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ANALYSIS OF STUDENTS' SELF EFFICACY REVIEWED BY GEOMETRIC THINKING LEVELS AND GENDER USING RASCH MODEL

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Abstract

Self-efficacy, geometric thinking levels and gender are important. The Rasch model is an Item-Response Theory (IRT) that provides alternative measurements to assess the quality of the reliable and valid measurement. The study was aimed at obtaining an overview of the analysis of students' self-efficacy reviewed by geometric thinking levels and gender using the Rasch model. The study was set as a one-shot case study type of pre-experimental design that involved students in the third semester of Mathematics Education program consisting of 23 women and 6 men at one university in Indonesia. The study employed two data collection instruments that cover a level of geometric thinking test by the CDASSG Project proposed by Usiskin and a Likert scale questionnaire to see self-efficacy from which the data were then analysed by using Rasch model. The analysis of geometric thinking levels indicated that students' geometric thinking levels are in the first three levels and the results of statistical tests showed that there was a relationship among self-efficacy, gender and geometric thinking levels of students although it was not significant. The measurement results of the Rasch model for checking instruments and the results proved that the items (statements) used were reliable and acceptable for measuring students' self-efficacy.

Keywords: Gender, Geometric thinking levels, Mathematics education, Pre-experimental designs, Rasch models, Self-efficacy.

1. Introduction

Geometry is significant because it has a role in the concepts of algebra, statistics, calculus, astronomy, chemistry and biology [1]. Geometry plays a role in logical thinking [2]. Geometry has a role in critical thinking, visualization ability, reasoning [3]. van Hiele and his wife [4] as Montessori secondary school teachers in the Netherlands were disappointed by their students' low geometric thinking abilities due to the failure of communication between students and teachers. According to their learning, there are three elements, namely: teacher, students and teaching materials. If one of them is problematic, it creates the wrong conditions. The teacher knows about the concept, but his knowledge is different from the student. Thus, the explanation is not understood by students. The teacher needs to identify the geometric thinking level of the student.

Martyanti [5] commented that one of the factors that influence the process and results of learning mathematics is self-belief. One of the self-belief factors is self-efficacy [6]. According to Bandura [7], self-efficacy is defined as people's beliefs about their ability to produce specified levels of performance that affect events that affect their lives. Large differences in gender in mathematics self-efficacy are found, men significantly are more confident than women [8]. Mathematics achievement is found to influence mathematics self-efficacy, which significantly predicts the choice of courses in mathematics [9]. All forms of self-efficacy will be related to academic achievement [10]. Thus, gender in mathematics learning is important since it may be the first to be established as a strong social justice movement in mathematics education [11]. Gender distinctions surely induce physiological distinctions and influence psychological distinctions in learning. Thus, male and female students surely have many distinctions in mathematics learning [12]. Gender dissimilarity at the university has been a solemn tendency [13]. Thus, gender must be the attention of lecturer in the learning process [14].

Lecturers find difficult to observe and assess students in lectures. Instruments must be developed to assess students. Study on instrument testing plays a prominent part in the collecting data. Inferences from the right study can be made from sample researches [15]. The major indicators of the quality of the study instruments are reliability and validity [16]. The Rasch model can determine the reliability and validity of research instruments [17, 18]. The practice of the Rasch model may result in preferable and more right measurement instruments [19]. The advantages of Rasch modelling are being able to provide linear scales at the same interval, predict the missing data, provide estimates that are more precise, detect model inaccuracies and produce measurements that are replicable [20].

The purpose of this study is to analyse the student self-efficacy review from the geometric thinking levels and gender using the Rasch model. Thus, we will discuss, geometric thinking levels, relationships between self-efficacy, gender and geometric thinking levels, instrument self-efficacy and self-efficacy analysis in terms of gender and geometric thinking levels with Rasch models.

2. Method

This study by Usiskin [20] was set as a pre-experimental design that employed a one-shot case study type. The research participants were 29 third semester students of mathematics education programs from Mathematics 3A class that consists of 23 women and 6 men. The participants have attended analytical geometry lectures using a GeoGebra software and its manipulatives where topics about coordinate system, straight line, circle, conic, point in space, plane, straight line in space, surfaces and curves were discussed.

