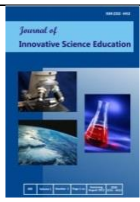
JISE 11 (3) 2022 : 373-380

Journal of Innovative Science Education

http://journal.unnes.ac.id/sju/index.php/jise



Concept Mastery and Mathematical Problem Solving Ability of High School Students in Uniform Straight Line Motion

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Article Info

Article History :
July 2022
Accepted
October 2022
Published
December 2022

Keywords:
glbb, concept mastery, mathematical problem solving ability.

Abstract

This study aims to describe the pattern of the relationship between student's concept mastery and mathematical problem-solving ability in GLBB material. This is qualitative associative/constructive research. This investigation was conducted with grade X MIA2 students at SMAN 1 Nita. This study's instrument included a test of concept mastery and mathematical problem-solving ability, documentation of student answer sheets, and unstructured interviews. The technique for data analysis consisted of five stages: data collection, description of raw data, data reduction, data categorization, and construction of category relationships. The findings revealed a reciprocal relationship between concept mastery and mathematical problem-solving ability. In addressing physics problems, mastery of concepts and mathematical problem-solving ability play mutually reinforcing roles. The level of concept mastery of students increases with their problem-solving abilities, and vice versa: the higher the level of conceptual mastery, the greater the mathematical problem-solving abilities. The results showed that there was a semantic congruence between issue solving using the Polya step indicator and problem solving at the levels of analyzing (C4), evaluating (C5), and creating (C6).

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p-ISSN 2252-6412
e-ISSN 2502-4523

INTRODUCTION

Students can analyze a phenomenon logically and mathematically through physics (Suprapto, 2021). The purpose of physics learning is to increase students' awareness of the significance of physics by developing a deeper understanding of its concepts and principles. Learning orientation sharpens reasoning skills, allowing for the mathematical solution of problems ranging from simple to complex (BSNP, 2020). This implies that the formation of physical knowledge cannot be separated from the development of concepts and mathematics. Concepts are abstract ideas or conceptions used to organize various types of information (Yusuf, 2019). Whereas mathematics in physics functions as a symbolic language to communicate abstract concepts in a more concrete manner so that they are easy to understand, mathematics in other disciplines functions as a symoblic language (Munfaridah, 2021).

In fact, students have not mastered these two aspects well. One of them consists of GLBB-related content (Uniform Motion in a Straight Line). According to Artiawati (2018) students have misconceptions about the Uniform Straight Line Motion (GLBB) material. Students have difficulty writing information into physics symbols, have forgotten the concept of GLBB, and cannot perform mathematical arithmetic operations, according to the results of the diagnostic test (Mananggel, 2019). Stockard (2018) states that it is much easier to learn a new concept than to forget the wrong conceptualizations that have formed in one's memory.

The results of observations at SMAN 1 Nita, Sikka Regency, East Nusa Tenggara Province, revealed that some students had difficulty mastering the GLBB material. Students were not been able to fully absorb the material, even though the learning process depicts the teacher directing pupils to understand the material as best as possible. When given a question, students are unable to develop their knowledge because they can only solve the same problem model as the teacher. This is because students have not mastered the concept and possess good mathematical problem-solving abilities.

Conceptual mastery is one of the cognitive domain's, which requires a higher level of reasoning ability than memory and memorization (Gumala, 2020). The parameter level of concept mastery uses Bloom's taxonomy at the Higher Order Thinking Skill (HOTS) level as analysis (C4), evaluation (C5), and creation (C6). Indicators of problem-solving ability are based on Polya's steps, which include understanding the problem, formulating a resolution plan, implementing the resolution plan, and re-examining the answers (Mwadzaangati, 2019).

The purpose of this study, based on the previous explanation, is to describe the pattern of the relationship between concept mastery and students' mathematical problem-solving ability in GLBB material.

