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Analysis of Students' Cognitive Structure through the Assimilation and Accommodation Framework on Work and Energy Material

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Abstract

This study aims to find out how the cognitive structure and problem-solving of high school students in business materials and energy based on the framework of assimilation and accommodation. The method used is a mixed research method with an explanatory sequential design. Data collection was carried out on 53 students in class X using diagnostic test instruments in a five-tier format, then continued with the provision of description tests and interviews to three research subjects with different comprehension categories. The test results showed that students' understanding of concepts was 30.2% in the energy change sub-material, and 52.8% in the non-understanding of concepts in the relationship between potential, kinetic and mechanical energy. Meanwhile, the misconception of the concept was known at 23.6% where students considered the amount of effort to depend on the length of the trajectory taken. Solving problems of subjects with different comprehension categories showed that all three subjects had a less coherent local cognitive structure. Subjects with a conceptual understanding category (S3) have a better assimilation process than subjects with a non-conceptual category (S2). However, it was found that there were subjects with a misconception category (S1) who could solve problems through the assimilation process from beginning to end, this shows that the assimilation process can occur when the subject has the same knowledge scheme as the problem at hand. The accommodation process shows that the subject has a different knowledge scheme with new information/problems faced, especially in mathematical calculations and foreign terms. This is due to associative thinking, intuition and incomplete reasoning.

Keywords: accommodation; assimilation; concept; energy; work

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INTRODUCTION (10%)

One of the important objectives of learning physics is to bring students to understand in depth the basic concepts in physics so that they can be applied to solve a problem. Problem solving is the activity of synthesizing and applying the knowledge you already have to different situations and conditions. Problem solving can begin with understanding, planning, implementing and reviewing the chosen solution(Docktor & Mestre, 2014; Maulyda et al., 2019; Sutopo, 2016).

Understanding concepts is necessary in solving student problems. Students with a good understanding of concepts tend to have good problem-solving skills as well. Understanding the concepts of physics refers to a coherent and complete understanding.The coherent understanding of concepts includes understanding

that has two types of knowledge, namely qualitative and quantitative. Qualitative knowledge includes concepts and facts, while quantitative knowledge includes rules, skills, and techniques. These two types of knowledge must be closely connected so that learners can have a complete understanding of physics concepts(Chabibah et al., 2019; Misbah et al., 2022; Sofna et al., 2023)..

Understanding the concept becomes a benchmark for students to define an event in mathematical representation (equation) (Mariano-dolesh & Collantes, 2022; Misbah et al., 2022) In solving physics problems, students tend to memorize equations and match them with solutions based on their knowledge (schemes). This condition is also found at the SMA / SMK and MA levels (High school). The process of choosing equations is not based on the analysis of events but only on students' habits in doing physics problems, including on matter of work and energy (Dessella et al., 2018; Handhika et al., 2023)

Work and energy are materials that are closely related to students' daily lives, although it is not uncommon to find difficulties and understanding different concepts in students during the learning process. The cognitive structure becomes a frame of reference in understanding a concept with other concepts so that integration is formed and gives birth to new knowledge for students. Cognitive structures can be formed from the experiences and concepts of lessons that have been learned. The cognitive structure possessed by students is related to the process of assimilation and accommodation(Fiorella & Pilegard, 2021).

Assimilation is the process of processing new information received according to the knowledge scheme possessed. While accommodation is a process of processing new information and is not in accordance with the knowledge scheme possessed. In this accommodation process, students adapt by modifying the knowledge scheme they have in solving a problem(Aldianisa et al., 2021; Utami et al., 2021).

Understanding the concepts of subject matter will be more easily accepted when students have cognitive structures and can relate initial concepts related to the material. Students' diverse apprehension and perception of the process of assimilation and accommodation causes students to develop concepts that are wrong and different from those of experts(Mufit & Puspitasari, 2020). Misconceptions or alternative concepts that exist in the minds of students can hinder students from understanding the correct concepts. A teacher has an important role and influence so that students can absorb and understand concepts well (Inggit et al., 2021; Pentang, 2021).Understanding students' concepts is something that needs attention, especially after distance learning during the Covid-19 pandemic(Agayon et al., 2022).

The results of pre-research that has been conducted at SMAN 15 Muaro Jambi obtained information that there are problems in learning, including understanding the concepts of students who are quite diverse. The factor that causes this to happen is due to the lack of motivation and confidence of students in the concepts mastered in doing the tasks given. Researchers also obtained information that educators have not used diagnostic test instruments in identifying students' understanding of concepts.

