Jurnal UM_Elsiaulavita Gracia

by Stepanus Sahala S

Submission date: 28-Jun-2022 01:20AM (UTC+0900)
Submission ID: 1863755461
File name: Elsiaulavita_Gracia_Jurnal_UM.pdf (336.36K)
Word count: 5909
Character count: 31966

p-ISSN: 2337-5973
e-ISSN: 2442-4838
http://ojs.fkip.ummetro.ac.id/index.php/fisika/

JPF Jurnal Pendidikan Fisika
Universitas Muhammadiyah Metro

Difficulty Analysis of Solving HOTS Problems on Harmonic Vibration Using Heller Troubleshooting

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Diterima: Tanggal, Bulan, Tahun. Disetujui: Tanggal, Bulan, Tahun.

Abstrak

Penelitian dilakukan dengan tujuan menentukan jenis dan penyebab kesulitan yang dialami peserta didik dalam menyelesaikan soal HOTS materi getaran harmonis. Penelitian ini merupakan penelitian kualitatif deskriptif. Penelitian dilakukan di SMA Negeri 10 Pontianak dengan jumlah sampel 44 orang. Teknik pengumpulan data yaitu memberikan tes soal HOTS dan wawancara kepada peserta didik kelas XI IPA. Analisis data dilakukan dengan mereduksi data, menyajikan data, dan membuat kesimpulan. Kesulitan yang dialami peserta didik dibagi menurut tahapan pemecahan masalah Heller. Hasil penelitian menunjukkan bahwa (1) kesulitan memvisualisasikan masalah disebabkan peserta didik tidak memahami soal, serta kurangnya pembiasaan untuk mengubah masalah pada soal ke dalam bentuk gambar; (2) kesulitan deskripsi fisika disebabkan kurangnya pemahaman dalam memahami masalah; (3) kesulitan rencana solusi disebabkan kurangnya pemahaman konsep; (4) kesulitan menjalankan rencana disebabkan kesalahan pada tahap deskripsi fisika dan tahap rencana solusi, peserta didik tidak mengetahui konsep yang digunakan pada soal, dan kurangnya penguasaan pada operasi hitung; (5) kesulitan memeriksa dan mengevaluasi disebabkan peserta didik tergesa-gesa serta kurang teliti dalam menyelesaikan dan memeriksa jawaban. Persentase rata-rata kesulitan yang dialami peserta didik sebesar 85,17% dengan kategori sangat tinggi.
Kata Kunci: Analisis Kesulitan, Menyelesaikan Soal, Higher Order Thinking Skills (HOTS), Getaran Harmonis, Pemecahan Masalah Heller

Abstract

The research was conducted to determine the types and causes of difficulties experienced by students in solving HOTS questions on the material of harmonic vibrations. This research is descriptive qualitative research. The study was conducted at SMA Negeri 10 Pontianak with a total sample of 44 people. The data collection technique is giving HOTS test questions and interviews to students of class XI science. Data analysis is done by reducing the data, presenting the data, and making conclusions. The difficulties experienced by students are divided according to Heller's problem-solving stages. The results showed that (1) the difficulty in visualizing the problem was caused by the students' lack of understanding of the questions and the lack of habituation to convert the problems in the questions into pictures; (2) the difficulty of physics description was due to a lack of understanding in understanding the problem; (3) the difficulty of planning solutions was due to a lack of understanding of the concept; (4) difficulties in carrying out the plan

were caused by errors in the physics description stage and the solution plan stage; (5) the difficulty of checking and evaluating is caused by students' being in a hurry and not being thorough in completing and checking answers; and (6) the difficulty of checking and evaluating is caused by students' being in a hurry and not being thorough in completing and checking answers. The average percentage of difficulties experienced by students is 85.17%, with a very high category.
Keywords: *Difficulty Analysis, Problem Solving, Higher Order Thinking Skills (HOTS), Harmonic Vibration, Heller Problem Solving.*

INTRODUCTION

One way to improve assessment standards is to improve students' needs in analyzing and critical thinking by international standards (Hidayah, 2018). The 2013 curriculum learning prioritizes the learning process that requires students to be better and more active in observing, asking questions, reasoning, and communicating, so that they can understand, apply and analyze the learning they receive (Andrian & Rusman, 2019; Andriani et al., 2020). Higher-order thinking skills can be a trigger to encourage students to think actively, broadly, and critically.

