**Jurnal Pendidikan Fisika**
Volume 13 Nomor 2 December (2024), pages 122-129
ISSN: 2301-7651 (Online) 2252-732X (Print)
DOI : 10.24114/jpf.v13i2.58926

# STUDENT'S HIGHER ORDER THINKING SKILLS AS TRANSFER IN HIGH SCHOOL PHYSICS

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Submitted: 02 June 2024, Revisied: 01 August 2024, Accepted: 08 November 2024

**Abstract.** The purpose of this study is to examine high school students' higher order thinking skills (HOTS) in relation to the transfer aspect in order to give a general picture of how far the transfer aspect has come, at least since it was included in the Indonesian 2013 curriculum. Five questions on linear motion from the Physics subject make up the HOTS oriented research instrument. The research instrument used is a HOTS-oriented test consisting of 5 questions on linear motion from the Physics subject. The results stated that 47% of students succeeded in transferring from C1 to C4 and factual to metacognitive in question number 1. Then there were 10% of students who succeeded in transferring from C1 to C4 and factual to metacognitive in question number 2. Unfortunately, none of the students succeeded in answering questions number 3 (C4), number 4 (C5) and number 5 (C6) correctly. Students' failure to transfer their cognitive and knowledge is divided into several factors, namely lack of factual knowledge, lack of conceptual knowledge, lack of mathematical ability, not being used to using units in problem solving and not being familiar to HOTS questions.

***Keywords:*** *Transfer, Higher Order Thinking Skills, Cognitive Process Dimension, Knowledge Dimension.*

## INTRODUCTION

The Indonesian government expects students to meet significant learning goals through the 2013 curriculum (K13). Students should be able to respond to the difficulties of the 21st century and be prepared to compete globally, which emphasizes literacy, character education, 21st century skills, and higher order thinking (Ariyana et al., 2018; Eliyana et al., 2019; Krisna et al., 2020; Liana et al., 2020; Panjaitan et al., 2020). There are three aspects of higher order thinking skills (HOTS) in guidebook published by the Indonesian Ministry of Education and Culture (Kemendikbud) namely transfer of knowledge, critical and creative thinking, and problem solving (Ariyana et al., 2018; Hartini & Martin, 2020; Panggabean et al., 2022). Of these three aspects, transfer of knowledge is a keyword that seems new compared to the other two, the term transfer of knowledge is more often used in the fields of business economics, management, humanities, and information systems, each of which even has a different meaning (Bender & Fish, 2000; Huber, 2001; von Malmborg, 2004). Meanwhile, articles in educational journals more often use the keyword "transfer" in the title and content of the article.

Transfer itself is one of the most important educational goals. Transfer, to put it simply, is the capacity to apply information from one context to another. Since applying transfer will require elements from each category of prior cognitive processes dimensions to some extent, students who are able to do so already possess a higher order thinking skill. Then in each cognitive process, there is a series of processes called knowledge dimensions (Anderson et al., 2001; Brookhart, 2010; Hergenhahn et al., 2000; Martaida et al., 2018; Panjaitan et al., 2020; Tanjung & Bakar, 2019).

Similar to the cognitive process dimension, transfer also happens in the knowledge dimension. Conceptual knowledge can be transferred from factual knowledge, which forms the basis of learning focused on higher order thinking (Brown et al., 2014). Conceptual knowledge can assist students in applying their knowledge to new concept (National Research Council, 2000), so the relationship of concepts put together to respond or solve a problem is what is called procedural knowledge. Then, using multiple procedural knowledge sets to solve an issue is referred to as metacognitive knowledge, and the more procedural knowledge used, the higher the level of metacognitive knowledge (Abdullah, 2018). Therefore, transfer in the context of HOTS refers to students' ability to transfer their abilities from lower order thinking problems to higher order thinking problems. Despite the fact that transfer is valued highly and stated in their HOTS guidebook, observations indicate that there is currently a lack of research on transfer in the context of education. Similarly, a survey conducted among a several numbers of teachers and post-graduates revealed that many appeared to misinterpret transfer as the act of sharing knowledge to others.

