INDONESIAN JOURNAL OF EDUCATIONAL RESEARCH AND REVIEW
Volume 6 Nomor 2 2023, pp 372-382
E-ISSN: 2621-8984; P-ISSN: 2621-4792
DOI: https://doi.org/10.23887/ijerr.v6i2.60367

Free Fall Motion Learning Design with Tracker Software to Improve Graphic Literacy

Nurfaizal[1], Khairil Anwar[2*], Zulkarnain[3]
[1,2,3] Physics Education Department, Universitas Muhammadiyah Mataram, Mataram, Indonesia
*Corresponding author: khairila593@gmail.com

Abstrak

Pembelajaran fisika merupakan pembelajaran berbasis keterampilan proses. Salah satu keterampilan proses sains yang harus dikuasai siswa adalah literasi grafis. Materi gerak jatuh bebas merupakan pelajaran yang menuntut siswa memiliki keterampilan literasi grafis, namun fakta di lapangan menunjukkan bahwa tidak sedikit siswa yang mengalami kesulitan dalam membaca dan mengelola informasi berbasis grafik. Penelitian ini bertujuan untuk menganalisis peningkatan literasi graf siswa yang dilakukan di SMA. Subyek penelitian adalah siswa, sampel penelitian berjumlah 21 siswa kelas X MIA. Menggunakan metode kuasi eksperimen dengan pendekatan kuantitatif, one group pre-post test design. Instrumen penelitian menggunakan soal pretest dan posttest, modul, dan LKS. Analisis data menggunakan software JASP untuk mendapatkan hasil t-test dan ngain. Hasil penelitian menunjukkan bahwa terdapat perbedaan yang signifikan kemampuan literasi grafis siswa sebelum dan sesudah menggunakan video tracker yang ditunjukkan dengan hasil uji-t sampel berpasangan dengan nilai sig. (P) 0,001 < 0,05. Setiap indikator literasi grafis siswa mengalami peningkatan meskipun tidak semuanya berada pada kriteria tinggi. Penguasaan literasi sains siswa dapat dengan mudah menyelesaikan soal-soal tentang gerak lurus beraturan.

Kata kunci: *Desain Pembelajaran, Gerak Jatuh Bebas,Tracker, Litersi Grafik*

Abstract

Physics learning is process skill-based learning. One of the science process skills that students must master is graphic literacy. The material on free fall motion is a lesson that requires students to have graphic literacy skills, but the facts in the field show that not a few of the students have difficulty reading and managing information based on graphs. This study aims to analyze the improvement students' graph literacy, which was conducted at Senior High School. The research subjects were students, the research sample amounted to 21 students of class X MIA. Using a quasi-experimental method with a quantitative approach, one group pre-post test design. The research instruments used pretest and posttest questions, modules, and LKS. Data analysis using JASP software to get t-test results and Ngain. The results showed that there was a significant difference in students' graphic literacy skills before and after using the video tracker as indicated by the results of the paired samples t-test at a sig value. (P) 0,001 < 0,05. Each indicator of students' graphic literacy has increased even though not all are at high criteria. Students mastery of science literacy can easily solve problems about regular straight-line motion.

Keywords: Learning Design, Free Fall Motion, Tracker, Graph Literacy

History:
Received : March 03, 2023
Revised : March 04, 2023
Accepted : July 06, 2023
Published : July 25, 2023

Publisher: Undiksha Press

1. INTRODUCTION

Physics learning is concept-based learning and process skills, process skills are a learning approach that aims to develop physical and mental abilities as a basis for developing other abilities contained in students, these process skills are known as science process skills. One of the science process skills that students must master is graph literacy, for example, interpreting graphs is important in physics because graphs are tools used in presenting ideas (Amelia et al., 2020; Tamyiz et al., 2020; Wityanita et al., 2019). The facts of the Program for International Student Assessment (PISA) study results in 2015 show that the achievement of Indonesian children in the field of science is still below the average international score of 403 out of 493 and out of 76 countries, Indonesian children ranked 69th, which is up six ranks after previously ranking second lowest in the 2013 PISA ranking. One of the test indicators in it is interpreting data and graphs, but Indonesian students have difficulty

answering questions about data and graph interpretation (Hewi & Shaleh, 2020; Raflesiana et al., 2019).

