Diagnosis of students zone proximal development on math design instruction: A Rasch analysis

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Diagnosis of students zone proximal development on math design instruction: A Rasch analysis

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Abstract. Every student could be studying optimally when movements within the zone of proximal development (ZPD). The ZPD among students in a class may diverge. This research tried to analysis of students ZPD in numerical skills on math learning. The study covered 28 third-grade students in elementary school at Padangkeling, Singaraja, Bali. Numerical data understanding of students obtained through the 10 items essays numerical understanding test for elementary school students. Rasch Model analysis is used to examine the properties and quality of numerical understanding tests and to describe each student's ZPD in numeric understanding. This study basically shows that through Rasch analysis it is known that ZPD of students in one class are absolutely different and diverse. There are 11 students identified as having ZPD under the control of the material based on the numerical understanding test so that it requires a special learning program. Four students have ZPD zones that are under some materials requiring more intelligent adult tutors or peers. The other fourth students have ZPD that suited to the comprehensive work in the test, and nine students are students with specific skills who require to look at enrichment in learning program.

1. Introduction

Every student received a zone of capability which is the latest intellectual development of a specific task or called Zone of Proximal Development or ZPD [1]. The ZPD illustrates the distance between the substantial status of student development as determined by the ability to deal with problems independently with the level of potential development determined through the problem-solving ability that the student can perform with the help of adults, or by collaborating and assisted by the intelligent peer [2].

Optimal study can arise when every student advances in the ZPD [2][3]. This indicates that essentially all youngsters have the possible to gain something different or build up all the capacity that exists. In this zone, youngsters will enjoy, challenged, and excited to study. These calls for may be new material, or new activities that youngsters need to comprehend but cannot be achieved separately if they go on not get a social support and services.

There are two risks that can arise if the information given in the classroom is outside the student's ZPD, first, the material is not imposing or very easy, simple and not advance; so it causes students bored and passive to study. Second, the material presented is very high related to the basic competence of the students so that it involves difficulty to understand it. If it goes on like that, students will encounter failure. In reality both conditions are inhibiting learning and can contribute to failure among students [4], especially in students at the elementary level.

Mathematics learning in elementary schools consists of a hierarchy of similar concepts between grades one to a greater grade. The deficiency to realize the theories below leads to failure to learn on subsequent concepts [3]. The well-connected and theoretical knowledge allows learners to remember, connect, transfer and connect between ideas to solve problems in mathematics that require solutions through previously learned strategies [5]. Understanding ZPD helps class instructors to begin learning from what students can do with independent based on past learning to associate existing theory with the learning they can look at with social support [6].

In this study the diagnosis of ZPD students in mathematics learning was done by Rasch Model analysis. Rasch analysis model is an analytical model born from Item Response Theory (IRT) that links between student conditions or responses with instruments items [7][8]. Through the Rasch Model analysis identified the current student's variance of knowledge that describes ZPD in numeric understanding materials.

2. Methods

The study involved 28 students (Male = 13, Female = 15) at SDN 1 Padangkeling, Buleleng, Bali. The mean age of respondents is 8.63 years. The study was conducted by performing a numerical understanding test to the participants. The test is conducted by class instructors in February 2018.

The 10 essay items numerical understanding of the paper and pencil-based test consists of 3 items measuring the ability of students to understanding simple fractions; 4 items measure the ability to compare simple fractions and 3 items of problem-solving abilities related to simple fractions. Students answer each question accompanied by a calculation step or explanation. A score of 0 is given if the student does not answer or answer but is wrong; Score 1 is given if the answer is false but provides an appropriate explanation; a score of 2 is given if answered correctly but does not provide a sufficiently accurate explanation; 3rd chorus is given if the answer correctly and provides an appropriate but incomplete explanation; and a score of 4 is given if answered correctly and indicates the correct reason with complete evidence, principle, formula or calculation. The data were analyzed using Polytomous Rasch analysis perform by WINSTEPS 3.73[8]. The research dataset can be accessed via https://osf.io/v9xj5/ from Open Science Framework [9].

3. Results and Discussions

To achieve the objectives of this study, the report begins with assessing the property and quality of numerical understanding tests. The ZPD analysis of students in numerical understanding is conducted by comparing the student's ability position with the difficulty level of items.