Prior studies on the HOTS as transfer have found an increase, but no empirical evidence can be found to describe the structure of this transfer or how it happens within the context of HOTS. What makes these articles interesting is that they don't contain a single definition or explanation of what transfer is (Abidah et al., 2020; Kurniawan et al., 2017; Purnama & Surya, 2018). However, not only talking about Indonesia, previous research on an international scale has mentioned the large number of studies that examine transfers, but the solution to whether transfers occur has made little progress (Barnett & Ceci, 2002), and the current research that discusses transfer is not related to HOTS (Gjerde et al., 2020; Whitcomb et al., 2021; Zu et al., 2019).

In considering the above description, we aim to investigate HOTS as transfer in order to gain insight into its accomplishments at least since its introduction in the Indonesian 2013 curriculum, and the process of transfer in order to identify potential issues with students' transfer abilities at the high school level, particularly in the area of physics learning, and to better understand the urgency of transfer in achieving higher order thinking skills. Therefore, the research question is what are the students' higher order thinking skills in the transfer aspect, especially in Physics subjects? It is hoped that this research can be used as a first step to find out the importance of higher order thinking skills as transfer in physics learning.

## METHOD

This research uses a descriptive qualitative method which aims to describe the students' HOTS as transfer, especially in high school physics subjects. The research was conducted in the odd semester of the 2022/2023 academic year, participants were selected using a purposeful sampling technique (John. W. Creswell, 2015). The participants in this research were 46 students from class XI and class XII who had studied Physics linear motion. Participants came from four schools in Palu City which were selected based on Indonesian school accreditation, namely very good (A), good (B), fair (C), and not accredited (TT). Details of participants from each school can be seen in Table 1.

Table 1. Details of Participants from Each School

| No. | Accreditation | Number of participants |
|---|---|---|
| 1. | A | 25 |
| 2. | B | 12 |
| 3. | C | 7 |
| 4. | TT | 2 |

The fact that the schools used for the research were private owned had an impact on the wide range of participant counts. Private schools typically have fewer students than government schools, which nearly always have the maximum number of students in each class. The selection of private schools was based on their accreditation diversity as opposed to public schools, which are all accredited "A". To ensure a good mix and depth of data, the author made an effort to collect data from schools with varying accreditation. The test blueprint is displayed in Table 2 as the data was gathered from participant test results. The instrument is available at the link in the reference (Instrument, n.d.). Later on, the exam results will be used as one of the criteria to choose a number of participants who will take part in the research as respondents. We conducted interviews with individuals who were chosen as respondents in order to delve deeper into the data collected. At least, three factors are used to identify the respondents: the test results, the questions they answered, and the accreditation of their school from.

Table 2. Test Blueprint

| Question number | Cognitive Level | Topics | Knowledge dimension |
|---|---|---|---|
| 1 | C4 | Uniform | Metacognitive |
| 2 | C4 | motion | Metacognitive |
| 3 | C4 | & | Metacognitive |
| 4 | C5 | non-uniform | Metacognitive |
| 5 | C6 | motion | Metacognitive |

To make it easier to understand, how to determine respondents based on the school accreditation category and the number of questions taken can be seen in table 3. Then the criteria for categorizing test result can be seen in table 4. It should be noted in table 2, the number of respondents selected does not necessarily correspond to the total number of question numbers plus accreditation, some respondents will include several question items to suit the situation and circumstances. Therefore, the selected respondents in this study were 9 people with respondent codes as in table 4.