The difficulty so far faced by students in high school to university students is the difficulty in reading and interpreting graphs. There have been many previous studies related to students' ability to read and interpret graphs. The results of research by previous study showed that students' graph reading and graph interpretation skills are still inadequate, besides that proficiency in analyzing graphs depends on the type of graph and the level or type of question developed (Purwana et al., 2020). The results of research by other study found that students have difficulty in reading, interpreting, and understanding the information depicted in the graph (Setyono et al., 2016). Research conducted by other study revealed the ability to interpret thermodynamic graphs of students at the high school level (Martin et al., 2017). In addition, the results of research conducted revealed that the average percentage that the conception of class X students for the concept of the kinematics of straight motion was 50.00% leading to misconceptions, while students with good understanding, answering correctly by guessing and having less knowledge were 21.67%, 10.42%, and 17.50% respectively (Huzainah et al., 2020). The ability to interpret graphs is needed so that we can get the right information from the data presented (Mustain, 2015; Nazriana, 2017; Purwana et al., 2020).

Based on the results of the literature, many efforts have been made by other researchers to improve students' ability to read graphs, but from previous studies, no one has used the help of tracker software media to improve graph literacy. The results of previous researchers' research show the same thing that students' graphic literacy skills consisting of several indicators have not been fully mastered by students. In particular, MAN 3 Mataram students have not been able to fully master the understanding of graphic literacy which can be seen from the results of the low daily test scores of free fall motion material which is below the KKM because the teacher still uses conventional learning methods. Seeing the above conditions, researchers need to conduct a study on the learning design of free fall motion assisted by Tracker Software to improve graphic literacy.

The use of Tracker video analysis software can facilitate students in practicum activities. This is supported by preliminary research conducted by the author on mechanics practicum with the acquisition of relative errors in straight motion experiments at 0.38%, parabolic motion experiments at 1.75%, and simple harmonic motion experiments at 5.32%. This value shows that the results obtained are more precise (Amanda et al., 2022; Raflesiana et al., 2019). Through tracker activities, analyzing a phenomenon of experimental results can be done easily and accurately. The results of video analysis using Tracker are in the form of tables and graphs so that students can draw conclusions based on statistical data obtained from the Tracker software (Nurjanah et al., 2021; Sari & Putra, 2022). Because the information shown by the tracker is in the form of tabular data and graphs, students can become literate about graphs. In addition to data tables and graph information, trackers can also display data in the form of images and mathematical equations (Khotijah et al., 2019; Subhan et al., 2020).

Experiments conducted in the form of videos can maximize student involvement in the learning process because it prioritizes activities so that students can become more active where students are required to gain direct experience and discover their knowledge (Hardi et al., 2019; Istiqomah & Lubis, 2023). Tracker is a free software designed to use video recordings of an object's motion phenomena as input data, so it can be used to analyze and simulate physical phenomena (Amanda et al., 2022; Melinia et al., 2021). This Tracker software allows students to analyze the motion of objects in a video by making traces following the motion of objects in the video.

Objects dropped from above will fall to the earth because the object gets gravitational acceleration (g) whose direction always goes to the center of the earth (Bara, 2021; Ilma et al., 2022). Free fall motion is one of the natural phenomena studied in physics, the movement of objects in free fall is the simplest and most common example of motion with changing speed (Agustinasari & Sumarni, 2021; Atani et al., 2019). Free fall motion is an example of straight-line motion. An object is said to be in free fall if it is released from a certain height toward the ground with no initial velocity (Futra et al., 2022; Ristiawan, 2018; Sukadi & Angraeni, 2019). In general, the material of free fall motion and straight motion changes regularly is a scope of motion or kinematics material that presents information or displays problems using graphs, therefore students must have graphic literacy skills.

Graph literacy is the ability to read, write, understand, express, and analyze an outline or image used to create visualization objects from data in tables to provide information about data from the presenter of the material to the recipient of the material. Defining graph literacy as the ability to understand graphical representations emphasizes that graphs are ubiquitous in various data sources (Aoyama & Stephens, 2003; Harsh et al., 2019). Graphic literacy is not only the ability to draw and read diagrams correctly but also shows the level of knowledge of students. (Harsh et al., 2019; Ozodovich, 2021). According to previous study graphs are often considered as mathematical aids, because communicating through graphical representations requires mathematical competencies such as visual perception, logical thinking, plotting data, predicting line movements, and inferring relationships between variables (Yıldırım, 2016). The eight graphic literacy indicators used by researchers that can represent the scope of graphic literacy, namely: 1) Mathematical Competence; 2) Translation (ability to translate); 3) Mentioning the parts of the graph; 4) Explaining the meaning of lines in the coordinate axis; 5) Changing the table into a graph; 6) Interpretation (ability to interpret); 7) Reading and making tables; 8) Drawing graphs based on data.

Seeing the above conditions, the researcher needs to conduct a study on the learning design of free fall motion assisted by Tracker Software to improve graphic literacy. From this, the objectives of this study are: 1) to analyze the difference in students' graphic literacy skills before and after using Tracker Software, and (2) to analyze the increase in students' graphic literacy skills.