Characteristics of higher-order thinking skills: (1) measuring higher-order thinking skills, (2) based on contextual problems, (3) using various forms of questions, and (4) measuring cognitive levels C-4 (analyzing), C-5 (evaluating), and C-6 (creating) (Fanani, 2018; Herman et al., 2022).

HOTS is defined as the way students think at a high cognitive level, and is expected to be able to think critically, solve problems, have creativity and innovation, and have communication and collaboration skills (Herman et al., 2022; Pratiwi et al., 2019). The 2013 curriculum learning process guides students to find out information from the learning delivered, which is built with a divine attitude and social values (Kusdianti et al., 2019). Finding out requires a smart, critical, and creative way of thinking, which means it requires higher-order thinking skills.

The ability to analyze, evaluate, and create is part of higher-order thinking skills, because it involves more complex judgment skills to think critically and solve unusual problems in everyday life (Widiawati, L., Joyoatmojo, S., & Sudiyanto, 2018). Physics learning aims for students to develop the ability to reason and think analytically, to use the

concepts and principles of physics in explaining various natural events, and to be able to solve problems. Not a few students have difficulty in understanding the concepts of physics and accepting the material being taught, are unable to interpret the problem, and have the ability of students in mathematical calculations (Habibullah & Hartono, 2019).

PISA questions are always oriented to the problem- solving, such as the characteristics of HOTS questions that require critical thinking skills. According to the survey results from the data Programme for International Students Assessment (PISA) in 2018, the ability of students in Indonesia for reading, math, and science skills was included in the low category, which was ranked 74th out of 79 countries, evaluated with scores of 371, 379, and 396, respectively (Hewi & Shaleh, 2020). Based on the scores obtained, proves that the reading, math and science skills possessed by students in Indonesia are still low.

The ability of students who are lacking in analyzing problems and visual problems makes it difficult for students to understand concepts and solve problems related to harmonic vibrations in everyday life. Students of SMA Negeri 10 Pontianak class XI IPA have studied the harmonic vibration meter. However, the evaluation activities for harmonic vibration materials are still quite difficult.

When given exercises that are different from the examples presented, students have difficulty completing them because they lack mastery of concepts. In general, to solve physics problems, skills are needed to convert questions into pictures or diagrams, understand relevant basic concepts, as well as analyze and write down known and asked variables on the questions (Bradley et al., 2019; Wijayanti et al., 2019).

Parameter analysis related to the problem is needed so that students can plan the solution to physics problems correctly. Therefore, to find out the difficulties experienced when solving HOTS questions, Heller problem solving is used with the stages of visualizing the problem, describing physics, planning solutions, implementing solutions, and checking and evaluating (Hudha et al., 2017; Mulyani et al., 2021).

Ability in higher-order thinking becomes a very important aspect for students when describing or explaining a physical phenomenon (Ratnasari et al., 2021). Physics learning that is focused on these abilities is expected to build higher quality thinking. The need for habituation to provide HOTS-oriented problems is expected to be able to improve the ability of students to think critically, be able to analyze, and evaluate a lesson (Akmala et al., 2019; Saraswati & Agustika, 2020).

This research is expected to be a means to analyze the difficulties of students in solving HOTS questions using Heller's problem-solving stages, and make it easier for teachers to determine appropriate actions when overcoming difficulties, because it can be seen how students focus on problems, draw physics situations, plan solutions, implement plans, and evaluate the answers.

METHODS

This research is descriptive and qualitative. Data collection techniques in the form of HOTS description questions and interviews. Descriptive qualitative research was used to analyze the difficulties experienced by students when solving HOTS questions on the material of harmonic vibrations based on the stages of Heller's problem-solving.

The research was carried out in the odd semester of the 2021/2022 academic year at SMA Negeri 10 Pontianak, in physics in November 2021. All students in class XI science at SMA Negeri 10 Pontianak, 3 classes were the subjects in the study. Data was collected by giving a description test in the form of HOTS questions to 44 students, and interviews were conducted with 9 students who scored high, medium, and low.

HOTS questions are given to determine the type of difficulty according to Heller's problem-solving stages. Interviews were conducted to find out the causes of difficulties experienced by students in solving HOTS questions. Interview subjects were selected based on scores highest after analyzing the student answer sheets.

