Exploring of mathematics learning difficulties for students based on heterogeneous group and cognitive style in elementary school

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Abstract. Students with mathematics learning difficulties (MLDs) are heterogeneous. They can grow from various socio-economic groups or based on specific district areas. Cognitive style is likewise worked as a reference to perform grouping of children into certain sub-type MLDs. This study aims at exploring sub-types of MLDs in elementary school students by gender, district area, and cognitive style. This study involved 153 elementary school students in Buleleng Regency, Bali. The students tested their underlying of mathematical abilities for numerical understanding, geometry, and measurement materials. The cognitive style was determined to utilize the Children Embedded Figures Test (CEFT). Data were analyzed using Rasch Model. There are 137 students have a problem with mathematics based on MLDs test. The female students and the dependence on an urban or suburbs school have a most serious problem in mathematics learning. These findings have means for the intervention of MLDs based on specific gender groups, district areas, and cognitive styles.

1. Introduction
Learning disabilities are disorders that involve a series of significant difficulties in the acquisition and use of listening, speaking, reading, writing, excessive or mathematical abilities. These abnormalities are specific to the individual (vary significantly between individuals) and predicted to be associated with dysfunction of the neurons system and brain [1].

The results of the PISA study by the OECD noted that the ability of students in Indonesia is in low level. Successive average score achievement Indonesian students in science, reading and mathematics is ranked 62, 61 and 63 from the 69 countries evaluated. Rating and an average score of Indonesia students ability are not much different with the test results and previous PISA survey in 2012 which also should be in the low mastery of the science, reading and mathematics material [2].

There are various predictable factors contributing to the difficulty of learning the mathematics of the elementary school students, that may include cognitive or learning styles, motivation, self-efficacy, mindfulness, self-regulated learning and so on [3][4]. Differences in teaching quality between rural and urban schools, management systems, school infrastructure and infrastructure conditions, parental care conditions and socioeconomic levels linked to MLDs [5]. Gender also is predicted as a factor related to students’ ability in mathematics [6]. But it seems that a meta-analysis study by Hyde [7] suggests that
differences in mathematical abilities between male and female students are very small, although it is predicted that the problem-solving ability of female students is lower than that of male students.

Field dependence-independence (FDI) is a one of dimension in a cognitive style that for decades predicted to refer to students' academic success in the fields of language, mathematics, science and other fields [8][9][10]. The FDI represent the individual differences in the use of cognitive processes such as thinking proses, remember, problem-solving, analytical, critical thinking, and information processing [9]. Analytical ability in analyzing and problem-solving is closely related to students' abilities in mathematics [11]. Insufficient attention was devoted to exploring how the effect of the FDI with mathematics learning difficulties of students in elementary schools.

2. Methods

2.1. Participants

Subjects of the study consisted 153 of third-grade elementary schools students at Buleleng Regency, Bali. Four schools where is an urban school (n = 91 students) and four other is suburbs schools (n = 62). The mean of age respondents of this study is 8.53 years, consists of 74 male and 79 female students.

2.2. Procedures

The implementation of the test in this study was conducted in February 2018. On the first stage, participants completed 24 items of Children Embedded Figures Test (CEFT) for 25 minutes. The second stage on the second day, they answered 24 MLDs test items with 80 minutes. All tests are paper and pencil based test format. The tests were conducted by the class instructors.

2.3. Measuring

The 24 items of CEFT were administered to measure the cognitive force on the FDI dimension in each participant. Students who scored higher (> 12) were expressed as the field independence, while those with lower scores (≤ 12) were field dependence [12]. The 24 items of MLDs test in the form of multiple choice were prepared by classroom teachers based on three competency standards (SK) namely (1) numerical understanding (SK 3); (2) geometry (SK 4); and (3) measurement materials (SK 5). Students choose one of four alternative answers provided (ABCD); a score of 1 is given for each correct answer and score 0 for the wrong answer.

2.4. Data Analysis

The results of the data collection were analysed using dichotomous Rasch analysis perform by WINSTEPS 3.73 [13]. This research dataset can be accessed via osf.io/5spd9 from Open Science Framework [14].

