Matching the student’s ability and their math test using Rasch analysis

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Abstract. Individuals who have high abilities than other individuals should have a better chance of accurately performing the exam questions. On the other hand, the quality of the exams provided should be adhering to what the students received during the classroom. This study tried to assess the level of accuracy of students ability in math exams on geometry and fractional subjects. The study covered 20 elementary school students in Southeast Sulawesi. Data were tested using Rasch Model. The results of this study indicated that the overall students ability is below average (-10 logit) and is slighter in order with the given mathematical test. More pointedly, students meet it problematic to work out the image in fractions and determine the circumference of the building area. Instead, students are comfortable to write down the fractional symbols, and arrange the images that have the smallest to the largest angle size. Furthermore, investigations of potential student scandalous action during the exam and the disparities in abilities between male and female students are also interesting points discussed in this article. This finding suggests that classroom teachers review math learning in the classroom as well as the quality of exam questions applied to students.

1. Introduction
Assessment of learning outcomes means to understand the improvement of student learning outcomes in terms of mastering the teaching material that has been learned with the expressed objectives [1]. Bloom has long said that evaluation of student learning must be performed in detail to serve teachers to develop their teaching and learning strategies in the classroom [2]. The issue is the assessment of student learning outcomes is generally deficient because the information presented is not rich, restricted and meaningless [3]. Furthermore, it was recognized that the potential for cheating [4], careless [5], lucky guess [6] and other unfair conduct [7] what students act when the exam takes place is still familiar in schools. Not only that, lately there is a trend for the preparation of test exams not prepared properly by the teacher. It is understood, exam elements may be in accordance with the learning program in school, but the results obtained by students still show unsatisfactory results.
Mathematics is a field of science that is usually looked at a terror for students. Some previous studies reported that mathematics created anxiety in students [8-11]. The content of learning mathematics calls for the ability of students to think simple to complex. Sadly, the measurement of students' abilities is still influenced by the scoring pattern based on Classical Test Theory (CTT) which retains many limitations [12]. On the other hand, Rasch modeling is increasing rapidly [13-15] to reduce the limitations of CTT. Rasch modeling can: (1) estimate students' abilities appropriately, (2) conquered missing data, (3) provide a linear measurement between the structure of the test and students' abilities, (4) detect students' misconceptions in learning, and (5) recognize students who are not serious/cheating during the exam by paying attention to student response patterns.

Matching between students' abilities and math tests aims to map the location of students' abilities with the given test. This is truly important to support teachers recognize their students' abilities so that teachers can be involved in assistance for students in need, where the attention of teachers is believed to foster positive acceptance for students [16] and encourage students to engage in learning [17] and improve their learning achievement in school. This study tries to evaluated the students' actual ability to perform math tests; compare abilities between male and female students, and; identify potential cheating, inaccuracy, and lucky guess on students when the math test takes place.

2. Method
This research involved 20 students at Public Elementary School in Southeast Sulawesi. We got access to evaluate the results of the student's final tests on mathematics course in academic year 2017/2018. Math test are developed into 30 multiple-choice questions with correct or incorrect assessment criteria. Basic competencies controlled through this test are presented in Table 1.

Table 1. Distribution of students basic competencies on mathematics exams.

| No. | Basic Competencies                                                                 | Number of Items                  |
|-----|-----------------------------------------------------------------------------------|----------------------------------|
| 1.  | Determine images in fractions                                                     | 1,2,3,4,5,6                      |
| 2.  | Explain and determine the circumference and area of a square, rectangle, and angle | 7,8,9,10,11,12,13,14             |
| 3.  | Explain the name, type of angle, circumference and flat building area             | 15,16,17,18,19,20                |
| 4.  | Write a fraction, the nature of the square, and the circumference and width of the flat building | 21,22,23,24,25                  |
| 5.  | Explain fraction numbers, flat build, triangle angle and square area              | 26,27,28,29,30                   |

The five competency standards as reported in Table 1 are units that are investigated using Rasch model [18] and complete by WINSTEPS 4.2.0 [19] Rasch Measurement Computer Programs. The research dataset and the results of the analysis can be accessed through https://osf.io/3jbs4/ Open Science Framework [20]. Information of all students in this study is credential; used for research purposes and no conflict of interest by the school, researchers, and/or respondent.

3. Results and Discussions

3.1. Assessing of Test and Student Quality
In this section we evaluate students' abilities and the math test content that was tested. The objective is to analyse and/or pair whether the applied mathematics test is in accordance with the student’s current ability. The results of data analysis indicated that the reliability of the math test was in a satisfying level (α = .84) and was able to maintain adequately stable measurement information (39%). On the other hand, we found the fact that the consistency of the students' answers to the applied mathematics test was still unsatisfactory (α = .66). The average ability of students to did math tests is below average (-.10 logit). Visualization of measurement of students' abilities and math tests as displayed on Figure 1.
Figure 1. Matching student ability and the math test on linear measurement (N=20, I=30)m.

Furthermore, items No. 2, 23, and 24 are the most difficult questions for all students (+3.19 Logit). On the contrary, items no. 26 and no. 28 are items that are the easiest to perform by all students (-4.59 Logit). It is crucial to recognize that the most difficult and easiest items can cut down the quality of measurements produced by the overall math test. Examples of the most difficult and easiest math test items determined by all students as showed in Figure 1 and Figure 2.

