Development of Digital Simple Pendulum Learning Media

Azizahwati Azizahwati, M.Rahmad, Rifki Zamri
Physics Education – FKIP, Universitas Riau
Jl. HR. Soebrantas, Km. 12.5, Pekanbaru, 28293, Indonesia
azizahwati@lecturer.unri.ac.id

Abstract. This study aims to produce a digital simple pendulum prototype. ADDIE model has been used in this study. This research was carried out up to the develop stage. The developed digital simple pendulum consists of mechanical and electronic devices. The processor used is the Arduino Uno microcontroller. The resulting prototype is declared to be functional if it meets the period and frequency equations on the pendulum. The results obtained show that: (1) the frequency and period are affected by the length of the string, (2) the period and frequency are not affected by the mass of the object. The prototype that has been produced can be an alternative learning media that leads to STEM.

1. Introduction
Oscillatory motion is motion back and forth around the equilibrium point. An object will oscillate if a force is applied so that it moves back and forth past these points. The restoring force will return the system to its state [2]. One example of oscillatory motion is a simple pendulum [3,4]. The small deviation given to the pendulum then causes the pendulum to oscillate past its equilibrium position [5,6]. During oscillation, the pendulum will have a frequency and a period. Period states the amount of time it takes to make one full vibration, the frequency of vibrations that occur per second. Based on the concept of a simple pendulum, the period depends on the length of the string [7].

Students' understanding of the simple pendulum concept is not optimal due to several problems. The limitations of teaching aids cause many difficulties in learning. Students easily understand the concept if in learning using teaching aids because the concept that was abstract becomes concrete. However, the availability of teaching aids to support experimental activities is often not found in schools [8]. The use of manuals allows for errors in data collection and requires a long time [9]. Experimental manual procedures usually using a stopwatch, ruler, etc., were found to be ineffective because they were less accurate [10].

The findings in the field indicate that: 1) The lack of mathematical pendulum learning media using industrial technology information systems 4.0., 2) Students' understanding of the mathematical pendulum concept is not optimal because several problems are caused by inaccurate data information obtained due to lack of learning media. Technology in the field of sensors, transducers and microcontrollers continues to develop so that it becomes an opportunity in the development of learning media. Digitization using Arduino UNO Chip with read/write capability. The completeness of the features contained in this microcontroller chip makes the resulting props easy to use, just by
connecting the Arduino UNO with a PC using a USB cable or using a DC adapter, the circuit is ready to use [11].

Innovation in learning requires the development of experimental tools that are integrated with science and technology. This is done in an effort to educate the nation's life. The development of information technology in today's global era has had an impact on every line of life, including the field of education. Based on this, the researchers developed a simple pendulum teaching aid using a microcontroller to improve the quality of learning.

2. Methodology
This study has used the ADDIE model. The stages that have been carried out are only in the develop stage. The development in this research is to produce a simple digital pendulum experiment prototype. This prototype only arrived at the functioning of a simple digital pendulum. The prototype made in the form of a simple digital pendulum experimental tool consisting of a mechanical part and an electronic part. The resulting electronic part uses an infrared sensor and an Arduino Uno microcontroller. The physical parameters measured by this prototype are the frequency and period of a simple pendulum. The pendulum experiment is declared to be functional if: The pendulum experiment is declared to work if: (1) the length of the string affects the period and frequency, (2) the mass of the object does not affect both.

3. Results and Discussion

3.1. Analysis
Literature studies and surveys to schools have been carried out as a reference for the analysis of research needs. Literature study shows that the problem of the simple pendulum concept is that the experimental tool developed previously was still less accurate and took a long time because it was done manually. The simple digital pendulum that has been researched has yet to show that an object's mass does not affect its period. Therefore, it is necessary to develop digital visual aids that are able to show this relationship.