2. METHODS

This study used a quantitative approach with a quasi-experimental method with a one-group pre-post test design (Sundayana, 2018). Research subjects The students of MAN 3 Mataram class X MIA amounted to 21 people (12 girls and 9 boys). The research instruments used were modules, LKS, and tests (pre-test and post-test). The test instrument was used to measuring the extent of students' graphic literacy both before and after treatment. Data collection is carried out by the test method (multiple choice and essay) mastery of graphic literacy. All test instruments were validated for content, language, and technology before use. The material given in the test questions includes regular straight motion, and regular changing straight motion in free fall motion, each of which represents an indicator of graphic literacy. The research stages are presented in Figure 1.

The first step in Figure 1 shows that researchers compiled a learning design in the form of a practicum module assisted by Tracker Software as a guide for students to understand the concept of free fall motion, how to use Tracker Software for practicum, and understand graph literacy, Interpretation, and Solution student worksheets to direct students to do practicum and indicators to be achieved in the process of practicum activities.

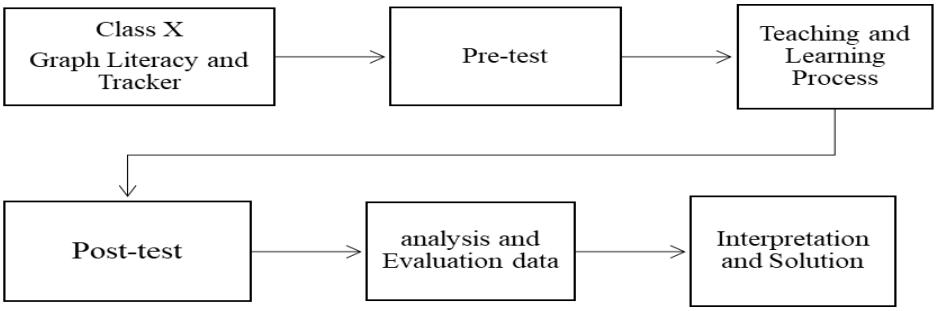

Figure 1. Research Chart

The second step is that students and teachers carry out the teaching and learning process for three meetings by conducting a practicum. In the first meeting students are given a pre-test question consisting of 11 numbers (essay and multiple choice) to measure students' initial graphic literacy, then students are given a module in the teaching and learning process in which there is free fall motion material, how to use trackers software, and the graphic literacy process. Furthermore, students will conduct a practicum on free fall motion material with the help of tracker software with the guidance of modules and student worksheets.

The third step is carried out in the third meeting where students are given post-test questions as a form of evaluation to determine the improvement of students' graphic literacy after the learning and teaching process, as well as taking data on the results of the post-test done by students.

The last step is that researchers analyze the nature of data distribution and normality. Inferential statistics of normal data and then use paired sample t-tests to determine the difference in students' graphic literacy skills before and after treatment. Data analysis, normality, harmonicity, and t-test use the help of JASP software to ensure the validity of the data analysis process. Meanwhile, to determine the improvement of students' graphic literacy, the calculation was carried out using the $N_{\text{-Gain}}$ formula between the pre-test and post-test through the equation. The decision-making criteria for the graphic literacy improvement category in the interpretation of $N_{\text{-Gain}}$ is shown in Table 1.

Table 1. N-Gain Interpretation Criteria

$N_{\text{-Gain}}$ (g)	Interpretation Criteria
$0{,}70 \leq (g)$	High
$0{,}30 \leq (g) < 0{,}70$	Medium
$(g) < 0{,}30$	Low

3. RESULTS AND DISCUSSION

Results

Based on the pre-test and post-test data, the students' graphic literacy achievements before and after treatment are shown in Table 2.

Table 2. N-Gain value

Literacy Aspect Graph	Pre-test	Post-test	N-Gain	Description
Indicator 1 (Mathematical competence)	45.83	85.12	0.73	High
Indicator 2 (Translation)	23.81	77.38	0.70	High
Indicator 3 (Mentioning the	50.00	90.48	0.81	High

Literacy Aspect Graph	Pre-test	Post-test	N-Gain	Description
parts of the graph)				
Indicator 4 (Explaining the meaning of lines in coordinate axes)	23.81	50.00	0.34	Medium
Indicator 5 (Converting a table into a graph)	55.95	88.10	0.73	High
Indicator 6 (Interpretation)	90.48	95.24	0.50	Medium
Indicator 7 (Reading and making tables)	66.67	80.95	0.43	Medium
Indicator 8 (Drawing graphs based on data)	42.86	64.29	0.38	Medium

The increase in scores on the Literacy Graph indicator or aspect can be seen from the graphical display in Figure 2.

