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The Analysis of Students' Computational Thinking Skills Through The Implementation of GeoGebra Integrated Student Worksheets on Motion

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Abstract

Computational thinking skills can help students in solving problems. Teaching materials such as student worksheets are still limited to textbooks. Physics learning can use GeoGebra to help visualise phenomena. This study aims to analyse the computational thinking ability of students through the implementation of GeoGebra integrated student worksheets on motion material on indicators of abstraction, decomposition, algorithm thinking, and generalisation. This type of research is a combination of quantitative and qualitative. Quantitative data analysis uses formula calculations to assess student worksheets. Meanwhile, qualitative data analysis uses an interactive approach by Miles and Huberman. The results showed that the students' computational thinking ability on the abstraction indicator of as many as 25 people, decomposition on as many as 20 people, and algorithmic thinking on as many as 25 people are classified as very good. This is indicated by students being able to determine important information, identify problems to be simpler, and explain steps systematically. In the generalisation indicator, students' average computational thinking ability is in a good category. In short, most students in computational thinking skills on abstraction, decomposition, and algorithm thinking are classified as very good, while the generalisation indicator is classified as good.

Keywords: computational thinking; GeoGebra; student worksheets; straight motion changing direction

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INTRODUCTION

In the 21st century, advances in information and communication technology can change learning in schools, so teachers and students must be able to adjust to these changes. Currently, computer simulation media in learning physics can help visualise complex phenomena presented in tabular or graphic form (Asbanu, 2021; Kamil et al., 2021). All the skills a person needs to face the 21st century to succeed in life's challenges. Some skills that must be possessed in the 21st century are the 4C, namely creativity and innovation, critical thinking and problem-solving, communication, and collaboration

(Hidayatullah et al., 2021; Septikasari & Frasandy, 2018).

Computational thinking skills can be used for problem-solving. One of the abilities that must be possessed in technological development is the ability to think computationally (Cahdriyana & Richardo, 2020; Candraningtyas & Khusna, 2023). In the 21st century, computational thinking can guide one's life when facing challenges. Computational thinking skills are basic abilities that involve various fields, including education, to solve problems and understand basic computer science concepts (Afifah et al., 2023; Handayani et al., 2022). Computational thinking has four skills: abstraction, decomposition, algorithmic thinking, and generalisation. Computational thinking skills can help students get used to analysing, structuring, and making decisions with logical reasoning (Simanjuntak et al., 2023; Veronica et al., 2022). Computational thinking skills can be used to solve logic equations well. Computational thinking can be trained when students do classroom learning, such as project-oriented learning (Nurasiah et al., 2023; Yuntawati et al., 2021). In physics learning, computational thinking can be done by using simulations that help visualise physical phenomena. Problem-solving using the concept of computational thinking in everyday life can improve students' learning ability (Rich et al., 2019; Zulfa & Andriyani, 2023). The results of interviews that researchers conducted with high school teachers in one of the schools in Jember Regency showed that students never make motion simulations when learning physics. Physics learning in the school also never taught computational thinking to students, so it still needs attention.

Limited teaching materials can lead to problems in education. Using students worksheets can help achieve learning objectives (Ariani & Meutiawati, 2020; Hamidah et al., 2018). Based on the results of preliminary research conducted by researchers in one of the high schools in Jember, which obtained the results of interviews with physics teachers, the use of teaching materials for students' worksheets is still limited to the package book. Teaching materials like student worksheets can be used to improve computational thinking. Student worksheets summarise the material, systematic steps, and questions for student development exercises (Jamalludin et al., 2022; Munawaroh et al., 2022). Student worksheets can be used in physics learning. Student worksheets can be used in physics learning to help students understand physics concepts and, problem-solving guidelines make it easier for teachers to explain. The use of student worksheets gives good responses in learning (Mahyuny et al., 2022; Munawaroh et al., 2022; Setiani et al., 2021). Student Worksheets are teaching materials that can be used to help students understand the material and practice questions. Student worksheets can be used as a support to achieve student competencies easily. Students worksheets can make it easier for students to solve a problem. Student worksheet development can be done using GeoGebra technology (Finali et al., 2020; Novitasari et al., 2021; Supriyadi et al., 2021; Rahayu et al., 2021).

