various natural phenomena. In order to improve comprehensive understanding of waves principle for student class of XI, we implement science, technology, engineering, and mathematics (STEM) in physics learning by using theremin based light dependent resistor (LDR). In this paper, theremin as music instrumental non-contact will be used as teaching aid. Physics understanding of the students will be observe and investigated during a class. Analyses will be focus on adjustment of frequency will provide pitch of tones. As results, by theremin, student will have better understanding of waves principles.

1. Introduction

Science is a collection of knowledge that is explored, compiled, and developed systematically using a particular method, which is based on scientific evolution to explain certain natural and / or social contexts. The 2013 curriculum is a further step in the development of a Competency-Based Curriculum and KTSP which includes integrated attitude, knowledge and skills. The aim is to prepare Indonesian people to have better life skills as individuals and citizens. The development of the 2013 curriculum based on juridical provisions is from the Instruction of the President of the Republic of Indonesia in 2010 concerning character education, active learning and entrepreneurship education which requires the development of a new curriculum philosophical foundation and empirical foundation [1].

In practicum activities it is very possible for the application of various science process skills as well as the development of scientific attitudes that support the process of acquiring knowledge (scientific products) in students. This is where it appears how practicum has a very important position in science learning, because through practicum students have the opportunity to develop and apply science process skills, scientific attitudes in order to gain knowledge [2].

Practical activities are very important to do in physics learning to provide direct learning experience and see real phenomena that occur [3]. This aims at the 2013 curriculum which states that knowledge cannot be transferred from teacher to student. Students must be able to actively search, process, construct and use knowledge. So, learning is expected to contain the opportunities given to truly understand and be able to apply knowledge to improve students' understanding of concepts.
Sound waves are material in class XI High School Physics subjects based on KD.3.10 and 4.10 in the 2013 curriculum. The basic competencies that must be possessed by students are applying the concepts and principles of sound waves and light in technology and conducting experiments on sound waves and/or light, following the presentation of the results of the experiment and its physical meaning such as a sonometer and diffraction lattice.

Based on the results of the needs analysis of learning media with sample observations to 16 schools, the analysis data revealed that only 37.5% of the availability of learning media tools on KD.3.10 and 4.10 in class XI sound wave material. With this percentage it is stated that there is a lack of equipment available in sound wave material.

Thus, one that can be done in improving students' understanding of concepts is by developing learning media that consider several aspects, namely, cognitive, affective, and psychomotor [4]. So it is necessary to do research related to the development of learning media props for theremin music in wave material to improve students' understanding of concepts. The purpose of this study study related to Theremin's design is to be able to make a new innovation in the development of the world of electric music, can inspire musicians to make or play Theremin and also be able to know what factors can influence the frequency produced by Theremin.

2. Method
In this study using research and development methods. The method in this study was chosen to see the effectiveness of the tool. The developed Theremin is suitable for use as a learning medium. The development of Theremin devices developed for wave material can help improve students' conceptual understanding. This research was conducted at SMAN 15 BEKASI in April 2019.

The research method used was a development research method with a design model Borg and Gall. Stages carried out consisted of the research phase and information gathering with observation and literature study, the planning stage to make learning media design developed, making lattice instruments and organizing instruments, developing the initial form of the product by creating learning media. Reflecting the wave material, preparation stage for field testing validation by material experts and instructional media lecturers, the main product revisions were revised by experts, the main field testing phase was carried out small group trials of 1-3 schools with 6-12 students, implementation of the revised stages of product evaluation and media revisions based on the results of trials small group, the operational field trial stage by conducting large group trials with 30-100 students [5]. Planning chart the following model can be seen at Figure 1.

The implementation of the trial through observation and learning outcomes using the pre-test and post-test. The final product revision stage is where revisions are based on the results of large group trials to determine the feasibility of learning media in Theremin tools, so that they can be used in learning activities to improve student learning outcomes, and dissemination and implementation stages as product reporting at meetings and professional journals.

The learning media for wave materials at Theremin tools were tested for two students of class XI Science at SMAN 15 BEKASI. Students are given a pre-test and post-test to determine the increase in learning outcomes before and after learning. To prove the benefits of wave learning, media can use N-Gain analysis.

