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# The Mastery of Science Concepts in Solving Physics Problems for Junior High School Students

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***ABSTRAK***

*Rendahnya daya serap siswa mencerminkan kesenjangan antara tuntutan kurikulum dengan tingkat kemampuan berpikir siswa. Ketidakmampuan siswa dalam mengerjakan suatu tugas bukan hanya karena mereka tidak memiliki pengetahuan prasyarat yang diperlukan, tetapi juga keterbatasan kemampuan mereka dalam mengolah sejumlah informasi yang diterima. Penelitian ini bertujuan untuk menganalisis hubungan penguasaan konsep IPA, khususnya fisika terhadap kemampuan siswa dalam memecahkan soal-soal fisika. Penelitian ini merupakan penelitian eksperimen dengan jenis pre-experimental dan desain one-shot case study. Populasi dalam penelitian ini adalah siswa kelas 9 SMP. Penentuan sampel dilakukan dengan metode purposive sampling, sehingga diperoleh sampel sebanyak 48 orang siswa. Pengumpulan data dilakukan dengan menggunakan instrumen berupa tes hasil belajar penguasaan konsep IPA (fisika). Analisis data dilakukan secara deskriptif dan inferensial. Hasil penelitian menunjukkan bahwa mean (rata-rata) 77.40 dan standar deviai (sd) 6.58, termasuk kategori baik, sedangkan untuk tes kemampuan memecahkan soal fisika mean (rata-rata) 80.16, dan standar deviasi (sd) 6.28 juga dikategorikan baik. yang dapat melampaui nilai patokan kriteria ketuntasan minimal (KKM) di atas 70. Besarnya indeks koefisien korelasi (r) adalah 0.815 (tinggi), dengan koefisien determinasi ($r^2$) sebesar 0.6642, yang mengindikasikan bahwa sedikitnya 66,42% penguasaan konsep IPA (Fisika) dapat berkontribusi terhadap kemampuan peserta didik dalam memecahkan soal-soal fisika.*

**ABSTRACT**

The low learning absorption of students reflects the gap between the demands of the curriculum and the level of students' thinking abilities. The inability of students to do a task is not only because they do not have the necessary prerequisite knowledge, but also their limited ability to process the amount of information received. This study aims to analyze the relationship between mastery of science concepts, especially physics, on students' ability to solve physics problems. This research is an experimental research with a pre-experimental type and a one-shot case study design. The population in this study were 9th grade junior high school students. Determination of the sample was carried out by purposive sampling method, in order to obtain a sample of 48 students. Data collection was carried out using an instrument in the form of an achievement test for mastery of the concept of science (physics). Data analysis was carried out descriptively and inferentially. The results showed that the mean (average) was 77.40 and the standard deviation (sd) was 6.58, which was included in the good category, while for the physics problem solving ability test the mean (average) was 80.16, and the standard deviation (sd) was 6.28 which was also categorized as good. which can exceed the minimum completeness criterion (KKM) score above 70. The magnitude of the correlation coefficient index (r) is 0.815 (high), with a coefficient of determination (r2) of 0.6642, which indicates that at least 66.42% mastery of the concept of science (Physics) ) can contribute to students' ability to solve physics problems.

## 1. INTRODUCTION

Education is one of the efforts to educate the nation's life and is the main key to achieving the ideals of a nation. Developments in the field of education will affect the development of science and technology so that it has placed science (physics) as one of the important subjects (Bakri et al., 2020; Pratiwi et al., 2019). Developments in the field of education will affect the development of science and

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technology so that it has placed science (physics) as one of the important subjects. Given that science (physics) is one of the important subjects at various levels of education, it is only natural that it should be developed and paid attention to by all education actors, but in reality the ability of students is still very low (Andrian & Rusman, 2019; Maison et al., 2020). The results of studies carried out by International Educational Achievement (IED) organizations for science abilities are only ranked 40th out of 42 participating countries. This fact is also supported by the statement of the science teacher at SMP Nasrani 1 Medan that the average score for the Computer-Based National Examination (UNBK) in Science is only 5.68 and is lower than the average score for mathematics (Argina et al., 2017; Hadi & Novaliyosi, 2019). The low ability of science is influenced by several factors from inside and outside the students themselves. Based on the results of experience when delivering the subject matter of physics, many students are not motivated and interested in following it because they think that physics is a lesson that is difficult to understand and less interesting (Astalini et al., 2018; Napsawati, 2020).