GeoGebra can be used as a computer-based interactive simulation media in physics learning. GeoGebra utilisation in physics learning can help teachers improve concept understanding, critical thinking, and procedural skills and reduce misconceptions in students (Arjana & Suastra, 2022; Nugroho, 2022). In physics learning, GeoGebra is proven effective for developing students' knowledge, logical reasoning, and communication. In physics learning, GeoGebra has not been widely researched (Asbanu, 2021; Solvang &

Haglund, 2021). Based on the results of interviews with high school teachers in one of the schools in Jember, it was found that they did not know GeoGebra and had never used it for physics learning. The advantages of GeoGebra are that it can make it easier for students to solve problems, it can be used in various places, and it can be used on laptops, computers, and smartphones. GeoGebra can also help students visualise mathematics problems (Nuritha dan Tsurayya, 2021; Fatimah & Yerizon, 2019).

Physics learning in one school shows that many students still experience difficulties due to a lack of mastery of concepts, formulas, and calculations. One of the concepts of physics material that can be explained through practicum activities is motion material (Safitri et al., 2020; Supriyatna & Roza, 2021). Physics lessons can be presented using computer simulations to illustrate motion events. One of the sub-materials of motion in physics is straight motion changing direction. Students have difficulty in straight motion changing direction material in using formulas for calculations (Fatimah, 2023; Jerfi et al., 2022; Kereh et al., 2020). Object velocity analysis can be done through mathematical calculations using graphs to describe the object's motion in the material of straight motion changing direction. The ability to understand the graphical presentation of data needs to be emphasised to get the right information. The importance of students' understanding of graphs because many physics materials are related to the results of experiments that are presented using graphs such as in straight motion material (Fatimah, 2023; Musliha et al., 2020; Nurullaeli, 2020). Previous research conducted by Musliha et al. (2020) used an essay test instrument to determine students' ability to make kinematics graphs. Meanwhile, in this study, the process of making graphs was carried out by making motion simulations using GeoGebra in accordance with the steps contained in the student worksheet.

Based on the above problems about students' difficulties in understanding motion material, a study entitled " The analysis of students' computational thinking skills through the implementation of geogebra integrated student worksheets on motion material" is necessary.

METHOD

This type of research uses mixed methods, which combine quantitative and qualitative methods. This research method combines qualitative and qualitative strengths. The research design used is the concurrent embedded strategy model. The mixed methods method aims to overcome the weaknesses that exist in quantitative and qualitative approaches (Azhari et al., 2023; Hendrayadi et al., 2023; Sugiyono, 2020).

Quantitative data collection in this study is the student worksheet assessment of student work to analyse computational thinking skills. The assessment of the student worksheet uses a formula with values ranging from 0 to 100. The main quantitative data in this study are the results of student worksheet answers. The results of student answers on the student worksheets were corrected in accordance with the answer key. Then, each student's answer is given an assessment score to obtain the final score (Apertha et al., 2022).

Learners' final scores are grouped into several criteria. These criteria include: very good, good, less, and very less. Table 1 depicts the assessment criteria on student worksheets (Jamna et al., 2022).

Table 1 Student worksheets assessment criteria

Value	Criteria
$85 \leq n \leq 100$	Very good
$70 \leq n < 85$	Good
$55 \leq n < 70$	Less
$0 \leq n < 55$	Very Less

Qualitative data collection in this research includes structured interviews, observation sheets to observe student activities and learning implementation, and documentation. Data analysis qualitative in this study used an interactive approach proposed by Miles and Huberman. This interactive approach consists of four stages: data collection, data reduction, and data presentation (Rijali, 2018; Sugiono, 2019).

RESULT AND DISCUSSION

The student worksheets used have components: table of contents, instructions for use, concept map, learning objectives and indicators, how to download GeoGebra software, material summary, problems, practicum activities, questions, bibliography, and glossary. Figure 1 is a student worksheet integrated with GeoGebra:

Figure 1 GeoGebra integrated student worksheets

The main data of this research is the result of students' computational thinking ability, which is measured using four indicators: abstraction, decomposition, algorithm thinking, and generalisation. The computational thinking ability of students studied in this study using the results of student worksheets. Table 2 is the data of the recapitulation of computational thinking on student worksheets.

