Analysis of instruments and mathematical disposition using Rasch model

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Abstract. The purpose of this study is to analyze the instruments and mathematical dispositions of students. The instrument consisted of 22 items of mathematical disposition statements. Instrument testing was conducted on 18 private vocational students consisting of 6 males and 12 females. Analysis of the instruments and students' mathematical dispositions was carried out using the Rasch model. The aspects analyzed consisted of mathematical disposition instruments, students' mathematical disposition abilities, the interaction between the instruments and students' abilities of mathematical dispositions, and instrument quality. The results of the analysis of mathematical disposition instruments show that there are four items of instruments with difficult categories, thirteen items with medium categories, and five items with easy categories. Generally, the ability of students' mathematical disposition is still low, compared to the demands of instrument difficulty. The interaction between instruments and students' mathematical disposition abilities is very good. The consistency of answers from students is good, and the quality of the mathematical disposition instruments is sufficient.

1. Introduction
Student competencies are assessed among others based on students' abilities in cognitive and affective aspects. The study of student attitudes receives attention in mathematics education research [1]. Amado and Carreira conducted a study of student attitudes and problem-solving in learning mathematics [2]. Martino and Zan conducted a study of attitude and student learning achievement in mathematics [3]. One of the topics of study of attitudes that is important to study in mathematics education is students' attitudes towards mathematics, namely mathematical disposition [4-7].

Mathematical disposition is an attitude of students appreciating the usefulness of mathematics in student life, which has curiosity, attention, and interest in learning mathematics, as well as tenacity and confidence in solving mathematical problems [6,8]. Mathematical disposition enables students to see mathematics as a useful way to describe situations, have a tendency to think and act positively [5-7,9]. The mathematical disposition of vocational students can be identified through analysis using the Rasch model. Through Rasch model can find out the quality of instruments and mathematical dispositions of students, as well as the relationship of instrument items and students' mathematical dispositions.

The Rasch model was born from the ideas of Georg Rasch, a mathematician from the University of Copenhagen, Denmark. This model deals with statistical techniques, to assess measurements [10,11]. In this paper, the Rasch model is used to determine the relationship between the level of mathematical disposition instrument items and students' mathematical disposition. The Rasch model uses log-odds...
units (logits) which describe the level of mathematical disposition instrument items and the students' mathematical disposition level. Based on the logit value, it can be concluded that the mathematical disposition of students is influenced by the level of mathematical disposition of students and the level of mathematical disposition instrument items [12-15].

The Rasch model can produce good and accurate measurement instruments, because the Rasch model meets four objective measurement criteria, namely: (a) provides a linear scale with the same interval, (b) provides a more precise estimate, (c) is able to detect inaccurate models, (d) produces replicable measurements [11,15].

2. Method
This study aims to analyze the instrument and mathematical disposition of students using the Rasch model. The instrument used was a mathematical disposition questionnaire of 22 statement items. The instrument was tested on 18 11th grade private vocational students consisting of 6 males and 12 females. The data collected was then analyzed using Winsteps software version 4.4.5. Data analysis is divided into four parts, namely: (a) mathematical disposition instruments; (b) students' mathematical disposition abilities; (c) the interaction between instruments and students' abilities of mathematical disposition; and (d) instrument quality.

3. Result and discussion
The results of the analysis of the instruments and students' mathematical disposition abilities are as follows.