3.2 Design
The digital simple pendulum design consists of two parts. The first part is the mechanical device. This mechanical device is in the form of a pendulum holder, a pendulum and a rope that will be used as well as setting the angle of the pendulum deviation. All of this must be proportional including the small deviation given to the pendulum. This small deviation is a requirement for the simple pendulum concept. The second is an electronic device consisting of a set of electronic circuits. The electronic circuit consists of input, process and output. Digitalization of electronic devices using infrared sensors and Arduino Uno microcontroller.

The pendulum digitization flow chart is as shown in Figure 1. To make efficient use of learning time, the number of swings on the pendulum needs to be set so that it is not too much. The element of constructivism in learning needs to be considered. In addition to learning elements, the digital pendulum prototype that will be made must also pay attention to the functionality of the tool, comfort, aesthetics and equipment safety.
3.3. Develop
Making a simple digital pendulum experiment tool assembled according to the design (input, process and output). The input section uses an infrared sensor, for the process it uses an Arduino Uno microcontroller and the output uses an LCD. This experimental device is expected to make learning effective so that students are motivated to continue learning.

![Figure 1. Digital simple pendulum flow chart](image)

![Figure 2. Digital simple pendulum prototype](image)
The operation of a simple digital pendulum begins with turning on the power supply and deviating the pendulum. The infrared sensor will capture the input. Then the on button is pressed and the pendulum is released to swing. The microcontroller performs its function as a processor and finally the output data is displayed on the LCD.

Experiments to determine the frequency and period of a simple pendulum are carried out with: (1) constant mass of load, (2) constant string length. The experimental results can be seen in tables 1 and 2.

**Table 1.** Measurement data of the frequency and period of the pendulum for constant m (mass)

| l (cm) | n  | t (s) | f (Hz) | T (s) |
|-------|----|-------|--------|-------|
| 30    | 3  | 3.21  | 0.93   | 1.07  |
| 32    | 3  | 3.31  | 0.91   | 1.10  |
| 39    | 3  | 3.58  | 0.84   | 1.19  |

**Table 2.** Frequency measurement data and pendulum period for L (string length) constant

| m (grams) | n  | t (s) | f (Hz) | T (s) |
|-----------|----|-------|--------|-------|
| 80        | 3  | 3.58  | 0.84   | 1.19  |
| 100       | 3  | 3.58  | 0.84   | 1.19  |
| 120       | 3  | 3.58  | 0.84   | 1.19  |
Based on table 1 obtained a linear relationship between the length of the rope to the period and frequency. Table 2 shows that they are not affected by the mass of the object. This corresponds to the formulas for period \((T=2\pi\sqrt{L/g})\) and frequency \((f=(1/2\pi)\sqrt{g/L})\). If applied in learning, students can further explore understanding through this experimental tool. For example, students can calculate the value of gravity through existing data. The data obtained can be explored into a graph. Analyzing graphs can help students optimize critical thinking skills [12]. The use of teaching aids can overcome the abstraction of physics concepts that students learn. Teaching aids can be used to improve the learning process [13], improve students’ conceptual understanding [14] and improve process skills [15,16].

This simple digital pendulum prototype that has been produced can be continued to the expert validation stage and also field trials. Learning today requires innovation in educational practice, especially learning media that leads to the industrial revolution 4.0 [17]. Furthermore, a manual for the use of experimental tools will be made so that students can conduct experiments in a directed manner. The resulting prototype will then be further developed, such as making a simple digital pendulum based on STEM (Science, technology, engineering and mathematics). Several STEM studies related to learning media can make students motivated and creative so that they better understand the concept [18,19].

4. Conclusion

The digital simple pendulum prototype that has been produced shows that the period and frequency do not depend on the mass of the object but depend on the length of the string. This teaching aid also provides space for students to further explore their knowledge. Digitizing learning will be interesting, time-saving and integrated with STEM.