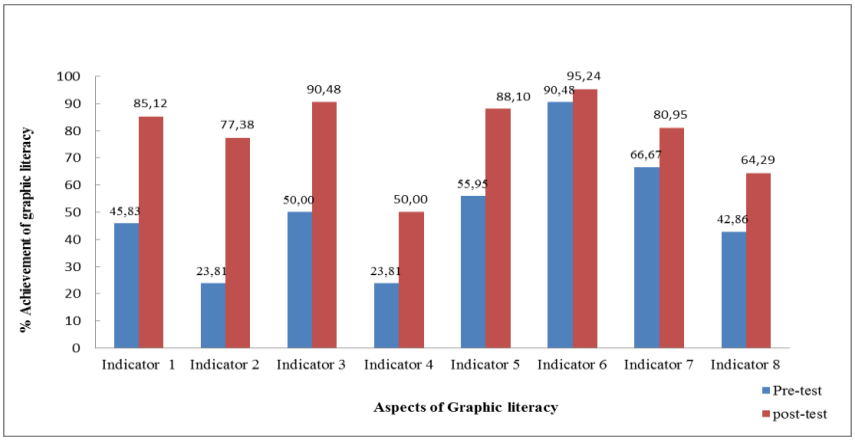

Figure 2. Graph of the results of the pre-test and post-test of the Graph Literacy Indicator

Base on the pre-test and post-test result obtain as show in Figure 2. The normality test on the data of the pre-test and post-test results is show in Table 3.

Table 3. Normality Test Results

Test of Normality (Shapiro-Wilk)			
		W	P
Pre-test	Post-test	0.962	0.565

Based on Table 3, the normality test uses the Shapiro-Wilk technique where the sig value for the pre-test and post-test is 0.565 which is above the standard significance of 0.05 so that the data from the pre-test and post-test are normally distributed. Therefore, the paired sample t-test is fulfilled to determine the difference in means. The results of the paired sample t-test data analysis using JASP can be seen in Table 4.

Table 4. Paired Samples T-Test Results

Paired Samples T-Test				
Measure 1	Measure 2	T	Df	P
Pre-test	Post-test	-5.931	20	0.001

Guidelines for decision-making in the paired sample t-test based on the significance value (sig) where H0 indicates there is no difference in mean between the pre-test and post-test, and Ha indicates there is a difference in mean between the pre-test and post-test. Based on the results of the Paired Samples t-test on the sig value. (P) 0.001 <0.05 then H0 is rejected and Ha is accepted, meaning there is a difference in students' graphic literacy.

Discussion

Based on the results of the calculation data using the N-Gain formula in Table 2, it can be seen that the highest value is found in the 3rd indicator, namely mentioning the parts of the graph with an N-Gain value of 0.81. The lowest or minimum value is in the 4th indicator with a value of 50.00, namely explaining the meaning of lines in the coordinate axis. Some indicators include indicator 1 with an N-Gain value of 0.73 with high information, followed by indicator 2 with a value of 77.38, high and indicator 5 with a value of 0.73, indicators 6 and 7 with a value of 0.50 and 0.43 with medium information, and indicator 8 value of 0.38 with medium information. From the results of the N-Gain value, we can conclude that 8 indicators have increased, which are divided into several improvements: high (indicator 1, indicator 2, indicator 3, and indicator 5), and there are some that are the medium category (indicator 4, indicator 6, indicator 7, and indicator 8) (Soeprajogo; Purnama & Ratnaningsih, 2020).

The researcher also displayed a graph of the pre-test and post-test results to show the difference between before and after treatment. The graph shows the results of the achievement per literacy aspect of the graph, the initial ability of students in indicator 1 of mathematical competence. The ability to answer student questions from the results of reading the graph, with a pre-test score of 45.83 and a post-test of 85.12, increased with high criteria, a significant change, students already have a fairly good initial ability, and after being treated with the ability of students to increase on the variables (information) on the x and y axes and the use of the right formula to solve cases on the graph. Students become accustomed to answering problems represented by graphs, especially the material of regular straight motion and regular changing straight motion, free fall motion.

This statement is inversely proportional to the results of research by previous study that low-ability students only fulfill the mathematical representation indicators of solving problems involving mathematical expressions and writing down the steps of solving mathematical problems in words (Hakim et al., 2019). The increase experienced by students is an indicator of mathematical competence because all students have been able to read the information on the graph and use the right formula to solve the problem because they are used to reading and extracting information/data from the graph in the tracker software so that students are accustomed to answering math problems with graphs and data displays. Students have no difficulty in determining the use of the right formula in the material content because students have mastered it.