METHODS

This type of qualitative research was descriptive associative/constructive and aims to construct phenomena and identify research hypotheses (Sugiyono, 2020). This study's subjects were grade X MIA2 SMAN 1 Nita students from Sikka Regency, NTT Province. The subject will be determined using a test administered to 25 students. Research subjects were selected using a technique of purposive sampling, based on whether they had been taught the GLBB material.

In this study, the researcher was the main instrument, with HOTS test questions, documentation, and free interviews serving as supplementary instruments. The answers to the questions are then scored using the rubric of mastery of concepts and problem-solving ability adopted from Retta (2021) and Purnamasari (2019).

After analyzing the scores of the students, they were categorized into upper, middle, and lower groups (Arikunto, 2012). The data analysis of this research was carried out with the steps of data analysis from Sugiyono (2020) in the form of data collection, description of raw data, data reduction, data categorization, and the construction of categorization relationships.

Research data must be examined using technical triangulation tests to determine their credibility.

RESULT AND DISCUSSION

Figure 1 shows the proportion of concept mastery scores and the problem-solving ability for each question with the same pattern.

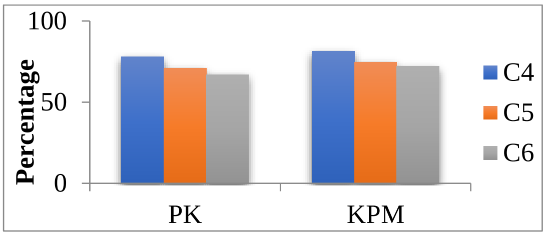


Figure 1. Graph of Student Score Percentage on Each Test Question

After analyzing the scores of the students, they were categorized into upper, middle, and lower groups. The grouping results in Table 1 show that the percentage of students' mastery is proportional to the percentage of students' mathematical problem-solving abilities. One student from the upper group and one student from the lower group were then interviewed for further analysis.

Table 1. Grouping of Students

Category	Concept Mastery		Problem Solving Ability	
	Score	Student's Percentage (%)	Score	Student's Percentage (%)
Upper	> 80.84	24	> 82.08	24
Intermediate	63.16 – 80.84	64	70.27 – 82.08	64
Lower	< 63.16	12	< 70. 24	12

Upper Group (S5 subjects)

The graphs in Figure 2 and Figure 3 demonstrate the high percentage of students who have mastered concepts, supported by their good mathematical problem-solving ability. The indicator for analyzing showed the highest level of concept mastery (C4). This is supported by problem solving-ability on question C4 getting the highest percentage compared to questions C5 and C6.

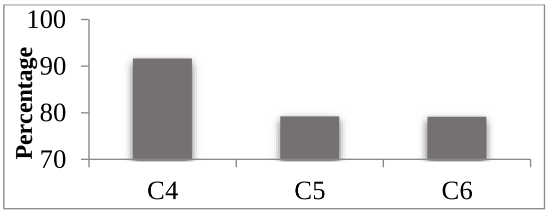


Figure 2. Percentage of Concept Mastery Indicators in the Upper Group

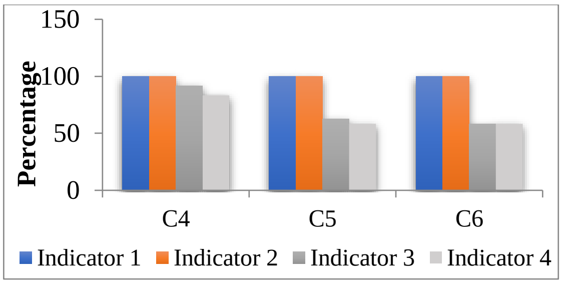


Figure 3. Percentage of Problem Solving Ability Indicators in the Upper Group

This is in line with the idea of Puspitasari (2019) that problem solving ability is one of the basic skills that must be mastered by students because it can develop students' thinking skills.

a. Subject Answers at Analyzing Level (C4) Question

The subject's answers in Figure 4 showed that they were able to write down the relevant information to solve the problem and connect the information to the question, but the answer was incomplete. Therefore, it is stated that the subject understands and plans problem-solving extremely well, but has not been able to execute the plan and reexamine it effectively. The following are excerpts from the interview on the subject of S5.