A diagnostic test is a test used to find out the strengths and weaknesses of students when learning something, so that the results can provide follow-up (Makhrus & Hidayatullah, 2021). Diagnostic tests can be multiple-choice tests or description questions. Several researchers have developed multiple-choice diagnostic tests with confidence and reasoning levels in various formats, including

two-tier diagnostic tests, three-tier diagnostic tests, and four-tier to five-tier diagnostic tests that are equipped with information on the main sources of student understanding (Erwinsyah et al., 2020; Fatonah et al., 2022). However, description tests and interviews are also needs to gain in depth student understanding (Resbiantoro et al., 2022; Soeharto et al., 2019)

A student's conception of alternatives is very important and the teacher must be able to understand what the student is thinking. The alternative concept of students gives the teacher an idea to build a new and more complete conception (Keeley, 2015) Based on this, knowing the conception and steps of solving student problems through assimilation and accommodation frameworks is something that needs to be done.

METHODS (15%)

This research is a mixed method research using an explanatory sequential data collection design. Explanatory sequential is a research design with quantitative data collection at the beginning and continued with qualitative data collection. This research aims to analyze students' cognitive structures on work and energy material. This research was conducted in February-March 2024 at SMAN 15 Muaro Jambi. The subject of this research is a grade X student. The research instruments consist of a five-tier diagnostic test and a description test as well as an interview sheet that has been validated by expert lecturers

Table 1. Test Grid.

Matery	Cognitive Competency
Work, force and displacement	Distinguish the largest and smallest work on an object Analyze the graph of the displacement function of the beam with the force acting
Potential energy and kinetic energy	Analyze the velocity of a body at a given position with the law of conservation of energy Analyze the potential energy and kinetic energy of a vertically thrown ball
Work and energy relationship	Determine the path that has the greatest effort based on figures related to the law of conservation of energy

The research procedure began with the provision of five-tier diagnostic tests to grade X students totaling 53 students. The results of the diagnostic fier tier test are used to select research subjects with different categories of understanding concepts. The subjects of the study were given a description test to see the steps and problem-solving abilities. Researchers used a think aloud approach by asking subjects to express thoughts during the description test. The researcher proceeded to the stage of unstructured interviews with subjects about the words expressed as a confirmation step.

Table 2. Problem-Solving Indicators.

Problem-solving Indicators	Operasional Form
Understanding the problem	Writing the information in the problem. Writing the question statement based on the problem.
Devision a plan	Devising and writing the mathematical models (or equations) for solving the problem.
Carry out the plan	Carrying out the procedure for solving the problems. Doing the calculation correctly.
Looking back	Writing the conclusion correctly.

Table 3. Proses Asimilasi dan Akomodasi

Framework	Characteristic
Assimilation	Students can directly apply their knowledge
Accommodation	Students modify their knowledge to adapt to existing problems Students form new knowledge to adapt to existing problems

The data analysis techniques used began from the stages of data reduction, presentation and conclusion drawn. The analysis stages are carried out interactively and continuously to get a complete conclusion(Miles et al., n.d.)

RESULTS AND DISCUSSION (70%)

This study aims to determine the problem solving of students with different categories of understanding concepts on work and energy materials based on assimilation and accommodation frameworks. The results of the study consisted of the results of five-tier diagnostic tests and description tests and student interview sheets. The results of diagnostic tests can be seen in figure 1 dan 2.

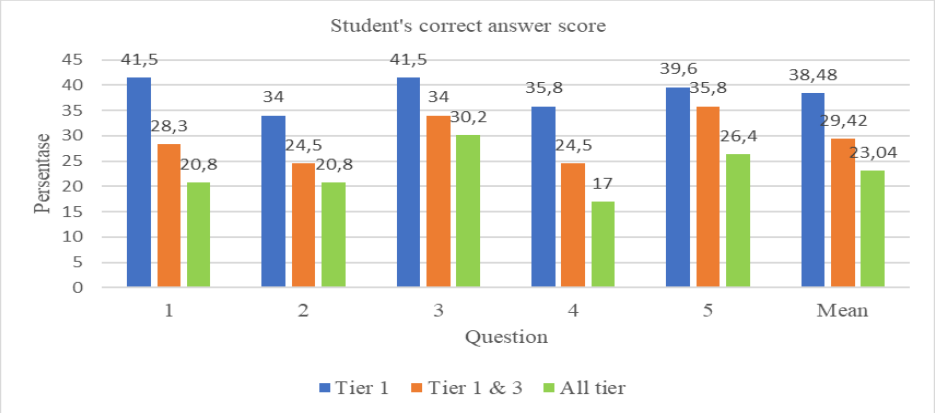


Figure 1. Student's Correct Answer Score

Figure 1 shows the average correct answer of students for the first level with the largest percentage being in questions number 1 and 3, which is 41.5%. Meanwhile, the average correct answer of all question items at the first level was 38.48%. Students can be said to understand concepts when students can answer all levels correctly and confidently. The average correct score for the answers at the first and third levels of all question items was 29.42%. Meanwhile, the average percentage of answers at all levels of all question items was 23.04%. This shows that the average understanding of students in answering correctly from the five question items is <30% and is included in the low category.