3.1. Mathematical disposition instrument
Analysis of the mathematical disposition instrument is useful for finding out instrument items that are difficult, moderate, or easy for students to agree on. The analysis of mathematical disposition instruments can be done using Table 1 about the logit values of each instrument item. Data were displayed sequentially from the largest logit value to the smallest. Large logit values indicate items of mathematical disposition are difficult to approve, whereas small logit values indicate items of mathematical disposition are easy to approve. If the logit values are the same, then the degree of approving with the statements of mathematical disposition is the same [11,12,14].

| Number | Logit Value | Item | Number | Logit Value | Item |
|--------|-------------|------|--------|-------------|------|
| 1      | 1.08        | D2   | 12     | 0.02        | D21  |
| 2      | 0.73        | D19  | 13     | -0.15       | D4   |
| 3      | 0.67        | D11  | 14     | -0.15       | D12  |
| 4      | 0.61        | D6   | 15     | -0.15       | D22  |
| 5      | 0.48        | D17  | 16     | -0.24       | D1   |
| 6      | 0.48        | D20  | 17     | -0.24       | D18  |
| 7      | 0.41        | D7   | 18     | -0.62       | D8   |
| 8      | 0.33        | D13  | 19     | -0.62       | D9   |
| 9      | 0.26        | D5   | 20     | -0.71       | D15  |
| 10     | 0.10        | D3   | 21     | -1.00       | D10  |
| 11     | 0.02        | D14  | 22     | -1.29       | D16  |

Based on table 1, the most difficult disposition statement item to approve is D2 with a logit value of +1.08 with a total score of 37. The D2 statement is that I believe I can get good skills in mathematics. D16 is the easiest mathematical disposition statement to be approved with a logit value of -1.29 and a total score of 67. D4, D12, D22 are mathematical disposition statements with the same level of approving, with the same logit value of -0.15 and a total score of 0.55.
The data in table 1 has a mean value of 0 and the standard value of the logit deviation is 58. Based on the mean and the standard deviation value, the level of approval of the mathematical disposition statement items can be grouped as in table 2\[16\].

**Table 2.** Classification of mathematical disposition instruments.

| Range                                    | Categories     |
|------------------------------------------|----------------|
| Logit Value > 0.58                       | Difficult      |
| -0.58 ≤ N Logit Value ≤ 0.58             | Moderate       |
| Logit Value < -0.58                      | Easy           |

Based on the categories in table 2, there are four items of mathematical disposition that are difficult for students to approve, namely the items of D2, D6, D11, and D19. There are thirteen moderate categories of mathematical disposition items, and five items are easily approved.

### 3.2. Students' mathematical disposition abilities

Students' mathematical disposition analysis can be used to determine the categories of students' mathematical disposition abilities. The mathematical disposition abilities of 18 students seen in table 3 with the logit value of each student. Data are displayed sequentially from the largest logit value to the smallest. A large logit value indicates a high level of students' mathematical disposition abilities, while a small logit value indicates a low level of student mathematical disposition. If the logit values are the same, this shows the level of students' mathematical disposition abilities is the same\[11,17\].

**Table 3.** Logit value of student mathematical disposition.

| Number | Logit Value | Student | Number | Logit Value | Student |
|--------|-------------|---------|--------|-------------|---------|
| 1      | 0.98        | 05F     | 10     | -0.81       | 03F     |
| 2      | 0.75        | 08M     | 11     | -0.88       | 16F     |
| 3      | 0.36        | 13F     | 12     | -0.88       | 18M     |
| 4      | 0.29        | 09F     | 13     | -1.00       | 04M     |
| 5      | -0.33       | 11M     | 14     | -1.17       | 02F     |
| 6      | -0.48       | 01M     | 15     | -1.17       | 12F     |
| 7      | -0.62       | 06F     | 16     | -1.22       | 07M     |
| 8      | -0.62       | 15F     | 17     | -1.22       | 10F     |
| 9      | -0.62       | 17F     | 18     | -1.22       | 14F     |

Table 3 shows that students who have the highest mathematical disposition are students 05F with a logit value of +0.98. There are three students who have low mathematical disposition namely 7M, 10F, and 14F with a logit value of -1.22. Students 6F, 15F, and 17F have the same logit value of -0.62, this shows the three students have the same level of mathematical disposition abilities.