Figure 1 is a manipulative learning system. The first ellipse *A* is a circle manipulative with equation $\frac{x^2}{100}+\frac{y^2}{75}=1$. Second manipulative is the ellipse B with the equation $\frac{x^2}{47}+\frac{y^2}{44}=1$, third, the ellipse *C* with the equation $\frac{x^2}{49}+\frac{y^2}{37}=1$ and last, ellipse *D* which is a special ellipse in the form of the circle with equation $\frac{x^2}{25}+\frac{y^2}{25}=1$. Meanwhile, Fig. 2 is teaching materials about fields in space with GeoGebra software. A line segment connects points (5.2, -1) and (-1.4,5). Find the equation for the sphere whose diameter is the line.

The solutions are: The centre of the sphere is (2,3,2). Thus, radius of sphere is $\sqrt{(5-2)^2+(2-3)^2+(-1-2)^2}=\sqrt{19}$. Then, the equation of the sphere is $(x-2)^2+(y-3)^2+(z-2)^2=19$.

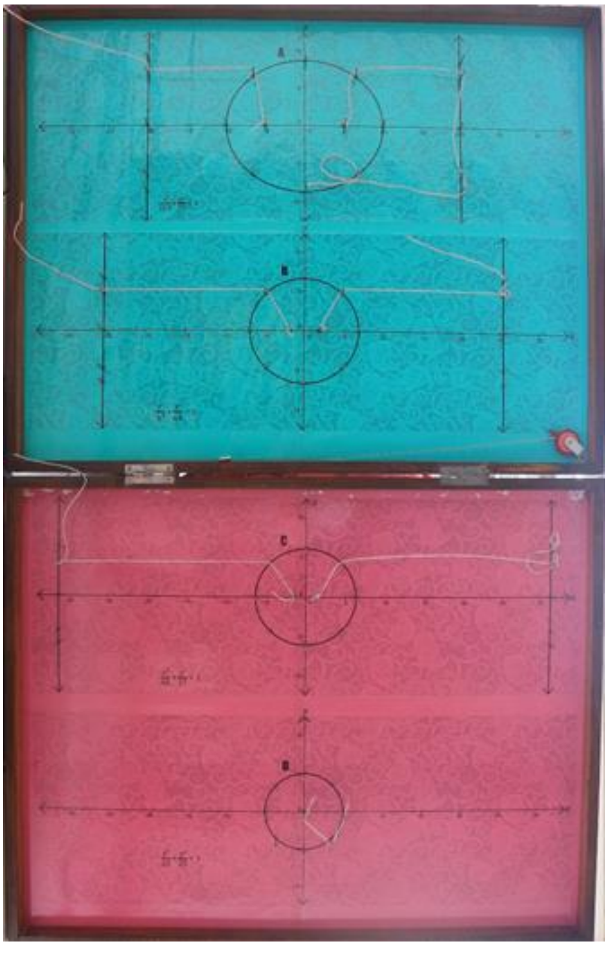

Fig. 1. Circle manipulatives based on definition of conic.

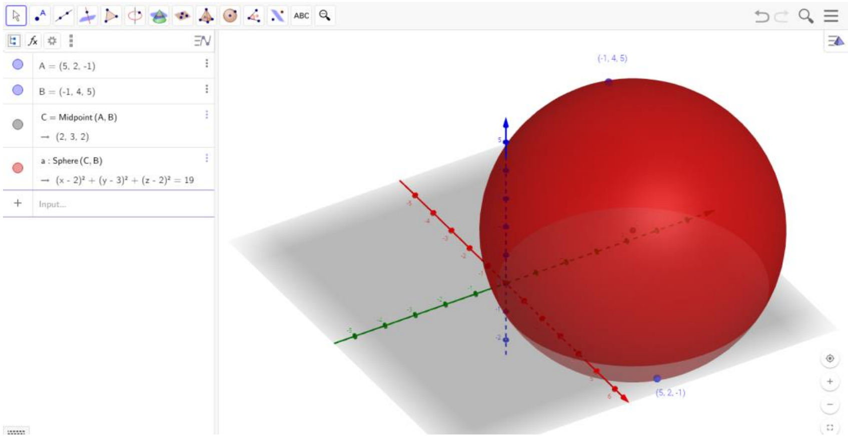

Fig. 2. Teaching materials using GeoGebra software.

