Analysis of concept understanding and skill of problem solving on circular motion topic using Creative Problem Solving model

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Abstract. Technology development in 4.0 industrial revolution era demands students to have 21st century skills, one of them is the skill to solve problems. The aim of the research is to describe and analyze the concept understanding and skill of physics problem solving on circular motion topic using creative problem solving (CPS) model. The research was conducted in one of State High Schools in Malang. The sample consisted of sixty eight students divided into one experiment class group and one control class group. The technique of data collecting used test of concept understanding in the form of multiple choices and test of problem solving in the form of problem analysis. The data analysis used two-ways anova. The result of the research shows that there are; concept understanding of students that are taught using CPS is higher than using Problem Solving (PS) model, (2) concept understanding of students who have high and low problem-solving skills that are taught using CPS is higher than using PS model.

1. Introduction

Physics is the foundation of all knowledge, which participates in advanced technology development in 4.0 industrial eras which demands us to have some 21st century skills and one of them is the skill to solve problems. Physics has requirement which explains about product, process, and behavior; it means very important for students to have concept understanding and skill to solve problems, and to experience learning situation which teaches product, process, and behavior in physics learning [1].

However in fact, teachers at school still often teach physics by only giving product using conventional method of which the learning is still focused on the teacher as the speaker that it does not really involve the mutual process which students need to experience [2]. No students’ involvement in learning will have them accustomed to receive anything their teacher give without understanding what has been delivered, and this has the students accustomed to study by memorizing [3]. This memorizing habit will only affirm the stigma that physics is difficult subject for students [4]. It affects the students’ disability to understand the concept that they cannot solve physics problems given [5]. Understanding physics concept is a level where a student does not only know physics concept, but also understands it well. It shows by his/her ability to solve various physics problems, both connected to the concept itself and the application in new situation [6].
Concept understanding and problem solving with correct reasons on physics lessons which are mechanics, kinematics, dynamics; will be one of indicators for students to master physics well because the lessons are connected each other. One of important physics lesson is circular motion which is in kinematics physics. With the characteristics on circular motion lesson which needs process of concept understanding and problem solving skill well. However, students still think it is difficult to understand and solve the problems connected to circular motion lesson. Moreover, they are still confused and have misconception that they often experience difficulty in solving problem in learning circular motion lesson [7,8]. Students still need affirmation to understand and to solve problem in this lesson [9].

Various learning models are applied and examined to be able to solve various problems, it relates to how teachers teach physics which enables students to have problem solving skill [10]. One of learning models which focuses on problem solving skill which functions as a bridge for education that students can learn to master problem solving creatively is the Creative Problem Solving (CPS) learning model. Based on the existed research, CPS learning model can also improve students’ concept understanding in physics [11,12]. CPS model can improve students’ concept mastering as their skill to solve physics problem [13]. CPS learning model is expected to be able to accompany students in facing twenty-first-century demand, if students are also completed with skills in technology which can optimize the process of physics learning, for example the learning experience which uses interactive learning technology media, because learning based on Communication and Informational Technology cannot be separated from the demand of twenty-first-century learning [14].

The aim of the research is to describe and analyze the concept understanding and skill of physics problem solving on circular motion topic using creative problem solving model. Good problem solving skills are very influential in understanding the concept of student physics [6,12], in reality there are still many students who are not accustomed to solve physics problems with the solving problem, therefore the application of CPS is strongly advised to stimulate students to think creatively in resolving the problem and will ultimately have a significant impact on the concept of understanding.

2. Research methods
Method used in the research is the method of quantitative research with quasi-experiment type, and refers to Post-test Only Control Group Design. Sample of the research consisted of 68 students who were divided into two classes; they were X Science G1 with 34 students as experiment class which received CPS learning model and X Science H1 with 34 students as control class which received Problem Solving (PS) learning model. The research’s principle in deciding control class and experiment class was the research’s consideration because both classes had the right to be control class or experiment class. Method used to collect data in the research was test documentation method. Documentation method was done to collect data of physics scores in previous lesson. The data was then used to compare between experiment class and control class. On the other side, test method was used to collect data of concept understanding and test of problem solving skill using proper instrument. The same test was given to both classes and was used to collect final data. The tabulation data result was used to test the validity of hypothesis.

