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The Relationship of Students' Conceptual Mastery and Problem Solving on Rigid Body

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Abstract: This study aims to determine the relationship between students mastery of concepts and problem solving on the rigid body lesson. This research was a correlational study. The research sample consisted of 64 students of 12th class of the state senior high schools were selected using purposive random sampling. The research instrument consisted of multiple choice questions to measure students 'mastery of concepts and problem descriptions to measure students' problem-solving. The average value of students' mastery of concepts and problem solving students respectively were 52.81 (11.98) and 31.95 (10.06). Data results of both tests were analyzed with Pearson product moment correlation. The results showed a positive correlation between mastery of concepts to problem-solving student.

Key Words: mastery of concepts, problem solving, rigid body

Abstrak: Penelitian bertujuan untuk mengetahui hubungan antara penguasaan konsep dan pemecahan masalah siswa pada materi benda tegar. Jenis penelitian adalah penelitian korelasional. Sampel penelitian terdiri dari 64 siswa kelas XII dari dua sekolah SMA Negeri yang dipilih menggunakan *purposive random sampling*. Instrument terdiri dari soal pilihan ganda untuk mengukur penguasaan konsep dan uraian untuk mengukur pemecahan masalah. Rata-rata nilai penguasaan konsep dan pemecahan masalah berturut-turut adalah 52,81(11,98) dan 31,95(10,06). Data hasil kedua tes dianalisis dengan korelasi *pearson product moment.* Hasil penelitian menunjukkan adanya korelasi positif antara penguasaan konsep dengan pemecahan masalah siswa.

Kata kunci: penguasaan konsep, pemecahan masalah, benda tegar

INTRODUCTION

Mechanics is one of the basic concepts of physics that has been taught from elemen tary to tertiary levels. One of the material mechanics taught to high school students in class XI is rigid equilibrium and rotational dynamics. This material is important to understand because of its many applications in everyday life. The material of rotational dynamics in class XI SMA includes several submaterials, namely torque, moment of inertia, center of gravity, and angular momentum on rigid bodies. In addition it is also added to the equilibrium of rigid bodies. In fact, several studies have found some problems with this material. Agustihana and Dwikoranto (2015) found that students' abilities were still lacking in analyzing and drawing free diagrams of the forces causing rotational motion so students were unable to understand concepts to solve problems related to rotational dynamics. This is also shown by the results of Sa'adah's research (2014) which states that almost 50% of students experience difficulties on the subject of rotational dynamics and rigid equilibrium. In addition, rotational dynamics material requires high analysis and accuracy of simple events. Problems in this material include the determination of formulas used in solving problems that are not easily memorized, students need more mastery about the causes of silence and the movement of an object, as well as what factors affect the spinning or not of an object (Hudhori, 2013). Structural equilibrium subject matter and moment of inertia is one of the physics subject matter which is quite difficult for most students, because besides requiring vector mathematical operations, this material is also a combination of translational and rotational motion. But in its development, research is

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rarely found on the material dynamics of rotation and equilibrium of rigid bodies. Even though the material is still problematic because it is considered difficult by students.

Structural equilibrium learning and rotational dynamics must be based on problem-solving activities because it is a hierarchy of physics learning itself. Gagne places problem solving as the highest hierarchy in learning types (Winkel, 1987). But in reality learning in the classroom tends to override students' physics problem solving abilities (Hoellwarth et al, 2005). Ogilvie (2009) states that the strategies taught in learning are only to solve problems that require mere mathematical calculations. This is in accordance with the findings of Redish (2005) that students are only able to solve simple quantitative problems but lack the ability to solve more complex problems. Whereas one of the goals of learning physics is to make students human beings who are able to solve complex problems by applying the knowledge and mastery of the concepts they have to everyday situations (Walsh et al, 2007).

Physics problems that arise in everyday life are complex so that a thorough mastery of concepts is needed to solve them. Students will be able to solve problems well if they have understood related concepts. Costa (1985) states one of the stages of a person in solving a problem is to collect concepts and related information. Therefore students are expected to be able to understand each concept given. This is also in accordance with Permendiknas No. 22 of 2006 states that one of the objectives of learning physics is to master the concepts of physics. Mastery of concepts can help students in defining a concept (Arends, 2008). Hermawanto (2013) states that the problem faced by physics teachers in learning physics is the level of mastery of the concept of students who are still low. Mastery of a concept learned can be obtained from student involvement in learning activities (Arends, 2008; Muijs & Renolds, 2008). Based on the studies obtained, it is necessary to conduct research that has the aim of increasing students' mastery of concepts and problem solving, especially on rigid objects equilibrium and rotational dynamics.