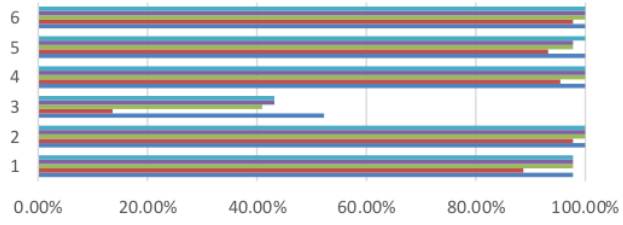
The research instrument was used in the form of harmonic vibration HOTS questions and interview guidelines. The interview is unstructured and uses Indonesian. The interview guide is in

the form of an outline of the problems to be asked, adjusted to the stages of solving Heller's problems, then asking further questions that are more goal-directed based on an analysis of each respondent's answers.

After obtaining data from the results of answers and interviews, then grouped based on the formulation of the problem and analyzed. In this context, Milles and Huberman model data analysis is used, namely: (1) data is reduced based on the results of answers and interviews; (2) the data is presented in the form of tables and descriptive text in the form of the results of interviews in general from the students selected as research subjects; and (3) draw conclusions (Sugiyono, 2021).

RESULTS AND DISCUSSION

In the process of collecting data for analysis, the research subjects amounted to 44 students who were given HOTS (*Higher Order Thinking Skills*) test questions in the form of descriptions, and 9 students were selected based on scores after the answers were analyzed.



	1	2	3	4	5	6
Memeriksa dan Menevaluasi	97.72%	100%	43.18%	100%	100%	100%
Menjalankan Rencana	97.72%	100%	43.18%	100%	97.72%	100%
Rencana Solusi	97.72%	100%	40.90%	100%	97.72%	100%
Deskripsi Fisika	88.63%	97.72%	13.63%	95.45%	93%	97.72%
Memvisualisasikan Masalah	97.72%	100.00%	52.27%	100.00%	100%	100%

Figure 1. Percentage of Difficulty in Solving HOTS Problems in Harmonic Vibration Physics

Overall, the percentage of students who experience difficulties is 88.51% in the very high category. Difficulties are analyzed based on Heller's problem-solving stages. The average difficulty percentage at the stage of visualizing the

problem is 91.66%, the average difficulty percentage at the physics description stage is 81.58%, the average difficulty percentage at the solution plan stage is 89.39%, the average difficulty percentage at the stage of carrying out the plan is 89.77%, and the average difficulty percentage at the stage of checking and evaluating is 90.15%. The profile of the difficulty of solving the HOTS questions on harmonic vibrations can be seen in the following table:

Table 1. Student Difficulty Profile Number 1

No	Heller Stages	Indicators/Problems	Difficulty Profile	F	%
1	Visualize the problem	Sketch the problem	Students have not been able to describe the motion of a period correctly.	43	97,72%
2	Description of physics	Write known and asked	Students have not been able to write what is known and asked completely.	40	88,63%
3	Planning a solution	Write the equation or formula used to solve the problem	Students have not been able to use period and time equations correctly.	43	97,72%
4	Execute the plan	Substituting the values into the equation and completing the calculation	Students have not been able to substitute values into the equation and have not completed calculations.	43	97,72%
5	Check and evaluate	Check the completeness of answers, marks, units, and values	Students have not been able to complete answers, grades, units, and values correctly.	43	97,72%

In question number 1 with the cognitive level evaluation (C5), on the indicator predicting an event related to the pendulum, the average percentage of difficulties experienced by students is 95.9%. Students who have difficulty at the stage of visualizing the problem, planning solutions, executing plans, as well as at the checking and evaluating stage are 43 people or 97.72%. While the difficulty of physics description was experienced by 40 students or 88.63%.

Table 2. Student Difficulty Profile Number 2

No	Heller Stages	Indicators/Problems	Difficulty Profile	F	%
1	Visualize the problem	Sketch of the problem	Students have not been able to describe the change in strain	44	100%

			and the equilibrium state of the spring correctly.		
2	Description physics	Write known and asked	Students have not been able to write what is known and asked completely.	43	97,72 %
3	Planning solution	Write the equation or formula used to solve the problem	Students have not been able to use the equation of the spring period correctly.	44	100%
4	Execute the plan	Substituting the values into the equation and completing the calculation	Students have not been able to substitute values into the equation and have not completed calculations.	44	100%
5	Check and evaluate	Check the completeness of answers, marks, units, and values	Students have not been able to complete answers, grades, units, and values correctly.	44	100%

In question number 2, the cognitive level evaluates (C5), on the indicators students can conclude the length of the rope and the speed of the pendulum from the picture presented, the average difficulty experienced by students is 99.54%. Students who have difficulty at the stage of visualizing problems, planning solutions, carrying out plans, and the stage checking and evaluating are 44 people or 100%. Meanwhile, the difficulty in describing physics was experienced by 43 students, or 97.72%.