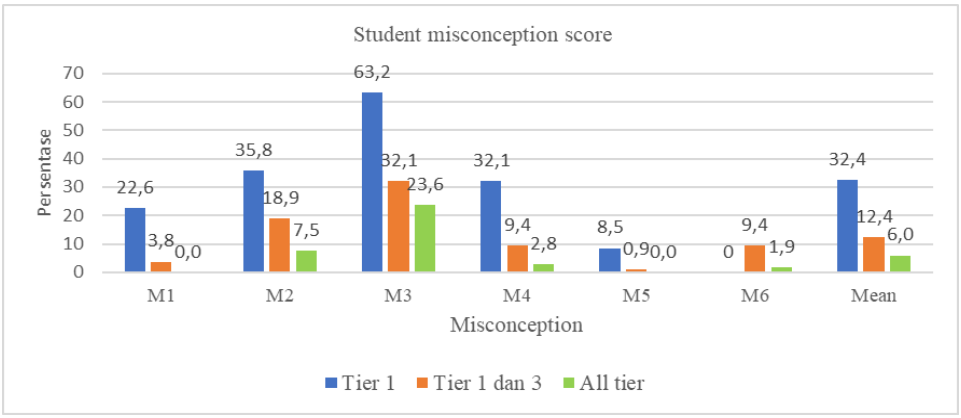


Figure 2. Student's Misconception Score

The diagnostic test has two answer keys, namely the correct answer and the misconception answer. Figure 4.2 shows the average misconception answer of students for the first level with the largest percentage being in the M3

misconception, which is 63.2%. At the first and third levels by 32.1%. Meanwhile, for all levels, it is known that the misconception of M3 is 23.6%. The M3 misconception is related to the idea that "the more difficult or longer a trajectory is to travel, the greater the effort". Students are said to have misconceptions when students answer all levels incorrectly and confidently. The percentage of misconceptions for the average answers at the first and third levels of all question items was 12.4%. Meanwhile, the average percentage of answers at all levels of all question items was 6 The researcher continued the analysis of students' answers for the False Positive (FP), False Negative (FN) and Lack of Knowledge (LK) categories. The results of the percentage of student answers in the categories of false negative, false positive and lack of knowledge can be seen in table 4.

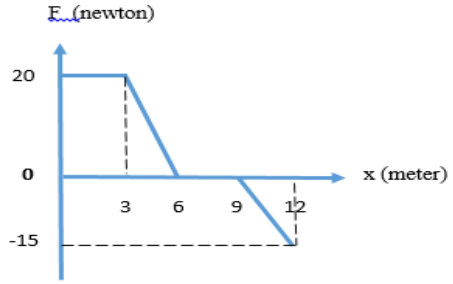
Table 4. Analysis of False Positives, False Negatives and Lack of Knowledge

Category	Question					Mean
	1	2	3	4	5	
FP	5,7	7,5	1,9	3,8	0	3,78
FN	11,3	3,8	5,7	9,4	0	6,04
LK	43,4	32,1	39,6	52,8	41,5	41,88

Students are said to be in the false positive category when students answer questions correctly and confidently but the reasons given are wrong and confident. Furthermore, students with the false negative category when students answer questions incorrectly and confidently, but the reasons given are correct and confident. Table 4 shows that the highest number of student answers in the false positive category is in question item number 2 at 7.5% with an average of 3.78% of all items. Meanwhile, in the category of false negative answers, the highest is in question number 1 of 11.3% with an average of 6.04% of all items. As for the lack of knowledge answer category with the highest percentage of 52.8% in question item number 4.

The results of the diagnostic test provide an overview of student groups based on the category of understanding concepts in work and energy materials. This study took subjects with diagnostic test answers in the category of students with the most misconception categories (S1), not understanding concepts (S2) and understanding concepts (S3). Subjects in each category are selected based on the criteria needed by researchers with the aim of seeing problem solving on the description test questions.