Students were given a test of the level of geometric thinking, self-efficacy tests and interviews after students have finished taking analytical geometry courses. The instrument of the geometric thinking abilities of van Hiele's levels of the CDASSG Project was conceived based on previous studies [21], which consists of multiple-choice questions of 25 questions. Each group consists of five questions representing the types of thoughts in each of the five levels of van Hiele. Questions first to fifth represent level zero, questions sixth to tenth represent level 1 and others. Students can pass van Hiele's level if, in each five questions group, they can correctly answer at least three questions. A student cannot be at van Hiele level without having gone through level n-1. If students answer only less than three in each five questions group, students are at the pre-visualization level. The following Table 1 is a description of the levels.

Self-efficacy instruments were Likert scale questionnaire. Self-efficacy indicators were arranged according to the literature [7]. This Likert scale consists of a set of statements whose responses reflect the scale of the subject's attitude towards an object. The statement is positive (favourable) and negative (unfavourable) with four choices of answers without neutral choices, namely strongly agree, agree, disagree and strongly disagree. Neutral choices in the questionnaire were omitted to avoid participants who did not want to read the questionnaire. Furthermore, self-efficacy analysis by geometric thinking levels and gender Wawa then analysed using Rasch model using Minitab software.

Table 1. van Hiele levels.

Level	Explanation
0 (visualization)	Identify, name, compare and operate on geometric figures according to their appearance.
1 (analysis)	Analyse wake in terms of components and relationships between components and find property/rules empirically
2 (deductive informal)	Can associate properties/rules found previously by giving informal arguments.
3 (deductive)	Can prove his theory deductively and determine the relationship between theorems.
4 (rigor)	Can set theorems in different postulate systems and analyse/compare these systems.

3. Results and Discussion

3.1. Geometric thinking levels

The following data in Table 2 shows students' geometric thinking levels. Many female students who are at the level of visualization, analysis and informal deduction, deduction and rigour are 7, 2, 8, 5 and 1, respectively, while male students are 1, 0, 1, 4 and 0. Other students at the pre-visualization level were eight female students and one male student.

This finding revealed that almost all students were in the first three levels. Since the majority of high school courses are taught at level 3, it is not surprising that research has also concentrated on lower levels [22]. Van Hiele also discussed only in the first three levels in particular [23].

Table 2. van Hiele levels for all students.

van Hiele levels	0	1	2	3	4
Number of female students	7	8	2	5	1
Number of male students	1	0	1	4	0

3.2. Relationship between self-efficacy, geometric thinking levels and gender

The analysis of the relationship between self-efficacy, gender and geometric thinking levels using the Minitab software 16. Pearson correlation of average self-efficacy and geometric thinking levels was 0.127 with p-Value = 0.512 > 0.05 ($\alpha = 0.05$) then H_0 was accepted. Pearson correlation of average self-efficacy and gender = -0.146 with p-Value = 0.449 > 0.05 ($\alpha = 0.05$) then H_0 is accepted. The Pearson correlation of gender and geometric thinking levels are -0.245 with p-Value = 0.200 > 0.05 ($\alpha = 0.05$) then H_0 is accepted. This means that there is a relationship among the average self-efficacy, gender and geometric thinking level. However, it was not significant at the level of $\alpha = 5\%$. This finding is similar to previous studies [24] that self-efficacy and the level of geometric thinking have a relationship yet it is weak.

3.3. Instrument of self-efficacy

Data gained were inputted in the mineral software based on the sequence of respondent numbers, gender, geometric thinking levels and questionnaire answers. The following is the results of research and discussion with Rasch models.

Reliability and separation item

According to Table 3, person measurement (+0.82) shows the average self-efficacy. The average value that is more than logit 0.0 shows the tendency of respondents who answer more agree [19]. Cronbach alpha value 0.26 means that reliability is poor [25]. The value of person reliability is 0.21, which means weak. Thus, the consistency of respondents is weak, but the reliability value of 0.91 means that it is very good, informing that the quality of the items is very good [19].