Based on the background above and consider that the ability to master concepts and problem solving students are related. Then a study was conducted to find out more about the relationship between mastery of concepts and problem solving students on rigid body material.

METHOD

This research was a correlation study conducted by providing concept mastery tests and problem solving in two schools: SMAN 1 Lawang and SMAN 1 Tumpang. The research variable was the mastery of the concept (X) as an independent variable and problem solving (Y) as the dependent variable. Before the test, students in both schools were given reinforcement regarding rigid material. This was done to remind students of the material they learned a year ago. By giving reinforcement or a short tutoring about rigid body material, they are expected to be able to pass the test smoothly.

The test that was administered to 64 students in two schools was a validated test item. The concept mastery test was in the form of 20 multiple choice questions that had been validated with a large count > r_{table} (0.349) and said to be valid, questions were also tested for reliability with $r_i = 0.93$ while $r_t = 0.05$, then $r_i > r_t$ and said to be reliable. This problem was used for a research post-test entitled "The Effectiveness of Deductive Hypothetical Learning Models on Science Process Skills and the Mastery of Physics Concepts on Solid Object Balance Materials" by Winoto (2012). Whereas the problem solving test has passed expert validation regarding the suitability of concepts, indicators, activities, and language. This problem is a post-test study entitled "Learning to Solve Contextual Problems through Free Body Diagrams (FBDs) on Rotational Dynamics Material in Vocational Schools" by Wiratama (2015).

The test was given to 64 students of class XII in two different schools namely 34 students of class XII MIA 3 of SMAN 1 Lawang and 30 students of class XII MIA 2 of SMAN 1 Tumpang. Samples were selected using purposive random sampling technique. Scoring the mastery test concept was done by counting the number of correct answers from 20 items. Whereas the scoring of problem solving tests is carried out with the help of a rubric referenced from Wiratama's (2015) thesis. Rubric arranged according to the items given to students.

Research data processing began by calculating the average value of mastery of concepts and problem solving students in each school. The average value will be accompanied by a standard deviation value. Minimum and maximum values both in concept mastery and problem solving of students from both schools were also calculated. In addition, it is also

necessary to know the value of each section in order to be able to know which sections are difficult for students. This difficulty is seen in the mastery of concepts and problem solving of students.

Then the first prerequisite test is a normality test which is used to find out data from the study sample coming from normally distributed populations. Normality test is performed on each student's concept mastery and problem solving data. The normality test uses the Liliefors test through the Kolmogorov-Smirnov test in the statistical processing software. If $L_{count} < L_{table}$, then the data is normally distributed. Conversely, if $L_{count} > L_{table}$ then the data distribution is not normal. Other requirements are normally distributed data if the value of sig > 0.05.

The second prerequisite test is the homogeneity test. Homogeneity test is used to find out whether the variants of several populations are the same. The data have homogeneous variance if $F_{count} < F_{table}$. Another requirement that can be used is if the significance value > 0.05 then the data used is homogeneous.

The next analysis prerequisite test is the linearity test. Linearity test is used to test the relationship of research variables are linear or not. The linearity test result table is listed in Table 4. The linearity test criterion is that the relationship is linear if $F_{count} < F_{table}$ or significance probability value > 0.05.

If the criteria in the prerequisite test analysis have been met, then proceed with the correlation analysis. This analysis was performed using Pearson Product Moment correlation test. The purpose of this analysis is to find out how closely the relationship between mastery of concepts and problem solving students. If the results of calculation of correlation data show a correlation value > 0.000 or a significance value < 0.05, it can be said that there is a relationship between mastery of concepts and problem solving of students. Instead the two variables are said to be unrelated if the correlation value = 0.000 and the significance value > 0.05.

RESULTS

Mastery of Concepts and Problem Solving Students on Rigid Body Material

The data in this study were obtained by providing a test of mastery of concepts and problem solving students. Descriptive statistical data on both variables namely mastery of concepts and problem solving of students on rigid objects are listed in Table 1.

Table 1. Mastery of Concepts and Problem Solving Students on Solid Object Material Descriptive Statistics

No	Remarks	Mastery of Concept	Problem Solving
1	Average	52,81	31,95
2	Standard deviation	11,98	10,06
3	Minimum	20,00	10,00
4	Maximum	80,00	55,00

Based on the data in Table 1, the average value of students' mastery of concepts is 52.81 with a standard deviation of 11.98. The average value of solving students' problems is 31.95 with a standard deviation of 10.06. The minimum value obtained by students on the concept mastery test is 20 while the maximum value is 80. Then the range of students mastery test results on rigid objects is 60. The results of students' problem solving tests show that the minimum and maximum values obtained by students are 10 and 55. The range of students' problem solving values on rigid body material is 45.