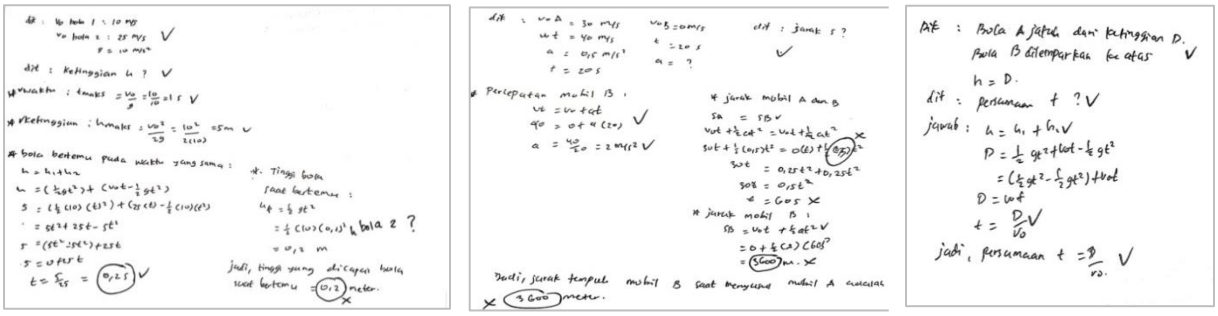
P: *Why do you use a different object height formula model?*

S5: *Because when the balls meet, ball 1 experiences a free fall motion while ball 2 experiences a vertical upward motion.*

P: *Take a look at your answers, have you finished your work? Has the result you get not been the height value calculated from the first ball?*

S5: *Oh yes ma'am. That means I have to subtract the maximum height value again from the first ball's height value. So 5 – 0.2 = 4.8 m.*

Based on the results of the interview, the subject can understand the concept and can correct the wrong answer.



(C4) (C5) (C6)

Figure 4. Answer Subject S5

b. Subject Answers at Evaluating Level (C5) Question

The subject's response in Figure 4 shows that he can present data information and provides reasons to support his idea; however, the reasons provided were insufficient because the arithmetic operations performed contain errors. This demonstrates that the subject comprehends and plans the problem well, but there is an error in calculating the time the two cars meet during the implementation stage. Following is an excerpt from an interview with S5's subject.

P: *What information do you get from the graph?*

S5: *It is known that in car A, $v_o = 30\ m/s$, $v_t = 40\ m/s$, $a = 0{,}5\ m/s^2$. In car B, $v_o = 0\ m/s$, $v_t = 40\ m/s$, asked s.*

P: *Pay attention to your answer when calculating the time the two cars meet, do you think the value you substituted in the formula is correct?*

S5: *Already ma'am.*

P: *Then can you prove the statement in the question?*

S5: *Yes, ma'am, because I have obtained the value of the mileage, which is 3600 m.*

The subject was able to interpret the data on the graph and explain the problem-solving procedure, but the final answer was incorrect due to an error in substituting the value of car B's travel time.

c. Subject Answers at the Creative Level (C6) Question

The subject's answer in Figure 4 showed that the subject can combine the existing information to create a new equation by adding up the equation for the height of an object moving vertically upwards with an object moving in free fall. This showed that the subject can understand the problem, plan problem solving, carry out the settlement plan and re-examine very well. The following is an excerpt of an interview with the subject of S5.

P: *I saw that you added to the two equations together. Why ?*

S5: *Because both balls move at the same time.*

P: *Have you obtained the equation t ?*

S5: *Yes Ma'am, equation $t = \frac{D}{V_0}$.*

The results of the interview indicate that the subject was able to relate the concepts of vertical upward motion and free fall motion to generate new equations and correctly explain the calculation process.

Lower Group (S24 subjects)

The graph in the Figure 5 and Figure 6 demonstrates the low percentage of students' mastery of concepts due to inadequate problem solving abilities.

