HOTS Based Scientific Reasoning: Cognitive Model Assessment in Work and Energy Material

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Abstract. Higher Order Thinking Skill (HOTS) is one of the higher thinking skills that must be possessed in 21st-century education. HOTS is a higher cognitive level of humans thinking in explaining concepts, thinking logically, and solving problems. The purpose of this study is to describe HOTS students based on several indicators of scientific reasoning as one of the models of evaluation of innovative learning at the college level, specifically in the field of science. The research method uses quantitative and qualitative descriptive research using a design explanatory where an explanation of the qualitative data will follow the data description of the quantitative data. This research involved 32 students majoring in Physics education at Musamus University Merauke who had or were programming introductory physics courses. The data collection technique uses in the form of a test essay followed and evaluated extensively using the scientific reasoning indicator. The results of the study indicated that students have an entry-level HOTS category based on criteria at the scientific reasoning level. This is evidenced by the acquisition of a percentage 62.5% of students' HOTS abilities at the beginner level. As many as 25% of students' HOTS abilities are at a competent level. As many as 12.5% of students' HOTS abilities are at the professional level. Interview data reinforced the gain to several students that they did not yet have a good page in evaluating the HOTS level integrated scientific reasoning problem.

Keywords: HOTS · Scientific Reasoning · Cognitive · Assessment · Work & Energy

1 Introduction

Higher order thinking skills (HOTS) is one of the knowledge and cognitive skills for individuals in the era of society 5.0. At the college level, HOTS is a determining factor for students in practicing the ability to reason scientifically, think analytically, and think multiliterate. HOTS cognitive level Includes the ability to analyze [1], evaluate, and create. HOTS is related to studying Physics, especially in understanding concepts,

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argumentation [2], and problem-solving ability [3]. HOTS individuals have three categories of knowledge, namely beginner, competent and experienced. The one topic in the fundamental physics course is the matter of work and energy. This material includes sub-topics of energy concepts, energy concepts, the concept of energy work relations, and the law of conservation of mechanical energy. Some of the findings are related to students' difficulty in solving problems and understanding the concepts of WORK and energy topics. Students have difficulty using scientific arguments in solving hots-level effort-energy issues [4] and challenges in identifying scientific literacy and basic concepts [5, 6]. Effort-energy and effort-solving structures still use intuitive knowledge. For example, in the process of learning physics, students only understand problems if given in the form of mathematical problems so that they are accustomed to using mathematical procedures in solving physics problems. Another difficulty is related to the material content of energy efforts. Students need a high level of research and research to correlate the concept of effort and energy with other mechanics concepts. As one example, learners associate the concepts of effort and energy with different concepts of mechanics, such as dynamics, kinematics, and momentum impulses.

Based on the results of observations and preliminary analysis of HOTS Students of the Department of Physics Education, Musamus University showed that 67.4% of students were still at the level of low thinking ability or beginners in work and energy materials. One of the contributing factors is that scientific reasoning (SR) is still low. The research results reinforce that the low HOTS is influenced by students' low level of scientific reasoning (SR) [7]. Most students do not have scientific arguments and basic concepts for solving physics problems. Individuals with low scientific reasoning ability have more difficulty communicating problem-solving strategies ranging from understanding concepts [4, 8] to planning, evaluating, and creating well-solving physics problems. The urgency in this study is for prospective physics teachers in the era of society 5.0, where the competence of future teachers is competent who not only have a basic contra understanding but must also have problem-solving skills, argumentation, critical thinking, and a high level of scientific reasoning. Therefore, at a high level of learning, process patterns and learning assessments are recommended to integrate high-level thinking skills through modifications to the development of HOTS assessments based on the SR indicator model as one of the alternative solutions. So far, many studies have identified and developed SR assessments on Physics material that have not been combined with indicator HOTS. The development of HOTS instruments is still generally not yet integrated with SR. There is still little research on developing SR-based HOTS test instruments on HOTS physics materials. Therefore, this study explores SR-based HOTS and students specifically on effort and energy materials by using modifications of reasoned essay test instruments that follow the material being tested.