The low ability of students to solve problems is due to the lack of ability to understand the concept of physics itself. This is in line with the opinion of previous research that state problem solving is the ability to use thinking processes in solving problems by collecting facts, analyzing information, compiling alternative solutions, and choosing more effective problem solutions (Hidayatullah et al., 2021). This means that problem solving is a search for solutions through a systematic thought process. The low absorption of students reflects the gap between the demands of the curriculum and the level of thinking ability of students. The inability of students to do a task is not only because they do not have the necessary prerequisite knowledge, but also their limited ability to process a number of information received (Ismiyati et al., 2019; Siswono, 2017; Wityanita et al., 2019). This ability is closely related to the level of cognitive development which consists of two major parts, namely, a. cognitive development in general which is spontaneous and is an internal totality and b. cognitive development in schools is external, influenced by events in the classroom, such as teacher information, teacher teaching methods and teaching media. Cognitive can develop when children experience or take direct action on objects, for example by changing their shape, touching, measuring, classifying, arranging rows, separating and so on (Önder et al., 2020; Rokhman et al., 2019).

Based on the stages of children's cognitive development, junior high school students are already in the formal operations stage which are considered to be able to understand concepts and solve physics problems properly and correctly by focusing on the thought process, and giving freedom to take their own initiative in learning (Sheppard et al., 2021; Suryawati & Osman, 2018). The freedom of the intended students remains under the supervision, direction and guidance of teacher, for example when making observations about static electricity, students must interact and cooperate with each other in preparing tools and materials such as electroscopes, balloons, woolen cloth, combs, rollers. In addition, the teacher continues to monitor the activities that are being carried out by students, and if they experience difficulties, the teacher must immediately and be ready to help. In addition, in the world of education, children must be given full freedom to find something according to their own abilities (Mazid et al., 2021; Pramudyani, 2020). The task of educators is only to provide an optimal learning environment, which allows the formation of meaningful learning outcomes for students themselves. Therefore, it is not unreasonable if there is a certain person trying to accelerate their intellectual development, but we must be able to help shape the development of the cognitive structure of the learners themselves. Mastery of science concepts (physics) is a form of learning that includes the ability to define concepts, distinguish certain concepts from other concepts and the ability to explain the meaning of a concept in everyday life which are the building blocks of thinking higher mental processes in formulate principles and generalizations (Astuti, 2017; Siswono, 2017).

Some of the relevant research results that have been carried out relating to the problems in this study include those found by previous study that there is a positive and significant relationship between mastery of physics concepts and the ability to solve problems on the subject of static electricity for class X science students of SMA Nasrani 1 Medan, where the correlation coefficient is 0.776 and the linear regression equation Y = 5.369 + 0.992 X1 with a contribution of 60.2% (Silaban, 2014). In line with that previous study in instilling the concept of physics, 1) students should be more active and always ask the teacher about material that is still not understood and further increase concentration and accuracy because the concept of physics is not only memorizing, but students must also be required to to understand the concept, and 2) teachers should give more practice questions to students, especially on calculation questions so that students understand more about symbols in physics (Fitriyah et al., 2018).

Furthermore physics learning should pay attention to the nature of physics as a process, product, and attitude. Students construct knowledge actively by involving thinking skills in learning. Students play an active role in constructivist learning and modify their initial knowledge through interaction with the environment (Duda et al., 2019; Leasa et al., 2020). Students' knowledge structures can be identified and

developed through categorization of questions based on the basic concepts of the problem, analogical comparison using worked examples, and synthesis problems. In connection with this research of previous study found that giving complex and contextual problems will help students in practicing physics problem solving skills (Sujarwanto et al., 2014). Giving complex and contextual problems also allows students to have more awareness of the environment. This is in line with the 2013 curriculum which assesses knowledge not only based on results.