Table 2 Computational thinking indicator

Computational Thinking Indicator	Frequency			
	Very good	Good	Less	Very less
Abstraction	25	10	0	0
Decomposition	20	10	5	0
Algorithmic Thinking	25	5	5	0
Generalisation	20	5	10	0

This research analyses the ability of computational thinking on the material of Regularly Changing Straight Motion using student worksheets integrated with GeoGebra. In this study, the indicators of computational thinking are abstraction, decomposition, algorithmic thinking, and generalisation. The following is a more detailed explanation of each indicator of computational thinking ability:

Abstraction

The first indicator with most students getting a very good category is abstraction. The average score obtained was 93.75. Abstraction is the stage for students to find important information (Jamalludin et al., 2022). In this indicator, most students are classified as very good because they are able to determine important information in the problem, convert units from km/hour to m/s, and explain the advantages and disadvantages of simulation. This is in line with research conducted by Yuntawati et al. (2021) The results of the observation sheet assessment on the abstraction indicator showed that the respondents were able to solve problems on the abstraction indicator very well, so that the computational thinking ability could be seen. The results of the observation sheet assessment on the abstraction indicator show that most students are classified as very good when conducting group discussions. The problem presented in this study is about the application of Regularly Changing Straight Motion to cars. Based on this problem, students are asked to determine the important information contained in the problem in the form of data on initial speed, final speed, and time. In addition, students also calculate the unit conversion results.

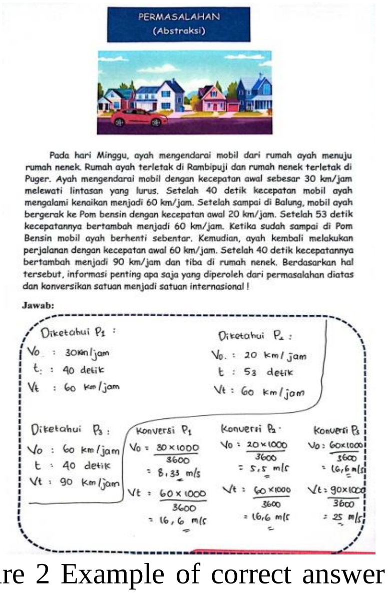

Figure 2 Example of correct answer for abstraction indicator

Figure 2 is an example of students' student worksheet answers in determining important information about the problem and the results of unit conversion calculations on the abstraction indicator:

Then, students can also explain the advantages and disadvantages of the simulation they have made. Students' answers about the advantages and disadvantages of the simulation varied. Rich et al. (2019) state that abstraction indicators can train students' computational thinking skills because they relate to analysing problems, finding solutions, and ignoring irrelevant information. The following is an example of a student's explanation during a group discussion that shows the abstraction indicator in explaining the advantages and disadvantages of simulation results:

> " The simulation can be a solution to the problem of being able to know the value of the car's mileage" (K7. NS_{13})

The 10 students in the good category were able to calculate the unit conversion correctly and explain the simulation's advantages and disadvantages. However, these students did not write down important information contained in the problem, which is data on initial speed, final speed, and time.

After determining important information, students are expected to understand the problems given. Computational thinking skills in abstraction indicators can make it easier for students to solve problems by focusing on important information (Veronica et al., 2022). Abstraction ability can also be used as a foundation for learning a physics concept (Handayani et al., 2022). So, abstraction is a fundamental first step to finding a solution to a problem by ignoring unnecessary information.

Decomposition

Decomposition is an indicator of computational thinking that is used to identify complex problems into simpler ones for easier resolution (Munawaroh et al., 2022). The average score obtained was 90.62. In this study, the majority of students, as many as 20 out of 35 people, were classified as very good. This is in line with the results of research conducted by Jamna et al. (2022), who obtained the results that students in the excellent category were able to fulfil the indicators of decomposition and pattern recognition. Students show excellent decomposition indicators because the questions about experimental variables, calculating acceleration values, and identifying the results of calculating the distance travelled manually and from simulations are answered correctly. Students answer correctly if they are able to explain the three experimental variables correctly, namely, independent variable, dependent variable, and control variable. Then, the acceleration value produced in the three stages of travel is the same, which is 0.2 m/s2. The identification results of manual and simulation calculations are equal to 493,2 m, 572,4 m, and 824 m. Figure 3 is an example of a correct answer on the decomposition indicator:

