Assessing graph interpretation of high school students: an examination by students’ gender

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Abstract. The research aims to assess graph interpretation among high school students in Karawang. The research used the analytic description method because graph interpretation shows students’ conceptual understanding. This research is focused on the kinematics concept and participants involved student 10th grade of high school which consists of 72 students (25 male students and 47 female students). The instrument that used in this research is the standard test of Understanding Graphs-kinematics (TUG-K) which consists of 21 multiple-choice. The data were analyzed using the Rasch model. The results of analysis by using Winsteps 4.4.3 in the form of Wright map display indicate that graph interpretation of gender (male and female student) has a gap. The graph interpretation of high school students with Rasch model have conclusion there are the value of person reliability is categorized as “sufficient”, the person measure shows that the average ability of students is fair than the item difficulty, the outfit mean-square into acceptable category, which indicates the excellent conditions for measurement, the outfit standardized Z is categorized acceptable too and student code started from high ability graph interpretation (02F) headed for low ability (13M).

1. Introduction

Graphic interpretation is a basic ability that must be possessed by a scientist. Creating and interpreting graphs is very important because both are part of an experiment or as the heart of physics [1]. This ability is very closely related because physics cannot be separated from experimental data sets which must be interpreted. This research is focused on the objectives to obtain an assess graph interpretation of high school students and examination by students’ gender. This finding will be very important as an initial effort to determine the ability of students to interpret in general, know the parts where students have difficulty in interpreting graphs, and as material for appropriate learning designs as an improvement effort [2]. By knowing the location of students' difficulties in interpreting graphs appropriately, it is also expected to find effective and efficient remedial measures to improve students learning outcomes [3, 4].

Interpreting graphs usually kinematics subject because that subject forms the basis for further physics learning. Many students' abilities can be developed from this learning. The concepts of position, speed, and acceleration are the basic concepts of kinematics learning. Another approach to learning this basic concept can be done with a graphical approach. The understanding approach through graphics can cover several things that are beyond the reach of mathematical analysis. These things are to train students to place the exact amount on the coordinates used, provide an understanding of the slope of the positive or negative graph, and train to provide an appropriate scale in showing the relationship of two variables.
In interpreting graph especially showing the relationship of two variable we can used test for measure ability students in interpreting graph. Then we can analyzing the data on instruments have relied heavily on parametric and nonparametric tests using Microsoft Office Excel software and SPSS[5]. Aside from those two ways, other alternatives can be used to analyze response analysis; one of which is the Rasch model. The Rasch model allows the researcher to gather a more comprehensive and elaborate result. It was designed by Georg Rasch for constructing tests with items and person parameters [6-8]. Georg Rasch developed an analysis model of item response theory (IRT) [9]. Then, this model was popularized by Ben Wright [10-11] in the form of the Rasch model application for the educational assessment using computer software designed for the Rasch model application. The Rasch technique allows the data to be expressed on an interval scale, people measure on the logit scale (intervals) to be calculated, and items are measured on the same logit scale to be calculated. Rasch model will create a hierarchical relationship between the respondent (person) and the items used. Interval scale logit unit for persons and items are the same, these two things can be compared directly so to produce more complete information about the tests performed and the ability of students who take the tests.

The output table section is on the menu bar that will be used in the analysis of this research. Such complete and detailed analysis is still rarely found for interpretation research, particularly on graph interpretation. In response to the problems elaborated above, the research is aimed at investigating the capability of high school students’ graph interpretation. Then will be analyzed with the Rasch model, assisted by Winsteps 4.4.3 software used in Rasch analysis. The research is expected to provide information for future teaching and learning with graph interpretation can be maximum with other interpretations such as a diagram, table, or another visual. Because of capability students of graph interpretation unlimited to one interpretation. This research aims to assess graph interpretation among high school students in Karawang and then results of analysis by using Winsteps 4.4.3 in the form of Wright map display indicate that graph interpretation of gender (male and female student).

2. Methods

2.1. Research Design
This research uses the analytic description method. It is a method that describe and give an overview of the object under study or collected data as it is without analyzing and making conclusions that apply to the public. Beforehand the participants were taught about a kinematic concept by a physic teacher. Then students were asked to fill a graph interpretation questionnaire. It is because that the graph shows students' conceptual understanding. As the result, the students' responses can be analyzed using the Rasch model on Winsteps 4.4.3 software.

2.2. Participants
The participant who involved in this research is 72 students of 10th grade senior high school (25 male students and 47 female students) in Karawang. Karawang city is about 94 km from Bandung, the capital of West Java. Figure 1 shows a map distance Bandung-Karawang.
2.3. Instrument

The instrument used in this research is a standard test of *Understanding Graph Kinematics (TUG-K)* [5]. The test consists of 21 multiple-choice questions and given to students after the learning of kinematics concept. The measured concept consists of several concepts related to kinematics, such as position, velocity, and acceleration. This material has been adapted to the curriculum in force in schools. The collected data of graph interpretation given a score of 1, if it is answered correctly and score 0, if it is answered incorrectly. Table 1 shows the question distribution of graph interpretation.