Based on the description above, that mastery of concepts with the ability to solve problems there is a very close relationship that influences each other. In other words, the concepts of physics that are owned or that already exist in students will be able to be mastered properly if students often carry out exercises in solving problems or questions related to the topics that have been studied. Based on these various descriptions, he was motivated to carry out research with aims to analyze the relationship between mastery of science concepts, especially physics, on students' ability to solve physics problems.

## 2. METHOD

The research population was all students of SMP Nasrani 1 Medan and the sample was class IX students of SMP Nasrani 1 Medan. Sampling was done by means *of purposive sampling* in one class as many as 48 people, with the consideration that students have abilities and backgrounds that are not much different. Testing the instrument in the form of a concept mastery test physics and problem-solving ability tests, each 20 items in the form of one question on the subject matter of static electricity and electric fields, were given to 22 students of 9$^{th}$-4 SMP Negeri 21 Medan. The concept mastery test indicators consist of analyzing, naming laws, identifying, classifying, distinguishing, interpreting, connecting several concepts, comparing, recognizing constants, solving mathematically, describing, and symbolic responses.

Hypothesis testing is done by descriptive analysis with t-test and *product moment correlation test.* While the requirements test (classical assumption test) is the normality test with the Liliefors test. The linearity test of the independent variable with the dependent variable aims to determine the linearity of the correlation with the regression equation Y= aX+ b. The regression significance test was carried out using ANOVA test with the following criteria: if $F_h > F_t$ or sig. ($p_{value}$) < α , then the regression equation means the chosen one and on the contrary is not significant. Furthermore, the statistical tests used were correlation and regression techniques, and were tested using the t-test, provided that Ho was rejected if sig. (pvalue) < with = *0.05* and (db) = n-2 where n is the number of samples. Furthermore, based on the results of data analysis, the linear regression equation, Y= aX + b, is determined and interprets the meaning of the equation.

## 3. RESULT AND DISCUSSION

### Result

The results of the instrument testing conducted on 22 students of 9$^{th}$ SMP Negeri 21 Medan, it was found that in general the two instruments were valid and reliable with the Cronbach Alpha correlation index of 0.80 and 0.78, respectively. The level of difficulty of the questions analyzed showed that of the 20 questions for mastering physics concepts that were tested, it turned out that 4 items were classified as easy, 12 items were classified as moderate, and 4 items were classified as difficult (difficult). As for the 20 questions of solving ability that were tested, 3 items were classified as easy, 14 items were classified as moderate, and 3 items were classified as difficult (difficult). Thus, both instruments have met the requirements to be used as data collection instruments in the research sample of 9$^{th}$ SMP Nasrani 1 Medan. Furthermore, the questions that have been tested are used to measure the ability of students after being treated with discovery learning, then the average value (mean) of each mastery is obtained. Based on the results of data analysis, the average value *(mean)* of mastery of physics concepts and ability to solve problems is 77.29 which is classified as good and 80.16 is classified as very good with standard deviations of 6.58 and 6.28, respectively.

Based on the results of the average value that Ho on the hypothesis and the hypothesis is accepted and vice versa Ha is rejected. The description of the indicator of mastery of physics concepts on the subject of static electricity after completing two lesson plan is presented in the form of a pie chart in Figure 1.