Indicator 2 regarding translation (ability to translate) is the ability of students to read and translate the meaning of the graph, with a pre-test of 23.81 and a post-test of 77.48. Although there is an increase in graphic literacy which is in the high category, students still find it difficult to explain the relationship between the lines and how the meaning of the connecting points between the x-axis and y-axis on the graph. Students are still unable to explain the information on the x-axis and y-axis and the meaning of the information on the x-axis and y-axis to interpret the graph based on this information. In line with the results of research conducted by previous study student's ability to read graphs is quite good, student understanding is above 50% (Purwana et al., 2020). With the help of software tracker analysis, students are much easier to read and translate the graph, because all information is presented in the form of graphs, so students are accustomed to solving problems and finding

information through graphs on software trackers, and researchers also carry out activities to increase students' understanding of graph literacy, starting from reading variables on the x-axis and y-axis, the meaning of coordinate growth, and the easiest information to translate graphs through graph names.

Indicator 3 mentions the parts of the graph, with a pres-test of 50.00 and a post-test of 90.48 changes that are in high criteria. On average, students already understand and can mention the parts that are on the graph. For example, the name on the graph by being able to distinguish which variable (information) is the x-axis and which variable is the y-axis. Meanwhile, according to previous study the mistakes that many students make are not writing the name of the graph or not giving an explanation on the x-axis and y-axis, because most students do not understand how to explain the graph (Tamyiz et al., 2020). The same difficulties were experienced by students at the beginning of the pre-test, but when the researcher conducted repeated training in reading and mentioning the parts of the graph, starting from giving the name of the graph by paying attention to the information on the x-axis and y-axis, providing information for the x-axis and y-axis, according to the information obtained, and the graph displayed on the tracker software greatly helped improve students' understanding of mentioning the parts of the graph.

Indicator 4 explains the meaning of lines in the coordinate axis pres-test achievement score of 23.81 and post-test 50.00, an increase that is at a moderate level. The initial ability of students and after being given treatment in the form of teaching and learning processes and practicum did not experience a good improvement. The greatest difficulty experienced by students is explaining how the purpose and purpose at the connecting points between the x-axis and the y-axis, in this case, most often presented in graphs, namely free fall motion material, for example, coordinate points show that objects have fallen with a height of 2 meters takes 3 seconds, things like this that have not been mastered by students. In line with the results of research stated that students' abilities were not good in making graphs, had errors in naming coordinate axes, were not good at placing point positions, and did not know how to name curves on the graph (Hakim et al., 2019). But with the help of a simple graphic display on the tracer software and the data displayed is very simple, and complete, it can make students experience an increase with moderate criteria.

Indicator 5 converts tables into graphs, pres-test 55.95 and post-test 88.10 changes are in a high position. The initial ability of students is good but there are some things that students do not understand, especially determining the variable (information) which becomes the x-axis and becomes the y-axis, most students make mistakes between the variable (information) which becomes the x-axis and the y-axes is wrong most of the titles given on the graph are also reversed, and connect the points or deduce the lines in the table. The thing that students master the most is to give a numbering for the x-axis and y-axis of the table given, after being given treatment students master all the things that are an obstacle except deducing the coordinate line on the graph. While according to previous study students' ability to make graphs is unsatisfactory, where there is little or no understanding of the concepts, the explanations made are not satisfactory, and the graphs drawn are not precise. Most students can make kinematics graphs, but they are still relatively low (Tamyiz et al., 2020). Again, the increase in student understanding is at a high criterion compared to previous research results with unsatisfactory/low student ability. The tracker software not only presents data in the form of graphs but also tables. One practicum activity with tracker software will present a lot of data, ranging from graphs and tables, so that during the implementation of the practicum students easily understand tables and graphs simultaneously or at one time.

Indicator 6 interpretation (ability to interpret), with a pres-test of 90.48 to a post-test of 95.24. Being in the medium improvement criteria, students' initial ability to interpret the graph is quite high. Meanwhile, according to previous study the ability of high school

students to interpret numerical graphs of regular straight motion - regular changing straight motion is categorized in the low category (Gebre, 2018). This is similar to that expressed by other study that students' difficulties in connecting graphs are interpreting changes in height and changes in slope (Bollen et al., 2016). And continued by previous study that found the average graph problem-solving ability is still low with the percentage of each ability starting with graph interpretation ability (48.30%) (Setyono et al., 2016).

