Journal of Education and Learning (EduLearn)
Vol.12, No.3, August 2018, pp. 382~391
ISSN: 2089-9823 DOI: 10.11591/edulearn.v12i3.7343

Developing Assessment Instrument as a Mathematical Power Measurement

Imam Kusmaryono[1], Hardi Suyitno[2], Dwijanto[3], Nur Karomah Dwidayati[4]
[1] Department of Mathematics Education, Sultan Agung Islamic University, Indonesia
[2,3,4] Department of Mathematics Education, Semarang State University, Indonesia

Article Info

Article history:

Received Sep 19, 2017
Revised Apr 23, 2018
Accepted Jun 2, 2018

Keywords:

Instrument development
Assessment
Mathematical power

ABSTRACT

This was a field research (literature review and exploration) with descriptive quantitative approach. This study aims: (1) to develop a model (scheme) to assess mathematical power, (2) to test the validity of instruments of mathematical power assessment, and (3) to developa valid and reliable test and non-test instrument prototypes as a mathematical power measurement. The research instruments consist of 4 items of essay test, 20 sheets of observation on investigative activities, and 20 items of questionnaires. Validity test was conducted through constructions built up from 3 aspects of mathematical power ability. Result of instrument analysis showed that: (1) the *r* of instrument test = 0.947, meaning that the instrument is reliable, (2) the *r* of activity observation sheets = 0.912, meaning that the instrument is reliable, and (3) the *r* of questionnaires = 0.770, meaning that the questionnaire is reliable on 0.05 significance level. This study concludes: (a) the steps in the model (scheme) of mathematical power assessment may be used as a reference for assessing mathematical power, (b) test and non-test instruments are valid and reliable, and (c) prototypes of test and non-test instruments may be used as a measurement in mathematical power assessment

Corresponding Author:

Imam Kusmaryono,
Department of Mathematics Education,
Sultan Agung Islamic University, Indonesia,
Kaligawe Raya KM.4, Genuk Semarang 50112, Semarang, Indonesia.
Email: kusmaryono@unissula.ac.id

1. INTRODUCTION

Mathematics is a way and means of thinking. Meanwhile, mathematics learning process is basically a mental process in which students are trained to think (mathematically) and obtain knowledge, skill and attitude shaping [1]. Mathematical thinking process is a core process of mathematic activity in order to apply general thinking ways [2].

The process of learning mathematics is considered as an active process of acquiring knowledge. It refers to a process in which teachers take role to help students acquire new knowledge and restructure old knowledge and so on, rather than as a process in which students passively adopt certain mathematical content and acquire comprehensive knowledge [3]. Considering this active process, surely mathematical thinking ability is a dynamic and comprehensive activity including *doing mathematics* [4]. Furthermore, to think mathematically it should engage *mathematical power*.

After reviewing some literatures [5-8], *mathematical power* is defined as student ability to use mathematics knowledge in non-routine problem solving, by digging deep into it and estimation, logical reasoning (*reasoning*); communicating mathematical ideas (*communication*); and connecting the ideas in mathematics or toother disciplines (*connection*) in order to encourage confidence and mathematical disposition [4]. Meanwhile, reasoning, communication and connection are components of mathematical power [8].

National Council of Teachers of Mathematics (NCTM) in the affirmation of *"Vision of Mathematical Power for All"*, argued that problem-centered learning instructions for all students by emphasizing on mathematical power development for all students and mathematical power should become the integral parts of curriculum [5]. This is reaffirmed in content standard of Indonesian elementary and high school curriculum 2013, stating that learning competence for mathematics is to have a trust on mathematical power and mathematics usability, which are formed by learning experiences [9].

Many researches about mathematical power ability have been published, generally concluding that student mathematical power on aspects of communication, connection and reasoning ability is still very low [6], [3], [8]. It is because of inappropriate usage on learning model and on choosing assessment. Students' mathematical power assessment should be in wide scoupe and include all aspects (cognitive, psychomotor, and affective). Mathematical power assessment could not be considered as a separated and isolated competence assessment [6]. Although one of mathematics knowledge aspects might be more emphasized than the other in a certain assessment, it should be clear that mathematical power includes all aspects of mathematics knowledge and its integration.

The latest survey results from OECD PISA in 2015, Indonesia is still in the bottom group that is ranked 69 out of 76 countries surveyed [10]. The aspects surveyed by PISA in mathematics and science were the abilities of understanding, problem solving, reasoning, and communication. Apparently, the tests developed by PISA contains ability aspects of mathematical power. Based on PISA survey's ranking in 2015, it could be interpreted that mathematical power ability of Junior High School students in Indonesia is still low.

