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Analysis of High School Students' Conceptual Understanding of Physics on Temperature and Heat Concepts

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Abstract

This study aimed to determine the mastery of the concept of students on material temperature and heat. This research is a qualitative descriptive study. The research subjects were class XI students of school A Samarinda, school B Samarinda, school C Samarinda, and school D Samarinda. The data collection technique used was purposive sampling. Data on concept mastery was obtained using a multiple-choice test instrument totaling 24 items based on the revised bloom taxonomy indicator. The research results on mastering the concept of school A Samarinda at C1 level 79%, C2 level 67%, C3 level 63%, C4 level 63%, C5 level 57%, and C6 level 50%. Concept mastery of school B Samarinda at C1 level 83%, C2 level 68%, C3 level 56%, C4 level 56%, C5 level 55%, and C6 level 47%. Mastery of school C Samarinda concepts at C1 level 88%, C2 level 75%, C3 level 65%, C4 level 59%, C5 level 49%, and C6 level 38%. mastery of school D Samarinda concept at C1 level 86%, C2 level 68%, C3 level 61%, C4 level 62%, C5 level 61%, and C6 level 42%.

Keywords: Mastery of concepts, Revised Bloom's taxonomy, Temperature and heat

INTRODUCTION

Physics is a branch of science that studies natural phenomena and is closely related to everyday life. As one of the foundations of applied science and engineering, after studying physics, students are expected to be able to apply and develop the concepts they have learned for the advancement of science and technology in the future. Conceptual understanding is one of the important abilities for students to develop in studying physics.

Concept mastery is an effort that students must make to record and transfer back some information from a particular subject matter that can be used in solving problems, analyzing, and interpreting certain events (Oktaviani et al., 2017). This shows that a good understanding of concepts is needed for higher-order thinking in the physics learning process. Mastery of students' concepts in learning physics is of great concern to researchers and physics teachers. Understanding of the right concepts can improve students' ability to solve problems, develop knowledge and environmental analysis, and improve creative thinking skills in solving problems (Musa & Kusairi, 2020).

The teacher can know students' conceptual understanding after a learning evaluation is held. Evaluating the teacher requires a test. The instrument was made using a diagnostic test of multiple choice questions based on indicators of mastery of the revised Bloom's taxonomy. In Bloom's taxonomy, the revised dimensions of the cognitive domain consist of two dimensions, namely knowledge, and cognitive dimensions. The dimensions of knowledge are

divided into four, namely the dimensions of factual, conceptual, procedural, and metacognitive knowledge. The cognitive process dimension is divided into six categories, namely the ability to remember (C1), understand (C2), apply (C3), analyze (C4), evaluate (C5), and create (C6).

Students' understanding of physics concepts in East Kalimantan tends to be low (Fajrina et al., 2016). Low mastery of concepts has become a common problem. The lack of mastery of physics concepts and critical thinking skills is one of the reasons that students are not much involved in constructing a concept in their minds (Husein et al., 2015). Based on research by Fajrina et al. (2016), the cause of students' low mastery of concepts is that learning physics is presented as a collection of formulas that students must memorize, so important concepts in physics are often overlooked. Based on observations made during practicum at school A Samarinda, students' mastery of physics concepts still needed to improve. Many students think physics is a challenging, scary subject with nothing to do with everyday life. Students often need help connecting the material studied with its application in everyday life.

Temperature and thermodynamics learning material is one of the materials that have a lot of applications in everyday life and is one of the basic concepts for understanding other physics concepts. However, in reality, students have not been able to master temperature and thermodynamics material and apply it in everyday life. Musa & Kusairi (2020) said that students could not analyze the relationship between heat and temperature. This shows that students have not mastered the relationship between heat and temperature and energy transfer (heat) terms. Yaumi & Zulaikah, (2019) also revealed that students still needed help with mathematical calculations and had not been able to apply the relationship between pressure and volume in a constant temperature process. In addition, Rahmawati & Syuhendri (2014) concluded that understanding concepts in thermodynamic material are still considered low, as evidenced by obtaining an average percentage score of 27.66%. This shows that research is needed on mastery of concepts in temperature and thermodynamics material to describe students' mindsets in mastering concepts and difficulties experienced by students. The results of this study can be used as a reference in developing and choosing appropriate learning methods for students. So that it can help students master the mastery of concepts correctly, have fun, and have extensive and intact knowledge.

