AIP Conference Proceedings

Preface: International Conference on Mathematics and Science Education (ICMScE 2021)

Cite as: AIP Conference Proceedings **2468**, 010001 (2022); https://doi.org/10.1063/12.0010336
Published Online: 29 December 2022

Preface: International Conference on Mathematics and Science Education (ICMScE 2021)

ICMScE is one of the conferences held by Universitas Pendidikan Indonesia. This year, ICMScE was conducted on 12 June 2021 with the theme "Sustainable-Thinking Competences Awareness toward Society 5.0 in the Light of COVID-19". This theme is considered to represent the needs of mathematics and science education in the present and beyond to meet a smart and sustainable society. Due to growing concerns about COVID-19, ICMScE 2021 cancelled its physical conference this year instead of shifting to a virtual conference. The ICMScE participants came from various universities in Indonesia and abroad; therefore, it became an opportunity for the participant to share knowledge, exchange ideas, and have the opportunity to collaborate.

This conference presents five Keynote Speakers: **Prof Charles Hopkins** from UNESCO Chair in reorienting teacher education towards sustainability, York University, Toronto, Canada; **Dr. Ida Kaniawati, M.Si**, from Universitas Pendidikan Indonesia; **Prof. Beno Csapo** from the University of Szeged, Szeged, Hungary; **Prof. Muammer Calik** from Trabzon University, Trabzon, Turkey and **Prof. Ts. Dr. Faaizah Binti Shahbodin** from University Teknikal Malaysia. In addition to the keynote, there were also invited speakers from Indonesia who contributed to ICMScE: **Prof. Dr. Nahadi, M.Pd., M.Si** (Chemistry Education), **Prof. Topik Hidayat, M.Si., Ph.D** (Biology Education), **Dr. Eko Hariyono, M.Pd** (Science Education), **Prof. Turmudi, M.Ed., M.Sc., Ph.D** (Mathematics Education) and **Prof. Dr. Wawan Setiawan, M.Kom** (Computer Education). A total of 531 participants participated in ICMScE 2021, 451 of whom were presenters. After reviewing and selecting 210 selected articles to be published to the present proceeding

The Editors,

Dr. Achmad Samsudin, M.Pd.
Dr. Lilik Hasanah, M.Si
Dr. Galuh Yuliani, M.Si.
Dr. Mimin Iryanti, M.Si.
Yohanes Freadyanus Kasi, S.Si., M.Pd.
Ari Syahidul Shidiq, M.Pd.
Lilit Rusyati, S.Pd., M.Pd.

International Conference on Mathematics and Science Education (ICMScE 2021)
AIP Conf. Proc. 2468, 010001-1–010001-1; https://doi.org/10.1063/12.0010336
Published by AIP Publishing. 978-0-7354-4288-7/$30.00

AIP Conference Proceedings

Students' ability in analysis and interpretation of data from physics investigation about motion kinematics

Cite as: AIP Conference Proceedings **2468**, 020013 (2022); https://doi.org/10.1063/5.0103041
Published Online: 29 December 2022

Suryadi, I. Ketut Mahardika, Sudarti, et al.

Students' Ability in Analysis and Interpretation of Data from Physics Investigation About Motion Kinematics

Suryadi[1, a)], I Ketut Mahardika[2, b)], Sudarti[2, c)], and Supeno[2, d)]

[1]*SMA Negeri Jenggawah, Jl. Tempurejo Jenggawah Kabupaten Jember, Jawa Timur, Indonesia*
[2]*Science Education Study Program, University of Jember, Jl. Kalimantan 37 Jember, Jawa Timur, Indonesia*

[a)]Corresponding author: zuryathee@gmail.com
[b)]ketut.fkip@unej.ac.id
[c)]sudarti.fkip@unej.ac.id
[d)]supeno.fkip@unej.ac.id