Referring to some researches conducted by experts and the result of OECD PISA survey, it is suggested that test questions created by teachers should be under SOLO Taxonomy guidance based on grade level. The questions should be non-routine problem-solving questions for the sake of mathematical power development. According to the experts, teaching based on problem solving on one hand could contribute to greater student thinking activities, which in turn showed greater activities during the class [11],[12]. On the other hand, students' problem solving ability became a measurement for students' achievement in learning mathematics [12].

One of recommended learning approaches to improve mathematical power ability is investigation-based learning. By investigation, students could learn actively and explore mathematics tasks, and possibly a logical solution might be acquired [13]. In short, a learning activity with investigation approach has improved reasoning, communication and connection ability; while these three are the main components of mathematical power [8].

Reviewing based on cognitive aspects of mathematical power and Structure of the Observed Learning Outcomes (SOLO) Taxonomy, many of mathematics test questions composed by teachers independently or in mathematics teachers' forum still focus on routine issues and have not accommodated the development and improvement of mathematical power and SOLO Taxonomy characteristics based on grade level. Therefore, there has been a contradiction between program target and evaluation target. Besides, it is clear that assessment is an integral part of learning process as well as a crucial part in improving the effectiveness of learning [2].

Structure of the Observed Learning Outcomes (SOLO) Taxonomy is a hierarchial model which is suitable for measuring subject learning result in different grades for all kinds of tasks [14-16]. SOLO Taxonomy classifiesthe ability of students' responses to problems into 5 different hierarchical levels: *pre-structural, uni-structural, multi-structural, relational* and *extended abstract*. When an assessment is conducted in SOLO Taxonomy, the pre-structural level must be excluded from the thinking level, because at that stage there is usually no opinion about the topic to learn, or the proposed ideas are irrelevant [15].

According to the experts [16], some criteria that could be used to determine whether a test question includes to *uni-structural, multi-structural, relational* or *extended abstract* are as follows:

a. A question with *Unistructural* criteria has all information that could be instantly used to obtain a solution.
b. A question with *Multistructural* criteria would implicitly need a formula to obtain a solution usingtwo or more information and separated from what is in the question.
c. A question with *Relational* criteria provides all information but could not be instantly used to obtain a solution. The solution is by connecting information provided using general principle or formula to acquire new information. Then, based on the new information, solution would be obtained as the final answer.

d. A question with *Extended Abstract* criteria provides all information or data, but could not be instantly used to acquire final solution. The final solution could be obtained after synthesizing the new information.

Mathematics learning has much greater effort than just helping students to acquire problem solving skill and strategy. Furthermore, teacher should attempt to develop positive disposition to learn mathematics – aspects which have long-term effects in every things starting from students' trust on mathematics [17] [18], [19], including if mathematics would be their career choice or not [20]. Mathematical power assessment should consider student mathematical disposition level in mathematics learning.

Based on experts' findings (previous researches), it can be seen that mathematics learning in schools has not succeeded significantly in improving mathematical power. It is because the learning model, assessment form and assessment instruments have not been properly compiled according to mathematical power indicators and SOLO taxonomy characteristic level. Therefore, it is necessary to emerge a new formula that is an appropriate assessment model and test and non-test instruments to measure mathematical power.

Model to Assess Mathematical Powerwas fundamentally developed by the authors [6] based on portfolio assessment. Author [6] had developed a model to assess mathematical power, by conducting a test based on mathematical power indicators. However, the test is in the form of multiple choices, and then it is critisized as multiple choice tests which are quite inappropriate and considered not to be able to represent the real mathematical power ability of students. Furthermore, in this research, mathematical power test is developed in form of essays. On the other hand, NCTM document (1989) suggested a shift in assessment practice that is to assess students' mathematical power entirely; not only from the facts of isolated knowledge and skills [4, 21].

Assessment model developed in this research is a means to collect data in order to assess or measure mathematical power level of students based on grade level. This assessment model could evaluate cognitive, psychomotor and affective characteristic aspects, so that the measurement result could represent the progress of their mathematical power. The model of mathematical power assessment is made into this following scheme as presented in Figure 1.