Interviews and multiple-choice tests are appropriate instruments to determine mastery of physics concepts. Interviews with students are a way to discover students' understanding of physics material in depth, but the interview method takes a long time to collect and analyze

data. The multiple choice question method is the instrument that is often used because it is more efficient and can be applied to large-scale groups, and requires a short time in data collection and data analysis. Multiple choice test instruments can cover more material so that they can cover almost all competency standards and basic competencies.

METHOD

This type of research is a quantitative descriptive study in which the authors describe students' mastery of concepts in the material temperature, heat, and heat transfer, based on the average scores obtained from multiple-choice tests.

This research was conducted at school A Samarinda, school B Samarinda, school C Samarinda, and school D Samarinda. The population in this study were all students of class XI IPA at the senior high schools in Samarinda. The sample of this research is class XI students of school A Samarinda, school B Samarinda, school C Samarinda, and school D Samarinda. The sampling technique used in this study was purposive sampling. The sample selection is based on school accreditation with the division of the upper and middle categories.

The data collection technique used is the test technique. Tests are used to measure students' mastery of concepts. The test used is a multiple-choice instrument. The test will be carried out to collect data about students' understanding of concepts regarding the material temperature, heat, black principle, heat transfer, and expansion of matter in the form of 24 multiple-choice questions—a multiple-choice test based on the revised Bloom's taxonomy.

Conceptual understanding analysis was carried out to determine the students' concept mastery category. The results of the conceptual understanding test were analyzed based on each indicator of concept mastery (remembering, understanding, applying, analyzing, evaluating, and creating) and the sub-subjects of temperature, heat, and heat transfer through the following formula.

$$\mathrm{NP} = \frac{\mathrm{R}}{\mathrm{SM}} \times 100\%$$

The results of the percentage conceptual understanding obtained are categorized according to the criteria in Table 1.

Table 1 Percentage of conceptual understanding levels

Understanding levels	Category
86% < NP ≤ 100%	Very good
76 < NP ≤ 85%	Good
60 < NP ≤ 75%	Moderate
55 < NP ≤ 59%	Less
NP ≤ 54%	Very less

Nurvirani et al., (2011)

RESULTS AND DISCUSION

The instrument to determine students' mastery of concepts is multiple-choice tests totaling 24 questions. This instrument has six cognitive process dimensions: memorizing, understanding, applying, analyzing, evaluating, and creating.

Data on the results of the percentage of concept mastery instruments were categorized into very good, good, moderate, less, and very less. The percentage of concept mastery for each school can be seen in Tables 2, 3, 4, and 5.

Table 2 Percentage of conceptual understanding at school A Samarinda

Cognitive level	Percentage	Category
C1	79%	Good
C2	67%	Moderate
C3	63%	Moderate
C4	63%	Moderate
C5	57%	Less
C6	50%	Very less

Based on Table 2, the percentage of conceptual understanding of students at school A Samarinda can be presented in Figure 1.

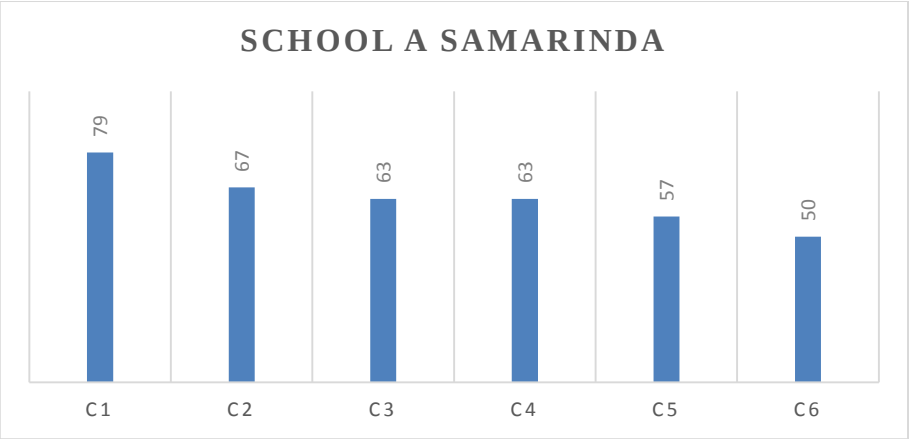

Figure 1 Diagram of conceptual understanding at school A Samarinda

Based on Table 2 and Figure 1, it can be seen that students' mastery of concepts at school A Samarinda school, at level C1 (remembering) students were able to answer correctly as much as 79% in the good category. At level C2 (understand), as much as 67% is in the

moderate category. At level C3 (applying), students answered correctly, as much as 63% in the moderate category. At level C4 (analyzing), as much as 63% were in the moderate category. At level C5 (evaluating), students answered correctly, as much as 57% in the less category. At level C6 (creating), students who answered correctly were 50% in the very less category.