The data then tested using normality and homogeneity tests in order to get proper treatment. The final data of the research was collected from the scores of concept understanding and problem solving skill tests in experiment class and control class after treated using CPS model for experiment class and PS model for control class. The data then analyzed using normality test, homogeneity test, two-ways anova hypothesis test, two-average equality test, and interaction test.

3. Results and discussion
3.1. Concept understanding
Concept understanding has indicators which stated by Anderson and Krathwohl, they are [15]; (1) Interpreting, (2) Exemplifying, (3) Classifying, (4) Inferring, (5) Comparing, and (6) Explaining. Result of the research which shows percentage of concept understanding indicators can be seen on Figure 1.
Concept understanding indicators are applied in the form of concept understanding test with type of problems as on Table 1. The interpreting indicator shows that there are 28 students who answer correctly in CPS Class with 34 students and there are 27 students who answer correctly in PS Class. The exemplifying indicator shows that there are 32 students who answer correctly in CPS Class with 34 students and there are 31 students who answer correctly in PS Class. The classifying indicator has two problems; there are 63 correct answers for both problems in CPS class and 60 correct answers in PS class. The inferring indicator has two problems; there are 58 correct answers for both problems in CPS class and 56 correct answers in PS class. The comparing indicator has two problems; there are 37 correct answers for both problems in CPS class and 54 correct answers in PS class. The explaining indicator has two problems; there are 55 correct answers for both problems in CPS class and 34 correct answers in PS class.

Table 1. Concept understanding indicators on example problem of circular motion.

| Concept Understanding Indicators | Problem of Circular Motion Concept |
|----------------------------------|------------------------------------|
| 1 Interpreting                    | Students are required to identify the right image to demonstrate the characteristic of the centripetal acceleration relationship with its linear velocity, in a circular motion with the directional centripetal acceleration always towards the center and perpendicular to the linear velocity. |
| 2 Exemplifying                    | Students are required to identify and give examples of the application of circular motion in daily life. |
| 3 Classifying                     | Students are able to classify the truth of the wheel relationship concept. The following application of circular motion in the right Wheel association is, On Wheels intersect \( v_1 \neq v_2 \). On the wheel concentric \( v_1 = v_2 \). On wheels connected with belt \( \omega_1 = \omega_2 \), on concentric wheel \( \omega_1 = \omega_2 \) and On wheels connected to the Belt \( v_1 = v_2 \). The correct answer is on concentric wheel \( \omega_1 = \omega_2 \), because the wheels correspond concentric so that the angle at the time of movement is the same as well as the speed of its angle. |
| 4 Inferring                       | In circular motion, the irregular angular acceleration value \( (\alpha) \) is changed. For in circular motion is changed in order, if the angular acceleration is in a direction of angular velocity, then the acceleration is negative. But when the angular acceleration is counterclockwise, the value of the rate is positive. |
| 5 Comparing                      | Students are required to compare angular velocity between wheels. The wheels A and wheel B intersect, while the C wheels with the B wheels are connected with a chain. How does the angular velocity compare? |
| 6 Explaining                     | Students are able to make a formula of comparison of properly connected wheels. An object moves at a constant speed of \( V \) through the trajectory of a circle-radius \( R \), with a centripetal acceleration \( (v) \). For centripetal acceleration to be twice from the original, then how is \( V \) and \( R \)? |
3.2. Problem solving skill

Problem solving skill has indicators which analyzed and observed based on result of problem solving skill test in the worksheet CPS model. Problem solving skill has indicators based on what Polya stated, they are; (1) understanding the problem, (2) planning on solving the problem, (3) applying the planning on solving the problem, and (4) reevaluating the solution. Result of the research which shows the percentage of problem solving skill indicators can be seen on figure 2. Histogram of Indicator Percentage.