Table 3. Rubric of Respondent Criteria

| Accreditation | Question number | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| A | 1 | 1 | 1 | 1 | 1 |
| B | 1 | 1 | 1 | 1 | 1 |
| C | 1 | 1 | 1 | 1 | 1 |
| TT | 1 | 1 | 1 | 1 | 1 |

Table 4. Rubric of Answer Categorization (Handayani, 2021)

| Category | Criteria |
|---|---|
| Correct | • Demonstrates problem solving with complete stages<br>• Fulfill all question requests |
| Incorrect | • Demonstrates poor problem-solving skills<br>• Not fulfilling question requests |
| Didn't answer | • Did not answer the question |

Table 5. Respondent Code

| No. | School Accreditation | Code |
|---|---|---|
| 1 | A | A07 |
| 2 | A | A11 |
| 3 | B | B07 |
| 4 | B | B09 |
| 5 | B | B11 |
| 6 | C | C06 |
| 7 | C | C07 |
| 8 | T | T01 |
| 9 | T | T02 |

To accommodate the maximum number of participants that the TT school could provide for this research (2 students), only two respondents per school were chosen. Still, three respondents intentionally selected B-accredited school because B09 offered information that other participants from other schools could not. This makes respondent B09's knowledge extremely valuable, although B09 is unable to supply the information that other respondents can, thus the best course of action is to include B09 without eliminating or substituting the previously chosen respondents in order for them to complement one another.

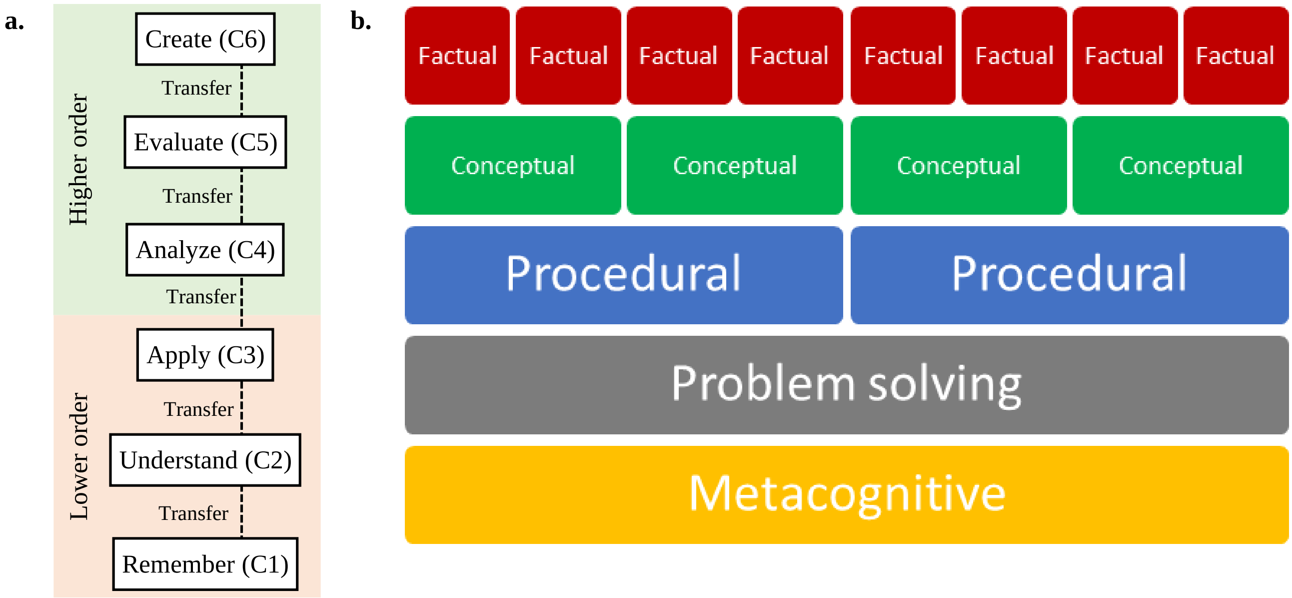


Figure 1. a. Transfer Framework on Cognitive Process Dimensions by Anderson & Krathwohl
b. Transfer Framework on Knowledge Dimensions by Abdullah

