Designing Prototype Learning Media for Circular Motion Uniform Based on Arduino Uno Microcontroller

Azizahwati Azizahwati*1,2, Hendar Sudrajat1, Fahrun Hidayat1, Muhammad Ridho2

1Physics Education – FKIP, Universitas Riau
2Science Education – FKIP, Universitas Riau
Jl. HR. Soebrantas, Km. 12.5, Pekanbaru, 28293, Indonesia
*azizahwati@lecturer.unri.ac.id

Abstract. This research aims to produce a prototype of a uniform circular motion learning media based on Arduino Uno microcontroller. The research design uses the Research and Development (R&D) method by using the 4D model which includes: (1) define, (2) design, (3) develop, and (4) disseminate. This research was conducted only at the design stage. The results showed that the accuracy of the learning media prototype was 95.24% and the measurement error was 4.76%. This research has succeeded in designing a uniform circular motion learning media based on the Arduino Uno microcontroller to be developed as an alternative learning media in determining frequency and angular velocity.

1. Introduction

Constructivism emphasizes various kinds of learning experiences so that students gain understanding of concepts [1]. In the teaching and learning process there are four important components that influence the success of student learning, namely learning material, learning atmosphere, media or teaching aids and learning resources, and the teacher as the subject of learning [2]. Research results have shown that the learning process of physics using teaching aids makes it easier for students to understand the material and can develop students' process skills [3]. Research results have shown that the learning process of physics using teaching aids makes it easier for students to understand the material and can develop students' process skills [4]. Research has also shown that learning using visual aids can improve student learning outcomes [5].

One of the studies in Physics is motion in two dimensions, namely uniform circular motion. Uniform circular motion is an important concept and has many applications in life. Students have difficulty in determining the angular velocity [6], and its application [7]. Difficulties experienced by students due to limited props [8,9]. The weakness of this manual props is the coin rotation which is sometimes unstable on its axis so that the measured time is wrong [11].

Circular motion uniforms taught at school still use manual props. The use of props that are manual does not rule out the possibility of errors in data retrieval. A large number of studies try to find out students' conceptions and understanding of circular motion and its application. The weakness of this manual props is the coin rotation which is sometimes unstable on its axis so that the measured time is wrong [11].
If the manual teaching aids are designed by adding technological elements, the experimental data obtained will be better. Technology has developed, especially in the field of sensors and transducers coupled with microcontroller technology, so there are opportunities to combine physics with technology.

Arduino UNO is a circuit board based on Atmega 328P microcontroller. The Arduino UNO module is a physical computing platform that is open source. In use, the Arduino UNO module is paired with a C programming language written using the IDE (Integrated Development Environment) [12].

Learning innovations, especially in the development of teaching aids need to continue to be developed to facilitate educators to deliver material. Globalization requires learning innovations to educate the life of the nation. Based on this, the purpose of this study is to design a prototype of a uniform circular motion learning media based on the Arduino Uno microcontroller.

2. Methodology

The research design used the Research and Development (R&D) method by using the 4D model which includes: (1) define, (2) design, (3) develop, and (4) disseminate. This research was conducted only at the design stage. The design stage is the final stage in this study to produce a prototype of a uniform circular motion visual aid. The design of this device consists of mechanical devices and electronic devices. Overall the media design includes input, process and output. The physics parameters that will be determined through this prototype are frequency and angular velocity. The prototype that has been produced will be tested for accuracy and measurement error.

3. Results and Discussion

3.1 Define

Problem identification is carried out to determine the difficulty of the teacher in explaining the concept of uniform circular motion and the limitations of teaching aids. The limitation of teaching aids makes the teacher has not maximized the teaching and learning activities. The results of the study were obtained that teachers need learning media that take advantage of technological developments that can be applied in learning. Problem identification is done to determine the difficulty of the teacher in explaining the concept of uniform circular motion and limiting teaching aids. The limitations of teaching aids make teachers not optimal in teaching and learning. The results of interviews with teachers found that teachers need technology-based uniform circular motion learning media in teaching. Data in the field shows that the teaching aids used are still simple, so better teaching aids are needed.

3.2 Design

Product design is done by selecting technology, designing systems through block diagrams and testing product results. A block diagram of a uniform circular motion measuring system is given in Figure 1.

![Figure 1. Block diagram of a uniform circular motion props design](image-url)
In this study, the design is done hardware and software. Hardware design in the form of design physical and mechanical props. While software design in the form of design the program on the Arduino Uno Microcontroller. Hardware design on props this is done designing tools that can describe the phenomenon of uniform circular motion. Block diagram hardware and software design of these props shown in Figure 2.

![Block diagram of hardware and software design of uniform circular motion props](image1)

**Figure 2.** Block diagram of hardware and software design of uniform circular motion props.

Software design in this study done programming on the Microcontroller Arduino Uno. Overall the results of the uniform circular motion prototype design can be seen in Figure 3. Photodiode sensor functions to trigger the initial calculation of the time the object begins to rotate and return to the starting point of rotation.