Table 3 Percentage of conceptual understanding at school B Samarinda

Cognitive level	Percentage	Category
C1	83%	Good
C2	68%	Moderate
C3	56%	Moderate
C4	56%	Moderate
C5	55%	Less
C6	47%	Very less

Based on Table 3, the percentage of conceptual understanding of students at school B Samarinda can be presented in Figure 2.

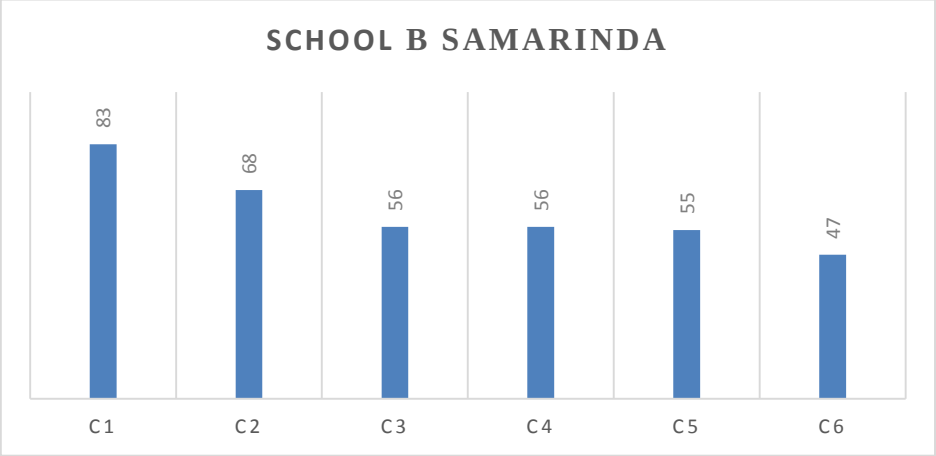

Figure 2 Diagram of conceptual understanding at school B Samarinda

Based on Table 3 and Figure 2, it can be seen that students' mastery of concepts at school B Samarinda school, at level C1 (remembering), were able to answer correctly, as much as 83% in the good category. At level C2 (understand), as much as 68% are in the moderate category. At level C3 (applying), students answered correctly, as much as 56% in the less category. At level C4 (analyze), as much as 56% are in the less category. At level C5 (evaluating), students answered correctly, as much as 55% in the less category. At level C6 (creating), students who answered correctly were 47% in the very less category.

Table 4 Percentage of conceptual understanding at school C Samarinda

Cognitive level	Percentage	Category
C1	88%	Very Good
C2	75%	Moderate
C3	65%	Moderate
C4	59%	Moderate
C5	49%	Very less
C6	38%	Very less

Based on Table 4, the percentage of conceptual understanding of students at school C Samarinda can be presented in Figure 3.