Based on Table 3, the Guttman scalogram pattern shows each student's response in a statement of self-efficacy. The items are sorted according to the easiest statement on the left to the most difficult statement located to the right of the Guttman scalogram. Students were sorted from high self-efficacy students at the top and the weakest at the bottom of the Guttman scalogram. If further checks are given to the scalogram, reliable respondents are 27L2 and 05P2 but other students seem to be inclined to answer the question inconsistently.

Table 3. Guttman scalogram.

Number of respondents	Item 271490351652438	
27	444444444444444	27L2
1	444424445444444	01P3
5	545444444444422	05P2
16	422444422442222	16P0

3.4. Items validity

The validity of items is measured according to Standardized Residual Correlation, Point Measure Correlation (PTMea Corr.), INFIT, and OUTFIT mean square (MNSQ) [18]. Based on Table 4, the MNSQ infit and outfit must be in the interval between 0.60 and 1.40 and the ZSTD infit and outfit values must be in the interval between -2 to +2 [19]. INFIT MNSQ 0.99 and OUTFIT MNSQ 0.95 is closer to 1.00 the better, meaning that conditions are good for measurement [19]. ZSTD INFIT was -0.10 and ZSTD OUTFIT was -0.20. The closer to 0.0 the better means that data has a logical forecast [19]. Grouping respondents H = (4xSEPARATION + 1) / 3 = (4×3.1 + 1) /3 = 4.46. Thus, there are four groups of respondents [21].

Based on Table 5, item I0008 with +1,59 logit shows the most difficult items approved by respondent, while I0002 item with -2,00 logit shows the item most easily approved by respondent [19]. According to Bond and Fox, if the value is shown at PTMea Corr. is positive (+), the item measures the construct. But, if the value obtained is negative (-), the item developed does not measure the construct. It must be discarded or refined because it is too difficult/easy or does not lead to the question (out of focus) [17]. The findings of this study showed that there is one item that has PTMea Corr. negative, while the others are positive. Accordingly, that one item needs to be discarded or revised.

Table 4. Summary of 29 students measurement.

	Total score	Count	Measure	Model error	Infit MNSQ	Infit ZSTD	Outfit MNSQ	Outfit ZSTD
MEAN	52.7	15.0	.82	.34	.99	-.1	.95	-.2
S.D.	3.7	.0	.41	.03	.49	1.2	.60	1.0

REAL RMSE .37 TRUE SD .19 SEPARATION .51 Person RELIABILITY .21
MODEL RMSE .34 TRUE SD .24 SEPARATION .71 Person RELIABILITY .33
S.E. of Person MEAN = .08
Person RAW SCORE-TO-MEASURE CORRELATION = 1.00
CRONBACH ALPHA (KR-20) Person RAW SCORE "TEST" RELIABILITY = .26

Table 5. Item statistics: Order measurement.

Measure	Model S.E.	Infit MNSQ	Infit ZSTD	Outfit MNSQ	Outfit ZSTD	Pt-measure Correlate	Pt-measure Exponential	Item
1.59	.23	.83	-.5	.77	-6	.63	.33	I0008
-2.00	.39	.93	-1	.93	-1	.13	.20	I0002

3.5. Analysis of self-efficacy by geometric thinking levels and gender

Person-Item Distribution Map (PIDM) is concerned on how the persons' ability on the latent trait responds to item difficulty [26]. As shown in Fig. 3, all respondents had positive self-efficacy, except for respondent 16P0. The respondents were 16th female with geometric thinking at level 0 (the lowest self-efficacy and negative). Respondent 27L2, namely 27th male respondent with geometric thinking at level 2, had the highest self-efficacy. The statement that is difficult to approve is statement number 8, namely I0008. The easiest statement to approve is statement number 2, namely I0002.

In Table 6, the following respondent 27L2 is respondents with 27th years old and male gender. Their geometric thinking at level 2 with +1.76 logit indicates respondent who has a tendency to high self-efficacy. Respondent 16P0 was respondents with 16th with the female gender. The geometric thinking at level 0.00 with -0.05 logit indicates respondents who had a low tendency to self-efficacy. The results are in good agreement with reference [19].

