Analysis of graphic representation ability in oscillation phenomena

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Abstract. This study aims to investigates how the ability of students to represent graphs of linear function and harmonic function in understanding of oscillation phenomena. Method of this research used mix methods with concurrent embedded design. The subjects were 35 students of class X MIA 3 SMA 1 Bae Kudus. Data collection through giving essays and interviews that lead to the ability to read and draw graphs in material of Hooke's law and oscillation characteristics. The results of study showed that most of the students had difficulty in drawing graph of linear function and harmonic function of deviation with time. Students' difficulties in drawing the graph of linear function is the difficulty of analyzing the variable data needed in graph making, confusing the placement of variable data on the coordinate axis, the difficulty of determining the scale interval on each coordinate, and the variation of how to connect the dots forming the graph. Students' difficulties in representing the graph of harmonic function is to determine the time interval of sine harmonic function, the difficulty to determine the initial deviation point of the drawing, the difficulty of finding the deviation equation of the case of oscillation characteristics and the confusion to different among the maximum deviation (amplitude) with the length of the spring caused the load. Complexity of the characteristic attributes of the oscillation phenomena graphs, students tend to show less well the ability of graphical representation of harmonic functions than the performance of the graphical representation of linear functions.

1. Introduction

Graphic representation is a form of scientific literacy through the interpretation of observed phenomena followed by activities of summarizing, processing and interpreting new information from complex data [1,2]. The graphic serves to communicate scientific data making it easier for readers to recognize and extract important information from the data set for analysis and to see trends or levels of change in the graph [3]. In the education aspect representation graphic part of multirepentasi which serves to know the level of student understanding [4]. Knowledge of graphs is used in various fields of science studies, among them as a basis for mathematics and physics learning [3,5].

The study of graphic research in physics and mathematics is not new and has been widely practiced in previous studies. Research on the analysis of graphic understanding in physics learning has been done in high school to college level [3,6,7]. The results show the complexity of the problem of graphical interpretation in the study of kinematics material on students and students. The findings of the complexity of the problem of the interpretation of kinematics material graphs include students' confusion in explaining the trend of the slope graph of the variable-speed relationship to time, the
confusion over the change of point intervals on the graph, and the least understanding of regional concepts under graph / curve on the physics problems [7, 3, 8].

Most research studies on graphic interpretation in physics learning lead to kinematics material to explain the concept of distance, velocity and object acceleration [9-11]. In addition, previous research is more likely to explore the understanding of linear graphs from the graph of speed over time. There is a need for new research studies that lead to the understanding of linear graphics or not linear in physics learning. The oscillation material can be one of the next research topics in assessing the understanding of physics charts that present linear or non-linear graphs.

Based on the revised 2013 curriculum physics curriculum for high school level, students are required to process data, analyze experimental results into graphs and be able to determine the graphic equations in explaining the characteristics of oscillations. Previous research findings confirmed the low ability of students to communicate and draw graphs [2]. Therefore, it is necessary to study a study of graphical representation analysis on oscillation material. Graphical representation can be reviewed from the students' ability to produce graphic that includes the ability to draw and explain the graphic orally and in writing [1].

2. Methods
Method of this research used mix methods. Mix methods is combines quantitative and qualitative methods. The research design uses concurrent embedded model that is mixing qualitative and quantitative research methods unbalanced. The subjects of the study were 35 students of grade X SMA 1 Bae Kudus applying the 2013 curriculum and obtaining the oscillation material. This research procedure has several stages including, a) Stage of Research Preparation b) Implementation Stage Research, c) Stage of Research Data Analysis, d) Conclusion Making Stage. Data collection in this research using test and non-test technique. The test technique used is essay about the ability of graphical representation of linear function and harmonic function on the phenomenon of oscillation, while nontest technique used is interview. Quantitative data analysis techniques use an appellate test of pre-test and post-test values based on each student group. And then, qualitative data analysis techniques using descriptive analysis based on indicators of understanding and analysis of written answers and student interviews. Next combine the results of analysis of quantitative and qualitative data.

3. Result and Discussion
Quantitative results on the students' ability to represent the functions of linear graphics and harmonic graph functions in the oscillation phenomenon are shown in Table 1, as follows:

| Group | Linear Function | Harmonic Function |
|-------|-----------------|-------------------|
|       | Pre-test | Post-test | Pre-test | Post-test |
| High  | 34.17    | 52.83    | 28.75    | 33.18     |
| Medium| 27.73    | 38.83    | 25.06    | 30.56     |
| Low   | 20.04    | 28.92    | 23.43    | 28.01     |

Based on Table 1, the average post-test score is higher than the pre-test results. Improved post-test results show the healing of treatment in the form of the use of computer software (logger pro) in helping students represent the graph. The findings support previous findings that the use of computer software can help students understand and interpret graphics [12]. However, quantitatively from the results of the students' values informed that the ability of students in representing linear graphs or harmonic graphs is still in the low category. And the graphical representation of linear functions is
better than the graphical representation of harmonic functions because students are more accustomed to plotting the graph of linear functions than the harmonic function of the harmonic function.