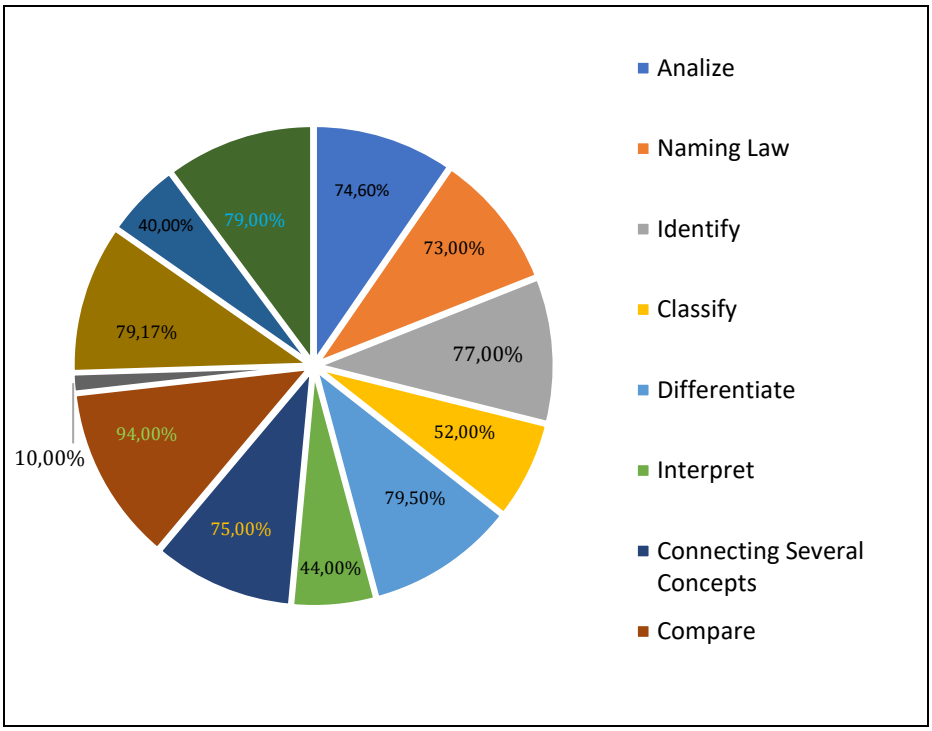


**Figure 1.** Pie Chart Description of Physics Concept Mastery Indicators

Based on Figure 1, it is found that the order of the acquisition value of mastery of physics concepts for students of 9th SMP Nasrani 1, from the highest to the lowest is comparing, connecting several concepts,solving mathematically, interpreting, identifying, recognizing constants, analyzing, naming laws, classifying, and differentiate. Description of the problem-solving ability indicator on the subject of static electricity which is also after comfortable presenting is also presented in the form of a pie chart in Figure 2.

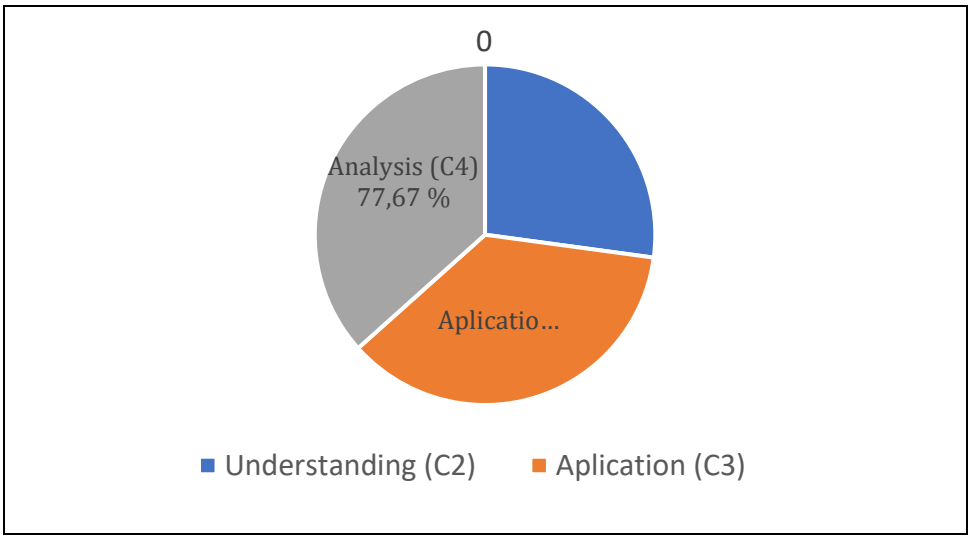


**Figure 2.** Pie Chart Average Percentage of Cognitive Level Per Each Indicator of Problem-Solving Ability

Based on Figure 2, it is found that students have high ability in analyzing questions which is one part of higher order thinking skills (HOTS). While the second or intermediate level, namely applying is also classified as high where students are able to apply the concept of static electricity in solving problems and also in various daily lives. The lowest level of understanding is classified as moderate which indicates that students tend to be able to solve problems from the intermediate level to the top . students are able to find the answer without special assistance by understanding the concept of science (physics) itself. In addition, students have been able to solve more high-level questions to lower levels. Dominant students

have been able to solve problems that are complex (top-down) than those that are complex (top-down) is basic (top- down).

