Developing practicum device using magnetic sensor for circular motion at Senior High School

F Desniarsyah*, B H Iswanto and V Serevina

Physics Education Study Program, State University of Jakarta, Pemuda Street No.10, Rawamangun – Jakarta Timur, 13220

*fldesniarsyah@gmail.com

Abstract. This research aimed to develop a circular motion practice device for senior high school. The device visualized uniform circular motion concept. The applied method of this research is an ADDIE (Analyze, Design, Development, Implementation, and Evaluation) development research method. The device has been designed which consists of a motor that drives a propeller with a magnet on it and hall effect A1319E magnetic sensor detects every rotation of the magnet. The final result obtained the number of magnetic rotations and the time taken which shows on the LCD (Liquid-Crystal Display). There was a controller box which made students could set the number of rotations to be counted and also adjusted the speed of rotation of the motor by increasing or decreasing its power. In addition, it demonstrated centripetal force by using springs as aids and loads that added to a rotating box above the propeller. The length of the spring which increased, could be seen using a stroboscope. The practice device be equipped with a student worksheet. Based on the results of the validity test, a material expert score was 96.88%, from the expert media score was 93.75% and from the expert learning score was 82.81%. The overall result of the validity test gets excellent interpretation for this developing practice device using magnetic sensor for circular motion.

1. Introduction

The aims of education were improving the standard of human life to be more qualified and able to compete with others. The government had given guidance by issuing Permendikbud No.20, 2016 about Graduate Competence Standard for junior and senior high school students. This competence standard explained the domain of knowledge, attitude and skill which acquired in different ways. Attitude was gained through accepting, running, appreciating, living, and practicing. Knowledge was gained through remembering, understanding, applying, analyzing, evaluating and creating. Skill was gained through observing, asking, trying, reasoning, tasting and creating [1].

Edgar Dale’s cone explained levels of experienced which decreased the abstraction of some topic. The bottom of the cone were strategies using media to involve students in a skit, role play, or simulation which recommended to be used in developing of technical skills or attitudes [2]. Besides that, new media extended the reach of artistic effects and the most important was exploring their creativity and abilities [3].

Many science teachers were reluctant to venture into perpetuating an illusion either that human problems were amenable to technical solutions where values and human need could be weighed by experts using value-free methods, or that ethics and values were not part of science. Citizen’s science requires a broader knowledge of how science work which limited to the statement that one knows not
only what a phenomenon is, but also how it relates to other events, why it is important and how this particular view of the world came to be [4]. Research by Ponimín concluded that using real media was acceptable for teaching uniform circular motion. Teaching and learning were well done, the students activated and motivated, student learning outcomes were better [5].

First step of this research observed two senior high schools. The situation in SMA Ksatria Jakarta and SMAN 2 Indramayu showed that from 45 students, 40% students had difficulties in physics, 60% had not understood circular motion, 71% motivated using learning media, 64% enthusiastic using media and 57% said that available practicum device inefficient for learning. The situation had been shown in graph as need analysis graph in figure 1.

![Figure 1 Graph of Need Analysis](image)

To overcome the problem above, a practicum device was developed. It was used to visualize the uniform circular motion process. The practicum device consisted of magnet, hall effect sensor, controller, and spring. Learning with this device, first, students explained the understanding of uniform circular motion whose angular speed and linear speed is constant. Second, students distinguished angular speed and linear speed with different distance from center of rotation. Third, students explained the direction of centripetal and centrifugal force. Fourth, students explained the influence of the mass, radius, and speed toward the centripetal force.

2. Methods
This research was a development research. The research used ADDIE research and development model. The research was conducted through five steps. The first step analyzed what media are needed in schools, teachers and students. The data was obtained from students who filled out questionnaires and teachers were interviewed. The second, designed media to be developed, in this step 2D design, learning design, and expert assessment were made. The third, developed the media required by schools, teachers and students was designed before. The fourth step was implementation of developed media in senior high school. Students tried the device as learning media, filled out pretest, posttest and questionnaires. The fifth step was evaluation which conducted by material experts, media experts and learning experts to assess the feasibility of developing media.

3. Results and Discussion
The result of this study was a practicum device that using magnetic sensor. Magnet moving in a circle on a propeller would be counted the number of its rotations and the time. These were components of a practicum device shown in figure below.
On the first practicum, the student calculated the number of rotation and times with different number of rotations but at the same speed. Students recorded the results in the observation table as below. The number of rotation and speed determined using the controller. This data was used to calculate the angular speed shown as table below.
Table 1. Relationships number of rotations, time, angular speed, and linear speed

| Rotation | Time (s) | Angular Speed (rad.s⁻¹) | Linear Speed (m.s⁻¹) |
|----------|----------|--------------------------|----------------------|
| 30       | 2,5764   | 23.2 π                   | 1.392 π              |
| 40       | 3,3636   | 23.78 π                  | 1.427 π              |
| 50       | 4,19     | 23.8 π                   | 1.428 π              |
| 60       | 5,0322   | 23.84 π                  | 1.430 π              |
| 70       | 5,8848   | 23.78 π                  | 1.427 π              |

![Uniform Circular Motion](image)

Figure 9. Graph of linear and angular speed of uniform circular motion

The second practicum, Students calculated the linear and angular speed for the same rotation and power but different radius. From the experiment, students got the concept that the angular speed of uniform circular motion is constant and the linear speed is influenced by the radius (Table 2).