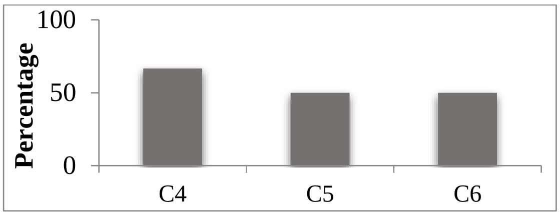


Figure 5. Percentage of Concept Mastery Indicators in the Lower Group

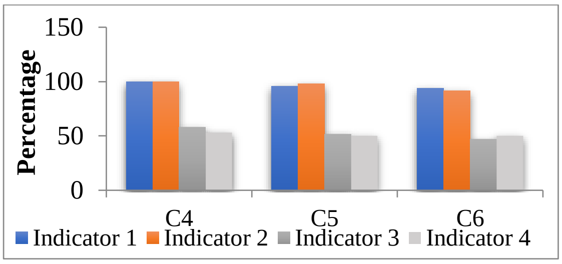


Figure 6. Percentage of Problem Solving Ability Indicators in the Lower Group

a. Subject Answers at Analyzing Level (C4) Question

The subject's answers in figure 7 demonstrate that he or she can write down and connect relevant information to solve the problem, but the calculations were imprecise. This demonstrates that the subject is adept at comprehending and planning problem-solving, but has not been able to execute the plan and reexamine effectively. The subject made an error when calculating the object's height using arithmetic operations. Following is an excerpt from an interview with S24's subject.

P: *What concept did you use to solve the problem?*

S24: *When the second ball is thrown, the first ball reaches the highest point and will fall back to the ground, the first ball experiences a free fall, while the second ball experiences an upward vertical motion.*

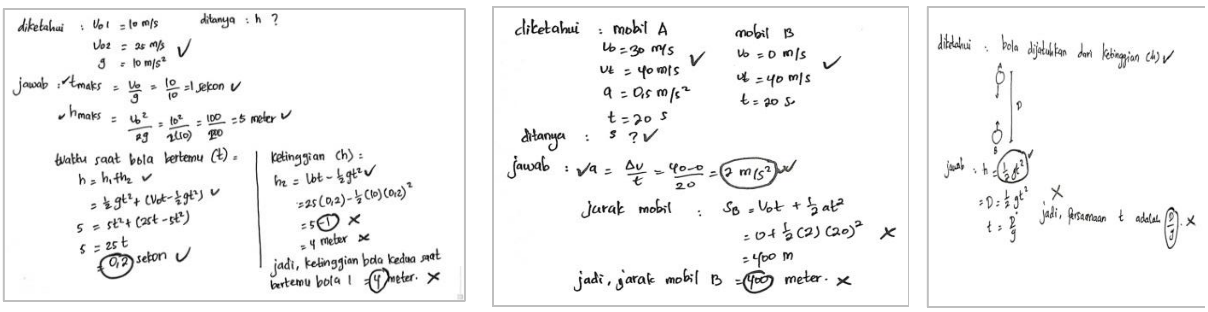
P: *Consider again the results of the calculation of the height achieved by the second ball. Is it true that the result is 4? Try to explain where the value of 5 and 1 from!*

S24: *I got 5 values from* $(25\ x\ 0.2)$ *value 1 from* $(\frac{1}{2}\ x\ 10\ x\ 0.2)^2$.

Based on the results of the interview, the subject was able to explain the problem's concepts and its relationship, but there was a calculation error in determining the height reached by the second ball when it met with the first ball.

b. Subject Answers at Evaluating Level (C5) Question

The subject's answers in figure 7 indicates he is able to present data information and provides reasons to support his idea; however, the reasons provided are insufficient because the arithmetic operations performed contain errors. This demonstrates that the subject understands the problem very well.



(C4) (C5) (C6)

Figure 7. Answer Subject S24

During the planning stage of the problem, the subject documents only a portion of the completion plan, so that the implementation of the plan does not solve the problem. The following is an excerpt from the interview with the subject of S24 to question number 2.