Indicator 7 reads and makes tables, pres-test 66.67 and post-test 80.95 there is the same improvement as indicator 6 which is moderate. The initial mistakes made by students in making tables from the data obtained students always forget to make the first row for the table is numbering, and for the second row and so on students already understand what is the 3rd row and so on from the information obtained. As previously known that there are many data results displayed by tracker software, one of which is graphs and tables, students do one activity but get a lot of data and knowledge in one tracker software display. Making it easier for students to understand many things in one activity, tracker software makes time much more flexible, because it can get a lot of information in just one activity.

As well as indicator 8 drawing graphs based on data, the pres-test was 42.86 and became a post-test of 64.29 a moderate increase. In contrast to making graphs from tables, making graphs from tables is quite easy because the table has provided sufficient data and is easy for students to understand, unlike the raw data presented in the form of a problem and then determining which one will be used as the x-axis and which one will be used as the y-axis, in this case, students have mastered which one is dependent and independent. Again, the note for students is to deduce the coordinate line. Meanwhile, according to previous study making velocity graphs against time, most of the majority are also at level 2 of the maximum score of 4, namely 33.7%, and for making acceleration graphs against time, most students are at level 1 of the maximum score of 4, namely 37.37%. This means that this study shows that students' ability to make kinematics graphs is still relatively low (Tamyiz et al., 2020).

Based on these comparisons students' ability to make graphs based on data increases due to the teaching and learning process and practicum using tracker software which will make students understand much better in making graphs, researchers also emphasize information that students must pay attention to the data obtained to make graphs. The improvement is experienced because students are accustomed to reading graphs from the results of the tracker software and exercises carried out by students in understanding how to make good and correct graphs based on the information obtained. Researchers realized that several indicators of graphic literacy were still incomplete or did not experience significant improvement, such as the indicator Explaining the meaning of lines in the coordinate axis, the Interpretation indicator (the ability to interpret, the indicator Reading and making tables, and the indicator Drawing graphs based on data, therefore this is a note for further research.

4. CONCLUSION

Based on the results of the study, it can be concluded that: there is a significant difference in students' graphic literacy skills before and after learning to use tracker software. There is an increase in students' graphic literacy where in the mathematical competence indicator, the translation indicator (the ability to translate), the indicator mentions the parts of the graph, and the indicator converts the table into a graph, is in the high category, while in the graphic literacy indicators that are still incomplete or do not experience significant improvement, such as the indicator Explaining the meaning of lines in the coordinate axis, the Interpretation indicator (the ability to interpret, the indicator Reading and making tables, and the indicator Drawing graphs based on data is in the medium category.

5. REFERENCES

Agustinasari, A., & Sumarni, R. A. (2021). Alat Penghitung Fisika Pada Materi Gerak Vertikal Berbasis Matlab. *Semnas Ristek (Seminar Nasional Riset Dan Inovasi Teknologi)*, *5*(1), 741–744. https://doi.org/10.30998/semnasristek.v5i1.4989.

Amanda, C., Sugiarti, & H. M. Lubis, P. (2022). Pengembangan LKPD berbasis Discovery Learning Berbantuan Software Tracker untuk Meningkatkan Pemahaman Konsep Peserta Didik Kelas X di SMAN 2 Babat Supat. *Jurnal Literasi Pendidikan Fisika (JLPF)*, *3*(1), 58–66. https://doi.org/10.30872/jlpf.v3i1.970.

Amelia, R., Azizah, R. S. N., Suwandi, A. R., Amalia, I. F., & Ismail, A. (2020). Application of augmented reality to physics practicum to enchane students' understanding of concepts. *International Journal of Scientific and Technology Research*, *9*(3), 1128–1131. https://www.researchgate.net/profile/Ali-Ismail-24/publication/340887215.

Aoyama, K., & Stephens, M. (2003). Graph interpretation aspects of statistical literacy: A japanese perspective. *Mathematics Education Research Journal*, *15*(3), 207–225. https://doi.org/10.1007/BF03217380.

Atani, O. A., Lapono, L. A. S., & Louk, A. C. (2019). Rancang Bangun Alat Peraga Praktikum Gerak Jatuh Bebas. *Jurnal Fisika : Fisika Sains Dan Aplikasinya*, *4*(1), 33–39. https://doi.org/10.35508/fisa.v4i1.1435.

Bara, F. M. (2021). Analisis Percepatan Gravitasi Menggunakan Aplikasi Phyphox Pada Gerak Jatuh Bebas. *Jurnal Luminous: Riset Ilmiah Pendidikan Fisika*, *2*(2), 11. https://doi.org/10.31851/luminous.v2i2.5923.

Bollen, L., De Cock, M., Zuza, K., Guisasola, J., & Van Kampen, P. (2016). Generalizing a categorization of students' interpretations of linear kinematics graphs. *Physical Review Physics Education Research*, *12*(1), 1–10. https://doi.org/10.1103/PhysRevPhysEducRes.12.010108.