3.1. Procedure & student error in graphical representation of linear function of Hooke’s Law case

Student representation on graph of linear function through student ability in making graph from case of Hooke law that is megeplot graph relation between force (F) and change of spring length (Δy). Here is a description of the student's procedures and errors in the graphical representation of linear functions:

3.1.1. Analysis of variable data.

The variable data analysis stage required to create a linear graph is not written on the student answer sheet, but the student writes the stage on another sheet of paper (oret paper). Most students of the moderate and low group experienced errors in analyzing the spring length change data due to confusion between the data of spring length (y) and the change in spring length (Δy). The confusion is because students have difficulty to interpret the meaning and meaning of the delta symbol (Δ) which shows the data of spring length change (Δy).

3.1.2. Placement of variables F and Δy on the coordinate axis.

Some students may place the position of variable F and Δy on the coordinate axis appropriately because the previous student reads the reference book and the LKS presents the graph of the relation F and Δy. But there are some inverse students placing the position of the variable F and Δy on the coordinate axis ie the load force variable (F) is placed on the X axis and the spring length changes (Δy) on the Y axis, since the students are wasting the variable symbol of the change in the spring length using the letter "y" indicating the location of the variable on the coordinate axis. The confusion of variable placement when drawing graphs also found previous research [2, 13] which resulted in misunderstanding the graph. However after the students are given explanatory guidance using the principle of linear function of the equation the law of hooke can realize the error and understand the meaning of the slope of the graph. The slope of the curve formed from the relationship between the force and the change in the length of the spring shows the value of the 'k' spring constant [8].

Hooke’s Law:

\[ F = -k\Delta y \]  

(Linier Function: \( y = mx + c \))  

3.1.3. Writing variable data information on the graph.

Writing variable data information on the graph includes the writing of the title, variable names on the coordinate axis and units. Most students do not care about writing the title of the graph that has been created. Furthermore, students in writing the names of variables and units on the graph there are 4 categories: a). Writing variable names with symbols are F and Δy with units / no units. B). Writing variable names with words that is the force load and change the length of the spring with units / without units. c). Writing variable names only with units only. d). Without writing variable and unit names.

Based on the result of title writing category, the name of the variable and the unit indicates the bad habits of students in writing the completeness of the information when presenting the graph, so that other people who read the graph do not get the correct information and correct from the graph presented. Not used to students in making graphics as one of the factors of the emergence of errors when drawing graphs.
3.1.4. Writing value interval scales on the coordinate axis.
The majority of students are not used to making scale interval scores correctly. But after the students are given guidance quickly able to respond and justify the mistakes that have been made. The students' bad habits in making scale intervals are shown in 'Figures 1' and 'Figure 2', as well as the student's inability to shorten the number intervals on the graph. Errors in setting intervals were found with previous researchers [3].

![Figure 1](image1.png) ![Figure 2](image2.png)

**Figure 1.** This picture shows the student's habit of scribbling the scaling of the data obtained without adjusting the proportional distance interval.  
**Figure 2.** This image shows students' habits of making scale intervals using a saw line that indicates a number before the interval number is written.

3.1.5. Connect the dots that make up the graph.
Students as a whole can connect two-variable data using / without dashed lines until a graph is drawn from the axis (0,0). There is a student incorrectly connecting the point formed with the main axis (0,0), resulting in a graph that causes misinterpretation in reading the graph of the load-style relationship and the change in spring length as 'Figure 3'.

![Figure 3](image3.png)

**Figure 3.** Error linking graph

3.1.6. Readings and graphical form explanations.
Students' explanations on the graph form the relationships of F and Δy vary, including students mentioning linear form of graphs, rising graphs and such as the GLBB graph of the relation of speed to time. Basically, however, students want to explain the linear effect of adding load to the change of spring length. There are some students who explain the graph using the hooke legal concept, but no student can explain the overall meaning of hooke's law.
3.2. Procedures and student difficulties in graphical representation of harmonic function of oscillation system

The students' representation ability on the harmonic function graph is reviewed through student completion in making the deviation harmonic function graph of time in case of mass-spring system oscillation. There are 2 types of Problem representation of the harmonic function graph is a matter that has been presented in the form of harmonic function equation and without the harmonic function equation (solving case).

The number of students who make the harmonic function graph is less than when making the graph of linear function that is reduced 6 of 35 students. The majority of students stated that it was more difficult to draw a harmonic function graph rather than a linear function because the students rarely even never made a harmonic function graph. Here is a description of the procedure and the students' difficulties in creating a deviation harmonic function graph of time:

3.2.1. Problem type by presenting harmonic function equation. Based on the analysis of written and oral answers, students understand the commands to be done, but confused to determine what steps should be cracked first. In general, students know the information contained in the harmonic function equation that has been presented is the amplitude (A) and angular velocity (ω).