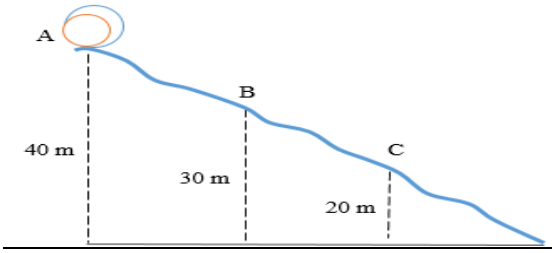
Table 5. Understanding Work Concept

Question	Understanding Concepts
Riska is a student. Riska rides a bicycle on his way to school. Riska's journey to school is depicted in the graph below with the direction of force F and displacement x.  The total amount of work that Riska did was...	S1, S2 and S3 answer the problem with the equation of work (w) = F.s S1, S2 and S3 substitute the information on the question so that w = 20 is obtained. 12 = 240 N S1, S2 and S3 reveal the work depends on the magnitude of the force (F) and the displacement of the object (s) S1, S2 and S3 do not pay attention to the area under the graph in solving problems on the problem

Problem-solving Indicators	Subjek 1 (S1)	Subjek 2 (S2)	Subjek 3 (S3)
Understanding the problem	Asimilasi	Asimilasi	Asimilasi
Devision a plan	Asimilasi	Asimilasi	Asimilasi
Carry out the plan	Akomodasi	Akomodasi	Akomodasi
Looking back	Akomodasi	Akomodasi	Akomodasi

Understanding of the work concept of S1, S2 and S3 subjects can be seen from solving problems on the problem. Problem solving of S1, S2 and S3 subjects begins with the assimilation process that occurs at the stage of understanding the problem and planning the solution. This assimilation process is shown by the subject understanding the notion and equation of work (w = F.s). At the stage of carrying out problem solving, there was an accommodation process carried out by the three subjects. The process appears in the final result when the subject reviewed the answer, the subject did not pay attention to the area under the graph in calculating the amount of work.

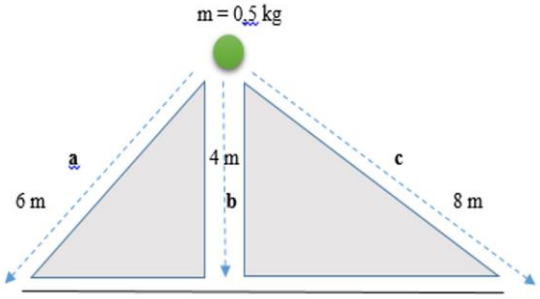
Table 6. Understanding the Concept of Energy

Question	**Mastery of Concepts**
Two objects are in the same starting position down the trajectory from points A to D. The mass of the objects is 5 kg and 15 kg, respectively. If the acceleration of gravity is 10 m/s^2. Determine the ratio of kinetic energy Ek_1 : Ek_2 at point B... 	S1 calculates kinetic energy using the mechanical energy equation ($Em_A = Em_B$) S1 completes calculations and compares values Ek_1 and Ek_2 S2 and S3 compare the values of Ek_1 and Ek_2 by comparing the masses of the two objects

Problem-solving Indicators	Subjek 1 (S1)	Subjek 2 (S2)	Subjek 3 (S3)
Understanding the problem	Asimilasi	Asimilasi	Asimilasi
Devision a plan	Asimilasi	Akomodasi	Asimilasi
Carry out the plan	Asimilasi	Akomodasi	Akomodasi
Looking back	Asimilasi	Akomodasi	Akomodasi

Table 6 shows the understanding of energy concepts in subjects S1, S2 and S3. Problem solving of S1 subjects on problems is carried out by understanding, planning and implementing solutions that show the assimilation process. This can be seen when S1 reviews and tells the steps for completion appropriately and systematically. While S2 and S3 solve the problem by directly comparing the two masses of objects without including the solution step. Although in the end the three subjects answered with the same final result, namely Ek_1 : Ek_2 = 1 : 3, but in the process it was different. S2 and S3 subjects seemed to carry out the accommodation process as seen from the confused expression in explaining the completion steps and the duration of thinking before answering.

Table 7. Understanding of the Concept of Work and Energy Relations.