2 Methods

The research methods used in this study are qualitative and qualitative research types of design explanatory. The research method used aims to describe the student's HOTS level based on SR. HOTS assessment data based on the accumulation of student answers will be strengthened by interviews with each student representative in the beginner, competent and experienced level categories. Participants in this study involved 32 students of

the Physics education department of Musamus University who had taken introductory physics courses. Sub-topics of work and energy materials include Work, energy, work-energy relations, and mechanical energy engineering laws. The data collection technique uses the SR-based HOTS test in the form of structured questions and interviews. The research instruments used are tests developed following hots levels ranging from lysis, evaluating, and creating and combined with the SR test model by Lawson. The type of question was developed using a well-founded essay. The matter has validity and reliability of 0.764 and 0.785 with valid and reliable categories. The SR pattern used is based on several indicators of reasoning ability by physical matter: proportional reasoning, variable reasoning, correlation reasoning, and hypothetical deductive reasoning. Table 1 is an SR-based HOTS assessment rubric on work and energy materials.

The data collection technique is that students take tests and do an interview. Data analysis was performed to determine the HOTS level in the assessment rubric with a minimum score range of zero and a maximum value of five. Student answers are grouped based on the similarity of hots categories. A score of 0 will be given if the student cannot provide answers or reasons according to the SR indicators. A score of 5 will be given if the student is able to exceed the answer or explanation according to the SR indicator. SR-based HOTS assessment follows an entry-level assessment scale with a total score range of 0–45, competent with a score range of 46–75, and experienced 76–100. Furthermore, the grouping of scientific reasoning levels will be determined based on the total scores obtained by students. The achievement of SR in supporting

Table 1. SR-based HOTS assessment rubric on work and energy materials

HOTS indicator	SR indicator	Question Indicators
Level C4 (Analyzing)	Proportional Reasoning (PP)	Students can analyze problems related to applying the concept of the relationship of work-energy in everyday life with proportional thinking patterns of reasoning.
Level C4 (Evaluating)	Correlation Reasoning (PC) Hypothetical Deductive Reasoning (HDR)	Students can evaluate the correctness of concepts based on the relationship of potential energy-kinetic energy-mechanical energy on the law of energy conservation with correlation reasoning patterns. Students can conclude the truth of the concept of work – energy based on several case examples with the Hypothetical Deductive Reasoning pattern.
Level C4 (Creation)	Variable Control (CV)	Students can create a problem-solving solution to the energy-effort concept based on the pattern of variable control.

HOTS is described in percentage form. Data analysis was also carried out to see the accomplishment of scientific reasoning indicators in each sub-indicator.

3 Result and Discussion

The data obtained shows that most HOTS based on SR, Department of Physics Education, Musamus University are still classified as beginners. The gain is evidenced by the distribution of percentage achievements in the total achievements located at the beginner level in Fig. 1. The beginner level indicates that students have not been able to analyze, evaluate and create physics problem solving based on the SR pattern, which is a tool and makes a way of thinking in solving physics problems.

Based on student answers, there are several variations of student answer categories, so it needs to be simplified into six types of simplified answer forms in grades 0 to 5. The result scores in the range of 0–1 indicate that students cannot give answers well and reasons that correspond to SR indicator. A score of 2–3 indicates that students can provide answers not accompanied by answers that are in accordance with the SR indicator. The acquisition of a score of 4–5 indicates that students can answer according to the concept accompanied by reasons that are in accordance with the SR indicator. The results showed that most students were at the novice HOTS level with a percentage of 65.5% or 20 participants. This indicates that students do not have a structure of understanding or the ability to identify, plan, evaluate and find solutions of the physics problem based on SR reasoning patterns. Supporting data through an interview with one of the student representatives explained that they were confused about the ethics of being asked to provide reason with the needs of variable which is necessary to finish work-energy problem. One of the examples in the SR indicator is proportional reasoning. In this indicator, students are asked to apply a special strategy in predicting the additional effort needed to move the boat. Students who have low reasoning are only able to provide mathematical problem-solving concepts and reasons for analyzing work-energy relationships, transfers, and styles. The number of students at the competent level obtained a percentage of 25% or 8 participants. These results indicate that students have been able to provide answers that