Table 3. Student Difficulty Profile Number 3

No	Heller Stages	Indicators/Problems	Difficulty Profile	F	%
1	Visualize the problem	Sketch of the problem	Students have not been able to describe the location of the maximum kinetic energy and potential energy of a ball rolling from a height	23	52,27%
2	Description physics	Write known and asked	Students have not been able to write what is known and asked completely.	6	13,63%
3	Planning solution	Write the equation or formula used to solve the problem	Students have not been able to use the formula to find the velocity of the bullet before and after the collision, and the amplitude correctly.	18	40,9%
4	Execute the plan	Substituting the values into the equation and	Students have not been able to substitute values into the	19	43,18%

		completing the calculation	equation and have not completed calculations.		
5	Check and evaluate	Check the completeness of answers, marks, units, and values	Students have not been able to complete answers, grades, units, and values correctly.	19	43,18%

In question number 3 with the cognitive level of analyzing (C4), on the indicators, students can relate the concepts of energy, collision, and harmonic vibrations on springs to measure the amplitude correctly, the average difficulty experienced by students is 38.63%. 23 students had difficulty in visualizing the problem or 52.27%. Difficulty in physics description was experienced by 6 students or 13.63%. Difficulty in planning solutions was experienced by 18 students or 40.9%. Difficulties in carrying out plans, as well as checking and evaluating experienced by 19 students or 43.18%.

Table 4. Student Difficulty Profile Number 4

No	Heller Stages	Indicators/Problems	Difficulty Profile	F	%
1	Visualize the problem	Sketch of the problem	Students have not been able to describe the direction of motion of the pendulum, the direction of the acceleration of the elevator, and the direction of the acceleration of gravity.	44	100%
2	Description physics	Write known and asked	Students have not been able to write what is known and asked completely.	44	100%
3	Planning solution	Write the equation or formula used to solve the problem	Students have not been able to use the formula for the period and time on the pendulum correctly.	44	100%
4	Execute the plan	Substituting the values into the equation and completing the calculation	Students have not been able to substitute values into the equation and have not completed the calculation.	44	100%
5	Check and evaluate	Check the completeness of answers, marks, units, and values	Students have not been able to complete answers, grades, units, and values correctly.	44	100%

In question number 4 with the cognitive level evaluation (C5), with the question indicator proving the time it takes to make one vibration on a pendulum swing, the average percentage of difficulties experienced by students is 99.09%. Students who have difficulty at the stage of visualizing problems, planning solutions, carrying out plans, and the stage checking and evaluating are 44 people or 100%. While the difficulty of physics description was experienced by 42 students or 95.45%.

Table 5. Student Difficulty Profile Number 5

No	Heller Stages	Indicators/Problems	Difficulty Profile	F	%
1	Visualize the problem	Sketch of the problem	Students have not been able to describe the state of the spring after the bullet hits and lodges in the block.	44	100%
2	Description physics	Write known and asked	Students have not been able to write what is known and asked completely.	41	93,18%
3	Planning solution	Write the equation or formula used to solve the problem	Students have not been able to use the formula for collision velocity, amplitude, and kinetic energy in springs.	43	97,72%
4	Execute the plan	Substituting the values into the equation and completing the calculation	Students have not been able to substitute values into the equation and have not completed the calculation.	43	97,72%
5	Check and evaluate	Check the completeness of answers, marks, units, and values	Students have not been able to complete answers, grades, units, and values correctly.	44	100%

In question number 5 with the cognitive level of analyzing (C4), on the indicators students can relate the concepts of collisions and harmonic vibrations to measure the kinetic energy of objects, the average difficulty experienced by students is 97.72%. The difficulty of visualizing the problem

was experienced by 44 students or 100%. The difficulty of physics description was experienced by 41 students or 93.18. The difficulty of planning solutions and implementing plans was experienced by 43 students or 97.72%. Difficulty checking and evaluating experienced by 44 students or 100%.