3.1 The Property and Quality of Numerical Understanding Test

The property and quality of numerical understanding test evaluated through assessment of instrument validity and reliability; the rubric test quality; test information function and the differential item function (DIF). In Table 1 summarized the results of the analysis of the quality of numerical understanding test.

Table 1. The Quality of Numerical Understanding Test (N item = 10)

Measured	Values
Item Reliabilities	.98
Item Separation Index	7.03
Mean Outfit MNSQ	1.10
Mean Outfit ZSTD	.2
Mean Measure	.00
Raw variance explained by measures	90.9%
Raw variance unexplained by measures	9.1%

280 Data Points. Log-Likelihood Chi-Square: 331.47 with 240 d.f. p=.00. Data in logit

Table 1 showed that the total amount of data analysis is given as 280 resulted in the Chi-square value of 331.47 with a degree of freedom (d.f) 240 (p = .00). The evaluation of the overall condition of the items based on Outfit MNSQ (1.10) and Outfit ZSTD (.2) which shows that the overall of

measurement where conducted in this study is good and significant[10]. The item reliability (.98) and the item separation index 7.03 indicates the numerical understanding test are excellent instrument quality[11][7]. The test is adequate classifies respondent numerical understanding in seven levels of ability (e.g., special, very high, high, medium, low, very low, special needs).

The mean measure logit value of a items is .00 logit, indicates the level difficulties of items numerical understanding test generally equivalent with the ability students[7]. The last, item dimensionality estimation analysis through principal analysis (PCA) showed that's the raw variance explained by measures is 90.9% in very strong quality[7][8], with the raw variance unexplained by measured only 9.1%.

There was five categories of scores that may be given to respondents based on the rubric in a numerical understanding test in this study (i.e., 0, 1, 2, 3, 4, and 5). To find out whether the five categories on the rubric, in Figure 1 are described the quality of each category of student responses based on the rubric test.

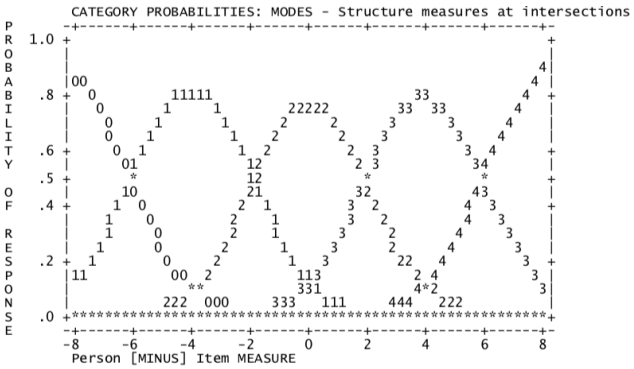

Figure 1. The Quality of Criteria Rubric Scoring

Figure 1 shows that the five assessment criteria in the rubric are above .6 (>60%). This were indicated that all the assessment criteria adequately classify the ability to answer each student on each item. This result is also supported by the graph of test information function (TIF) in Figure 2 which shows that the test is able to provide measurement information to students with low, medium or high ability. Figure 3 shows that there is no gender bias in overall item of numerical understanding test. From overall results of the property and quality instruments show that the numerical understanding test have excellent quality to measure student ability.

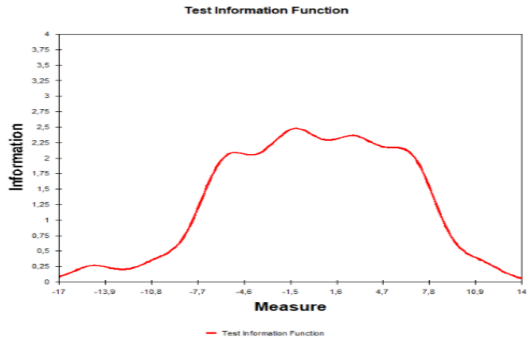

Figure 2. Test Information Function

Figure 3. Difference Item Function

3.2 Diagnosis of Student ZPD in Numerical Understanding Test Based on Rasch Fit Statistics

The ZPD students in numerical understanding are evaluated through (1) person measures, (2) Guttmann Scalogram and (3) Wright Maps (person-item maps).

Table 2 showed students' ability to manage numerical understanding tests is above average (+.55 logit > 0.00 logit). In other words, most students are able to deal with the tests properly and correctly. Consistency of students is also acceptable; as well as the interaction between students and items (α = 0.98)[7][10].