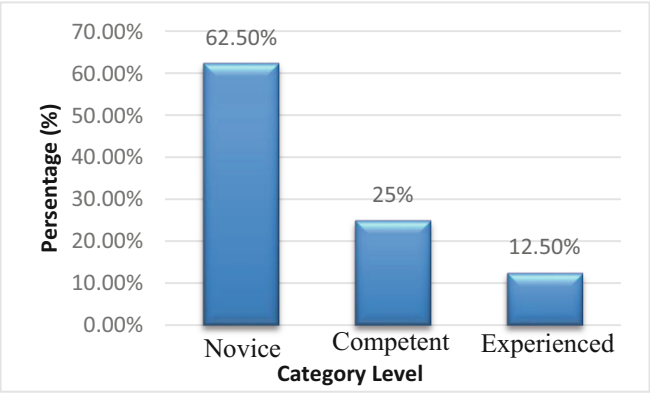

Fig. 1. Percentage of Student HOTS Levels

lead to the correct concept but are unable to provide arguments in accordance with the SR. Students in this category said that they were able to identify variables that supported the undertaking such as displacement force and displacement but had no reason to lead to indicator SR. The HOTS category is experienced level as many as 12.5% or 2 participants. These results indicate that students can provide answers that are in accordance with the correct concept and are able to provide arguments in accordance with the SR pattern. Students in this category said they were able to identify variables that supported the work such as style and transfer and the reasons for helping them direct focus on solving physics problems in accordance with the correct problem-solving procedures and concepts. Figure 2 follows. The result of an analysis of the achievement of reasoning patterns in each SR indicator.

Student answer acquisition is categorized into several answer models to determine the achievement of each reasoning model. Overall, the pattern of SR reasoning in supporting students HOTS is still relatively low, because the average achievement is still below 50%. The reasoning patterns with the lowest order are proportional reasoning patterns and hypothetical deductive reasoning patterns. The low pattern of proportional reasoning indicates that each student has a low effectiveness related to the use of low proportional thinking reasoning in solving relationship problems and energy in everyday life. The indication that occurs is that students only guess the answer, using the identification of force and displacement variables in planning the solution of the problem but on illogical grounds. This is in accordance with the results of research conducted by stating that individuals who have analytical skills must use knowledge of previous basic concepts to answer questions instead of relying on information in the questions or problems given. The low achievement of SR in the Hypothetical Deductive Reasoning indicator indicates that students have not provided strong evidence in evaluating the correct concept related to the analysis diagram of the relationship between potential and kinetic energy on the law of mechanical energy scarcity.

Based on quantitative analysis related to the achievement of SR in the HOTS assessment, it is known that there are still low results obtained in each aspect and sub-material. This is supported by the results of interviews on qualitative analysis. The results of the

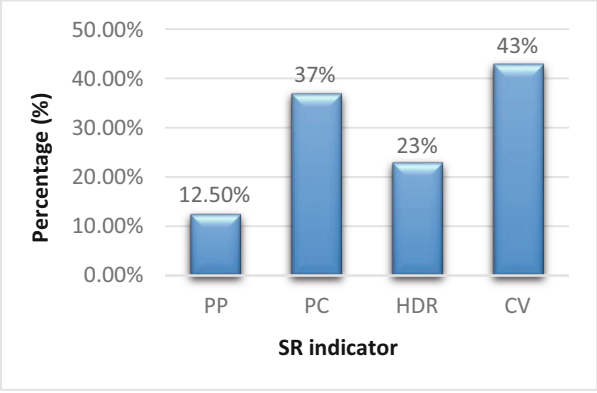

Fig. 2. Percentage of Achievement of Student SR Indicators

interview stated that students still experienced a misunderstanding of concepts related to factors that influenced the low scientific argumentation in supporting student HOTS in solving energy-effort material problems. The following are the results of the interview related to the problems found. (1) Students still consider that displacement has the same meaning as displacement so that it has an impact on the student's ability to provide reasons in determining positive efforts, negative work and make no effort. (2) Students consider that cases Effort Zero is only reviewed on the frame of reference when the object is stationary. (3) Students assume that objects that move at a constant speed must have a work. (4) Students conclude that kinetic and potential energy has a conception of negating each other. (5) The student has not been able to provide an appropriate reason for evaluating the appropriate data related to the data from the hook legal experiment. The form of SR achievement is one of the manifestations of HOTS Good scientific reasoning affects the students' mindset [9], namely the pattern of scientific reasoning used to find facts, scientific practice, and infer the truth of concepts, analyze the solution of the problem and plan the solution of the problem. Some of these abilities can be obtained during learning because scientific reasoning is a good predictor in achieving science[7, 10]. In addition, the student's mindset related to scientific reasoning is the improvement of knowledge based on facts with a process of searching through investigation or practice directly [11]. Therefore, SR is one of the important factors [12] for students in investigating the truth of physics concepts and supporting student HOTS.

4 Conclusion

Energy materials are still mostly classified as beginners. This result indicates that students need to be trained in terms of evaluating their HOTS-modified SR. One of the causes of low student HOTS is that the SR skills of students are still low. This needs to be followed up through learning activities that need to be improved with several approaches and methods. One of them is a multi-representational learning approach. The implication of knowing the student HOTS level is that it can be used as material for evaluating lecturers in learning activities to innovate in lecture activitie.

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