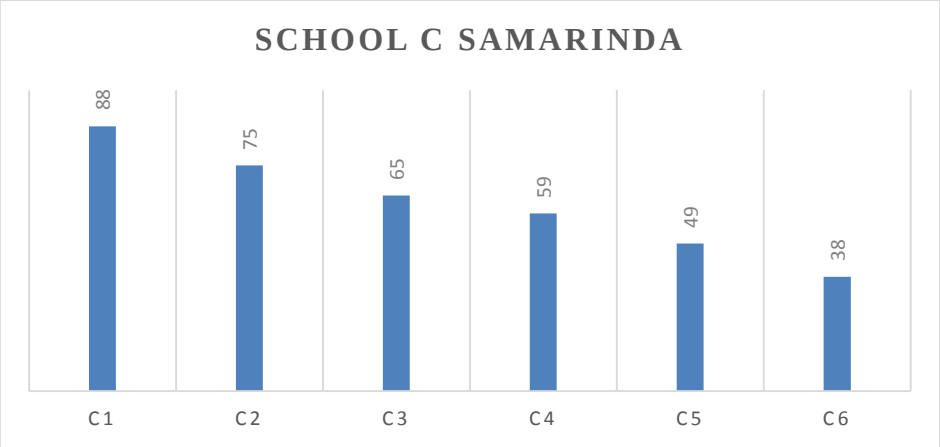

Figure 3 Diagram of conceptual understanding at school C Samarinda

Based on Table 4 and Figure 3, it can be seen that students' mastery of concepts at school C Samarinda school, at level C1 (remembering), were able to answer correctly as much as 88% with a very good category. At level C2 (understand), as much as 75% are in the moderate category. At level C3 (applying), students answered correctly, as much as 65% in the moderate category. At level C4 (analyzing), as much as 59% in the less category. At level C5 (evaluating), students answered correctly, as much as 49% in the very less category. At level C6 (creating), students who answered correctly were 38% in the very less category.

Table 5 Percentage of conceptual understanding at school D Samarinda

Cognitive level	Percentage	Category
C1	86%	Very Good
C2	68%	Moderate
C3	61%	Moderate
C4	62%	Moderate
C5	61%	Moderate
C6	42%	Very less

Based on Table 5, the percentage of conceptual understanding of students at school D Samarinda can be presented in Figure 4.

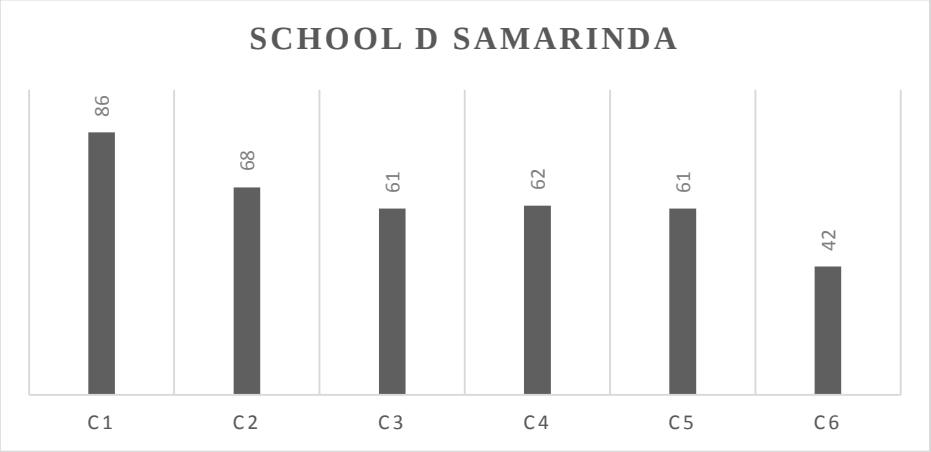

Figure 4 Diagram of conceptual understanding at school D Samarinda

Based on Table 5 and Figure 4, it can be seen that students' mastery of concepts at school D Samarinda school, at level C1 (remembering), were able to answer correctly as much as 86% with a very good category. At level C2 (understand), as much as 68% are in the moderate category. At level C3 (applying), students answered correctly, as much as 61% in the moderate category. At level C4 (analyzing), as much as 62% are in the moderate category. At level C5 (evaluating), students answered correctly, as much as 61% in the moderate category. At level C6 (creating), students who answered correctly were 42% in the very less category.

This study aimed to determine how students in class XI understood the concepts of temperature and heat based on the revised bloom taxonomy.

The population in this study were all students of class XI MIPA school A Samarinda, school B Samarinda, school C Samarinda, school D Samarinda. Sampling was carried out using a purposive sampling technique in which the sample members from the population were taken based on school accreditation with high and medium divisions. The samples in this study were students in class XI MIPA 1, XI MIPA 2, and XI MIPA 3 at school A Samarinda, students in classes XI MIPA 1, XI MIPA 2, and XI MIPA 3 at school B Samarinda, students in classes XI MIPA 1 and XI MIPA at school C Samarinda, students of class XI MIPA at school D Samarinda. The sample of this research is 202 students.

This research was conducted in 4 meetings, with one meeting in each class for 2 hours (2 x 45 minutes) in each school. The test lasted 90 minutes and was under the supervision of researchers and physics teachers at the school. Test work is carried out online, where students work through Google Form.

The instrument used in this study was a multiple-choice test with 24 questions. The instrument determines students' conceptual understanding according to the revised bloom taxonomy indicators. The indicators of concept mastery used in this study are remembering, understanding, applying, analyzing, evaluating, and creating. The value of students' conceptual understanding of the material temperature and heat for each question is 1.