Table 2. The Summarizes Quality of Person in Performing Numerical Understanding Test (N = 28)

Measured	Values
Person Reliabilities	.98
Cronbach Alpha (KR-20)	.98
Person Separation Index	6.82
Mean Outfit MNSQ	1.10
Mean Outfit ZSTD	.2
Mean Measure	.55
Raw variance explained by measures	90.9%
Raw variance unexplained by measures	9.1%

Data in logit.

The description of each student's ability to complete each item of a numerical understanding test in greater detail is shown in Figure 4, it can be seen that overall all students show a reasonable response to each item. In the sense that no students have the possibility of doing lucky guess or cheating on each other.

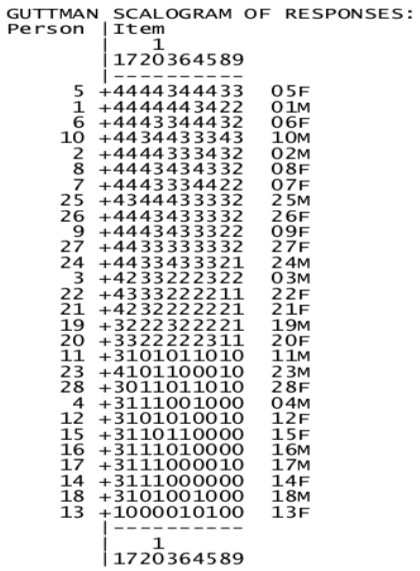

Figure 4. Guttmann Scalogram of Students Responses on Numerical Understanding Test

The first item (recognizing simple fractions) is the easiest item, while item 9 (solving problems related to simple fractions) is the most difficult. The student with code 05F is the student with the highest ability, able to answer all the items correctly, although on the question of number 8 and 9 (both about solving problems related to simple fractions) is not able to give explanation of the complete answer. While students with the 13F code are the students who have the lowest ability, not even provide answers to most items test. In Wright Maps (person-item map) in Figure 5 is presented more clearly the condition of each student's ability to the numerical understanding test material.

Figure 5 shows that 10 numerical comprehension test items can give an idea of the very unique variations of each student's ZPD. There are 11 students who need special attention in this class. Students with 13F, 04M, 12F, 15F, 16M, 14F, 18M, 17M, 11M, 23M and 28M are students who are only capable of mastering independently the material measured in item 1 (introduction of simple fractions 1).

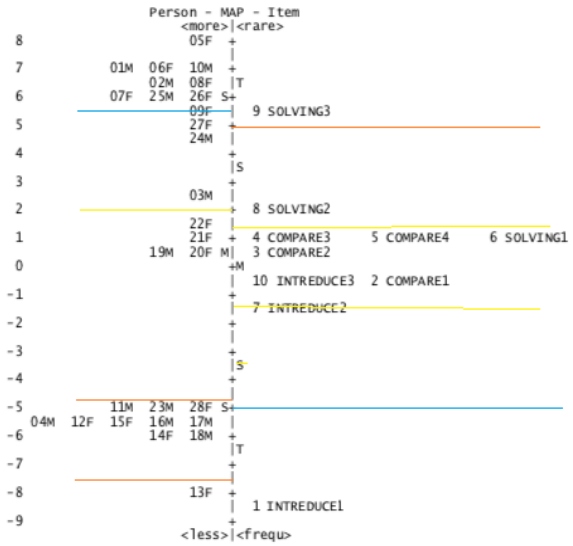

Figure 5. The Wright Map of the Analysis of the 28 Respondents to the 10 Numerical Understanding Test

The closest zone to these students is related to item 7 (the introduction of simple fractions 2) that can be solved if the assistance of adults or other students is more competent. While the subject matter on the other 8 items is a subject matter that is outside the ZPD zone 13F students. Even with the cooperation or guidance of their peers for now, these children will have difficulty completing the subject matter outside the ZPD zone. Related to these conditions, special learning programs are needed for these children. If forced to follow learning with materials that are matched according to the ability of friends in the classroom, they can experience frustration and failure in academic [2][3][4]. Specifically, a child with code13F is likely to be a slow-learning student, needs to be more thoroughly diagnosed to know the child's mental state so as to determine a more appropriate relief effort.