The research data were analyzed in accordance with the transfer of cognitive process dimensions in the revised Bloom's taxonomy whose framework is shown in Figure 1.a (Anderson et al., 2001). Where, transfer in the case of higher order thinking means that students are able to use their knowledge originating from lower thinking to be used in higher thinking problems or from lower level to higher level but not necessarily in accordance with existing order in taxonomy. The cognitive process dimension also has a series of complex processes called the knowledge dimension whose transfer framework is modeled in Figure 1.b, adapted from (Abdullah, 2018). He explains metacognitive knowledge as the use of various dimensions of procedural knowledge (including conceptual and factual) in solving problems, especially those related to problems in everyday life. The more procedural knowledge used in solving problems, the higher the level of metacognitive knowledge.

To make it easier to understand the transfer that occurs in student worksheets, each respondent's work will be given a color or label related to the cognitive process dimension and knowledge dimension (Table 6). Because the knowledge dimension is a process that occurs in each dimension of the cognitive process, the color given to the label C1/C2/C3/C4/C5/C6 for the cognitive process dimensions will match the color of the label for the knowledge dimension.

Table 6. Transfer Analysis Label on Respondent's Worksheet

| Label | Description |
|---|---|
| Red | Factual |
| Green | Conceptual |
| Blue | Procedural |
| Yellow | Metacognitive |

## RESULTS AND DISCUSSION

Since the 2013 curriculum, Indonesian government has either introduced or at least emphasized the need for students to acquire higher order thinking skills in order to meet the challenges of the 21st century skills and be competitive on a global scale (Afifah & Retnawati, 2019; Ariyana et al., 2018; Krisna et al., 2020). Nevertheless, unsatisfactory findings were obtained from a study with 46 participants who responded to five questions focused on HOTS.

The results showed that most participants did not successfully complete all the questions on the HOTS based test (see Figure 2). Even if we refer to participants from schools with A accreditation, only 40% of them were able to answer 2 questions correctly (red bar) and had the highest number of correct questions. Meanwhile, other schools that have accreditation below A are only able to answer 1 question correctly. There are participants from every school who receive a score of 0 or are unable to correctly answer even one question. It can be seen that 16% of participants from school A were unable to correctly answer any question. School B (purple bar) had a percentage of 8.33%, school C (orange bar) had a percentage of 85.71%, and participants from the TT school (brown bar) had a percentage of 100% on a score of 0—that is, 100% of the participants' answers were incorrect. This is not something that is surprising considering previous research which states that the quality of schools plays a significant role in students' abilities or achievements (Amri et al., 2022; Asrijanty, 2019).