Futra, A. D., Mulyadi, I. H., Mahdaliza, R., & Budiana, B. (2022). Modul Praktikum Pemodelan Gerak Jatuh Bebas menggunakan Infrared Obstacle Avoidance Sensor. *Journal of Applied Sciences, Electrical Engineering and Computer Technology*, *3*(01), 1–5. https://doi.org/10.30871/aseect.v3i01.4291.

Gebre, E. H. (2018). Young adults' understanding and use of data: Insights for fostering secondary school students' data literacy. *Canadian Journal of Science, Mathematics and Technology Education*, *18*(4), 330–341. https://doi.org/10.1007/s42330-018-0034-z.

Hakim, A. R., Hariastuti, R. M., Yusuf, F. I., & Matematika, P. P. (2019). Analisis Kemampuan Representasi Matematis Siswa Kelas X Pada Materi Grafik Fungsi. *Jurnal Inovasi Pembelajaran Matematika (JIPM)*, *1*(1), 31–40. https://www.e-jurnal.stkippgrisumenep.ac.id/index.php/JIPM/article/view/34.

Hardi, A., Wahyono, U., & Saehana, S. (2019). Pengembangan Multimedia Pembelajaran Materi Gerak Lurus Pada Permainan Tradisional Logo Berbantuan Software Tracker. *JPFT (Jurnal Pendidikan Fisik Tadulako)*, *7*(2), 53–57. http://jurnal.untad.ac.id/jurnal/index.php/EPFT/article/view/16659.

Harsh, J. A., Campillo, M., Murray, C., Myers, C., Nguyen, J., & Maltese, A. V. (2019). Seeing data like an expert: An eye-tracking study using graphical data representations. *CBE Life Sciences Education*, *18*(3), 1–12. https://doi.org/10.1187/cbe.18-06-0102.

Hewi, L., & Shaleh, M. (2020). Refleksi Hasil PISA (The Programme For International Student Assesment): Upaya Perbaikan Bertumpu Pada Pendidikan Anak Usia Dini). *Jurnal Golden Age*, *4*(01), 30–41. https://doi.org/10.29408/jga.v4i01.2018.

Huzainah, E., Mansyur, J., & Darsikin. (2020). Interpretasi Siswa SMA terhadap Grafik Kinematika. *Jurnal Pendidikan Fisika Tadulako Online (JPFT)*, *8*(3), 41–45.

http://jurnal.untad.ac.id/jurnal/index.php/EPFT/article/view/16943.

Ilma, A. Z., Kuswanto, H., & Hujatulatif, A. (2022). Jumping Motion of Gourami Fish Using Tracker Software as a Mechanical Energy Conservation Practicum. *Jurnal Penelitian Pendidikan IPA*, *8*(5), 2154–2158. https://doi.org/10.29303/jppipa.v8i5.2071.

Istiqomah, S., & Lubis, P. H. M. (2023). *Development of Problem Solving-Based Modules Assisted by Tracker Software to Improve Students ' Problem-Solving Skills in High School*. *11*(1), 47–58. https://doi.org/10.26618/jpf.v11i1.9592.

Khotijah, K., Arsini, A., & Anggita, S. R. (2019). Pengembangan Praktikum Fisika Materi Hukum Kekekalan Momentum Menggunakan Aplikasi Video Tracker. *Physics Education Research Journal*, *1*(1), 37. https://doi.org/10.21580/perj.2019.1.1.3961.

Martin, C. R., Ranalli, J., & Moore, J. P. (2017). Problem-based learning module for teaching thermodynamic cycle analysis Using PYroMat. *ASEE Annual Conference and Exposition, Conference Proceedings*, *2017-June*. https://doi.org/10.18260/1-2--28757.

Melinia, S., Lubis, P. H. ., & Sulistiawati, S. (2021). Pengembangan LKPD Berbasis Discovery Learning Berbantuan Software Tracker Untuk Meningkatkan Pemahaman Konsep Peserta Didik Kelas X di SMA Sriguna Palembang Pada Materi GHS. *Jurnal Pendidikan Fisika Dan Teknologi*, *7*(2), 80–86. https://doi.org/10.29303/jpft.v7i2.2782.

Mustain, I. (2015). Kemampuan Membaca dan Interpretasi Grafik dan Data: Studi Kasus Pada Siswa Kelas 8 SMPN. *Scientiae Educatia*, *4*(2), 1–11. https://doi.org/10.24235/sc.educatia.v4i2.493.