At level C1 (remembering), there are three indicator questions consisting of questions number 1, 2, and 3. In question number 1, with the indicator considering the rate of heat propagation factor, students are asked to determine the factors that determine the rate of heat propagation. In problem number 2, with the indicator of remembering the concept of heat transfer, students are asked to remember the idea of heat transfer by conduction. In problem number 3, with the indicator recognizing the use of thermometers, students are asked to identify the types of thermometers and their use in everyday life.

At level C2 (understanding), there are three indicator questions consisting of questions numbers 4, 5, 6, 7, and 8. In questions 4 and 7, with indicators identifying the properties of a substance based on specific heat, students are asked to associate the specific heating value with the nature of things. In questions 5 and 6, with indicators of understanding the concept of heat transfer, students are asked to understand heat transfer by convection and the concept of heat transfer in everyday life. In problem number 8, with indicators comparing the specific heat of a substance, students are asked to look for the relationship between adding other substances to the specific heat.

At level C3 (applying), there are three indicator questions consisting of questions number 9, 10, 11, and 12. In problem number 9, with the indicator converting temperature, students are asked to convert Fahrenheit temperatures to artificial thermometer temperatures. In questions 10 and 12, with the indicator applying the black principle, students are asked to calculate the mixture's temperature and the temperature rise of the object. In question 11, with the indicator calculating the heat transfer equation, students are asked to calculate the temperature of the junction of the two metals.

At level C4 (analyzing), there are five indicator questions consisting of questions 13, 14, 15, 16, 17, and 18. In question 13, with indicators analyzing material properties based on the conductivity coefficient, students are asked to determine the properties of the material if the conductivity coefficient is known. In question 14, with the indicator questions analyzing the graph of the heat propagation rate, a graph comparing the heat propagation rate with temperature changes is presented. Students are asked to determine the substance with the greatest heat of melting. In question 15, with indicators predicting the expansion of

substances in everyday life, students are asked to analyze phenomena related to volume expansion. In questions 16 and 17, with indicators analyzing problems related to heat transfer, students are asked to analyze the heat transfer rate in two different materials. In question 18, with indicators analyzing heat on the black principle.

At level C5 (evaluating), there are three problem indicators consisting of questions 19, 20, and 21. In problem number 19, with indicators checking actions related to temperature measuring devices in everyday life, students are asked to examine the actions of someone who measures body temperature using palms. In question 20, with the indicator of checking an action related to the concept of expansion, a problem is presented where students are asked to check the action of separating nuts and bolts that cannot be removed. In question 21, with the indicator checking an action related to its thermal conductivity, students are asked to check the right action in choosing a material as a heat conductor based on its thermal conductivity.

At level C6 (creating), there are three indicator questions: numbers 22, 23, and 24. In problem number 22, with indicators planning procedures for solving problems related to heat transfer, students are asked to plan experimental variations to find out the heat rate of radiation of objects. In question 23, the indicator makes a hypothesis based on the application of bimetal to iron. Students are asked to make a hypothesis about the relationship between the increase in the length of the bimetal and the automatic system on the iron. In question number 24, with the indicator of planning procedures to prove the black principle, students are asked to plan a simple experimental procedure to prove the black principle.

The students' conceptual understanding at school A Samarinda showed varying results. In question C1, the results were obtained with 79% of students answering correctly, so students are classified as good at this level. Students can answer questions at level C1 because, at this level, they are only asked to remember the concept of heat that they have previously learned and related to the use of tools that they often use in their daily lives. In question C2, the results were obtained, with 67% of students answering correctly and 67% in the moderate category at level C2. Students belong to the moderate category because students can associate the specific calorific value with the nature of objects. In question C3, the results were obtained with a percentage of 63% of students answering correctly, so it is sufficient at level C3. This is because students can calculate the heat transfer equation at the junction temperature of the two metals. In question C4, the results were obtained with a percentage of 63% of students answering correctly, 63% indicating a good category at level C4. This is because students can analyze problems related to heat transfer. In question C5, the results are

obtained with a percentage of 57%. At this level, students are categorized as needing more. This is due to the need for more students to understand the conductivity material. In question C6, the results are obtained with a percentage of 50%, so at this level, students are categorized as lacking. Students' conceptual understanding at level C1 is quite good, while at level C5, it is lacking, and C6 is quite lacking. Students only practice virtually through the Phet application, making it challenging to apply existing theories and laws to the subject matter of temperature and heat in everyday life. This causes students to have difficulty answering questions at levels C5 and C6, which contain evaluating actions and designing simple experiments related to temperature and heat.