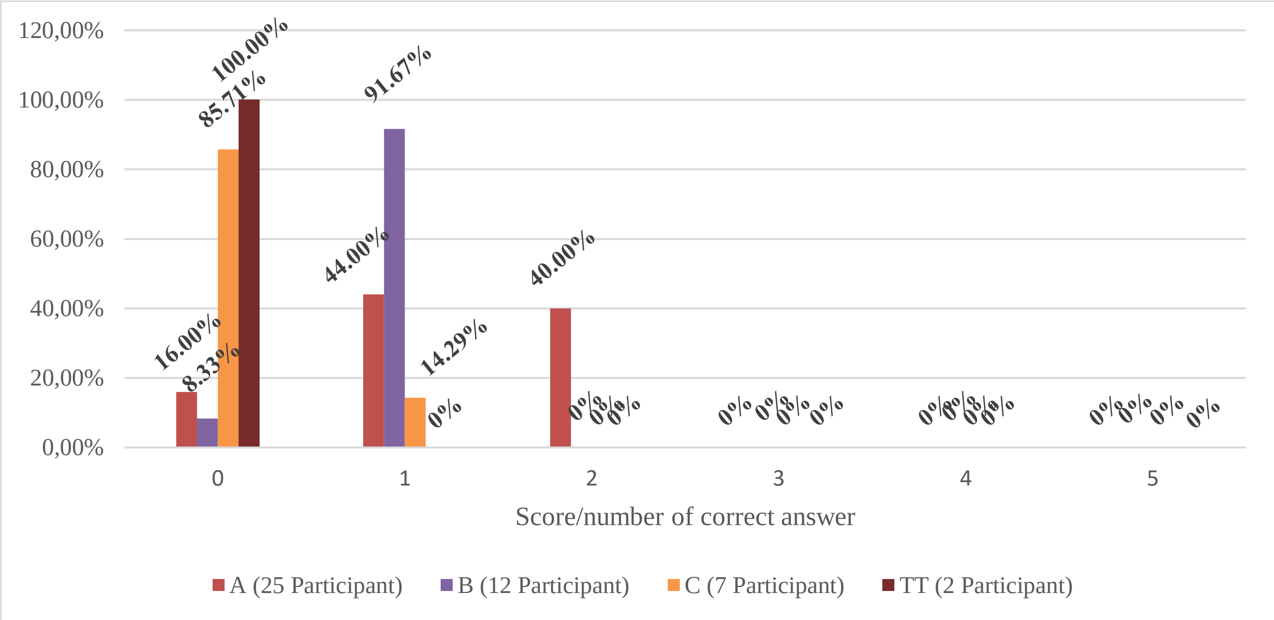


Figure 2. Percentage of Participant Scores for Each School Accreditation

According to (Barnett & Ceci, 2002), it is simple to determine whether a transfer occurred successfully if it is measured based on the near or far of the transfer, however the focus of this research is on whether the transfer occurs in problems that are geared toward higher order thinking. Regretfully, only two questions were answered correctly by participants, 47% of them answered question number 1 correctly, and 10% answered question number 2. Starting from question number 3 to question number 5, there were no more participants who could answer the question correctly or 0%. Thus, the transfer aspect of higher order thinking skills can only be analyzed through question number 1 and question number 2, while the other questions are analyzed to find factors or causes of participants' failure in solving the HOTS based question from the transfer aspect.

***Analysis of HOTS as Transfer***

The question number 1 refers to linear motion at level C4 which needs to be completed with HOTS, being able to analyze the linear motion events that occur in the problem, including applying the uniform motion equation and the non-uniform motion equation to be able to answer the question. Respondents from schools with A accreditation (A11), as shown in Figure 3, were able to answer the questions well. A11 first uses the uniform motion equation to determine the time t required for the car to stop after braking, then substitutes t into the 2nd non-uniform motion equation to answer the question. In order to solve the problem, A11 first changes the v value from 7200 km/h to 20 m/s. These kinds of abilities make up C3 procedural knowledge. He said that he was accustomed to solving the problem by directly substituting the known variables into it rather than writing down the known variables first.

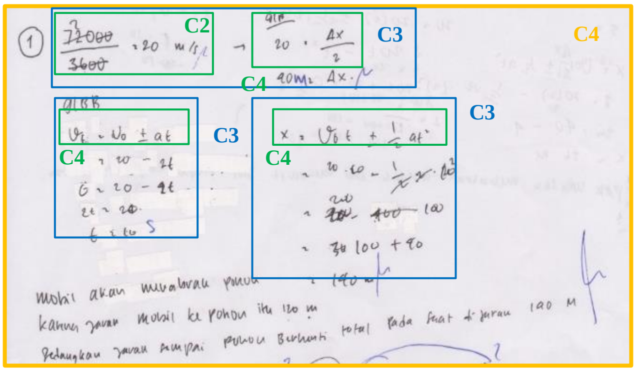


Figure 3. A11's Answer for Question Number 1

This explains why he skipped over all of the known variables on his answer sheet and instead done the conversion right away. After writing down the equation (green label), he continues with the first step, doing the calculation of the car's distance before braking by substituting the values into the uniform motion equation (blue label). Then proceed on to other equations till he is able to answer the question in the final step (metacognitive-yellow label).