Nazriana, L. (2017). Peningkatan Kemampuan Interprestasi Grafik Melalui Pendekatan Multi-Representasi Pada Materi Gerak Lurus. *In Prosiding Seminar Nasional USM*, *1*(2006), 114–118. http://ojs.serambimekkah.ac.id/semnas/article/download/365/332.

Nurjanah, A., Nyeneng, I. D. P., & Wahyudi, I. (2021). Pengaruh Pembelajaran Daring Berpraktikum Menggunakan Media Tracker Berbasis Inkuiri Terbimbing Terhadap Peningkatan Kemampuan Interpretasi Grafik. *Jurnal Inovasi Dan Pembelajaran Fisika*, *8*(2), 198–207. https://doi.org/10.36706/jipf.v8i2.15098.

Ozodovich, A. A. (2021). The Use Of Tasks That Create A Tendency To The Problems Of Making Typical Mistakes In The Possession Of Graphic Literacy. *The American Journal of Social Science and Education Innovations*, *03*(06), 99–103. https://doi.org/10.37547/tajssei/Volume03Issue06-16.

Purwana, U., Rusdiana, D., & Liliawati, W. (2020). Pengujian Kemampuan Menginterpretasikan Grafik Kinematika Calon Guru Fisika: the Polytomous Rasch Analysis. *ORBITA: Jurnal Kajian, Inovasi Dan Aplikasi Pendidikan Fisika*, *6*(2), 259. https://doi.org/10.31764/orbita.v6i2.3264.

Raflesiana, V., Herlina, K., & Wahyudi, I. (2019). Pengaruh Penggunaan Tracker Pada Pembelajaran Gerak Harmonik Sederhana Berbasis Inkuiri Terbimbing Terhadap Keterampilan Interpretasi Grafik Siswa. *Gravity : Jurnal Ilmiah Penelitian Dan Pembelajaran Fisika*, *5*(1), 1–12. https://doi.org/10.30870/gravity.v5i1.5207.

Ristiawan, A. (2018). Analisis Gerak Jatuh Bebas Dengan Metode Video Based Laboratory (Vbl) Menggunakan Software Tracker. *Journal of Teaching and Learning Physics*, *3*(2), 26–30. https://doi.org/10.15575/jotalp.v3i2.6556.

Sari, N. S. F., & Putra, N. M. D. (2022). Pengembangan Modul Praktikum Osilasi Teredam Pada Pegas Berbasis Analisis Video. *Unnes Physics Education Journal*, *11*(2), 9–16. https://journal.unnes.ac.id/sju/index.php/upej/article/view/60276.

Setyono, A., Nugroho, S. E., & Yulianti, I. (2016). *Unnes Physics Education Journal*. *5*(3). https://doi.org/10.15294/upej.v5i3.13729.

Soeprajogo; Purnama, M., & Ratnaningsih, N. (2020). Perbandingan Dua Rata-Rata Uji-T. *Universitas Padjajaran*, 5–20. https://perpustakaanrsmcicendo.com/wp-

content/uploads/2020/07.

Subhan, M., Suswati, L., Aryanti, F., & ... (2020). Pemanfaatan Media VBL (Tracker) Pada Materi GLB Melalui Model Inquiri Terbimbing Terhadap Pemahaman Konsep Fisika Siswa SMA Kelas XI. *Jurnal Pendidikan Ilmu Pengetahuan Alam (JP-IPA)*, *01*(02), 59–63. https://doi.org/10.56842/jp-ipa.v1i02.19.

Sukadi, E., & Angraeni, L. (2019). Penerapan Pedagogical Content Knowledge Pada Materi Kinematika Untuk Meningkatkan Hasil Belajar Mahasiswa. *Pendidikan Mipa Dan Teknologi II*, *1*(1), 202–214. https://journal.ikippgriptk.ac.id/index.php/snpmt2/article/view/1376.

Sundayana, R. (2018). *Statistika Penelitian Pendidikan*. Bandung: Alfabeta.

Tamyiz, M., Ismet, & Yusup, M. (2020). Analisis Kemampuan Siswa dalam Membuat Grafik Pada Pokok Bahasan Kinematika di SMA N 1 Indralaya. *Jurnal Literasi Pendidikan Fisika*, *1*(02), 145–151. https://doi.org/10.30872/jlpf.v1i2.263.

Wityanita, Djamas, D., & Yohandri. (2019). Validation of Physics student's worksheet based on cognitive conflict strategy to minimize student's misconception. *Journal of Physics: Conference Series*, *1185*(1). https://doi.org/10.1088/1742-6596/1185/1/012112.

Yıldırım, S. (2016). Infographics for educational purposes: Their structure, properties and reader approaches. *Turkish Online Journal of Educational Technology*, *15*(3), 98–110. https://eric.ed.gov/?id=EJ1106376.