The work steps for using the design theremin learning media are as follows:

- It starts by installing all the tools.
- Input, the LDR initialization condition to pin A0.
- Process of reading the LDR section.
- Output out the graph results from the pitch.
3. Result and Discussion
The purpose of developing theremin tools was developed so that they could be used as learning media and help improve students’ conceptual understanding. Where students not only see simulations through videos, books, and phenomena that exist. However, students can try to practice using simple media in learning activities on wave effect material. Theremin tool development uses electronic components, among others, resistors, LDR, and buzzer.

In this case, students can analyze wave material on the mirror tool. Where the use of the LDR component in Theremin is a light sensor. The light received by the LDR can change the frequency of the buzzer. The resulting frequency varies depending on the height of light received by the LDR sensor.

The theremin tool was then tested at school for students of class XI Science at SMAN 15 BEKASI. This field trial aims to determine the effectiveness of the practicum tool developed whether it can help improve students' conceptual understanding or not. This assessment is done by giving a pre-test and post-test to students who take lessons using media (practicum tools) and not. Improved learning outcomes before and after learning can be seen from the results of n-gain analysis with a score of 0.53415 which means there is an increase in understanding of concepts in the medium category.

The practicum tool developed after being validated was tried out to class XI students of SMAN 15 BEKASI to find out whether the tool could help improve students’ conceptual understanding or not. The results showed that there was an increase in understanding of concepts seen from the N-gain score of 0.53415 which means that there was an increase in learning outcomes in the medium category.

During activities, students become more active and interactive in trying therapeutic tools. Students have the desire to learn to know what processes will occur in it. Students communicate with groups to discuss together working on worksheets that have been given and students easily understand about the material taught based on the results of the interview. This is in accordance with Zainal and Sudjana, that...
the use of media is used as a tool to channel messages, stimulate the learning process and can attract students' attention which can foster motivation and desire to learn. Students become bored and teacher teaching methods are more varied.

The use of instructional media is not only seen or judged by the sophistication of the media, but its function and role in helping to improve the teaching process are very important. Practicum is one form to show the ability to master theoretical material in addition to training students' skills, perseverance and discipline.

Theremin experiments are carried out when the LDR sensor receives light that can change the frequency of the buzzer. Thus, students can analyze the changing frequency of the LDR sensor when the light is bright or dark. Students collect data with groups and then the experimental results can be calculated and adjusted to the existing theory that when the LDR sensor receives more bright light, the frequency issued by the buzzer will be higher and vice versa. So, students are not only good at calculating and memorizing, but they understand the concept of the wave material being taught.

| No | Pitch | Length (cm) | Frequency (Hz) |
|----|-------|-------------|----------------|
| 1  | Do    | 30          | 316            |
| 2  | Re    | 25          | 328            |
| 3  | Mi    | 20          | 355            |
| 4  | Fa    | 15          | 357            |
| 5  | So    | 10          | 411            |
| 6  | La    | 5           | 440            |

Based on the table 1, Theremin can reach the highest frequency of 440 Hz. By changing several heights in Theremin it can affect Theremin's resonance frequency, so that the brighter the light captured by the LDR the higher the frequency value.

In this case, the teacher not only can use sophisticated tools in learning activities, but can design and implement education that is more focused on mastering physical concepts that support daily life using simple media and facilities and being around. Thus, such learning can help introduce more students to natural phenomena and the surrounding environment.

4. Conclusion
Based on the results of the study, it can be concluded as follows, the theremin tool developed is suitable to be used as a learning media that can help improve students' understanding of concepts with an N-Gain score of 0.53415 in the medium category. The researcher hopes that the Theremin tool developed can be used as a medium of learning in the classroom to help convey the concept of wave material and learning to be fun. According to the research, the author gives suggestions to help improve student learning outcomes which teachers can design a physics lesson with a mature and fun.

References
[1] Kependidikan D T 2008 *Education, Types and Methods of Educational Research* (Jakarta: Ministry of National Education)
[2] Slameto 2010 *Learning and influencing factors* (Jakarta: Rineka Cipta)
[3] Elby A 1999 Another reason that physics students learn by rote *Am. J. Phys.* 67 S52–7
[4] Rovai A P, Wighting M J, Baker J D and Grooms L D 2009 Development of an instrument to measure perceived cognitive, affective, and psychomotor learning in traditional and virtual classroom higher education settings *Internet High. Educ.* 12 7–13
[5] Tegeh I M, Jampel I N, Pudjawan K 2014 *Development Research Model.* (Yogyakarta: Garaha Ilmu)