3. Results and Discussions

To accomplish the objectives on this research, the report is driven out in three stages: (1) identification of respondents' cognitive style based on FDI, (2) assessing the properties and quality of the MLDs test through assessment of the reliability of the instrument and the validation of respondents and items; and (3) differential item functioning (DIF) assessment by gender (male and female); district (urban and suburbs); and FDI style.

3.1. The Cognitive Styles

The result CEFT from 153 participants shows that 72 (47.1%) students is independence and 81 (52.9%) dependence; 39 the male participants (52.7%) is independence and 35 (47.3%) is dependence; 33 (41.8%) the female participants is independence and 46 (58.2%) is dependence. The comparison of styles based on school district area (urban school n = 91, suburbs n = 62) showed that 43 (47.2%) of students from urban school is independence and 48 (52.8%) is dependence; 29 (46.8%) of suburbs participants is independence and 33 (53.2%) is dependence.
3.2. The Property and Quality of MLDs Test

Evaluation of properties and quality MLDs test in the recent study conducted by some estimates, (1) the reliability and separation index, (2) construct validity, and (3) the fit and misfit item and person [15]. In Table 1, the summary statistics of respondent and items are presented.

**Table 1. Summary of Statistics Respondents and Item (N item= 24)**

| Measured                        | Values | Measured                        | Values |
|---------------------------------|--------|---------------------------------|--------|
| Item Reliabilities              | .82    | Person Reliabilities            | .42    |
| Item Separation Index           | 2.12   | Person Separation Index         | .83    |
| Item Mean Outfit MNSQ           | .99    | Person Mean Outfit MNSQ         | .99    |
| Item Mean Infit MNSQ            | 1.00   | Person Mean Infit MNSQ          | .99    |
| Item Mean Outfit ZSTD           | .00    | Person Mean Infit ZSTD          | .00    |
| Item Mean Infit ZSTD            | .00    | Person Mean Measure             | -.01   |
| Item Separation Index           |        | Raw variance explained by measures | 21.6%  |
| Item Mean Measure               |        | Cronbach Alpha person raw score | .70    |
| Raw variance unexplained by measures | 78.4% | "test" reliability              |        |

3672 Data Points. Log-Likelihood Chi-Square: 4112.90 with 3500 d.f. p=.00. Data in logit.

The total amount of data analysis in Table 1 that is given as 3672 resulted in the Chi-square value of 4112.90 with a degree of freedom (d.f) 3500 (p = .00), which shows the overall measurement is good and significant [14][16]. The evaluation of MLDs instruments based on the overall condition of the items indicated that the MNSQ 1.0 and MNSQ Outfit .99 inflation rates (expansion value 1.0); while the value of Inflation ZSTD and Outfit ZSTD .00 (value of expansion .00).

The reliability item (.82) with Cronbach alpha (.70), indicates that the overall instrument is of sufficiently good quality [15][16]. The average logit value of an item is .00 logit, this indicates that the items in the MLDs test generally have a level of difficulty equivalent to the level of student ability. This means that all items in these MLDs are in the student’s ability zone [15][16]. And the unidimensionality estimation analysis through principal component analysis (PCA) showed raw variance described with a size of 21.6% greater than the minimum unidimensionality requirement (20%), but the quality remained at a poor level < 50% [13].

The value of Infit MNSQ and Outfit MNZQ both item and person is .99 (the expectation is 1.0) were indicates the student’s responses pattern to the instrument as a whole in the good category. The ZSTD and ZSTD Outfit value of both the item and the person (.00 logit) is in accordance with the expected value (expectation .00) which basically indicates that the overall pattern of the respondent's answers tends to conform to the ideal model. However, the overall reliability of the respondents is quite low (.41 logit) which indicates that the consistency of students' answers to the instrument is in the weak category [15][16]. These results indicate the need for further assessment of each item and persons to identify misfit items and persons.