The other four students (19M, 20F, 21F, and 22F) can be referred to as students who are at the level of the ash zone ZPD. They are able to independently master the material associated with item 10 (the introduction of fractions 3), 2 (comparing simple numbers 1), and 7 (recognizing simple fractions 2). The four student learning zones today are the material associated with item 3 (comparing simple fractions 2), item 4 (comparing simple 3 fractions), item 5 (comparing simple 3 fractions) and item 6 (solving problems related to simple numbers 1). They are children who can still follow classical learning in class with help or discussions with adults or colleagues to complete material related to the item. While item 1 (recognizing simple fractions 1) is the material outside (below) their ZPD zone. Similarly, items 8 and 9 (both related to problem-solving materials related to simple fractions) are currently outside their ZPD zone.

The next four students (03M, 24M, 27F, 09F) are students who have the ZPD zone best suited to the overall material in the test. They are capable of mastering all items, except items 9 that require help from others. And 9 other students, especially students with code 05F are excellent students. Nevertheless, they are also students who are prone to learning failure, boredom and lazy to learn when teachers are unable to present new material enrichment and challenging new methods in this numerical understanding material. They need special learning programs, such as enrichment programs and special mentoring.

The results of this ZPD analysis can be valuable information for teachers in developing and developing lesson plans. Teachers can design learning by starting from what most students can do independently based on their existing knowledge and then proceed with the knowledge they can get with help. As students continue to practice, they can perform certain tasks independently in activities previously done with help. The shift that learners gain an understanding helps them find ways to try problems they cannot solve even with the help [3][6].

4. Conclusions

This study shows that (1) the property and quality 10 item numerical understanding test is an adequate measure of student ability based on the ideal measurement model, (2) there is an item of test that can be correctly answered by all students who are the lowest zone of student ability class and one other test item that can only be solved independently by some students only or is the upper zone of the students' knowledge in that class, and (3) ZPD analysis of 28 students in the mastery of numerical understanding material in the mathematics lesson based on 10 items test indicates the existence a unique variation of ZPD zone in each child, there is a predicted student who is slow learning, 10 others also require special learning program, 4 students need adult tutor or more intelligent peers, 4 other students have ZPD zone that best fit the whole material in the test, and 9 students are students who have special ability that needs to get enrichment learning program. The results of this study provide valuable information for teachers to apply preliminary assessments in designing and developing regular education programs in the classroom as well as special education programs for children with special needs or special abilities in learning.

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References

[1] Belmont J M 1989 Cognitive strategies and strategic learning: The socio-instructional approach. *Am. Psychol.* **44** 142–8
[2] Vygotsky L 1987 Zone of proximal development *Mind in society: The development of higher psychological processes* vol 5291 (Harvard University Press Cambridge, MA) p 157
[3] Siyepu S 2013 The zone of proximal development in the learning of mathematics *South African J. Educ.* **33**
[4] Chaiklin S 2003 The zone of proximal development in Vygotsky's analysis of learning and instruction *Vygotsky's educational theory in cultural context* vol 1, ed Alex Kozulin, B Gindis, V S Ageyev and S M M Is (Cambridge, UK: Cambridge University Press.) pp 39–64
[5] Stylianides A J and Stylianides G J 2007 Learning mathematics with understanding: A critical consideration of the learning principle in the principles and standards for school mathematics *Math. Enthus.* **4** 103–14
[6] Siyepu SW 2009 The zone of proximal development in the learning of differential calculus *Proceedings of the 15th Annual Congress of the Association for Mathematics Education of South Africa (AMESA): "Mathematical Knowledge for Teaching"* ed J M State. and A van Biljon (Bloemfontein: University of the Free)
[7] Boone W J, Staver J R and Yale M S 2014 *Rasch Analysis in the Human Sciences* (New York: Springer)
[8] Linacre J M 2011 *A user's guide to WINSTEPS: Rasch model computer programs.* (Chicago: MESA Pres)
[9] Suranata K 2018 Datasets Numerical Understanding Test, 3rd Grades Elementary School *Open Sci. Framew.*
[10] Bond T G and Fox C M 2013 *Applying the Rasch model: Fundamental measurement in the human sciences* (Psychology Press)
[11] Sumintono B and Widhiarso W 2014 *Aplikasi model Rasch untuk penelitian ilmu-ilmu sosial (edisi revisi)* (Trim Komunikata Publishing House)