Based on the interview results, the steps to graph the harmonic function equation include: a). Specifies the interval of the deviation variable scale using the amplitude value. The majority of students can write down 5 possible deviation scale ie A max, ½ max, 0, ½ A min, A min. B) Specifies the time scale variable interval. Only a small percentage of students can determine the value of time variable scale and other students only make axes without filling in the scaling interval of scale. The way of the students in determining the time variable is by substituting the maximum and minimum deviation value into the equation, so that the time to go through 1 wave can be determined. Overall the students did not understand the meaning of the deviation graph of the time it was made, it was shown from the incomprehension when explaining the correct deviation position for each time of the period that had been made. C). Graphics. After determining the interval deviation and time interval, the student graphs 1 wave mostly starting from the main axis point (0,0) to the positive deviation regardless of the position of the deviation based on the harmonic function which is written on the problem. The student tendency to sketch a graph that always passes the axis (0,0) as a common error form when drawing a graph [13].

3.2.2. Problem type without presenting harmonic function equations. In the type of problem without presenting the graph equations the students are faced with a more complex case, since it tests the ability to find the variable components to create a harmonic function graph. Here is a description of the procedure and the students' difficulties creating a harmonic function graph of the mass-spring system case: a). The student writes a mathematical representation of the problem. At this stage students have difficulty in distinguishing the amplitude of oscillations by changing the length of the spring when given the load. b). Student determines component of period variable or frequency used to create time interval of harmonic function graph. But in determining the value of the period mostly uses an equation that is not exactly the case at hand. c). Students write the harmonic graph function equations that tend to the harmonic function of the sinus (Y = A sin(ωt + θ)). The writing of scale intervals on each axis that depends on the poses determines the oscillation characteristics [14] in terms of the variable component of period, frequency, amplitude and so. In the case of type 2 most students fail to analyze the amplitude and period values, so that students originally draw a wave-like 'Figure 4'.

When the interview process there are students who understand the step of determining the component to create a harmonic function graph, but wrong in the calculation process. When the students were asked the process of drawing the graph did not understand the graphics made like 'Figure 5', one of the difficulty when asked the position of the beginning of the movement of objects.
even when asked when the guide was given. Students on case type 2 fail to find the graphics function equations, thus failing to create a harmonic function graph. In addition, most of the students when drawing did not pay attention to the initial condition of deviation from case number 2, so that the graph formed always starts from the point (0,0) which leads to the positive deviation. Students can only describe 1 wave in the form of 1 mountain and 1 valley without considering the proportional wave like Figure 4.

![Figure 4](image1.png) ![Figure 5](image2.png)

**Figure 4.** Failure of image harmonic graphics  **Figure 5.** Mismatch between graphs and cases function

Representation of harmonic function graph in case of type 2 problem can be solved student through computer software aid, but after graph formed student do not understand meaning of graph which havebeen formed and student difficult to draw graph in writing which is shown in software.

4. Conclusion

Graphs of linear and harmonic functions can facilitate students in understanding the material oscillation, but it takes a mature understanding in reading graphs, so that in the process of drawing the graph students know the meaning of the graph.

References

[1] Coleman J, McTigue EM and Smolkin LB 2011 *J Sci Teacher Educ* 22 613

[2] Branisa J and Jenisova Z 2015 *Procedia Soc Behav Sci* 197 2229

[3] Planinic M, Ivanjek L and Susac A 2013 *Phys Rev ST Phys Educ Res* 9 020103-1

[4] Theasy Y, Wiyanto and Sujarwata 2017 *Physics Communication* 1 1

[5] Araujo IS, Veit EA and Moreira MA 2008 *Comput Educ* 50 1128

[6] Planinic M, Milin-Sipus Z, Katie H, Susac A and Ivanjek L 2012 *Int J Sci Math Educ* 10 1393

[7] Ivanjek L, Susac A, Planinic M and Andrasevic A 2013 *Phys Rev Phys Educ Res* 12 010106

[8] Nguyen D and Rebello N S 2011 *Phys Rev ST Phys Educ Res* 7 010112

[9] Smith A L 2013 *Technology and Student Understanding of Kinematic Graph in the Physics Classroom* (Thesis: Montana State University)

[10] Laverty J and Kortemeyer G 2012 *Am J Phys* 80 724

[11] Tonelli Jr E P 2016 *Integrating Concept and Skills: Slope and Kinematics Graphs* (Dissertation: University Of Massachusetts Lowell)

[12] Oliviera M C 2010 *Spreadsheets in Educ* 3 1

[13] Hadjidemetriou C and Williams J S 2002 *Res Math Educ* 4 69

[14] Triana C A and Fajardo F 2013 *Revista Brasileira Ensino Fisica* 35 1