Figure 2. The most complicated mathematics test items for students (+3.19 Logit).

Figure 3. The easiest math test items for students (-4.59 Logit).

In relation with the level of students' ability in running on math tests, it is noted that out of 20 students receiving the exam, there are 8 students who had abilities above the average and 12 students had the ability below average. More specifically, 05L students are students with the highest math abilities (+1.95 Logit), whereas 17P students are students with low mathematical abilities (-1.64 Logit).

3.2. Disparities on math abilities between male and female students
In extension to matching the level of students' abilities with the applied mathematics tests, we also investigated differences in mathematical abilities between male and female students.
Table 2. Different Items Functioning (DIF) (N=20, I=30)

| Items | Prob. | Items | Prob. | Items | Prob. | Items | Prob. | Items | Prob. |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1     | .8823 | 6     | .7861 | 11    | .8823 | 16    | .9077 | 21    | .6567 |
| 2     | .6092 | 7     | .7379 | 12    | .5492 | 17    | .9617 | 22    | .3176 |
| 3     | .6127 | 8     | .7508 | 13    | .3118 | 18    | .1440 | 23    | .3165 |
| 4*    | .0471 | 9     | .4139 | 14    | .9099 | 19    | .2194 | 24    | .3165 |
| 5     | .2849 | 10    | .6821 | 15    | .5486 | 20    | .7387 | 25    | .5524 |

* Biases Items to Gender. DIF Item No. 26 and 28 are not calculated.

Table 2 demonstrates that out of 30 items attempted to students it is recognized that Item No. 26 & 28 cannot be measured because all students are capable to deal with both questions. Meanwhile, item No. 4 has a bias towards gender (.0471 ≤ 0.05). In Figure 4 it is undoubtedly that item No. 4 on the one hand is beneficial for female students and is detrimental to male students.

![Figure 4](image_url)

**Figure 4.** Distribution of disparities on math abilities between male and female students.

The discrepancy in the ability of male students on item No. 4 is incompatible; where male students are inferior to female students. This case didn’t take effect to other items in the math test. Another interesting fact in this study is that overall male students have higher mathematical abilities than female students. The difference in ability of male and female students is +0.058 Logit.

### 3.3. Potential of Student Scandalous on Action, Careless, and Lucky Guest During the Math Test

More specifically, to figure out students' ability to math test they work on, we also explore the potential for student on cheating, inadvertence, and lucky guest when the math test is performed. It is realized that students' abilities are not simply located on the scores they have but also determine whether students are prepared to answer questions from the lowest to the highest level of difficulty and analyse the potential for fraud during the exam.

In Figure 5 we adopt the Guttman Scalam to map students and math test items. We arrange the math test items horizontally from the easiest (left) to the most complicated items (right). Furthermore, the order of students' abilities is arranged vertically, that is, from students who have the highest ability (top) to students who have the lowest ability (below).
In Figure 5 it is recognized that Item No. 26 and No. 28 is the easiest item for all students. Conversely, Item No. 24 is the most difficult item for all students. Only 04P students can answer questions No. 24 correctly. If considered more deeply, it is discovered that the distribution of students' answers is inappropriate, or in other words that there are students who are careless or lucky in spelling out of math tests. For example, students with the highest ability (05L) are classified as careless or didn't concentrate on doing math tests, especially Item No. 25. 05L students are incapable to answer Item no. 25 but competent to answer Item No. 5, 14, 29, and 7 which are items that have a higher level of complexity than item No. 25. Another case, 17P students who are students with the lowest ability among all students participating in the exam are classified as students who are lucky guests. It can also be viewed from the response pattern provided by 17P students where she is capable to respond the most difficult questions (Item No. 6), but on the other hand there are quite a lot of collapses in dealing with questions that have a level of complexity below Item No. 6.

This study presents some unusual findings. When the test is carried out, it is known that students generally did not show a consistency and seriousness in working on the math test. Study conducted by Dew, Galassi and Galassi [21] which identifies mathematical anxiety factors as things that affect student's ability to the math test. On the other hand, overall mathematical abilities of male students are better than female students. Study conducted by Spelke [22] notes if male students are stronger at numerical, spatial, and cognitive abilities. Nonetheless, it should be noticed that in some aspects women also have superior abilities than men. Study conducted by Kiefer and Sekaquaptewa [23] reveals that women's performance in mathematics is implicit in certain stereotyped controls, and female students increase their abilities when in suitable conditions. Practically this verifies if there is a relationship between sexes and mathematics learning achievement [24]. Furthermore, special attention needs to be given to the performance of teachers and supervisors when the mathematics exam takes place.

4. Conclusions
An essential point in research in Bau-bau city, Southeast Sulawesi appears that overall students' mathematical capabilities are inadequate. Male students have higher math skills than female students. Another interesting fact was discovered that some students were classified as being careless and lucky
guest while performing on math tests. This finding shows that the teacher calls for to re-evaluate the structure of the mathematics test that is proved to accommodate the students' abilities. Teachers also require to develop the learning process in the classroom so that no students fail to realize the learning material, and arrange remedials for students to establish the subject matter.

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