Table 2. The relationship of radius, angular speed, and linear speed

| Radius (cm) | Time (s) | Angular Speed (rad.s⁻¹) | Linear Speed (m.s⁻¹) |
|------------|----------|--------------------------|----------------------|
| 6          | 2,576    | 23.2 π                   | 1.392 π              |
| 7          | 2,542    | 23.6 π                   | 1.652 π              |
| 8          | 2,581    | 23.8 π                   | 1.904 π              |
| 9          | 2,658    | 23.84 π                  | 2.146 π              |
| 10         | 2,692    | 23.78 π                  | 2.378 π              |
The third practicum visualized the centripetal force acted on circular motion. A spring connects the center of rotation and a little box which slide on the propeller. A stroboscope made user easier to read the scale of the radius of spinning little box. Students calculated the centripetal acceleration and force as table 3. In table 4, it showed if 10 gr mass added on little box on the propeller.

**Table 3.** The relationship of angular speed, 5,88 gr mass, and centripetal force

| Radius (cm) | Angular Speed (rad.s⁻¹) | Centripetal Acceleration (m.s⁻²) | Centripetal Force (N) |
|-------------|-------------------------|----------------------------------|-----------------------|
| 7,2         | 69,036                  | 343,15                           | 2,018                 |
| 7,5         | 76,183                  | 435,29                           | 2,559                 |
| 7,5         | 81,277                  | 515,26                           | 3,029                 |
| 8           | 84,98                   | 577,72                           | 2,397                 |
| 8,2         | 88,078                  | 636,14                           | 3,741                 |

**Table 4.** The relationship of angular speed, 15,88 gr mass, and centripetal force

| Radius (cm) | Angular Speed (rad.s⁻¹) | Centripetal Acceleration (m.s⁻²) | Centripetal Force (N) |
|-------------|-------------------------|----------------------------------|-----------------------|
| 8,7         | 62,508                  | 339,93                           | 5,398                 |
| 9,1         | 65,966                  | 395,99                           | 6,288                 |
| 9,5         | 67,965                  | 438,83                           | 6,969                 |
| 9,9         | 69,443                  | 477,41                           | 7,581                 |
| 10,2        | 70,298                  | 504,07                           | 8,005                 |
The next step of this research was to test the feasibility of this media, the assessment filled out by experts. There were material experts, media experts, and learning experts. Material experts assessed material suitability of this media was 90.62%, concept accuracy was 86.11%, and data accuracy was 87.50%. Media experts assessed the advantage and stability of this media was 100%, legibility was 93.75%, easiness was 91.07%, and design was 91.67%. Learning experts assessed instructional design suitability this media was 82.29% and working sheet suitability was 84.38%. Table 5 showed the average results of the feasibility assessment.

| Experts          | Score  | Interpretation |
|------------------|--------|----------------|
| Material experts | 96.88% | Excellent      |
| Media experts    | 93.75% | Excellent      |
| Learning experts | 82.81% | Excellent      |
| Average          | 91.14% | Excellent      |

Based on the feasibility test, the material expert scores with an average of 96.88%, the media expert scores with an average of 93.75%, and the learning expert gives the score with an average of 82.81%. Overall, this media got the assessment with very good interpretation. After the assessment from experts this media tested in MA Al-Kenaniyah. The students used this device as learning media to understand circular motion concept, then they filled out the questionnaires. Material suitability got 78%, interactive got 80.46% and design got 83.43% from 29 students who filled the questionnaires. Beside that, the device helped students to observed the uniform circular motion and centripetal force which score 79%, it also helped students to analyze angular velocity and centripetal force which score 73%, and the device made students to active in physics learning, add to curiosity and motivated them to study physics which score 80.46%

Technology and learning media can help discovery and investigation. Investigation is a time-consuming but effective process for tracing knowledge beyond textbooks[6]. The new science of learning is beginning to provide the knowledge to improve significantly people’s abilities to become...
active learners who seek to understand complex subject matter and are better prepared to transfer what they have learned to new problems and settings [7]. It is important for educators involved in the theorisation of twenty-first-century teaching and learning, in that rapidness of online interface development brings to bear a need for a new theoretical understanding of embodiment in an era of learning with new media [8].

4. Conclusion
This circular motion practice device is able to assist students in understanding the concept of circular motion irregularly, the influence of radius on angular speed and linear speed, and centripetal force. This media has been tested to the experts and get an excellent interpretation with average score was 91.14% and worthy of use as a medium of learning in school.

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