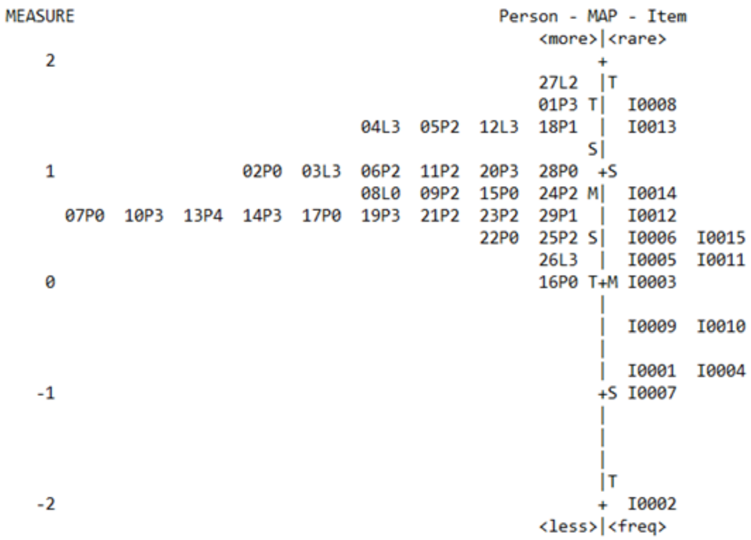

Fig. 3. Person-item measurement.

Table 6. Person statistics: Order measurement.

Measure	Model	Infit		Outfit		Pt-measure		Person
	S.E.	MNSQ	ZSTD	MNSQ	ZSTD	Correlate	Exponential	
1.76	.42	.31	-18	.25	-17	.00	.46	27L2
-.05	.31	1.33	1.0	1.34	.8	.40	.61	16P0

To clarify students who have the highest and the lowest self-efficacy, interviews were conducted. The following are the results of interviews with the 16th respondent with female gender at level 0 (16P0). *I* as an interviewer, researchers and *R* as respondent.

I : What do you think about geometry?

R : Geometry in my opinion is difficult, because it needs to be imagined, illustrated. Whereas, I cannot describe it.
I : Do you like it?
R : Just normal.
I : What about analytic geometry values?
R : Get A
I : How do you not believe in geometry but you can?
R : Even though I consider it is difficult, I study, study material and practice.

The following are the results of interviews of researchers with the twenty-seventh respondent who is a male and is at level 2 (27L2).

I : What do you think about geometry?
R : Most like geometry, because there is a shape.
I : Do you like it?
R : Like it
I : What about analytic geometry values?
R : Get A
I : How do you solve geometry problems?
R : Images, imagined, then resolved in algebra

Figures 4 and 5 are the answers of the two students during the examination with the question: Find the equation of the ball whose diameter is (1, 2, 3) and (2, -3, 1). Different results were obtained.