The value of the results of the test of mastery of concepts and problem solving of students on rigid objects then grouped by grades and categories. The value of students' mastery of concepts is interpreted in Table 2.

Table 2. Average Score of Students' Conceptual Mastery

No	Interval	(%)	Remark
1	0-25	4,69%	Low
2	26-50	40,62%	Average
3	51-75	53,12%	Good
4	76-100	1,56%	Very Good
Avg	**52,81**	**-**	**Good**

Based on Table 1, the average value of students' mastery of concepts in rigid body material can be categorized as good, which is 52.81 of the value of 100. Based on the results of the students' mastery of concept tests on rigid material material, students who obtained 25 are 4, 69%, ≥26 and ≤50 values were 40.62%, 51 and ≤ 75 values were 53.12% while ≥76 values were 1.56%. The results of the concept mastery test on rigid body material show that of 64 students who took the test as many as 63 students scored ≤75 and only one student who scored above 75. This shows that the mastery of the concept of students on rigid body material is still low.

Then, to find out the problem solving abilities of students on rigid body material, students are given a test in the form of five essay items. Interpretation of student problem solving test results on rigid body material is presented in Table 3.

Table 3. Average Score of Students' Problem Solving

No	Nilai	(%)	Remark
1	0-25	34,38%	Low
2	26-50	64,06%	Average
3	51-75	1,56%	Good
4	76-100	-	Very Good
Avg	**31,95**	**-**	**Sufficient**

Based on the data in Table 2, the average value of problem solving students on rigid body material is 31.95. Based on the data of students' problem solving test results on rigid body material, it can be seen that students who obtained the value of ≤ 25 was 34.38%, the value of ≥ 26 and ≤ 50 was 64.06%, the value of ≥ 51 and ≤ 75 were 1.56% while the value of ≥ 76 was 0%. The results of students' problem solving tests on rigid body material shows that of the 64 students who took the test, all students still scored ≤ 75. None of the students achieved grades above 75. This shows that the problem solving of students in rigid body material was still low.

Relationship Between Mastery of Concepts and Problem Solving Students on Rigid Object

Data on the results of the test of mastery of concepts and problem solving of students on rigid body material are then tested using the correlation test. Before conducting a correlation test, the prerequisite test, the normality test, the homogeneity test, and the linearity test were performed. After that the correlation calculation was done using Pearson Product Moment.

The results of the normality test using the Kolmogrov-Smirnov one-sample test are shown in Table 4. Based on Table 4, students' mastery of concepts has a significance value of 0.322 or > 0.05 thus the data on the mastery of the concept tests is normally distributed. Problem solving test data has a significance value of 0.442 or > 0.05 thus problem solving data is also normally distributed.

The second prerequisite test was the homogeneity test. This test was carried out using statistical processing software. Homogeneity test results of student problem solving test results based on students' concept mastery data is presented in Table 5.

Table 4. Kolmogorov-Smirnov Normality Test Results on the Concept Mastery Test and Student Problem Solving

Variable	Significance Value	Remark
Conceptual Mastery	0,322	Normally distributed
Problem Solving	0,442	Normally distributed

Table 5. Homogeneity Test Results for Problem Solving based on Students' Mastery of Concepts

Variable	Significance value	Conclusion
Problem Solving based on Students' Mastery of Concepts	0,212	Homogeous

Based on the data homogeneity test results, the variance of the two variables tested is homogeneous. That is, the problem solving variable data based on the concept mastery variable has the same variant.

The last prerequisite test was a linearity test. This test was performed to determine whether a variable depends on other variables. Linearity test was done by calculation using ANOVA Linearity in statistical processing software. The results are presented in Table 6.

Table 6. ANOVA Linierity Results

Variable	Significance	Conclusion
Problem solving* mastery of concept	0,302	Linear

Based on the data in the linearity test in Table 6, it is known that the data is linear when Deviation from linearity has a sig value ≥ 0.05. Based on the data in the table, the Deviation from Linearity is 0.302 or above 0.05, thus this data meets the criteria for linearity and there is a linear relationship between mastery of concepts and problem solving of students on rigid body material. Linearity in problem solving and mastery of students' concepts can also be seen in Figure 1.