P: *What information do you get from the graph?*
S5: *In Car A, $v_o = 30\ m/s$, $v_t = 40\ m/s$ with $a = 0{,}5\ m/s^2$. In car B, $v_o = 0\ m/s$, $v_t = 40\ m/s$ so s asked.*
P: *How do you solve this problem?*
S24: *Find the acceleration of car B, find the value of the distance traveled by car B when it overtakes car A and I get 400 m.*
P: *Then what about the time when the two cars meet?*
S24: *It's known from the graph ma'am.*
P: *Do you think the answers you get have proven the statements in the questions above?*
S24: *Already ma'am.*

Based on the results of the interview, the subject can explain the physics concept in the problem, but mentions only a part of the formula, resulting in an incorrect final result.

c. Subject Answers at the Creative Level (C6) Question

The subject's answer in figure 7 indicates that the subject was unable to combine the existing equations to create a new equation. This demonstrates that the subject did not fully understand the problem because he did not record all of the relevant information. During the problem planning phase, the subject only writes a portion of the solution plan. The questions were not answered in their entirety, so the final conclusions were not entirely correct. Following is an excerpt from an interview with S24's subject.

P: *Why do you use this formula?*
S24: *Because ball A moves in free fall.*
P: *Then what about ball B?*
S24: *I don't know, ma'am.*

The results of the interview on the subject S24 revealed that the subject could mention the relevant information, but it was insufficient. The presented problem-solving strategy is only partially accurate, therefore it does not answer the question.

Based on the data above, the author concluded that there was a match between the answers to the worksheets and the results of the interviews on both S5 and S24, so the data is deemed credible. The study of data indicates that mathematical problem solving provides challenging situations that promote the mastery of concepts and mathematical problem solving ability among students. Each indicator's level of concept mastery can be attained if students possess good problem-solving ability. Mastery of concepts requires problem solving ability. This study is relevant to the results of research conducted by Anisah (2018) and Pradani (2019) that from the ability to analyze, evaluate and create that students have, it can be seen their mathematical problem solving abilities.

Students will be able to master the concept if they can understand the problem, plan problem-solving, implement a settlement plan, and reexamine or draw conclusions about the problem. Mastery of concepts is demonstrated not only by knowing the concept of physics, but also by the ability to solve a variety of problems related to the concept and its application to new situations (Yunita, 2019). Result by Akuba (2020) shows that students' problem-solving abilities have a positive impact on the level of mastery of concepts.

Likewise, the ability to solve mathematical problems, supported by research results Fikriani (2020) If students can solve problems, they fulfill the requirements for analyzing, evaluating, and creating. The problem-solving ability of students demonstrates their ability to apply all of their knowledge (Nafi'an, 2019). This means that students with a high level of conceptual mastery will easily comprehend problems, plan problem-solving strategies, implement settlement plans, and check back.

There is a reciprocal relationship between concept mastery and the ability to solve mathematical problems. Both variables play reinforcing roles in solving physics problems. The level of concept mastery of students increases with their problem-solving abilities, and vice versa: the higher the level of concept mastery, the greater the problem-solving abilities. This study's results indicate that there was a semantic congruence between mathematical problem-solving ability as measured by the Polya step indicator and concept mastery as measured by Bloom's taxonomy indicators at the levels of analyzing (C4), evaluating (C5), and creating (C6).

CONCLUSION

Based on the results of the analysis of research data, it can be concluded that there is a reciprocal relationship between concept mastery and mathematical problem-solving abilities in GLBB material. The level of concept mastery of students increases with their problem-solving abilities, and vice versa: the higher the level of concept mastery, the greater the problem-solving abilities.

It is recommended, based on the findings of the research, that teachers provide more practice questions of the HOTS type, as they can assist students in improving their conceptual mastery and mathematical problem-solving ability. This study focuses on the description of the relationship pattern between concept mastery and the mathematical problem-solving ability on GLBB material. Therefore, further research utilizing the same material is required to describe the factors that influence levels of conceptual mastery and mathematical problem solving abilities.

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