Another example of a respondent who also answered question number 1 correctly is B07. He approaches A11 differently because, as shown in Figure 4, he uses the uniform motion equation to calculate the car's distance before braking and then substitutes the result into the non-uniform motion equation. B07 provided a more cogent response in accordance with the methods typically taught in schools. These methods begin with listing all known variables that are essential to the question (red label), followed by a relevant equation that uses the known variables to determine how far the car will travel before braking (green label), and lastly, the substitution of current values into the equation that needs to be solved mathematically (blue labels). when one eventually managed to respond to the question; this is known as metacognitive (yellow label).

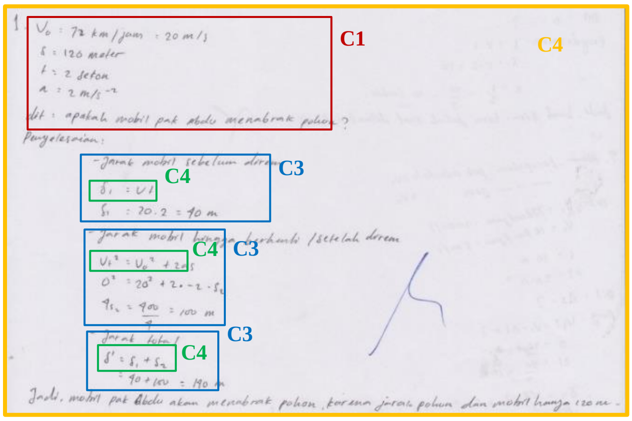


Figure 4. B07's Answer for Question Number 1

Next is question number 2, which is also at level C4 and requires higher order thinking skills to solve. Students must combine the uniform motion and non-uniform motion equations as part of the solution technique in order to answer the question. The respondent from school A (A07) answered the question correctly by comparing uniform motion and non-uniform motion equations to find the time t until the motorbike was overtaken, then substituting the t into the uniform equation to find the distance between the two intersections, see Figure 5. Although it can be seen that he did not separate the v variables from the rider and the police, Respondent A07 based on interviews knows about the uniform and non-uniform motion incidents in the question.

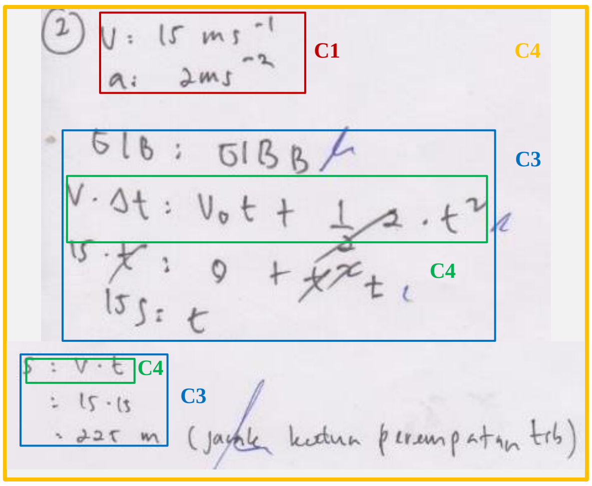


Figure 5. A07's Answer for Question Number 2

A07 writes down all the variables that are known and asked about in the problem (red label), writes the equation (green label), and then substitutes the values to determine the t value (blue label) in the equation. Then he continued looking value of distance s to answer what was asked in the question (blue label). This question also involves high level metacognition because more than one procedure is needed to solve the problem (yellow label).

***Causes of student failure to apply HOTS as transfer***

As previously said, no student was able to answer questions number 3, 4, or 5, meaning that there was a 100% failure rate for these questions. But this does not imply that student failure was limited to those three questions, students also failure in questions 1 and 2, with 53% of students failing question number 1 and 90% of students failing question number 2. Therefore, unlike before which explained how students answered each question number, this time the discussion was based on students' failure to answer HOTS questions.