Table 6. Student Difficulty Profile Number 6

No	Heller Stages	Indicators/Problems	Difficulty Profile	F	%
1	Visualize the problem	Draw a sketch of the problem	Students have not been able to describe the direction of the pull and strain on the spring.	44	100%
2	Description physics	Write known and asked	Students have not been able to write what is known and asked completely.	43	97,72%
3	Planning solution	Write the equation or formula used to solve the problem	Students have not been able to use the formula for maximum acceleration and potential energy in springs.	44	100%
4	Execute the plan	Substituting the values into the equation and completing the calculation	Students have not been able to substitute values into the equation.	44	100%
5	Check and evaluate	Check the completeness of answers, marks, units, and values	Students have not been able to complete answers, grades, units, and values correctly	44	100%

In question number 6 with levels of cognitive analysis (C4), on the indicator questions, students can relate the concepts of collision and harmonic vibration to measure the potential energy of an object based on the image presented, and the percentage of average difficulty experienced is 99.54%. Students who have difficulty at the stage of visualizing problems, planning solutions, carrying out plans, and the stage checking and evaluating are 44 people or 100%. Meanwhile, the difficulty in describing physics was experienced by 43 students, or 97.72%.

The causes of difficulties experienced by students can be seen in table 7.

Table 7. Description of Interview Results

Difficulty Type	Interview Response	Supporting Theory
Visualize the problem	Students do not know how to draw sketches or style diagrams for each of the questions presented.	Low ability at the stage of visualizing problems occurs due to a lack of spatial reasoning skills or lack of skills in thought processes to visualize and understand abstractly objects or symbols, as well as the importance of training students to visualize physics problems to help solve problems and improve their understanding of physics concepts (Bradley et al., 2019).
Description physics	Students do not understand the problems contained in the questions so they have difficulty writing what is known and asked.	Difficulty describing problems in physics occurs because they do not understand the concepts contained in the questions, so they have difficulty when writing down the information contained in the questions completely and accurately (Wijayanti et al., 2019; Zainuddin et al., 2021).
Planning solution	Students do not understand the concepts contained in the questions.	Difficulties at the stage of planning solutions/problem solving occur because students forget and are confused with the equations/formulas used, this happens because the student learning system memorizes physics formulas so that when faced with different questions but the formula used is the same, students experience confused with the formula to use (Hidayatulloh, 2020; Wijayanti et al., 2019).
Execute the plan	Students do not understand the problems in the questions so they are wrong to write known and asked, do not know the concepts used, and do not master arithmetic operations.	Difficulty carrying out the plan occurs because students have difficulty applying what is known to the equation, and have difficulty solving problems that require mathematical calculations (Wijayanti et al., 2019). The difficulty of students carrying out the plan at the arithmetic operation stage, namely, students are in a hurry and are not careful in doing calculations, are not interested in arithmetic operations, and are less skilled in doing calculations (Charli et al., 2018).
Check and evaluate	Students are in a hurry and are less thorough in completing answers.	Students are less careful when checking the completeness of answers, such as marks, units, and values, which is the cause of the difficulties experienced by students at the stage of checking and evaluating (Pratama et al., 2017).

The type of difficulty is known after the students' answers are obtained and analyzed, then to find out the factors causing the difficulty, interviews are conducted with 9 students who get high, medium, and low scores, then re-analyzed. The answers were analyzed along with the interview questions asked, adapted to Heller's problem-solving.

Based on the data obtained, it is known that the highest average difficulty percentage is 91.66% which is included in the very high category, namely at the stage of visualizing the problem. The highest average percentage of difficulty based on sub-materials is found in questions number 2 and 4 of 99.54% and is included in the very high category, with indicators concluding the length of the rope and speed through the phenomenon of harmonic vibrations on the pendulum, and linking the concepts of collision and harmonic vibration to measure the amount of potential energy based on the picture presented. The following will describe the student's difficulty profile according to Heller's problem-solving.

The type of difficulty experienced is divided into 5 stages according to Heller's problem-solving. It is said to have difficulty visualizing the problem if students cannot draw sketches or make mistakes when describing sketches and style diagrams of the problem. It is said to have difficulty describing physics if students cannot write what is known and asked. It is said to have difficulty planning solutions if students make the wrong decisions, write down, and do not write down the relationship between equations or derive the equations used to solve the problem. It is said to have difficulty carrying out the plan if students are wrong planning solutions, incorrectly applying problems to certain cases, and incorrectly substituting values into equations and their units. It is said to have difficulty checking and evaluating if students do not re-examine the work done, as well as the accuracy and completeness of answers such as marks, units, suitability of answers with questions from the questions, and conclusions at the end of the answers.