References

[1] Baker G and Blackburn J 2005 The Pendulum: a case study in physics New York: Oxford University Press Pages 9
[2] Palka L, Schauer F and Dostal P 2016 Modelling of the simple pendulum experiment, In MATEC WEB of Conferences 20th International Conference on Circuits, Systems, Communications and Computers 4(37) 1-8
[3] Elbori A and Abdalsmd L 2017 Simulation of simple pendulum International Journal of Engineering Science Invention 6(4) 33–8
[4] Tirtasari Y, Latief D F E and Amahoru A H 2016 Penggunaan teknik video tracking untuk mengamati fenomena osilasi terredam pada pegas. Prosiding SNIPS 785–794
[5] Widya H 2019 Variasi bentuk bandul untuk meningkatkan pemahaman peserta didik dalam penentuan nilai gravitasi bumi pada ayunan sederhana Jurnal Ilmu Fisika dan Pembelajaranannya 3(1) 42–46
[6] Borrachero A B, Brígido M, Davila M A, Costillo E, Canada F and Mellado V 2019 Improving the self-regulation in prospective science teachers: the case of the calculus of the period of a simple pendulum Heliyon 5(12) 1-13
[7] Mohazzabi P and Shankar S 2017 Damping of a simple pendulum due to drag on its string Journal of Applied Mathematics and Physics 5 122-130
[8] Hammond D L, Flook L, Cook-Harvey C, Barron B and Osher D 2020 Implications for educational practice of the science of learning and development Applied Developmental Science 24(2) 97-140
[9] Yulkifi, Yohandri and Hatthoahira 2017 Rancang bangun set eksperimen gerak harmonis sederhana menggunakan sensor ping dan photodiode berbasis mikrokontroller Jurnal Aplikasi Fisika 13(3) 78–85
[10] Tong-on A, Saphet P and Thepnurat M 2017 Simple harmonics motion experiment based on LabVIEW interface for arduino IOP Conf. Series: Journal of Physics 901 1–6
[11] Djuandi F 2011 Pengenalan Ardium Universitas Trisakti, Pages 10
[12] Supalo C A, Humphrey J R, Mallouk T E, Wohlers H D and Carlsen W S 2016 Examining the use of adaptive technologies to increase the hands-on participation of students with blindness or low vision in secondary-school chemistry and physics Chemistry Education Research and Practice 17(4) 1174-1189

[13] Prasetyarini A, Fatmaryanti S D and Akhdinirwanto R W 2013 Pemanfaatan alat peraga IPA untuk meningkatkan pemahaman konsep fisika pada siswa SMP Negeri I Bulu Pesantren Kebumen Tahun Pelajaran 2012/2013 Radiasi 2(1) 7-10

[14] Setyowati N, Susilo B E and Masruka 2016 Penggunaan Alat peraga untuk meningkatkan hasil belajar dan keaktifan siswa pada materi peluang Kreano 7(1) 24-30

[15] Hartati B 2010 Pengembangan alat peraga gaya gesek untuk meningkatkan keterampilan berpikir kritis siswa SMA Jurnal Pendidikan Fisika Indonesia 6(2) 128-132 [16]

[16] Oktafiani P, Subali B and Edie S S 2017 Pengembangan alat peraga KIT OPTIK serbaguna (AP-KOS) untuk meningkatkan keterampilan proses sains Jurnal Inovasi pendidikan 3(2) 189-200

[17] Depdikbud 2013 Peraturan menteri pendidikan dan kebudayaan Nomor 69 Tahun 2013 tentang kerangka dasar dan struktur kurikulum Sekolah Menengah Atas/ Madrasah Aliyah, Departemen Pendidikan dan Kebudayaan

[18] Kapila V and Iskander M 2014 Lessons learned from conducting a K-12 project to revitalize achievement by using Instrumentation in science education Journal of STEM Education 15(1) 46-51

[19] Rikardus H and Lamanepa H G 2019 Meningkatkan kreatifitas siswa melalui STEM dalam pembelajaran IPA Jurnal EduMatSains 4(1) 89-98