Abstract. Skills to analyze and interpret data from physics investigations are an essential aspect of learning physics. This research was conducted in four senior high schools in Jember district, East Java province, Indonesia. The selection of these schools is based on school accreditation and the standard of the teacher's physics learning process. The accreditation levels of the four schools have been accredited in the excellent category. Data analysis and interpretation is the process of solving the data that has been collected in the investigation activity and then synthesizing it into new knowledge. Students who have these skills will think analytically about hypothesizing activities, synthesizing, finding patterns, and connecting findings with problems. Teachers must know these skills to consider appropriate learning strategies so that student learning activities lead to these abilities. This study aimed to identify the power of high school students to analyze and interpret physics inquiry data on the topic of motion kinematics. The research data were obtained using a multiple-choice written test. The results showed that the students' ability to analyze and interpret the data was still unsatisfactory. Students must be involved in many investigative activities, collecting data, analyzing and interpreting data to formulate conclusions. Investigation-based physics learning activities are an alternative to develop these skills.

INTRODUCTION

Student involvement in the inquiry process is an essential part of learning physics activities. Students carry out scientific knowledge construction activities based on the results of the exploration of natural phenomena. When students explore natural phenomena through the inquiry process, one of the critical stages is analyzing and interpreting the data from the investigation results. Analysis and interpretation of data from the results of a physics investigation are the steps that students must take before they formulate a conclusion. Analysis and interpretation of data are determined quantity and describing the relationship between the data obtained to produce the calculation [1] and describing the reasoning process that links the data to the conclusion [2].

Data analysis and interpretation is the process of transforming data into scientific information or knowledge [3] [4]. The data analysis and interpretation process results can be used by students as evidence when they propose a scientific claim [5] [6]. Students must make predictions, describe boundaries, describe a particular model [7], and interpret the data that has been collected and synthesize new knowledge [8]. Another researcher [9] stated that the ability to analyze and interpret data includes: 1) the ability to transform data into standard forms such as tables, graphs, formulas; 2) determine the relationship between variables based on graphs, tables, text, and formulas; 3) determine the accuracy of the data; 4) comparing the investigation result data with the hypothesis; 5) describe the limitations of the investigation; 6) construct generalizations; 7) formulating new problems; and 8) draw conclusions.

The ability to analyze and interpret data can provide many benefits for students. Students who have good data analysis and interpretation skills will have the ability to think analytically about activities to hypothesize, synthesize,

International Conference on Mathematics and Science Education (ICMScE 2021)
AIP Conf. Proc. 2468, 020013-1–020013-6; https://doi.org/10.1063/5.0103041
Published by AIP Publishing. 978-0-7354-4288-7/$30.00

find patterns, and relate findings to problems [10] [11]. Students who actively participate in the inquiry process, including data analysis and interpretation activities, will develop their knowledge and understanding of scientific ideas [12]. Data analysis and interpretation activities will allow students to practice process skills, comprehensive skills, and reflection skills from a scientific investigation [13]. Through the inquiry process, students can develop the ability to analyze and interpret data so that it allows them to learn from various learning sources and develop critical thinking skills, laboratory activities, and research [14]. Students who can analyze have developed their thinking skills [15].

Although the ability to analyze and interpret data provides many benefits for students, the facts in the field show that students often experience difficulties. The results showed that some students still experienced problems analyzing and interpreting data, especially data obtained from investigating natural phenomena [16]-[18]. Students do not understand that data can be used as scientific evidence, and they do not believe that claims can be constructed based on data [2]. Students also still have difficulty analyzing the relationship between variables and interpreting data visualized in the graphical form [19]. Based on the results of data analysis and interpretation, students still have difficulty distinguishing between the results obtained from observations and conclusions [20] and difficulties in interpreting the results of observations [21], so that they have a problem in formulating decisions based on data analysis and interpretation [22]-[24]. In the learning process, teachers also have difficulty implementing learning in which there is an inquiry process, including activities to analyze and interpret data [25] [26].

In order to determine strategies and support systems for learning physics about motion kinematics, it is necessary to conduct a needs analysis so that learning can be carried out effectively and efficiently. One of the needs analyses that must be done is the identification of students' abilities in analyzing and interpreting data. Many natural phenomena about physics related to the kinematic material of motion can be described in the form of investigated data. The ability to analyze and interpret data from the investigation results is the main requirement for students so that they comprehensively master the physics material. By knowing students' initial abilities in analyzing and interpreting data, teachers can design effective and efficient learning strategies to facilitate students in learning physics, especially in developing the ability to analyze and interpret data as part of the inquiry process.