Figure 1 shows a linearity graph between the mastery of concepts and student problem solving, with a regression equation Y = 0.644X - 2.054. This graph shows that from the data generated from the concept

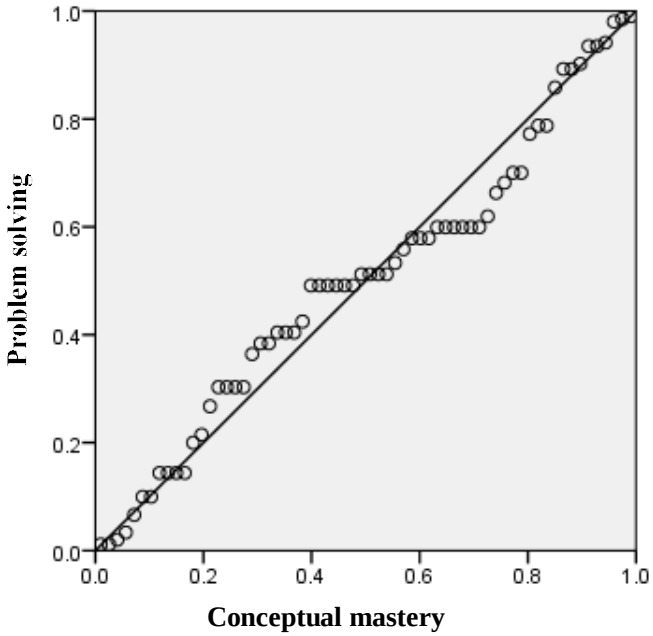

Figure 1. Linearity Graphs between Concept Mastery and Student Problem Solving on Rigid Body Material

mastery test and problem solving shows there is a linear line connecting the two variables. Linear lines can be interpreted that problem solving is related to students' mastery of concepts in rigid body material with a slope of 0.644.

After the prerequisite tests in the form of tests of normality, homogeneity, and linearity have been tested, then testing the relationship between mastery of concepts and problem solving students on rigid objects were performed. Table 7 shows the interpretation of the correlation coefficient.

In this study the relationship between mastery of concepts and problem solving students on rigid body material will be adjusted to the level indicated by Borg and Gall as in Table 5. The correlation coefficient value of the relationship between the independent variable with the dependent variable consists of five levels: a very weak relationship if the value of the correlation coefficient ≤ 0,20, a weak relationship if the value of the correlation coefficient >0.20 and ≤ 0.40, a moderate relationship if the value of the correlation coefficient > 0.40 and ≤ 0.60, a strong relationship if the correlation coefficient >0.60 and ≤ 0.80, and a very strong relationship if it has a correlation coefficient >0.80 and .001.00.

In this study, testing the relationship between mastery of concepts and problem solving of students on rigid body material was carried out using Pearson Product Moment. The results of the analysis are presented in Table 8.

Table 7. Interpretation of Correlation Coefficients (Borg & Gall, 2003)

Correlation Coefficient	r ≤ 0,20	0,20 < r ≤ 0,40	0,40 < r ≤ 0,60	0,60 < r ≤ 0,80	0,80 < r ≤ 1,00
Interpretation	Very weak	Weak	Mode rate	Strong	Very Strong

Table 8. Correlation Test Results between Mastery of Concepts and Problem Solving Students on Rigid Object Material

Variable	Correlation	Significance	Remark
Conceptual Mastery * Problem Solving	0,767	0,000	There is a correlation between concept mastery and problem solving

The data in Table 8 shows that the significance value is 0.000 or less than 0.05. The number indicates that there is a correlation between mastery of concepts and problem solving of students on rigid body material. Based on Table 8 it can also be seen that the two variables tested are mastery of concepts and problem solving of students on rigid body material positively correlated with the correlation coefficient R = 0.767. With the correlation coefficient R = 0.767, it can be stated that the data mastery of concepts and problem solving on rigid objects tested with the Pearson Product Moment correlation test has a strong relationship. Based on the value of R = 0.767, then the value of R2 = 0.59 or equal to 59%. The number shows that the concept mastery factor has a determination of as much as 59% of students' problem solving on rigid body material and 41% there are other factors that are related to students' problem solving.

