

Uniform circular motion concept attainment through circle share learning model using real media

Ponimin¹, Suparmi², Sarwanto² and W Sunarno²

¹Science Education Graduate Program, Sebelas Maret University, Surakarta, Indonesia

²Lecturer Science Education Graduatel Program, Sebelas Maret University, Surakarata, Indonesia

ponimin@student.uns.ac.id

Abstract. Uniform circular motion is an important concept and has many applications in life. Student's concept understanding of uniform circular motion is not optimal because the teaching learning is not carried out properly in accordance with the characteristics of the concept. To improve student learning outcomes required better teaching learning which is match with the characteristics of uniform circular motion. The purpose of the study is to determine the effect of real media and circle share model to the understanding of the uniform circular motion concept. The real media was used to visualize of uniform circular motion concept. The real media consists of toy car, round table and spring balance. Circle share model is a learning model through discussion sequentially and programmed. Each group must evaluate the worksheets of another group in a circular position. The first group evaluates worksheets the second group, the second group evaluates worksheets third group, and the end group evaluates the worksheets of the first group. Assessment of learning outcomes includes experiment worksheets and post-test of students. Based on data analysis we obtained some findings. First, students can explain the understanding of uniform circular motion whose angular velocity and speed is constant correctly. Second, students can distinguish the angular velocity and linear velocity correctly. Third, students can explain the direction of the linear velocity vector and the direction of the centripetal force vector. Fourth, the student can explain the influence of the mass, radius, and velocity toward the centripetal force. Fifth, students can explain the principle of combined of wheels. Sixth, teaching learning used circle share, can increase student activity, experimental results and efficiency of discussion time.

1. Introduction

Circular motion is an important concept and has many applications in life. Application of uniform circular motion in daily life such as the motion of vehicle wheels, the motion of the planets, the atomic theory, and satellite motion. Understanding of students on uniform circular motion concept is not optimal due to several problems. Students have difficulty on understanding of the velocity direction [1], the direction of the centripetal force [2, 3, 4, 5], acceleration [6, 7, 8, 9] and wheel combination. The difficulties do to the use the lecture method, mathematical approach, limited of media [10], the concept is abstract, and social system of student was not supporting to collaboration. To overcome the problem the real media was developed and used. It was used to visualize of uniform circular motion process. The real media consists of toy car, string, stopwatch, spring balance round table and wheel combination. The real media used to obtain uniform circular motion concept. First, students can



explain the understanding of uniform circular motion whose angular velocity and linear velocity is constant. Second, students can distinguish the angular velocity and linear velocity. Third, students can explain the direction of the linear velocity vector and the direction of the centripetal force vector. Fourth, the student can explain the influence of the mass, radius, and velocity toward the centripetal force. Fifth, students can explain the principle of combined wheels. The use of media can increase the student motivation can build the procedural and conceptual understanding, collaborative [11], increase high-level thinking skills [12].

Except the using of media, it is also used circle share model. Implementation of the circle share requires several stages. At first, the students discuss in their respective groups, after that they discuss between groups with circle-share models. The worksheet of each group evaluated by other groups. The first group evaluates the second group, the second group evaluates the third group, n group evaluate the first group (Figure 1).

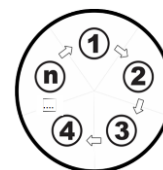


Figure 1. Circle Share Scheme

Circle share model aims to enable students to interact more programmatically and social system that occurs more widely. Interactions between groups can add information, stimulate new ideas and improve intellectual students [13].

2. Methods

This research is a qualitative descriptive study, using a sample of 40 students. The research was conducted through several steps. First, the students determine the working groups. Second, students conduct experiments in real media to obtain uniform circular motion concept, each group evaluated other group through circle-share models. The third, after a circle-share one of the group presents to get a conclusion the concept of uniform circular motion. Fourth, the assessment is to assess students' worksheets and post-test.

3. Result and Discuss



Figure 2. Toy car moving in the round table

The first experiment uses toy car move in a circle to get the concept of circular motion on the path and period. The second experiment, with the same tools, used to demonstrate that the circular motion angular velocity and speed is constant (Figure 2). It takes at an angle of 90° , 180° , 270° and 360° recorded. Next, calculate the angular velocity and linear velocity. The first and second experiment students get the concept that uniform circular motion has circular path, angular velocity and the linear velocity is constant (Table 1).

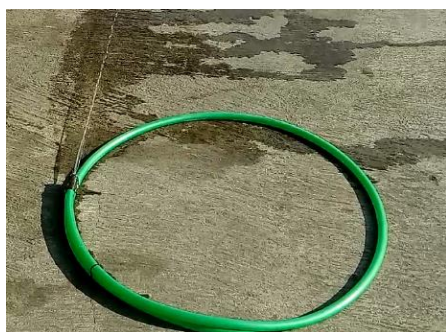
Table 1. Relationships of time, angular velocity, and linier

Point	Time (s)	Angular Velocity (rad.s^{-1})	Linear velocity (m.s^{-1})
A s/d B	4	$0,5 \pi$	$0,2\pi$
B s/d C	4	$0,5 \pi$	$0,2\pi$
C s/d D	4	$0,5 \pi$	$0,2\pi$
D s/d A	4	$0,5 \pi$	$0,2\pi$

The third experiment uses string ties toy car given point A, B and C. Then record the time and calculate the angular velocity and linear speed of points A, B, and C. From experiments the students get the concept that the circular motion angular velocity is constant and the linear velocity is influenced by the radius (Table 2).