METHOD

This research was conducted in four senior high schools in Jember district, East Java province, Indonesia; SMAN 1 Jember, SMAN Arjasa, SMAN Sukowono, and SMAN Jenggawah. The selection of these schools is based on school accreditation and the standard of the teacher's physics learning process. The accreditation levels of the four schools have been accredited in the excellent category. Physics learning in the four schools has also followed the provisions set out in the curriculum process standards. Each school is represented by twelve respondents who have been selected based on ability level criteria in such a way as to represent low to high ability students.

Identification of the ability to analyze and interpret data from the results of physics investigations is carried out by providing an assessment tool to high school students who have received physics learning on motion kinematics material. The assessment was carried out using a written test in the form of multiple-choice questions. The assessment tool was developed by researchers concerning the aspects of the ability to analyze and interpret data [1] [2], namely:

a. Transforms data into graphs and formulas.
b. Determine the relationship between variables based on graphs and formulas.
c. Comparing the investigation result data with the hypothesis.
d. Construct generalizations from the results of the investigation.
e. Formulating new problems.

These aspects are distributed into 40 items. Before being applied in assessment to students, the questions are first validated by peers and experts in learning and physics assessment.

Data analysis was carried out quantitatively and qualitatively. Quantitative analysis is carried out by determining the central tendency based on the score of the assessment results. The quantitative analysis includes the achievement score, highest score, lowest score, total score, mean, standard deviation. Qualitative analysis is carried out by describing the relationship between the answers given by respondents with each aspect of the ability to analyze and interpret the data being assessed.

RESULT AND DISCUSSION

The ability to analyze and interpret data from the results of physics investigations was measured using a multiple-choice written test. Students answer each test item by choosing one of the answer options that match the question. The test result for each item is given a score of 1 for the correct answer and a score of 0 for the wrong answer. The total score obtained by each student is then converted to a scale value of 0-100. The data on analyzing and interpreting data for all students were then tabulated and analyzed using descriptive statistical analysis to determine the central tendency. The descriptive statistical analysis results in the number of respondents, the highest and lowest scores, mean, and the standard deviation is shown in Table 1. The ability to analyze and interpret data in each school is presented in Table 2.

TABLE 1. Data analysis and interpretation skills

Data	Analysis Results
Number of Respondents	48
The highest score	95
The lowest score	20
Average	57
Standard Deviation	16,60

The ability to analyze and interpret data in each school describes in Table 2.

TABLE 2. Ability to analyze and interpret data in each school

Data	Data Analysis and Interpretation Skills			
	SMAN 1 Jember	SMAN Arjasa	SMAN Sukowono	SMAN Jenggawah
Number of Respondents	12	12	12	12
The highest score	95	75	50	70
The lowest score	55	45	20	45
Average	76	59	38	56
Standard Deviation	12.08	10.03	9.37	7.33

Based on Table 1, it can be seen that the highest achievement value is 95, and the lowest achievement value is 20 with an average of 57. It can be generally concluded that the ability to analyze and interpret data from high school students' physics investigation is still in the unsatisfactory category. Students have difficulty transforming data into scientific information or knowledge. However, there are still students with high scores, reaching 95.

Based on Table 2, it can be seen that students' abilities in analyzing and interpreting data in each school are relatively the same in the low category, except in SMAN 1 Jember. In that school, the highest score reached 95, the lowest score of 55, and an average of 76. Based on these average scores, it can be concluded that students already have the ability to analyze and interpret data. The other three schools showed almost equal power. Even though the achievement of the highest score of students at SMAN 1 Jember was up to 95, the highest score achievement at SMAN Sukowono only reached 50.

Table 3, shown students ability to analyze and interpret data in each aspect.