The average percentage of difficulty in visualizing the problem is 91.66% with a very high category. Based on the results of the interview, the causes of the difficulties experienced

were not understanding the problems contained in the questions, the lack of habituation to turning the problems in the questions into pictures, and the ignorance of students, so students tended to do the physics description stage. This is supported by the opinion of Bradley et al (2019), Low ability at the stage of visualizing problems occurs due to a lack of spatial reasoning skills or lack of skills in thought processes to visualize and understand abstractly objects or symbols, as well as the importance of training students to visualize physics problems to help solve problems and improve their understanding of physics concepts.

The average percentage of difficulty at the physics description stage is 81.58% with a very high difficulty category. Based on the results of the interviews, the difficulties experienced were caused by students not understanding the problems presented in the questions. Difficulty in describing physics occurs because students do not understand the problems that must be solved, so they cannot write what is known and asked. This is supported by the opinion of Wijayanti et al (2019), The difficulty in describing physics problems is because students do not understand the concepts, so they have difficulty writing down the information contained in the questions completely and accurately. Difficulties at the physics description stage occur because students do not understand the problems presented in the questions, so they cannot change or translate the information obtained from the questions into pictures of physics situations, or diagrams equipped with physical quantities.

The average percentage of difficulty at the solution plan stage is 89.39% with a very high difficulty category. Based on the results of interviews, the difficulties experienced were due to students not understanding the problems presented in the questions so they could not carry out the solution planning stages, did not understand the concepts that must be used, forgot the formulas, and had wrong concepts. This is supported by the research of Dali et al (2021), that the cause of difficulties at the stage of planning solutions to solve problems is because students do not know the formula or equation that must be used. The results of this study are also supported by the opinion of

Wijayanti et al (2019), that the cause of difficulty at the stage of planning solutions/problem-solving is because students forget and are confused with the formula that must be used, because the learning system of students who memorize physics formulas so that when faced with problems different but the formula used is the same, students experience confusion with the formula that must be used.

The average percentage of difficulty carrying out the plan is 89.77% with a very high category. Based on the results of the interviews, the difficulties experienced were because students did not/wrongly write known and asked so that errors occurred in substituting values into the equation, did not understand the concepts that must be used, experienced difficulties, and were not interested in arithmetic operations, and were not thorough. Difficulty carrying out the plan occurs if an error has occurred in the previous stage, so it cannot solve the problems presented correctly. This is supported by the research of Wijayanti et al (2019) that difficulties in carrying out the plan occur because students have difficulty applying what is known to the equation, as well as difficulty solving problems that require mathematical calculations. In the opinion of Charli et al (2018), the cause of the difficulty in carrying out the plan at the arithmetic operation stage is because students are in a hurry and are not careful in doing calculations, are not interested in arithmetic operations, and are less skilled in doing calculations.

The average percentage of difficulty at the checking and evaluating stage is 90.15% with a very high category. Based on the results of the interview, the cause of the difficulties experienced was not doing the four stages of Heller's problem-solving. The difficulty of checking and evaluating occurs because students are in a hurry when solving questions, forgetting, and not being careful when checking the completeness of answers. According to Pratama et al (2017), there are difficulties at the checking and evaluating stages because students are less careful when checking the completeness of answers, such as marks, units, and values.

CONCLUSION AND SUGGESTION

Based on data analysis and discussion, it can be concluded that 88.51% of students have difficulty

solving harmonic vibrations. The average difficulty at the stage of visualizing the problem is 91.66%, physics description is 81.58%, solution plan is 89.39%, executing the plan is 89.77%, and checking and evaluating is 90.15%.

The factors causing the difficulties experienced by students are difficulty in visualizing the problem because students do not understand the problem, and the lack of habituation to turn the problem in the problem into an image. The difficulty of physics description is due to a lack of understanding in understanding the problem. Difficulty in planning a solution is due to a lack of understanding of the concept. Difficulty in carrying out the plan is due to errors in the physics description stage, solution plan, not knowing the concepts used, and lack of mastery in arithmetic operations. Difficulties in checking and evaluating are caused by students being in a hurry and not being thorough in completing and checking answers.

The research results obtained will useful, as an alternative reference for teachers in diagnosing and analyze the difficulties experienced by students in solve HOTS questions, as well as consideration for next step.

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