![Figure 2. Histogram of problem solving skill indicator percentage in CPS Class and PS Class.](image)

Indicators of problem solving skill are applied in the form of problem solving test with the problems as on figure 3. Students are used to solve the problems sequentially according to the problem solving Model learning problem solving based on the constructivist philosophy that can give students an opportunity to actively engage in learning, finding and finding themselves information to be processed into concepts, principles, theories, or conclusions and prioritize on skills and activities of thinking for problem solving, mastering concepts and constructing solutions to problems faced by students [16].

![Figure 3. Worksheet case studies 1.](image)

Understanding the problem indicator is in every 5 problems given. For 5 problems, students of CPS-K class get total score 114 for answering correctly and 65 correct answers in PS class. The reason there is different indicator percentage between concept understanding and problem solving in CPS model and PS model can be explained by the analysis result of concept understanding and problem solving based on learning models and result of hypothesis tests using two-ways anova.

3.3. Analysis of concept understanding and problem solving skill based on learning models

Students who study using CPS model not only receive lesson and problems based on learning model, but also receive affirmation lesson through media Kahoot. Media Kahoot which is used by students in CPS learning supports students more in understanding the concept well which is showed in the higher result of indicator percentage of concept understanding than students in PS class. In other words, CPS model with its syntax really affects the indicators of students’ physics concept understanding. The analysis result using two-ways anova shows that students’ concept understanding who study in CPS-K learning model in experiment class have higher concept understanding score than the students in control
class who study in PS learning model. This can be seen on Table 3. Analysis Result of Two-Ways Anova Test.

Decision making is based on calculation result using SPSS with score gain sig 0.000 < 0.05 on learning model column and CPS model vs PS model. It is because the application of CPS learning model which conducted by the researcher gives positive result in students’ concept understanding which was observed during the learning process, the positive result which affects the concept understanding comes from the steps or phases of CPS learning model. Each phase creates more meaningful learning, the assistance of media kahoot makes students to be more interest, motivated, and able to memorize and understand the lesson [17].

Analysis result shows that students’ concept understanding in CPS class is higher than in PS class, and students’ concept understanding that has high and low problem solving skill in experiment class and study in CPS model is higher than score of students’ concept understanding who have high and low problem solving skill in control class. It is because the students in CPS class receive learning with the assistance of media kahoot as the affirmation lesson. Media Kahoot which takes part as the affirmation lesson affects the result of students’ problems solving skill test which done in group, it is helping the students gain more experience in understanding the lesson and solving the problems given. It is different from PS class where students only receive the lesson and solve the problems given only in fully PS model.

Hypothesis analysis result using SPSS shows that $H_0$ is accepted. The decision making is based on the analysis result which use two-ways Anova, where the significance of concept understanding and problem solving is > 0.05. Thus, it explains that there is no interaction between learning and level of students’ problem solving skill in concept understanding. This is supported when the research did an interview with the students who said there are internal factors, especially physic, psychology, and tiredness. The result of the research is supported by the result of the research conducted by which stated in his result of the research that concept understanding does not have interaction with cognitive force, he also stated in his research that concept understanding is not always affected by moderate variable which is accompanied by dependent variable. The research also gives result that there is no interaction between learning model applied with mastering (medium and low) lesson level in skill of lesson concept understanding. Besides the factors above, it is also because many limits in conducting research that the researcher is less able to control the factors outside learning activity.

4. Conclusion

Based on the analysis result of the research conducted, it can be concluded that: (1) The students’ concept understanding who study using CPS-K model is higher than they who study using PS model, (2) The students’ concept understanding who have skill of high and low problems solving who study using CPS model is higher than they who are in PS class.

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