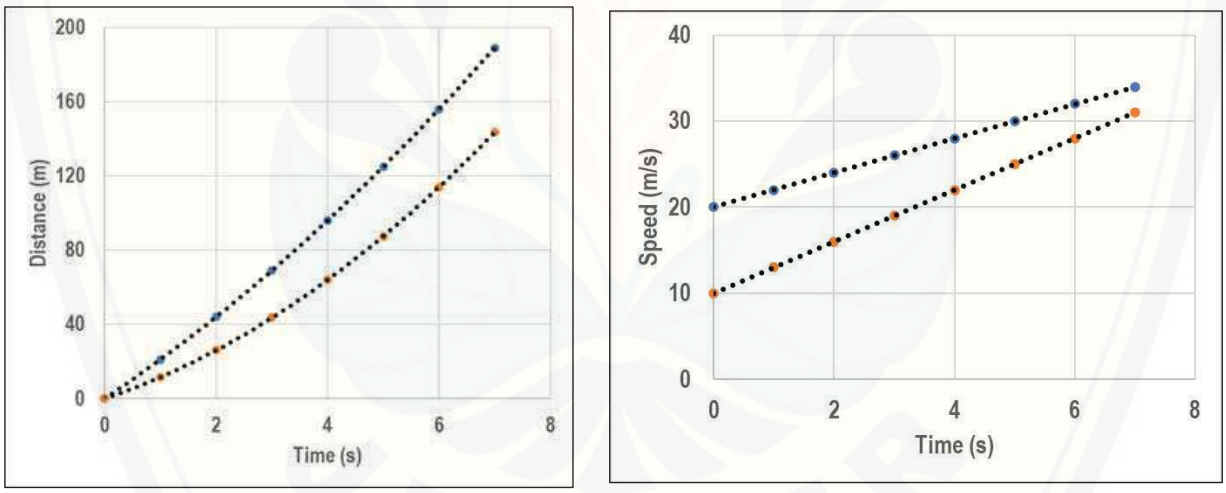
TABLE 3. Ability to analyze and interpret data in each aspect

Data	The ability of each aspect of data analysis and interpretation				
	Transform Data	Relationship Between Variables	Comparing Data with Hypotheses	Generalization Construction	New Problem Formula
Number of Respondents	48	48	48	48	48
The highest score	100	88	88	100	88
The lowest score	38	0	25	13	13
Average	69	53	60	59	46
Standard Deviation	17.67	18.90	16.76	19.63	20.30

Based on Table 3, it can be said that the ability of each aspect to analyze and interpret data is in the unsatisfactory category. The highest average is 69 in the data transformation aspect, and the lowest average is 46 in the element of formulating new problems. The ability to develop further issues reaches the lowest average. This shows that most students still do not have the ability to formulate a new problem based on the results of data analysis. Students' ability to construct generalizations is also in the unsatisfactory category. In general, it can be said that most students are still unable to formulate a general conclusion. The ability of students to compare data with hypotheses is still in the low category. Students are still not able to distinguish between the data from the results of the investigation and the predictions that have been formulated. Some students also have not been able to identify variables and describe the relationship between variables. The ability to transform data reaches the highest average, which is 69. However, this achievement is still in the unsatisfactory category. Students are still unable to convert data into other forms of representation, such as graphs or diagrams.

In general, the results showed that students were still not familiar with analyzing and interpreting data from physics investigations. The ability of students in every aspect is still in the low category. The results of this study are in line with previous studies, which show that students are often less able to analyze the relationship between variables [27]. The results of other studies indicate that students experience difficulties when faced with problems in which there is a graphical or diagrammatic representation [28].

One of the students' difficulties is analyzing and interpreting data on speed, distance, and travel time of two motorbikes crossing a downhill road. The two motors move with different initial speeds down a road that has a certain slope. The speed and mileage of the two motorbikes are getting faster with increasing travel time. the vehicle has a different initial speed then the data from the measurement results of speed, distance traveled, and travel time of the two motors are different. The graphical representation of the measurement data is shown in Fig. 1. Based on the data and graphs, students have difficulty determining: 1) which motor has the greater instantaneous speed, 2) which motor arrives first, 3) which motor has the greater acceleration. Students also have difficulty making a graphical representation of the motion of the third motor which has a greater speed than the previous two motors.