The fit and misfit both every items and every students responses is evaluated by using criteria MNSQ Outfit (+.5 <MNSQ < +1.5), ZSTD outfit (-2.0 < ZSTD < +2.0), and Pt Measure Corr value. (+.4 < Pt Measure Corr. <+.85) [15][16]. The evaluation showed that all of MLDs test items (n = 24) qualified as items that fit the ideal measurement model. Examination shows that overall MLDs test items (n = 24) qualify as fit items. Different results are shown from the assessment of responses that indicate some misfit responses as shown in Table 2.

**Table 2** showed there are four students have indicate a misfit or out layer responses (i.e., students with code 009FKI, 010MKD, 013FKI and 101MLD) who have Outfit ZSTD value < 2.0 and Pt Measure Corr is negative. These results indicate the misfit students who give answers that are not the congruence with the fit model. Further Misfit Person Analysis is completed by checking the arrangement of answers (Scalogram) obtained from the test results. The pattern of responses from four misfit students is shown by Guttman Scalogram in Table 3.
Table 2. Person Misfit (N = 4 from 153 Students)

| Student Code | Outfit MNSQ | Outfit ZSTD | Pt Measure Corr | Student Code | Outfit MNSQ | Outfit ZSTD | Pt Measure Corr |
|--------------|-------------|-------------|----------------|--------------|-------------|-------------|----------------|
| 009FKI       | 1.44        | 2.6         | -.61           | 013FKI       | 1.53        | 1.2         | -.33           |
| 010MKD       | 1.27        | 2.1         | -.32           | 101MLD       | 1.20        | 2.1         | -.20           |

Note: M= male, F= female; K= urban (kota), L= suburbs (luar kota); D= dependence, I= independence. Data in logit.

Table 3 explained the quality of test items from the left is the easiest to the most difficult on the right. The response pattern of the four students shown in Table 3 on the Guttman Scalogram in line with the earlier assessment shows a misfit response to the ideal model. For example, the student 010MKD cannot answer an easier item (on the left) but do for more difficult items, including the hardest item (on the right). This pattern of response is predicting as a lucky guess of answers. In addition, the response patterns of the student 010MKD are closely like the student 009FKI, is suspected of cheating each other. It is strong to argue that four such students are the misfit and should be excluded in the analysis.

Table 3. Summary of Guttman Scalogram Based on Original Responses (n = 4 from 153)

| Students | Items Number |
|----------|--------------|
| 010MKD   | +1 2 11211111 211 22 |
| 101MLD   | +01100100010110111110 |
| 009FKI   | +000001111110101101111101 |
| 013FKI   | +00011000000000001101111101 |

The item separation index score is presented in Table 1 is 2.12. If calculated by the formulation $H = [(4 \times \text{separation}) + 1] / 3)$ [16][17] the value $H = 3$. The result is adequate to separate the students’ math abilities into three groups, i.e., high, medium and low ability. The distribution of the abilities of students based on three groups can be shown in Figure 1.

Figure 1. Students Mathematics Ability Map (n= 149 from 153)
Figure 1 shows that the students 002MKD have the highest mathematical abilities based on the MLDs tests. There are six students who have a high ability (i.e., students 002MKD, 060MKI, 135MLD, 039FKD, 072FKD, and 145MLI). The other six students have a moderate ability (i.e., students 030MKD, 047FKI, 074FKD, 078MKI, 112MLI, and 139MLI). There are 137 students indicate as a student’s students who have difficulty learning math. Their ability is lower than eleven items test on MLDs test (as shown in Figure 1). The students 075FKD and 144FLD are the students with most serious difficulty on math.

3.3. The Gender, District, and Cognitive Style Effect to MLDs

To evaluate the learning difficulties of mathematics based on respondent characteristics that include gender, district and FDI dimension in this study using differential item functioning (DIF) assessment. Items having probability values below 5% (< .5) are expressed as items that have a biased [16][18]. The description of the bias condition on the items can also be seen in Figure 2, 3, 4 and 5.