Students' lack of factual knowledge which is the foundation for higher order thinking skills (Brown et al., 2014) is one of the factors in students' failure in solving problems. In this case, students were unable to simply identify the variables in the question. For example, respondent T02 in question number 3 (Figure 6), he did not write down the known variables in the question and immediately wrote an equation which was actually wrong. T02 failed to analyze the known variables in the question, which resulted in their failure to find the right answer to the question given. This factor has been discussed in (Jua et al., 2018), which states that if students fail to identify the variables involved, then students will fail in solving problems.

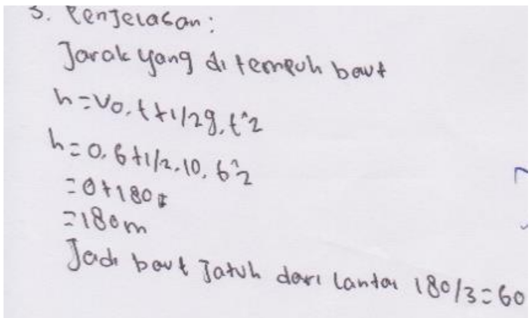

Figure 6. T02's Answer for Question Number 6

This lack of factual knowledge also has an impact on conceptual knowledge. Lack of conceptual understanding will make it difficult for students to apply their understanding to solve problems with high-level skills (Sari et al., 2022). Students cannot identify the uniform and non-uniform events that occur in the question. There are also many students who cannot even analyze the existence of two different subjects in problems that must be considered and solved with their respective equations of motion. They assume that every known variable in the problem comes from the same subject, so they use every variable in the problem in the same equation. Such understanding makes them confused when they find that there are two variables that are the same in one question. Problems like this indicate their weak conceptual knowledge, especially regarding the topic of linear motion. B11 wrote the variable v without separating or labeling different subjects (rider and police). It can be seen at Figure 7 that when he wrote the equation, he only used the GLBB equation. In fact, problem number 2 should be solved by combining the uniform and non-uniform motion equations as explained previously.

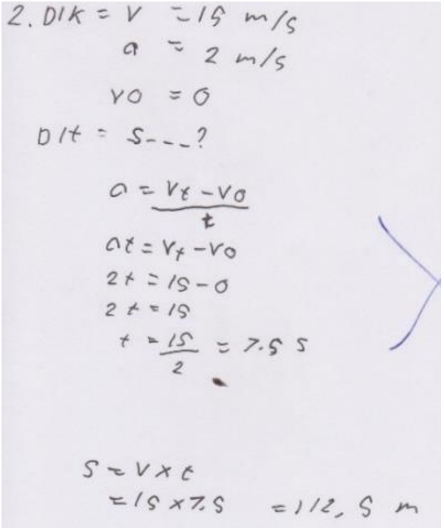

Figure 7. B11's Answer for Question Number 7

Lack of conceptual knowledge will have an impact on the difficulty of achieving procedural knowledge when referring to the transfer framework in the knowledge dimension (Abdullah, 2018), however, the analysis's findings revealed that students' poor mathematics abilities were the main reason behind their inability to deal with HOTS based test . It's true that a number of studies have indicated that mathematics is essential to the solution of many physics-related issues (Haryadi, 2016; Nurmaulida et al., 2018; Palmgren & Rasa, 2022).

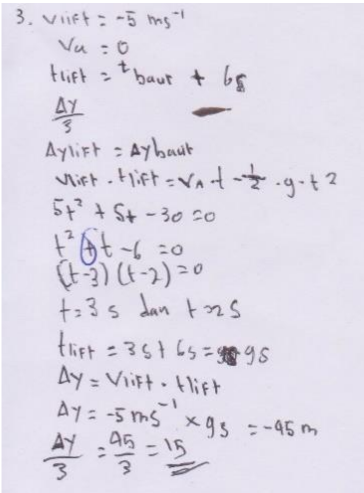

Figure 8. C06's Answer for Question Number 3

Lack of Mathematics skills will have an impact on the solving steps which usually occur in the procedural knowledge dimension. Some basic mathematical skills needed to be able to solve the 5 questions used in this research include substitution, Cartesian coordinates, and algebra. For example, respondent C06 as seen in Figure 8 tried to solve question number 3 did not seem to have mastered quadratic equations well. Not only did certain values arise out of nowhere, but he also employed positive and negative signs incorrectly. With quadratic equations, this is a serious mistake. The importance of mathematical skills for solving Physics problems has been discussed in recent study which states that transferring Mathematics knowledge can improve students' Physics problem solving abilities (Djudin, 2023; Ekasari et al., 2023; Siombone & Niwele, 2023).