The data in table 3 have logit mean and logit standard deviation values are -0.55 and 0.68, respectively. The mean data logit value in Table 3 is less than the mean of data logit value in Table 1. This shows that in general students' mathematical disposition abilities are lower than the difficulty level of mathematical disposition instruments. Only four students had mathematical disposition abilities more than the average logit value of mathematical disposition instruments, namely students 05F, 08M, 13F, and 09F. Visually, this situation can be seen in Figure 1. If using the reference in Table 2, there are two students (05F, 08M) who have a logit value of more than 0.58, four students (13F, 09F, 11M, and 01M) who have a logit value between -0.58 and 0.58. The other sixteen students have a logit score of less than -0.58. This shows that in general students' mathematical disposition ability is low. This condition is part of the indication, the low ability of vocational graduates. This situation has an impact on many unemployed of vocational graduates\[14\].

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3.3. Interaction between instruments and students' mathematical disposition abilities

The Rasch model can produce a wright map that illustrates the distribution of students' mathematical disposition abilities and the difficulty level of instrument items with the same scale [6,11]. Figure 1 is a wright map illustrating the distribution of 18 students' mathematical disposition abilities and the difficulty level of 22 instrument items.

![Figure 1. Wright map.](image_url)

The left side of the wright map shows the distribution of mathematical disposition abilities of 18 students from highest to lowest. Students of 05F have the highest mathematical disposition ability among other students with a logit score close to 1. Also, students of 07M, 10F, 14F have the lowest mathematical disposition abilities than other students with logit value below -1 [11]. The right side of the wright map shows the level of instrument items of the mathematical disposition from highest (difficult) to lowest (easy). D2 is the most difficult item with a logit value of 1.08, the means that the probability of all students agreeing to this disposition item is small. There is only one student (i.e. 05F) who agrees to D2. But D16 is the easiest item with logit value -1.29. This means that almost all students agree with this item [18,19]. There are several items with the same difficulty level, for example, D17 and D20. Figure 1 shows that students 01M, 05F, 08M, 09F, 11M, 13F are above D9. This means that item D9 was approved by all six students. This fact is evident from the six-student logit value more than the D9 logit value.

3.4. Instrument analysis

In the Rasch model, instrument analysis can be carried out in more detail in the form of statistical summaries. The statistical summary provides information about the overall quality of student response patterns, the quality of the instruments, and the interaction between students' abilities and instruments [11,15]. Table 4 is a statistical summary of 18 students who filled 22 instruments with a mathematical disposition item.

| Measure       | Mean of Logit Value | Infit MNSQ | Outfit MNSQ | Infit ZSTD | Outfit ZSTD | Reliability | Cronbach's alpha |
|---------------|---------------------|------------|-------------|------------|-------------|--------------|------------------|
| Instrument    | 0                   | 1.02       | 1.05        | -0.16      | -0.06       | 0.7          | 0.82             |
| Student ability | -0.55              | 1.03       | 1.05        | -0.16      | -0.13       | 0.82         |                  |

Table 4 shows that the infit Mean-Square (MNSQ) and outfit MNSQ for students are 1.03 and 1.05 (with an ideal value of 1, meaning that the closer to 1 is the better). The value of infit z-standard (ZSTD) and outfit ZSTD are -0.16 and -0.13 (the ideal value is 0, meaning that the closer to 0 the better). This shows that statistically, the mathematical disposition instrument meets the standards [20,21].
reliability value of instrument items is +0.7, which means that the quality of the instrument is sufficient. Cronbach's alpha value is 0.82 which means that the interaction between students' disposition abilities and instruments is very good. The reliability value of students' mathematical disposition abilities is +0.82. This shows that the consistency of student answers is good [11,19].

4. Conclusion

The results of the analysis of the instruments and students' mathematical disposition abilities show that the majority of mathematical disposition items are in the moderate category. A small number of students have high category and medium category of mathematics disposition abilities. In general students' mathematical disposition ability is low. The interaction between students' mathematical disposition abilities and instruments is very good. Students' answers are generally consistent, and the quality of mathematical disposition instruments is adequate.

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