(a) (b)

FIGURE 1. The graphical representation of the physical phenomena of motorcycle motion

The low ability of students to analyze and interpret data from the results of physics investigations is a common challenge, both researchers and physics teachers. The author proposes physics learning, which involves many students in investigative activities and data processing, one of which is by doing a home experiment. Physical investigations can be designed to involve many natural phenomena that are close to students' lives. Students will be interested and easy to explore because the object under study is close to the student's world. Another alternative is to apply science process-oriented learning [10] by assisting, one of which is in the form of a worksheet [29] [30]. Students will get used to collecting data, processing data, and formulating generalizations with the scientific process. If students experience difficulties, they can be assisted with a worksheet that contains instructions for data collection to data processing and formulation of conclusions. Furthermore, multimedia also facilitate student to solve the problem during physics learning [31].

CONCLUSION

The results showed that the students' ability to analyze and interpret the data from the physics investigation was still in the unsatisfactory category. Although some students have good skills, students are still unable to transform data, identify relationships between variables, compare data with hypotheses, construct generalizations, and formulate new problems. Students are not used to doing activities both cognitively and physically by involving physics data while learning. Students are also not used to converting data into a graphical, image, or mathematical representations. To overcome the existing conditions, the teacher can try physics learning by involving scientific process activities based on natural conditions or phenomena. Students are interested in real physics phenomena to be interested in conducting in-depth exploration of these phenomena through data collection to generalization formulation.

REFERENCES

1. Y. Lou, P. Blanchard, and E. Kennedy, J. Geo. Edu. **63**, 73-85 (2015).
2. H. K. Wu, and C. L. Wu, Res. Sci. Edu. **41**, 319–340 (2011).
3. P. Vahey, L. Yarnall, C. Patton, D. Zalles, and K. Swan, "Mathematizing middle school: Results from a cross-disciplinary study of data literacy." in *Annual Meeting of the American Educational Research Association* (San Francisco, California, USA, 2006), pp.1-15.
4. M. Schield, *IASSIST Quarterly* **28**, 6-11 (2004).
5. J. S. Lederman, N. G. Lederman, S. A. Bartos, S. L. Bartels, A. A. Meyer, and R. S. Schwartz, J. Res. Sci. Teach. **51**, 65–83 (2014).
6. J. Lederman, N. Lederman, S. Bartels, J. Jimenez, M. Akubo, S. Aly, C. Bao, E. Blanquet, R. Blonder, M. B. S. Andrade, C. Buntting, M. Cakir, H.E Deghaidy, A. ElZorkani, E. Gaigher, S. Guo, A. Hakanen, S. H. Al-Lal, C. H. Tosunoglu, A. Hattingh, A. Hume, S. Irez, G. Kay, O.K. Dogan, K. Kremer, P.C. Kuo, J. Lavonen, S.F. Lin, C. Liu, E. Liu, S.Y Liu, Bin Lv, R.M Naaman, C. McDonald, I. Neumann, Y. Pan, E. Picholle, A. R García, C. J Rundgren, D. S Gómez, K. Saunders, R. Schwartz, F. Voitle, J. V. Gyllenpalm, F. Wei, J. WishartZ. W. H. Xiao, Y. Yalaki, and Q. Zhou, J. Res. Sci. Teach. **56**, 486-515 (2019).
7. M. Pedaste, and T. Sarapuu, Int. Lear. Env. **22**, 309-325 (2014).
8. M. Pedaste, M. Mäeots, L. A. S. T. de-jong, S. A. N. Riesen, E.T. Kamp, C.C. Manoli, Z.C. Zacharia, E. Tsourlidaki, Edu. Res. Rev. **14,** 47-61 (2015).
9. Z. Ješková, S. Lukáč, M. Hančová L` Šnajder, J. Guniš, B. Balogová, and M. Kireš, J. Balt. Sci. Edu., **15**, 559-574 (2016).
10. F. Anjani, Supeno, and Subiki, Lantanida Jurnal **8**, 13-28 (2020).
11. M. Pedaste, M. Mäeots, Ä. Leijen, and S. Sarapuu, Technol. Instr. Cogn. Learn. **9**, 81-95 (2012).
12. D. J. Ketelhut, B.C. Nelson, J. Clarke, and C. Dede, J. Edu. Tech. **41**, 56-68 (2010).
13. J. Wang, D. Guo, and M. Jou, Comput. Hum. **49**, 658-669 (2015).
14. M. G. Weaver, A. V. Samoshin, R.B. Lewis, and M.J. Gainer, J. Chem. Edu. **93**, 847–851 (2016).
15. S. Supeno, S. Astutik, A. D. Bektiarso, Lesmono, and L. Nuraini. "What can students show about higher order thinking skills in physics learning?" in *The First International Conference on Environmental Geography and Geography Education" (ICEGE)-2018*, IOP Conf. Ser.: Earth and Env. Sci. 243, edited by Sumardi (University of Jember, Indonesia 2019), pp. 1-11.
16. Z. Kanari, and R. Millar, J. Res. Sci. Teach. **41**, 748-769 (2004).
17. Supeno, S. Astutik, and A. D. Lesmono, "Pre-service science teachers' understanding of scientific method for studying local environmental issues." in *second International Conference on Environmental Geography and Geography Education" (ICEGE)-2019*, IOP Conf. Ser.: Earth and Env. Sci. 485, edited by Sumardi (University of Jember, Indonesia 2020), pp. 1-7.
18. Suryadi, I. K. Mahardika, Supeno, and Sudarti. "Data literacy of high school students on physics learning." in *the Second International Conference on Lesson Study of Science, Technology, Engineering, and Mathematics (ICOLSSTEM)-2020*, IOP series, J. Phys.: Conf. Ser. 1839, edited by Suratno (University of Jember, Indonesia 2021), pp. 1-7.
19. H. O. Kapici, H. Akcay, and T. de Jong, J. Sci. Edu. and Tech. **28**, 231-250 (2019).