![Prototype of a uniform circular motion learning media based on Arduino Uno microcontroller](image2)

**Figure 3.** Prototype of a uniform circular motion learning media based on Arduino Uno microcontroller
The prototype parts:
1. The disc that can produce regular circular motion
2. The laser functions as a light source
3. Photodiode function as a beam receiving sensor from the laser
4. Flat mirror functions as a reflection to reflect light from the laser to the photodiode
5. Arduino Uno Microcontroller has a function to process data generated from the reflection of a flat mirror which will then be displayed on the LCD screen inside the Arduino Uno Microcontroller box.

Data on measurements of frequency and angular velocity on uniform circular motion props for three experiments are shown in Figures 4, 5 and 6.

a. Measurement I

![Measurement data I](image1)

Figure 4. Measurement data I

a. Measurement II

![Measurement data II](image2)

Figure 5. Measurement data II

a. Measurement III

![Measurement data III](image3)

Figure 6. Measurement data III

Measurements were made three times by focusing the laser beam toward a flat mirror, then the light will be reflected to the photodiode sensor. Discs on the prototype rotate with a constant angular velocity.

| Measurement | Frequency (Hz) | The angular velocity (rad/s) | Average Frequency (Hz) | The angular velocity (rad/s) |
|-------------|----------------|------------------------------|------------------------|------------------------------|
| I           | 23.811         | 149.5                        | 23.811                 | 149.5                        |
| II          | 23.811         | 149.5                        |                        |                              |
| III         | 23.811         | 149.5                        |                        |                              |
After this prototype is completed, experiments and tests are carried out to determine whether the frequency and angular velocity gauges can be used or not. Testing of the prototype is also useful for knowing the accuracy and measurement errors that occur. A total of three experiments conducted showed the same results. Based on theoretical frequency values should be obtained at 25Hz. There are 4.76% measurement errors. The accuracy of the prototype produced was 95.24%. This value is an acceptable number at the normal value of accuracy. Differences in measurement results with existing theories are caused by several factors including human error and other factors such as laser light on a flat mirror reflected by a photodiode that is not completely perfect. The distance from the centre of the disc to the designed edge should be proportional. This situation results in a match between frequency and the resulting angular velocity [13]. A good teaching aid must synchronize between the centre of the disc and the contour around the surface of the disc. As for the experiments and testing of measuring devices of the frequency and angular velocity, the results show that there is a relationship between frequency and angular velocity. Where the greater the frequency, the angular velocity will also be smaller.

4. Conclusion
Based on the results of the analysis and discussion, it can be concluded that the experimental data obtained using the Arduino Uno microcontroller device have results that are almost close to the existing formula and only require less time compared to manual learning media. This is due to the fact that the Arduino Uno microcontroller device has sophisticated technology that supports experiments that can determine frequency and angular velocity quickly, easily, and attractively.

References
[1] Bada and Steve O 2015 Contractivism learning theory: A Paradigm for teaching and learning IOSR Journal of Research & Method in Education 5(6) 66-70
[2] Zainal A 2016 Evaluasi Pembelajaran (Prinsip, Teknik, dan Prosedur) Cetakan Kedelapan, Jakarta: Rosda Karya.
[3] Ramadhan D 2016 Pengembangan alat praktikum viskometer metode bola jatuh bebas berbasis sensor efek hall UGN3503 sebagai media pembelajaran fisika, Prosiding Seminar Nasional Fisika (E-Journal)
[4] 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
[5] Setyowati N, Susilo B E and Masrukan 2016 Penggunaan Alat peraga untuk meningkatkan hasil belajar siswa pada materi peluang Kreano 7(1) 24-30
[6] Caplovitz G P, Hsieh P J and Tse P U 2006 Mechanisms underlying the perceived angular velocity of a rigidly rotating object Vision Research 46(18) 2877–2893
[7] Demircioglu S, Yurumezoglu K and Isik H 2015 Demonstrating the direction of angular velocity in circular motion Physics Teacher 53(8) 453-453
[8] Jaris P, Holford J and Griffin C 2012 The theory and practice of learning (2nd) Edition. London:Taylor&Francis eLibrary.
[9] Strevel R A, Litzinger T A, Miller R L and Steif P S 2008 Learning conceptual knowledge in the engineering sciences: Overview and future research direction Journal of Engineering Education 97(1) 279-294
[10] Sucipto K 2011 Media Pembelajaran Manual dan Digital Bogor:Ghalia Indonesia
[11] Ester F, Puji K, Debora N S and Ferdy S R 2011 Pemanfaatan Kamera Digital dalam Pembelajaran Fisika tentang Dampak Gaya Sentrifugal. Prosiding Pertemuan Ilmiah XXV HFI Jabat & DIY 175-178
[12] Djuandi F 2011 Pengenalan Arduino Universitas Trisakti, Jakarta.
[13] Barraza J F and Grzywacz N M 2003 Local computation of angular velocity in rotational visual motion Journal of the Optical Society of America A 20(7) 1382–1390