Furthermore, the results of data analysis using the SPSS 23.0 application obtained constant values (B) and regression coefficients of 20.051 and 0.778, respectively, so that the linear regression equation Y on X can be written Y = 20.051 + 0.778 X, which indicates that each mastery of physics concepts an increase of 1 unit will be followed by an increase in problem-solving ability of 0.778. Based on the results of ANOVA with the help of SPSS 23.0, it was obtained that the value of F = 90,703 and sig. ($p_{value}$) < 0.05 which means that the correlation between the two variances of the variables is linear. The correlation coefficient between mastery of physics concepts with problem solving ability is 0.815 which is high, with sig. ($p_{value}$) < 0.00; which shows a positive and significant correlation. Based on the linear curve of mastery of physics concepts with problem-solving abilities shown in Figure 3.

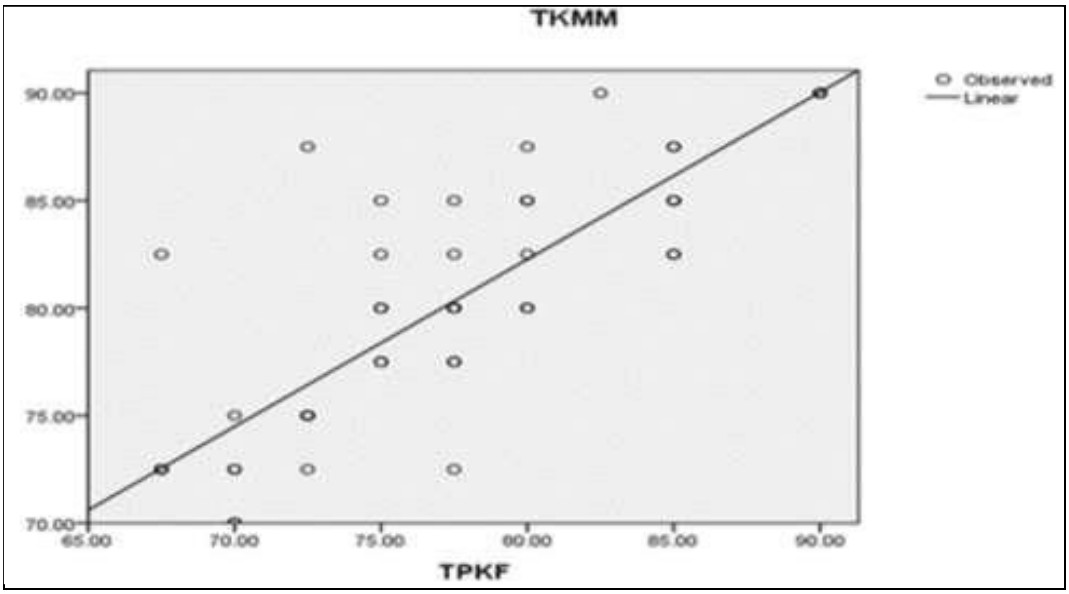


**Figure 3.** Linear Curve of Mastery of Physics Concepts with Problem-Solving Abilities

Base on Figure 3 it shows that the increase in the high mastery of physics concepts (TPKF) is followed by an increase in problem-solving abilities (TKMM) which shows a positive correlation. The results of hypothesis testing show that the correlation index between mastery of physics concepts and problem-solving skills is 0.815 and sig. ($p_{.value}$) of 0.00 and this value is smaller than (a) = 0.05 with a one-tail test which concludes that Ho is rejected and on the contrary Ha is accepted which states that there is a positive and significant relationship between mastery of physics concepts and the ability to solve problem.