20. D. Hanuscin, and M. Park-Rogers, Science and Children **45**, 56–57 (2008).
21. D. Peker, and C. S. Wallace, Res. Sci. Edu. **41**, 169–191 (2011).
22. L. Abrahams, and R. Millar, Inter. J. Sci. Edu. **30**, 1945–1969 (2008).
23. A. García-Carmona, A. M. Criado, and M. Cruz-Guzmán, Res. Sci. Edu. **47**, 989–1010 (2017).
24. C. V. Aufschnaiter, and C. Rogge, Eur. J. Math. Sci. Tech. Edu. **6**, 3-18 (2010).
25. J. Herranen, P. Kousa, E. Fooladi, and M. Aksela,. Int. J. Sci. Edu. **41**, 1977-1998 (2019).
26. E. A. Koksal, and G. Berberoglu, Int. J. Sci. Edu. **36**, 66-78 (2014).
27. M. Luedo, Supeno, and Maryani, Jurnal Penelitian Pendidikan Fisika, **6**, 132-136 (2021).
28. T. Z. Ucar, and N. E. Akdogan, Elementary Education Online. **8**, 391–400 (2009).
29. S. N. Indahsari, Supeno, and Maryani. "Student worksheet based on inquiry with vee map to improve students' scientific reasoning ability in physics learning in senior high school." in *The International Conference on Physics and Mathematics for Biological Science (ICOPAMBS)-2019*, IOP series, J. Phys.: Conf. Ser. 1465, edited by D. Wahyuni (University of Jember, Indonesia 2020), pp. 1-11.
30. T. R. D. Kusumawati, Supeno, and A. D. Lesmono, "Student worksheet based on inquiry with vee map to improve writing skills in physics learning." in *The International Conference on Physics and Mathematics for Biological Science-2019*, IOP series, J. Phys.: Conf. Ser. 1456, edited by L. Marlin (University of Jember, Indonesia 2020), pp. 1-11.
31. P. Siahaan, S. R. Hidayat, I. Kaniawati, D. T. Chandra, A. Samsudin, and E. Suhendi, J. Pengajaran MIPA (Online) **23**, 1-10 (2018).