Question	Mastery of Concepts
A ball as shown in the picture is dropped to the floor through a slippery field with three different paths, path a, path b and path c. Then the path that has the biggest work is... 	S1 performs calculations using the mechanical energy equation ($Em_A = Em_B$). S1 considers altitude equal to path length. S1 gets the amount of work from the count and chooses path c. S2 chose path a because it has a greater slope without doing mathematical calculations S3 chose paths a and c because they have a higher slope and a longer path without doing mathematical calculations

Problem-solving Indicators	Subjek 1 (S1)	Subjek 2 (S2)	Subjek 3 (S3)
Understanding the problem	Asimilasi	Asimilasi	Asimilasi
Devision a plan	Asimilasi	Akomodasi	Akomodasi
Carry out the plan	Akomodasi	Akomodasi	Akomodasi
Looking back	Akomodasi	Akomodasi	Akomodasi

Table 7 shows the understanding of work relationship and energy concept in subjects S1, S2 and S3. Problem solving of the three subjects on the question is carried out with different steps and final results. S1 subjects solve problems by doing calculations to get the amount of work on each path (a, b and c). The subject S1 in the final stage of completion chooses the path with the greatest work is path c. The assimilation process can be seen from a systematic step in understanding and planning for settlement. However, there is an accommodation process at the stage of solving the problem by misunderstanding altitude (h) as the path length when substituting it into the potential energy equation (Ep = m.g.h).

The concept of work and energy relationship understood by subject S1 shows that work (w) is a change in energy (Ep and Ek). This can be seen from the final answer S1 which uses the mechanical energy (Em) approach to obtain the kinetic energy (Ek) value. While the change in kinetic energy (ΔEk) is equal to the magnitude of work (w).

The S2 subject solved the problem by choosing path a on the grounds that it had a greater slope. While subject S3 chooses paths a and c by paying attention to the length of the track and the slope on the path. Second, the subject does not perform mathematical calculations and tends to carry out the accommodation process in solving problems.

S2 and S3 subjects in solving the problem showed a misconception in choosing the path with the greatest work. S2 and S3 consider that the more inclined or long a trajectory is traversed, the greater the work. While S1 considers the concept of ball displacement to be the same as the distance traveled by the ball. The subject has not realized the magnitude of work influenced by the conservative force. The conservative force does not depend on the trajectory traveled by an object but on the initial and final positions of the object.

Cognitive structures based on the interconnectedness of concepts in solving problems can be categorized into local and global coherence. Based on the problem solving in the description test questions that have been given to each subject (S1, S2 and S3), the three subjects have cognitive structures in the

category of less coherent locality. This shows that the subject has a conception of the answer based on a single concept that is not related to other concepts (Wadana & Maison, 2019).

The difficulties faced by S1, S2 and S3 subjects in solving problems can be seen from the steps of understanding, planning, implementing solutions and reviewing problems. S1, S2 and S3 subjects tend to solve problems at the stage of understanding and planning problems. While at the stage of implementing the settlement and reviewing it still shows obstacles. Although S1 subjects are included in the category of students with the most misconceptions, they can more easily understand in the description test. S1 is easier to solve problems with mathematical calculations.

The subject skill factor in mathematical calculations becomes something that needs to be considered in solving problems. When solving a problem, students must be faced with various obstacles, difficulties and challenges when solving a problem (Khasanah, 2021). It is well known that the character of each student is not the same, nor is the background of each student. Misunderstanding of the concept of the subject can be caused by associative, humanistic thinking, incomplete initial concepts and reasoning (Maison et al., 2020)

Success in solving a problem must be influenced by several factors including understanding concepts related to intelligence quetient and student comprehension which is the subject of research. Other factors to consider in solving are the emotional quotient and spiritual quotient. It turns out that the determining factor in success that is very important and still unfamiliar to the ear is the adversity quotient which can be the subject of future research.

CONCLUSION (5%)

The cognitive structure of the research subject with a conceptual understanding of different shows students belong to the category of less coherent locality. Test the diagnostics that have been carried out show students' understanding of concept of 30.2% on the energy change sub-material, and the lack of understanding of the concept of 52.8% on the relationship between potential, kinetic and mechanical energy sub-matter. Meanwhile, misconceptions of concepts are known at 23.6% where student consider the amount of work depends on the length of the trajectory traveled

The students' problem solving in the description test showed that during the completion of the three problems, the subjects carried out the process of assimilation and accommodation. The assimilation process tends to occur in the step of understanding and planning the solution strategy, while the accommodation process is more dominant in the step of implementing and reviewing the solution answer. The assimilation process at the beginning does not guarantee that problem solving can be carried out until the end. Subjects with a conceptual understanding category (S3) have a better assimilation process than subjects with a non-conceptual category (S2). There are subjects with misconception categories (S1) who can solve problems through the assimilation process from beginning to end, this shows that the assimilation process can occur when the subject has the same knowledge scheme as the problem at hand. Accommodation behavior shows that the subject has a different knowledge scheme with new information/problems faced, especially in mathematical calculations and foreign terms. On the other hand, the three subjects experienced a misunderstanding of the concept, such as

assuming that the amount of effort depends on a trajectory. This is due to associative thinking, intuition and incomplete reasoning.

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