DISCUSSION

Problem solving ability is one of thinking skills that must be possessed by every student. Ellis mentioned several essential abilities: i.e. problem solving skills, critical thinking, creative thinking, decision making, conceptualizing, and information processing (Carson, 2007). Problem solving must be possessed by students since it is essential in the context of professional life as Heuvelen wrote that Physics department graduates (undergraduate and postgraduate) use the ability to solve problems with the highest frequency compared to other abilities. Mourtos, Okamoto, and Rhee also stated that problem-solving is essential in most of the occupations (Mourtos et al, 2004).

Because the ability to solve problems is an important element in all aspects, students should be habituated earlier. However, the ability to solve student problems, especially in the discipline of Physics, is still weak. This is evidenced by the acquisition of an average problem solving value of 31.95 with a standard deviation of 10.96. All students have not yet scored 75 even though they have been given assistance and support. Setiono (2014) has also found the same thing that students' problem solving on rigid objects is classified as low. The low ability of students' problem solving is caused by several factors, one of which is teacher-centered strategy in learning in the classroom (Rahmat, 2014).

The problem solving process requires a mastery of concepts. This is also stated by Anindya (2016) that in solving problems, students apply concepts to determine a way and problem solving procedures. In addition to solving problems, students must also have a good mastery of concepts. But in reality, the students' mastery of concepts has not been able to reach 75 with an average of 52.81 and a standard deviation of 11.98. Then the students have not reached completion even though they have been given assistance or support. The low mastery of student concepts is caused by teacher-centered learning, monotonous and demotivating learning, and limited use of technology in learning.

The results of the concept mastery test which consisted of 20 questions stated that the students answered incorrectly on the questions regarding the completion of the rotational motion with Newton's Second Law (amounted to 51 students). Questions with similar topics are also considered difficult by students (50 students answered incorrectly). Followed by questions about the resultant analysis of force moments to determine the equilibrium, there were 49 students who answered incorrectly. Then, there were 49 students who answered incorrectly about the moment of force. In the matter of torque and system motion on the triangular rod there were 48 students who answered incorrectly. In addition, there were 40 students incorrectly answered questions about force moments, 34 students incorrectly answered incorrect questions about the motion of the system on the pulley, and 32 students incorrectly answered questions about rolling motion. The rest, there are more than half the number of students or more than 32 students who have answered correctly on other questions. This difficulty is consistent with what was revealed by Sa'adah (2014) and Hudhori (2013) regarding some of the students' difficulties in rigid body topic.

This study states that the results that students' problem solving is positively correlated strongly with mastery of concepts in rigid body material, with a corre-lation coefficient value of R = 0.767 and a value of determination of 59%. This shows that mastery of con-cepts is one of the factors that can improve students' problem solving on rigid body material with a value of determination of 59% and the remaining 41% comes from other factors. This finding is consistent with Bou-Jaoude (2003) that there is a positive correlation be-tween mastery of concepts and students' problem solv-ing. Likewise, Silaban (2014) found that there was a positive and significant relationship between the mas-tery of physical concepts with the ability to solve prob-lems on static electricity.

CONCLUSION

Based on the results of data analysis and discussion described in the results and discussion section, several conclusions can be drawn: the average value of students' mastery of concepts as a whole is 52.81 with a standard deviation of 11.98. The maximum and minimum values obtained by students are 20 and 80 respectively with a range of 60. While the average value of students' problem solving as a whole is 31.95 with a standard deviation of 10.06. The minimum and maximum values obtained respectively are 10 and 55 with a range of values of 45. Based on the results of the correlation test which had previously been conducted a series of prerequisite tests showed that there was a positive correlation between mastery of concepts and problem solving of students on rigid body topic in two high school with the results of the correlation R = 0.767, with a significance value of 0.000. Mastery of concepts is one of the factors that influence students' problem solving with a value of determination of 59%, while 41% is influenced by other factors.

This research shows that the higher the concept mastery value, the higher the students' problem solving in rigid body topic. The results of this study support the assumptions and findings from previous studies which state that mastery of the concepts possessed will support students' problem solving.

SUGGESTION

Based on the results of the analysis, the mastery of student concepts needs to be improved to improve students' problem solving abilities on rigid body material. This can be done by determining models and methods that are suitable for learning rigid body material. Suggestions to the furture researchers who will continue and develop similar research is the allocation of time to work on tests that have been prepared in accordance with student abilities. Furthermore, giving a module that contains a summary of the material that will be tested to students at least one day before the test is important thus it does not need to be reviewed before the test takes place. This is very important to remember that the material being tested is material that has been taken in class X. Use the test questions that have been tested validity and reliability, or first test the validity and reliability of the questions to be used. Prepare suitable models and methods according to the material character of the rigid body.

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