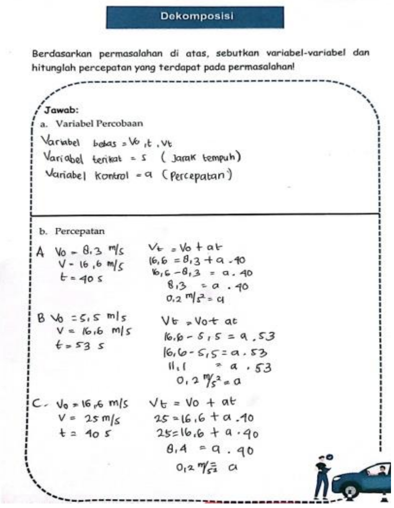

Figure 3 Example of correct answer on decomposition indicator

The results of discussions and interviews show that students are able to correctly mention answers about variables and calculations. As stated by Simanjuntak et al. (2023), the decomposition stage is classified as very good if students are able to identify problems into small parts that are better understood with the right solution. In the ten people who got the good category because the results of students' answers about the experimental variables had errors. However, students are able to calculate the acceleration value and identify the value of the distance travelled by manual calculation and simulation results. Then, in 5 people who get the less category because students are unable to identify in finding the value of distance manually or simulation results. This is because there are errors when doing mathematical calculations. Figure 4 shows the results of student worksheet answers in the decomposition indicator in the deficient category.

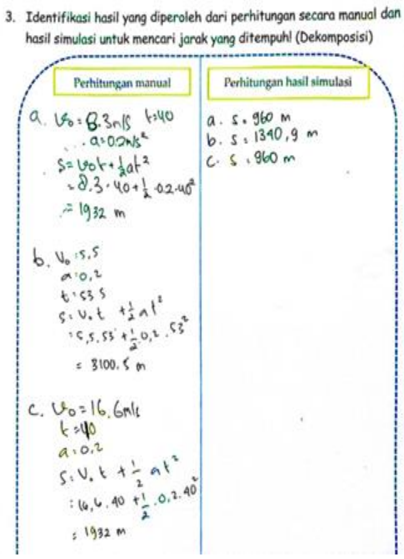

Figure 4 Students student worksheets answers in the less category

Figure 4 shows the results of students' student worksheet answers in the less category. Based on these answers, students have written the equation formula to find the value of the distance traveled correctly. However, the final results of manual and simulation calculations on these answers are wrong and classified as insufficient.

Algorithmic thinking

Algorithmic thinking is a way to organise steps in problem-solving (Cahdriyana & Richardo, 2020). The average score obtained was 87.5. Only 25 people get a very good category in the algorithm thinking stage. This is in line with research conducted by Simanjuntak et al. (2023), which shows that problem-solving respondents can carry out computational thinking processes, one of which is thinking algorithms. Algorithmic thinking indicators can be seen when students write data in tables, describe graphs from the results of experimental simulations, and make flowcharts correctly according to systematic steps. When making simulations of Regularly Changing Straight Motion, conducting trials, and making graphs are included in the algorithm thinking indicator. The ability to think algorithmically also appears from the beginning to the end when students solve problems (Cahdriyana & Richardo, 2020). Based on the interview results, students can also explain the steps in obtaining data in the table. The observation sheet results show that most students are classified as very good when conducting discussions in groups.

The results of students' answers in presenting data in the table are data on initial speed, acceleration, time, distance travelled, and final speed. The initial and final speed data are obtained from the unit conversion results. The acceleration value is obtained from the calculation results on each trip. Time data is obtained on important information in the problem. The distance traveled is obtained from simulations and manual calculations. Figure 5 presents the data in a table correctly.

Tabel 1 Data Hasil Percobaan GLBB

Kecepatan Awal (m/s)	Percepatan (m/s^2)	Waktu (s)	Jarak yang ditempuh (m)	Kecepatan Akhir (m/s)
8.3 m/s	0.2 m/s²	40 s	492 m	16.6 m/s
5,5 m/s		53 s	572,4 m	16,6 m/s
16,6 m/s		40 s	824 m	25 m/s

Figure 5 Correct data presentation

The five students who obtained the good category were able to present data in tables and draw graphs correctly. However, in making flowcharts, there are wrong steps and not systematic. Then, the five students who obtained the poor category in presenting the data had errors; there were wrong graph drawings, and the flowchart was correct. Figure 6 is an example of an answer to the algorithm thinking indicator in the less category.

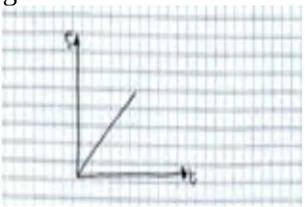

Figure 6 Example of an errored graph

Making simulations using GeoGebra requires the ability to think algorithmically because the steps are arranged sequentially. The process is carried out by discussion in groups. The graph of GeoGebra simulation results is shown in Figure 7.