Table 2. The relationship between the radius, angular velocity, and linear velocity

Point	Radius (m)	Time (s)	Angular Velocity (rad.s^{-1})	Linear velocity (m.s^{-1})
1. A	0,80	18 s	$0,11 \pi$	0.089π
2. B	1,20	18 s	$0,11 \pi$	0.130π
3. C	1,60	18 s	$0,11 \pi$	0.178π

**Figure 3.** Out of water hose according to tangent**Figure 4.** Direction of v vector and F vector

The fourth experiment uses toy cars equipped with two arrows. The first arrow describes the linear velocity vector. It's the direction of car motion. Second arrow is toward to the center circle to describe the centripetal force. To determine the direction of the linear velocity can be implemented in other ways. First, cut the rope when the toy car is moving and the students observe the direction of motion of the car as the linear velocity direction. Second, use circular flowing water in hose, the water that comes out of the hose is not circular but straight. From the experiments, the students get the concept that the direction of the linear velocity of the tangent in the circle. The direction of the centripetal force is towards the center of the circle (Figure 3 and Figure 4).

The fifth experiment uses tool that consists of three wheels (Figure 3), R_1 concentric with R_2 , while R_3 which is connected by rope. Wheel 1 is rotated once with a time of 4 seconds, then the wheels 1 and 2 wheel rotates once and the third wheel rotates twice, and then calculated the angular velocity and linear velocity of each wheel. From the experimental results, the students get the concept that the concentric wheel is same angular velocity but the linear velocity is different (Table 3). The wheels connected by a rope have different angular velocity but they have same linear velocity (Table 4).

Table 3. Relationship angular velocity and linear velocity on concentric wheels

Wheel	Angular Velocity (rad.s ⁻¹)	Linear velocity (m.s ⁻¹)
R1	$0,25\pi$	0,375
R2	$0,25\pi$	0,050

Table 4. Relationship angular velocity and linear speed on wheels connected ropes

Wheel	Angular Velocity (rad.s ⁻¹)	Linear velocity (m.s ⁻¹)
R 2	$0,25\pi$	$0,05\pi$
R 3	$0,50\pi$	$0,05\pi$

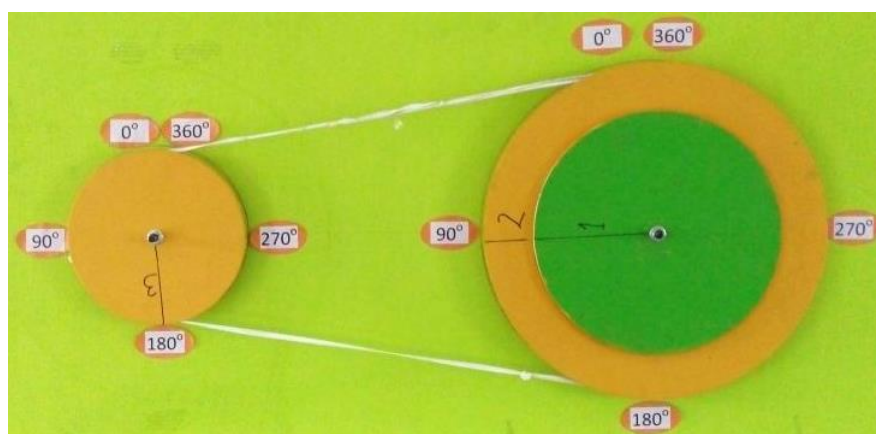


Figure 5. Wheel combination

Table 5. Radius relationship with centripetal force

No	Radius (m)	Force (N)
1	0,80 m	1,5 N
2	1,20 m	1,1 N
3	1,60 m	0,7 N

Table 6. Massa relationship with centripetal force

No	Massa (kg)	Force (N)
1	0,700	0,7 N
2	0,900	1,0 N
3	1,100	1,3 N

Table 7. Velocity relationship with centripetal force

No	Velocity (m.s ⁻¹)	Force (N)
1	4,5	0,7
2	5,5	1,1

The sixth experiment uses spring balance between the car and the center. Spring balance is used to measure the centripetal force. This tool (Figure 4) is used to determine the influence of the radius, mass and velocity toward the centripetal force qualitatively. From these experiments the students get the concept; that the centripetal force is influenced by radius (Table 5), mass (Table 6) and velocity (Table 7).