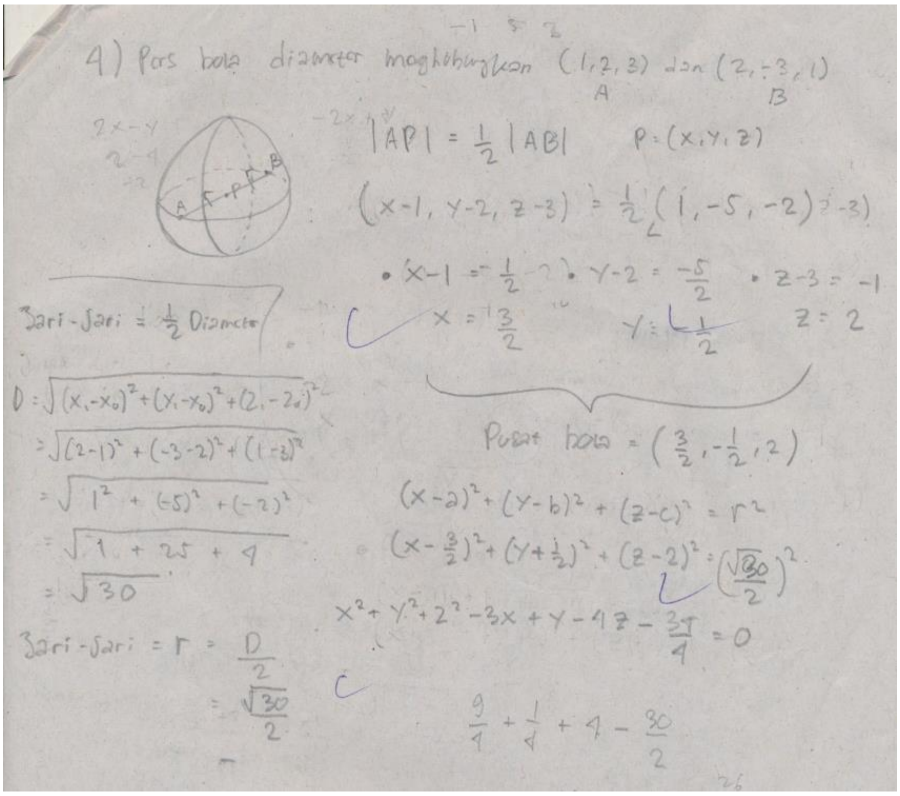

Fig. 4. Respondent's answer (27L2).

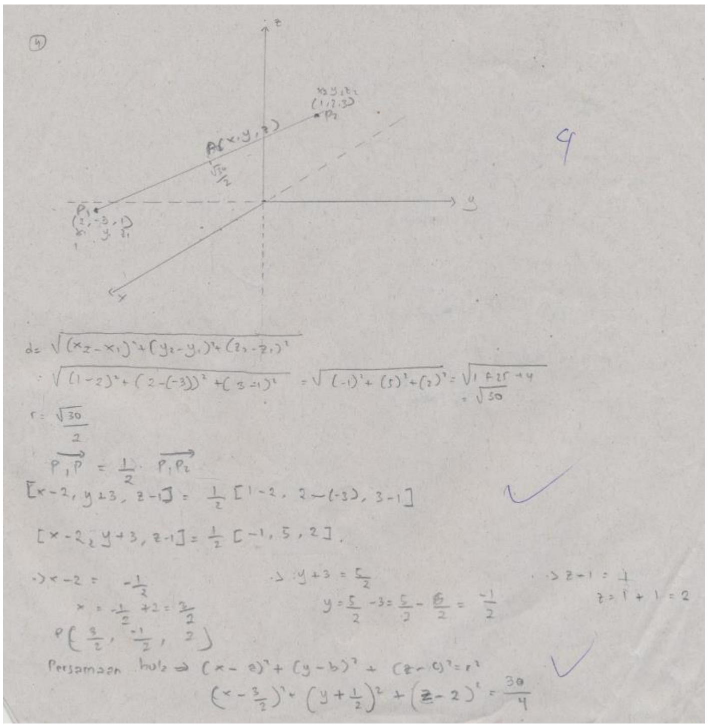

Fig. 5. Respondent's answer (16P0).

From Fig. 5, it is shown that respondent 16P0 could not make the ball picture that was asked. Meanwhile, based on Fig. 4, respondent 27L2 could make geometric drawings. This means that respondents with level 0 and negative self-efficacy cannot visualize and describe geometry. This finding is in accordance with the results of the interview, even though the final results were correctly resolved algebraically because of the concept of analytic geometry (geometry which was solved algebraically). Based on the findings in the study, Haristiani and Firmansyah [27], Haristiani and Aryadi [28] and Aji et al. [29], a model/technique/strategy/approach/ learning media are needed by paying attention to the students' self-efficacy and gender to improve geometric thinking level. Geometric thinking levels analysis is also needed with the instruments compiled by lecturers in the course because students have not been able to think at the van Hiele level which is the same in all fields of geometric content [30].

4. Conclusion

Based on this research, there is a relationship between self-efficacy, gender, and geometric thinking levels although it is not significant. The Rasch model has proven effective in investigating students' self-efficacy reviewed by gender and geometric thinking levels. Through the Rasch model, the reliability and validity of statements from the self-efficacy instruments can also be examined. The Rasch model can result in replicable measurements and tabulate them according to their self-efficacy and unexpected patterns of items and people so that they can be identified. The results of checking self-efficacy instruments proved that the items (statements) used were reliable and acceptable to measure students' self-efficacy.

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