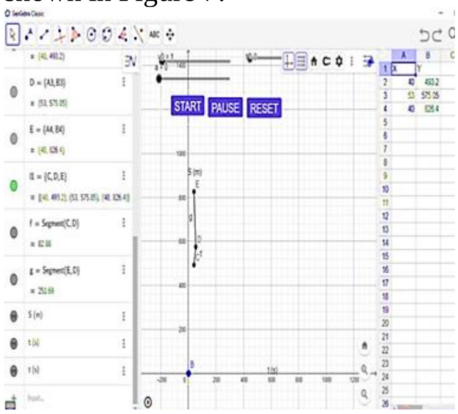

Figure 7 Graph of GeoGebra simulation results

Generalisation

Generalisation indicates computational thinking related to the ability to identify pattern similarities and make inferences (Rich et al., 2019). The average score obtained was 81.25. The results of the research that has been done show that as many as 20 out of 35 people are classified as very good. Students were able to explain the solution to the pattern equation and draw conclusions on the problem correctly. In addition, when students conduct activities to present the results of answers in groups, it is also included in the generalisation indicator. Based on the observer's assessment results, most groups received good scores. Students could explain the answers, explain the problem-solving steps, and convey the project's conclusions. Then, the results of the student worksheet answer students about pattern similarities and conclusions that vary. In this study, the average student in the generalisation indicator has a good ability. This is in line with research conducted by Kamil et al. (2021), which shows that students' ability to solve problems on generalisation indicators has answered the questions correctly, so they are classified as good. In the question about the pattern equation, students are able to answer that the acceleration generated on each trip is of a fixed value, the event is an example of straight motion changing direction, and there is data on initial speed, time, and final speed successively from the three trips.

Regarding the conclusion of the experiment results, each group has a varied answer. Students were able to explain the conclusions in the project work. The following is an example of an excerpt during the problem-solving discussion on the generalisation indicator:

> "In conclusion, this is about straight motion changing direction problems, and the value of can be known using the simulation, and then there is a relationship between distance and time" (Discussion_K3. AVA13)

Generalisation skills are important to apply in learning. This is because generalisation ability can be used in appropriate problems in the future by determining the pattern equation (Yuntawati et al., 2021). Generalisation indicators can be determined by identifying learning activities and experimental results. Here is figure 8 of an example of a conclusion answer.

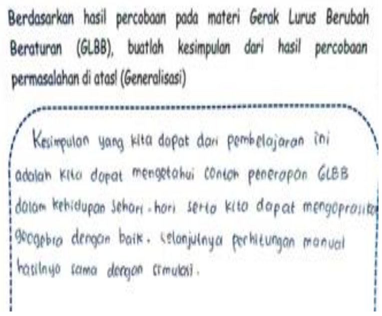

Figure 8 Example of conclusion with answer

In the 5 people who belonged to the good category, students were only able to mention three correct pattern equations and were able to conclude the results of the experiment. Then, 10 people were in the poor category because they could only mention one correct pattern equation and were able to make conclusions on the results of the experiment. Figure 9 is an example of the answers of students who are in the less category:

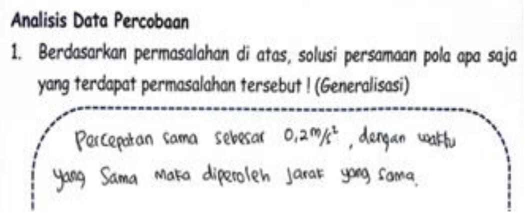

Figure 9 Student answers on the generalization indicator of the less category

Based on the explanation in Figure 9, the three indicators of students' computational thinking, abstraction, decomposition, and algorithm thinking, are included in the excellent category. The abstraction indicator is in the good category. In this study, students were able to perform a computational thinking process. In the discussion process, interviews, and student worksheets, it can be seen that students do computational thinking processes with stages according to computational thinking indicators. The process of computational thinking ability is the impact of using integrated student worksheets through GeoGebra. This is in line with research conducted by Manullang and Simanjuntak (2023), who showed that problem-based learning significantly affects students' computational thinking skills and gets a positive response when using GeoGebra.

CONCLUSION

Based on the research and discussion results above, students' computational thinking skills on the indicators of abstraction, decomposition, and algorithm thinking are in a very good category. Meanwhile, the generalisation indicator is included in the good category. This is because students are able to determine important information in the problem, identify the problem to be simpler, and explain the steps systematically. Generalisation ability also shows that students can determine the pattern equation of the problem, conclude the results of the experiment, and present the results. Student worksheets can be used as teaching materials for teachers and help students understand the material of regular straight-line motion. Further research needs to be conducted using a sample of more than one class to compare the treatment of control and experimental classes by implementing GeoGebra integrated student worksheets, and the motion material studied can be more extensive.

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