Figure 6. Linier velocity and centripetal force before circle share



Figure 7. Linier velocity and centripetal force after circle share

Figure 6 and Figure 7 show worksheet of student. Figure 6 is the example of worksheet of learners on drawing the direction of vector before circle share. The centripetal force vector drawing is correct, the direction toward to the center of the circle, but velocity vector drawing is wrong. Vector velocity straight and touch in the circle, but the vector drawing is curved. Figure 7 is the example result worksheet of learners on drawing the vector direction after circle share. The drawing of centripetal force vector is correct, the direction toward the center of the circle. The drawing of linear velocity vector is correct too, it is straight and touches the circle. Another student worksheet can be found in Appendix 1 and Appendix 2.

Student achievement focus on the data writing, data analysis and conclusions score before and after circle share. Furthermore, before and after the circle share score compared.

Table 8. Score of experiment

No	activity	before circle share	after circle share	Increase	Percentage
1	data recorded	9,54	10,00	0,45	4,80 %
2	data analysis	7,10	9,55	2,45	34,51 %
3	conclusions	7,60	9,45	1,85	24,34 %

Table 9 is student score. The average score before circle of data record is 9.54 and the score after circle share is 10.00, an increase of score is 0.46 or 4.80%. The average score of data analysis before the circle share is 7.10 and after the circle share is 9.55, an increase 2.45 or 34.51%. The average score on conclude before circle share is 7.60, after circle share is 9.45, an increasing 1.85 or 24.34%. Thus the circle share can improve students learning score in the experimental results; recorded data, data analysis and conclusions.

The end outcome of students consists of experimental results and post-test. All of 40 students, maximum score is 93, an average of 82, a minimum of 64. The student's score of 35 students are more than 70 (87.5%). The score of five students are less than of 70 (12.5%), according to the records when activity turns these students are less active in conducting experiments and discussions so that the concept obtained is not optimal.

Using real media makes it is easier for students to accept the concept. Students receive information through the senses; visual, hear, and touch [14]. Students accepted concept then stored in long-term memory, so it is not easily lost and easy to be called back [15, 16]. Learning uniform circular motion using real media can overcome difficulty of concept understanding of uniform circular motion. This media for six experiments, five experiments worked well. One experiment is the centripetal force is not optimal due to the frictional forces against the boards' toy cars [17]. Circle-share model application can improve learning outcome. Circle-share is a model of discussion to collaborate and cooperative each student group. Collaborative and cooperative learning can improve social skills and academic achievement [12]. Circle share model is discussion forms the application of a two-steps approach can reduce the cognitive load of students [18]. Interaction between groups is a widespread form of collaboration that can stimulate new ideas and improve student's intellectual [13].

4. Conclusion

Learning of uniform circular motion using real media and circle share models obtain some of the findings. The first finding is the use of real media that can visualize process of the uniform circular motion. The results showed that media is acceptable to teaching learning uniform circular motion. Teaching learning is well done, the students are active and motivated, student learning outcomes are better. Students obtain concept of uniform circular motion correctly. First, students can explain the meaning of uniform circular motion that has circular path with a constant angular velocity and speed. Second, the students obtain the concept that the angular velocity is constant but linier velocity being influenced by radius of the circle. Third, the direction of the linear velocity is the direction of the

tangent of the circle and the direction of the centripetal force is always towards the center of the circle. Fourth, the students obtain concept that the concentric wheel has same angular velocity but linear velocity is different. The wheels are connected by a rope has different angular velocity but the linear velocity is same. Fifth, that centripetal force is influenced by the radius, the larger radius causes smaller centripetal force; if the mass is greater so the centripetal force is greater too; If the speed is greater, so the centripetal force is greater too.

The second finding is that circle-share model can increase the experimental results of students. It can add new information from another groups, work in the group is not yet optimal. Circle-share model is a way to create more extensive social system than the social system within the group. Each group programmatically and systematically evaluates the worksheet of other groups. Evaluates to other groups can add the new information in each group. The response of groups to one another is different when it gets the results of his evaluation. The attitude of the group responding to the evaluation result is different; it makes different increasing one group with another group.

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Appendix 1. Student's worksheet before circle-share

Analisis

- waktu yang ditempuh setiap perpindahan titik sama
- kecepatan sudut setiap perpindahan titik sama
- kecepatan linier setiap perpindahan titik yang arahnya menyinggung sama.

Kesimpulan

- Waktu yang ditempuh A ke B ; B ke C ; C ke D ; dan D ke A besarnya sama
- Jadi kecepatan sudut sama dan kecepatan linier sama.

Appendix 2. Student's worksheet after circle-share

Analisis

Kecepatan Linier

- Hasil bagi antara perpindahan benda dengan selang waktu tempuhnya, arahnya menyinggung lingkaran.
- dinotasikan dengan v

v pada perpindahan AB, BC, CD, DA adalah sama $v = s/t = 0,2\pi \text{ m/s}$

Kecepatan Sudut

- perpindahan sudut setiap satuan waktu
- dinotasikan ω

ω pada perpindahan AB, BC, CD, DA adalah sama $\omega = \theta/t = 0,125\pi \text{ m/s}$

Kesimpulan

- dari percobaan tersebut disimpulkan bahwa kecepatan linier (v) dan kecepatan sudut (ω) adalah konstan.

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