Students' conceptual understanding at school B Samarinda school showed that in question C1, the results were obtained with a percentage of 83% of students answering correctly, so it can be said that students are classified as good at this level. Students can answer questions at level C1 because, at this level, they are only asked to remember the concept of heat that they have previously learned and related to the use of tools that they often use in their daily lives. In question C2, the results were obtained, with 68% of students answering correctly, and 68% were in the moderate category at level C2. In question C3, the results were obtained with 56% of students answering correctly, so it is lacking at level C3. This is due to the lack of students' understanding of the black principal. In question C4, the results were obtained with 56% of students answering correctly, 56% indicating a poor category at level C4. Students have yet to be able to analyze the graph of the rate of heat propagation against temperature changes. In question C5, the results are obtained with a percentage of 55%, so students are categorized as lacking at this level. In question C6, the results were obtained with a percentage of 47%. At this level, students were categorized as lacking. Students' conceptual understanding at levels C3, C4, and C5 is classified as lacking, while at level C6, it is classified as lacking. This is because, in the learning process, the teacher does not open online meetings and only provides material and assignments through Google Classroom. Students have never done direct practice and practice questions, so student learning motivation is reduced.

Conceptual understanding of students at school C Samarinda on question C1 was obtained, with a percentage of 88% of students answering correctly. So students are classified as very good at this level. Students can answer questions at level C1 because at this level. They are only asked to remember the concept of heat that they have previously learned and related to the use of tools that they often use in their daily lives. In question C2, the results were obtained with a percentage of 75% of students answering correctly; 75% were in the

moderate category at level C2. This is because students have understood heat transfer by convection. In question C3, the results were obtained with a percentage of 65% of students answering correctly, so it can be said that it is sufficient at level C3. At the C3 level, students can convert Fahrenheit temperatures to artificial thermometer temperatures. In question C4, the results were obtained with a percentage of 59% of students answering correctly, 59% indicating a poor category at level C4. This is caused by students' lack of understanding in analyzing the heat transfer rate in two different materials and the black principle. In question C5, the results are obtained with 49%, so at this level, students are categorized as lacking. At this level, students have yet to be able to evaluate materials as heat conductors based on their thermal conductivity. In question C6, the results were obtained with a percentage of 38%, so at this level, students are categorized as lacking. This is because students have never done a simple experiment. After all, the learning process does not carry out virtual or direct practicum. Students' conceptual understanding at level C1 is classified as very good, while at levels C5 and C6, it is classified as very poor.

Conceptual understanding of students at school D Samarinda school on question C1 was obtained, with 86% answering correctly. So students are classified as very good at this level. Students can answer questions at level C1 because, at this level, they are only asked to remember the concept of heat that they have previously learned and related to the use of tools that they often use in their daily lives. In question C2, the results were obtained with 68% of students answering correctly, and 68% were in the moderate category at level C2. This is because students can understand the concept of heat transfer. In question C3, the results were obtained with a percentage of 61% of students answering correctly, so it can be said that it is sufficient at level C3. At this level, students can convert Fahrenheit temperatures to artificial thermometer temperatures. In question C4, the results were obtained, with 62% of students answering correctly, 62% indicating a good category at level C4. At this level, students can analyze the properties of materials based on the conductivity coefficient. In question C5, the results are obtained with a percentage of 61%, so at this level, students are categorized as sufficient. This is because students can evaluate temperature-measuring instruments in everyday life. In question C6, the results were obtained at 42%, so at this level, students are categorized as lacking. Students' conceptual understanding at level C1 is very good, while level C6 is very poor. This is because, in the learning process, the teacher conducts online meetings via zoom and provides assignment exercises through Google Classroom. However, because students never practice directly and only do virtual simulations and experiments through Phet, C6 students' abilities are classified as very low.

CONCLUSION

Based on the results of the research, the advice that the writer can give is that students are expected to be more active in the learning process and improve their mastery of concepts so that it is easier to understand physics material in the next chapter. For researchers, similar research should be tested on other physics materials. Thus, the teacher can know the mastery of students' concepts and design appropriate learning for students. Teachers are also expected to be able to provide tests to train students' concept mastery abilities based on revised bloom taxonomy indicators.

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