**Discussion**

The results of this study prove that students are able to understand a concept by using their own thinking skills according to the level of cognitive development of the child himself. This is also supported by the statement that students can master concepts if the teacher gives examples, and introduces several examples of questions (Del Cerro Velázquez & Méndez, 2021). Furthermore, Vygotsky regarding the theory and its emphasis on the sociocultural nature of learning, believes that learning occurs when children work or learn to handle tasks that have not been studied but the tasks are still within the range of their abilities or the tasks are within their *zone of proximal development,* where independent problem-solving skills and developmental potential are defined as problem-solving abilities under the guidance of adults or more capable peers (Elkordy, 2016; Fitriani & Maemonah, 2022). In line with that, previous study said that the ability to understand a concept is strongly influenced by one's thinking ability (Mustofa & Hidayah, 2020).

While the level of mastery of the expected concept depends on the complexity of the concept and the level of cognitive development of students. Furthermore previous study states that the use of one's concept can be expanded by recognizing other examples of concepts, recognizing other concepts (in the hierarchy of subordinates, coordinates and superordinates), and using those concepts to form principles and problem solving (Chasanah, 2019; Nurdyansyah et al., 2017). Concept mastery is mainly determined by someone capturing stimuli that come from outside, organizing data, formulating problems, building concepts and solving problems as well as the use of symbols verbal and non-verbal.

In connection with pre-cognitive assessments that need to be known, namely the initial abilities of students, previous study said that by knowing the initial abilities of students before entering a level of education (institutions) it will be known whether later students are able to follow lessons and carry out the tasks assigned to him (Roll, 2021). In science (physics) subject matter, the ability to follow can be seen from the mastery of the concepts that have been given to students.

Furthermore problem solving ability is the skill or potential possessed by students in solving problems and applying them in everyday life. Problem solving is a learning method that requires students to find answers without special assistance (Albay, 2019; Castronovo et al., 2022). By solving problems, students will be able to find new rules of a higher level even though it is impossible for them to formulate verbally. Based on these various explanations, the science program (physics) should develop various abilities needed to solve problems. Be some of the abilities that must be mastered include 1) finding elements in a science (physics) problem that can be used in achieving the solution, 2) stating the relationship between the elements, 3) using the required formula, 4) performing mathematical operations with these formulas such as multiplication, division, squaring and so on, 5) using the units of measurement in the metric system or the English system, and 6) understanding the terms used in physics such as volume, velocity, mass, force and so on (Amelia & Pujiastuti, 2020; Vosniadou, 2019).

Taking into account the various descriptions above, it is clear that the knowledge and experience possessed by students before participating in learning has produced a cognitive structure in the brain, but it is not certain that the structure is correct and appropriate to accept new concepts. This will affect the mastery of the concepts given during the learning process (Patel et al., 2018; Susanto et al., 2020). In other words, smart students will be able to connect and generalize the concepts they have acquired in cognitive networks. The more complete, integrated and strong the relationship between the correct concepts in the minds of students, the more capable they will be in mastering the science (physics) subject matter. Meanwhile, to practice problem solving, which is the highest and complex level of learning, many prerequisites are needed, both rules and basic abilities.

The implication of this study provides an overview related to the application of mastery science concepts in solving physics problems for junior high school students. This research will be useful for teachers in applying learning concepts, especially in teaching physics. The limitations of this research are limited in research subjects which only involve students from one school institution. Therefore, it is hoped that future research will be able to further deepen and expand the scope of research related to the implementation of the mastery of science concept.

## 4. CONCLUSION

The average percentage of mastery of physics concepts for each indicator classified as good. Ability to solve problems with an average achievement in understanding, applying, analysis, and the average score of mastery on the subject matter tested is in good category. In general, mastery of concepts and ability to solve problems can reach the minimum completeness criteria (KKM). The linear regression equation Y on X was found that the two variable variances are linear. The t-value which means that the hypothesis $H_0$ is rejected and the contarary the hypothesis Ha is accepted which states that mastery of physics concepts has an effect on students' problem-solving abilities. Mastery of science concepts (physics) is closely related in solving problems (questions), and this has an impact on the seriousness of students in participating in learning.

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