Figure 2 shows that the male students better than female students in the numerical understanding (measured by items N3 and N6); and the geometry (N9 and N16). Meanwhile, female students are better than male students on measurement materials (N21). Figure 3 shows the students from suburbs better than the urban students on the numerical understanding (N6), but not in geometry (N9).

Figure 4 showed that the independence students do the better ability for numerical understanding (N6) than the dependence students. Meanwhile, the interesting information about the comparison of the characteristics of the students in answering the MLDs test can be obtained in Figure 5. The male students and the independence from urban and suburbs school (MKI, MLI) have a better ability for numerical understanding (N6) than others. The female students from urban and the dependence (FKD) have a serious difficulty to the numerical understanding.
4. Conclusions
This study shows that (1) the quality and properties of the 24 items MLDs test is adequate, (2) there was 149 from 153 students who have compatibility with the measurement model, (3) there are six students who have a high ability in answering MLDs test, another six students on an average ability, and 137 students have a problem with math, (4) there are differences ability of students on math based on gender, district and FDI cognitive styles, and (5) the female students and the dependence from an urban or suburbs school have the most serious mathematics learning difficulties. The results of this study become a reference for math learning program or remedial in elementary schools.

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References
[1] Lou H C, Henriksen L and Bruhn P 1990 Focal cerebral dysfunction in developmental learning disabilities The Lancet 335 8–11
[2] OECD 2016 OECD Programme For International Student Assesment (PISA) Result From PISA 2015 Indonesia: Country Note
[3] Akbari M, Arjomandnia A A, Afrooz G and Kamkari K 2014 The influence of mindfulness on self-regulation of students with dyscalculia Advances in Environmental Biology 942–947
[4] Schunk D H 1991 Self-efficacy and academic motivation Educational psychologist 26 207-231
[5] Acharya B R 2017 Factors Affecting Difficulties in Learning Mathematics by Mathematics Learners International Journal of Elementary Education 6 8–15
[6] Permatasari H R and Wahyudin W 2017 Gender : Its relation to Mathematical Creative Thinking Skill Gender : Its relation to Mathematical Creative Thinking Skill Journal of Physics: Conference Series PAPER vol 895(IOP Publishing)
[7] Hyde J S, Fennema E and Lamon S J 1990 Gender differences in mathematics performance: a meta-analysis. Psychological bulletin 107 139
[8] Witkin H A, Moore C A, Goodenough D R and Cox P W 1977 Field-dependent and field-independent cognitive styles and their educational implications Review of educational research 47 1–64
[9] Saracho O N 1997 Teachers and students cognitive styles in early childhood education (London: Bergin & Garvey)
[10] Nicolaou A A and Xistouri X 2011 Field dependence/independence cognitive style and problem posing: an investigation with sixth grade students Educational Psychology 31 611–27
[11] Lavy I and Shriki A 2010 Engaging in problem posing activities in a dynamic geometry setting and the development of prospective teachers’ mathematical knowledge The Journal of Mathematical Behavior 29 11–24
[12] Witkin H A, Oltman P K, Raskin E and Karp S A 1971 Manual for embedded figures test, children’s embedded figures test, and group embedded figures test (Palo Alto, Calif: Consulting Psychologists Press, Inc)
[13] Linacre J M 2011 A user’s guide to WINSTEPS: Rasch model computer programs. (Chicago: MESA Pres)
[14] Suranata K 2018 Datasets of RASCH analysis: Mathematics learning difficulties
[15] Boone W J, Staver J R and Yale M S 2014 A Rasch rating scale analysis (step I): Reading data and running an analysis Rasch analysis in the human sciences (New York: Springer)
[16] Bond T G and Fox C 2007 Applying the Rasch Model. Fundamental measurement in the Human Sciences (New Jersey: Lawrence Erlbaum Associates, Publishers)
[17] Nazlinda A and Lim B K 2013 Parallel Circuit Conceptual Understanding Test (PCCUT) Procedia - Social and Behavioral Sciences 90 431–40
[18] Tennant A and Pallant J F 2007 DIF matters: A practical approach to test if differential item functioning makes a difference Rasch Measurement Transactions 20 1082–1084