**Table 1. Indicators of graph interpretation instrument**

(The framework was adopted form Beichner R. J, et al [5])

| No. | Indicator                                                                 | Items |
|-----|---------------------------------------------------------------------------|-------|
| 1.  | Identification graph from data                                           | 16, 17, 18, 19, 20 |
| 2.  | Determine variable independent and variable dependent from data into the graph | 14, 15 |
| 3.  | Determine data from range variable                                       | 2     |
| 4.  | Determine variable name on the coordinates (X, Y)                        | 4, 9, 10 |
| 5.  | Determine data (X, Y) on graph                                           | 5, 11 |
| 6.  | Prediction data between to measure data on graph                          | 1, 13 |
| 7.  | Determine extrapolation from measure data on graph                       | 14    |
| 8.  | Determine relation between variable on graph                             | 3, 7, 8, 12 |

The example question in this research is question 10 as shown in Figure 2. This question is of interest because there is a large gap in the proportion of correct answer on both the test. The answer choice of males and females can tell us about their different graph interpretation.
10. Five objects move according to the following acceleration versus time graphs. Which has the smallest change in velocity during the three-second interval?

![Graphs](image)

Answer: A

Figure 2. Question 10 of the test of Understanding Graph Kinematics (TUG-K)

2.4. Data Analysis

One of the features of the Rasch model is that it produces a map that illustrates the ability of students/respondents and the distribution of the difficulty level of questions with the same scale. In this research we analyzed using the Rasch Model with Winsteps 4.4.3 software so we can see the examination by students gender (male and female students) for each test item. The output tables of analysing step used in this study are the Summary Statistics and Variable (Wright) Map. The summary output contains student reliability, item reliability, and Cronbach alpha (KR-20). Student reliability shows consistency of students answer. The criteria for individual suitability are shown by outfit mean square (MNSQ) and outfit Z-standard (ZSTD) with .5 < MNSQ < 1.5 being the acceptance value for MNSQ and -2.00 < ZSTD < +2.0 being the acceptance value for ZSTD [12]. For see examination students by gender we used the output off Person-Item DIF so we can compare female students and male students in graph interpretation.

3. Result and Discussion

3.1. Instrument Analyzed

The result of the Rasch statistical analysis on instrument analyzed from summary statistics of Winsteps 4.4.3 are shown in Figure 3 displays the value of person reliability .51 and .59, which suggests that the reliability for a person is categorized as “sufficient”. In the meantime, person measure .70 shows that the average ability of students is fair than the item difficulty. The Cronbach alpha value of .54 falls to “bad” category. The outfit mean-square value of 1.20, this value falls into acceptable category, which indicates the excellent conditions for measurement. Moreover, the outfit standardized Z value of .27 is categorized acceptable too, which suggests that the data has a logical estimation.

![Summary Statistics](image)

Figure 3. Summary statistics on Rasch analysis
Another information is that the most difficult question is Q10, Q13, Q11 and Q16 with Q5, Q1, Q18, Q14, Q19, Q7, Q2 and Q20 the easiest question. Item Q10 asks the students about the determine variable name on the coordinates (X, Y), and almost all students fail to answer the question. Further analysis related to person is shown in Figure 4.

Figure 4. Wright map showing the distribution of students’ ability for graph interpretation

From Figure 4 shows graph interpretation scores depicts that student 02F (female student) has the highest ability and student 13M (male student) has the lowest ability. For student 02F logit value is a +3.55 logit, that student can solve the problem correctly as much 17 from 21 question. And we can compare to student 13M, for that student logit value is a -1.64 logit, so that student only answer 8
question correctly from 21 questions. In Rasch model student code started from high ability graph interpretation (02F) headed for low ability (13M).

3.2. Examination students by gender
The result of the Rasch analysis on examination students by gender from DIF output of Winsteps 4.4.3 are shown in Figure 5 is a person-item DIF display. Based on the graph in Figure 5, we can evaluate student achievement on each item. Item Q1 occur bias between the achievement of male students and female students. Item Q1 contain graph identification from data. This question is more easily answered by female students than male students. Although both groups of students are both under 0.0 logit or lower than the average level of difficulty of the questions. Items that are biased in the ability of female and male students are also found in Q2. Although the difference is not too far away, the mastery of the concept of female students is better than that of male students. Q2 contain determine data from range variable. The ability of male and female students is the same in Q3 and Q4. Both of these questions are biased for both gender groups of students. The achievement of male and female students in Q3 and Q4 was higher or was the easiest problem. Problem Q3 contains determine variable name on the coordinates (X, Y). While the Q4 are about determine data (X, Y) on graph. Differences in the ability of male female students also occur in other problems. The ability of male students is higher than female students in the Q6, Q10 until Q13 and Q16. For ability of female students is higher than male students in the Q5, Q7 until Q9, Q14, Q15 and Q18 until Q21.

![Graph item DIF](image)

**Figure 5.** Graph item DIF

Based on previous research [5] students can answer correctly at most 13 items, namely students with number 71 while the smallest students are only able to answer correctly 5 items that are students with number 73. So student high school in Karawang can be more answer the test graph interpretation. Besides that from previous research [5] male students can better answer graph interpretation questions compared to female. This is because male students are more interested in learning science than female students who are more interested in social. But in this research the opposite happened, female students were more able to answer graph interpretation test more than male students, so the reasons for interest in the world of science did not depend on gender.

4. Conclusion
In general, the graph interpretation of high school students with Rasch model have conclusion there are the value of person reliability is categorized as “sufficient”, the person measure shows that the average ability of students is fair than the item difficulty, the outfit mean-square into acceptable category, which
indicates the excellent conditions for measurement, the outfit standardized Z is categorized acceptable too, the most difficult question is Q10, Q13, Q11 and Q16, the easiest question Q5, Q1, Q18, Q14, Q19, Q7, Q2 and Q20, student code started from high ability graph interpretation (02F) headed for low ability (13M) and graph interpretation of gender (male and female student) has a gap on each item question.

5. References
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