Then there is an essential factor in Physics but which is now often ignored in solving Physics problems, namely the use of units. It can be seen in the students' answer sheets that they do not really involve units in any physics problem solving procedures because this makes them confused. Of course, ignoring writing units can save time in taking tests, but researchers assume that the problems with basic mathematics might be resolved if when solving physics questions students pay more attention to the use of units. Although this requires further scientific study, units play an important role in solving Physics problems because they help ensure that the answers obtained are dimensionally consistent. Not without basis, this analysis refers to the article (Sanny et al., 2016) which discusses how to solve physics problems, where the first thing to pay attention to is to always check the units. They explain that if the unit in the answer is wrong, it is necessary to repeat the solution procedure again. When creating the test instruments used in this research, units are also very helpful for researchers to stay on the right track.

Apart from the factors previously explained, the researchers discovered another one students' inability to respond correctly to complex questions was mostly caused by their lack of experience with similar level of problem. Particularly when talking about creation or C6, the highest level in Bloom's taxonomy, whose approach to solving it differs from that of the levels below. For example, the solution approach that researchers use in this research for questions at level C6 is that students must come up with their own solution method for problems at level C6, starting from the variables involved, their values, the equations to be used, and ending with the solution process.

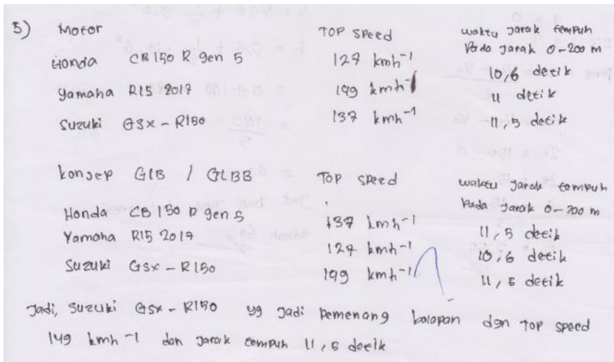

Figure 9. B09's Answer for Question Number 5

Respondent B09, as seen in Figure 9, tried to answer this C6 question by simply modifying the order of data in the table presented in the question. So instead of being categorized as "creating" for C6, he only does "deconstruction" (C4). Time was the reason he was not successful in solving the problem, but when challenged if he was given enough time to do it, he denied being able to solve it. This familiarize factor has been discussed in previous study by (Agarwal, 2019), who state that one way to improve higher order thinking skills is to familiarize students with high-level problems, and the best results will be obtained if learning is given in a mixture of low-level and high-level learning.

## CONCLUSION

Since the time when higher order thinking skills became a concern in the Indonesian 2013 curriculum (K13), various efforts have been made so that students have these skills. However, transfer, which is one aspect of achieving higher order thinking skills, is not given much attention. Based on the research results, 47% of students succeeded in transferring their abilities from C1 to C4 and factual to metacognitive in question number 1. Then there were 10% of students who succeeded to transferring in question number 2. Unfortunately, in question number 3 (C4), number 4 (C5) and number 5 (C6) none of the students managed to answer correctly. Researchers divide the causes of students' failure to transfer their cognitive and knowledge to solve problems oriented towards higher order thinking skills into several factors including (1) lack of factual knowledge; (2) lack of conceptual knowledge; (3) lack of mathematical skills; (4) not used to using units in solving Physics problem; and (5) unfamiliar with HOTS.

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