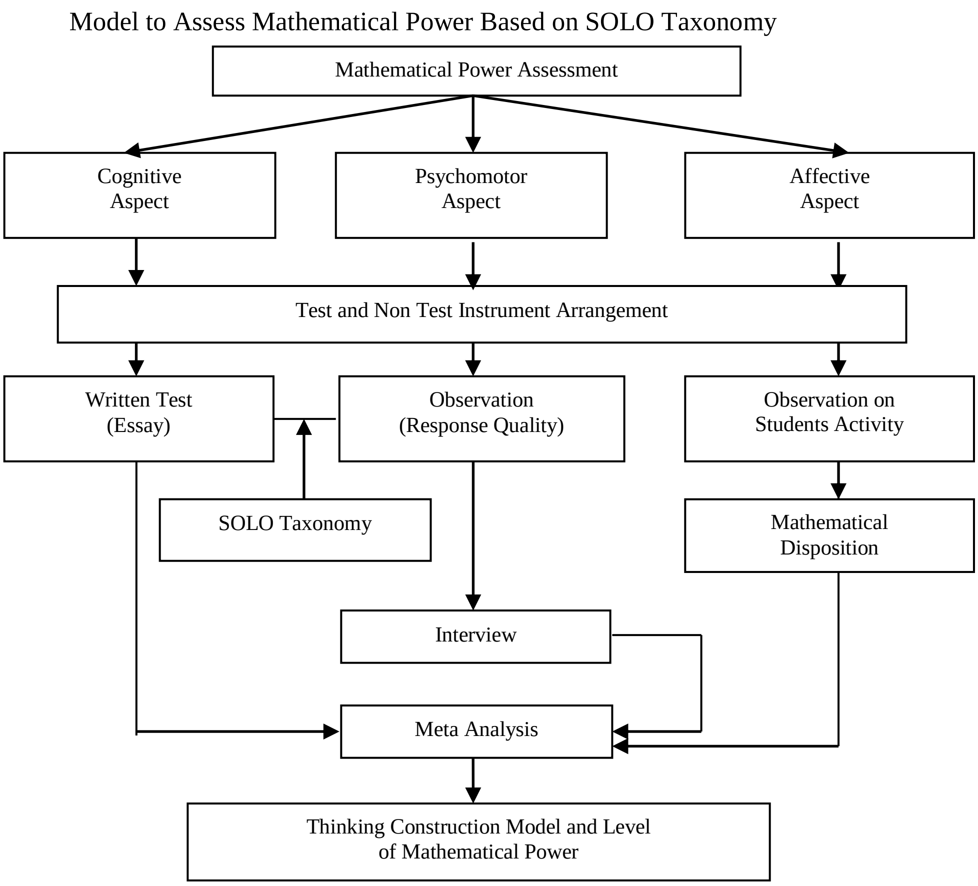


Figure 1. Scheme of Mathematical Power Assessment Model

Referring to the scheme of mathematical power assessment model based on the SOLO Taxonomy as illustrated in Figure 1, this assessment model which will be implemented in schools should follow the following steps: (1) determining the learning objectives, (2) determining the material according to the grade level, (3)) preparing the learning instruments (syllabus and lesson plan) and learning media, (4) preparing the research instrument i.e. test instrument (essay writing test) compiled based on mathematical power ability and SOLO Taxonomy level and non-test instruments (student activity observation sheets and interview guidance books), (5) managing mathematics learning by applying learning models and approaches which can improve and develop students' mathematical skills, e.g group investigation, discovery learning, inquiry, problem based learning and other similar models, (6) observing student activities in learning, (7) conducting essay writing tests, (8) conducting observation on students' answer sheet to obtain data of students' response quality (9) conducting in-depth interviews on selected subjects (students) with purposive snowball sampling technique, (10) recording, analyzing and describing interview results, (11) conducting a meta-analysis that is combining and discussing the research result between quantitative and qualitative data, and (12) drawing conclusions so that the level description and students' mathematical thinking construction can be obtained.

2. RESEARCH METHOD

This research used descriptive quantitative approach which was conducted through field research [22]. The subjects of this research were 20 eighth graders in Sultan Agung Islamic Junior High School 4 Semarang, Indonesia. The instruments developed in this research included test instruments (essay items) and non-test instruments (guide book of observation on investigative activities [23] and mathematical disposition questionnaires [17]). Quality of test items was reviewed its validity, reliability, difficulty and discriminating power. Before tested, the test instruments' construction were validated by expert team as the reviewer. Data collection technique was conducted by test, documentation, and observation. Quantitative analysis on the test items was based on the data from the items that had been tested.

The research procedure was conducted by following stages: (1) field (school) observation; (2) determining research samples; (3) arranging research instruments; test instruments (written and essay questions) referring to mathematical power ability and SOLO Taxonomy, and non-test instruments (observation on students activity) which were compiled based on learning activity instruments; (4) research instrument tests i.e. test and non-test instruments; (5) conducting analysis of instrument test result; (6) arranging quantitative description; (7) providing conclusions; and (8) compiling research result report.

The development of mathematical power test instruments was conducted by two phases; arranging test instrument and test instrument validation. These phases arethe improvement of ideas obtained from the author's previous research result [17]. The following is a scheme showing relevant activities for each phase of developing test instruments as mathematical power measurement on Figure 2.

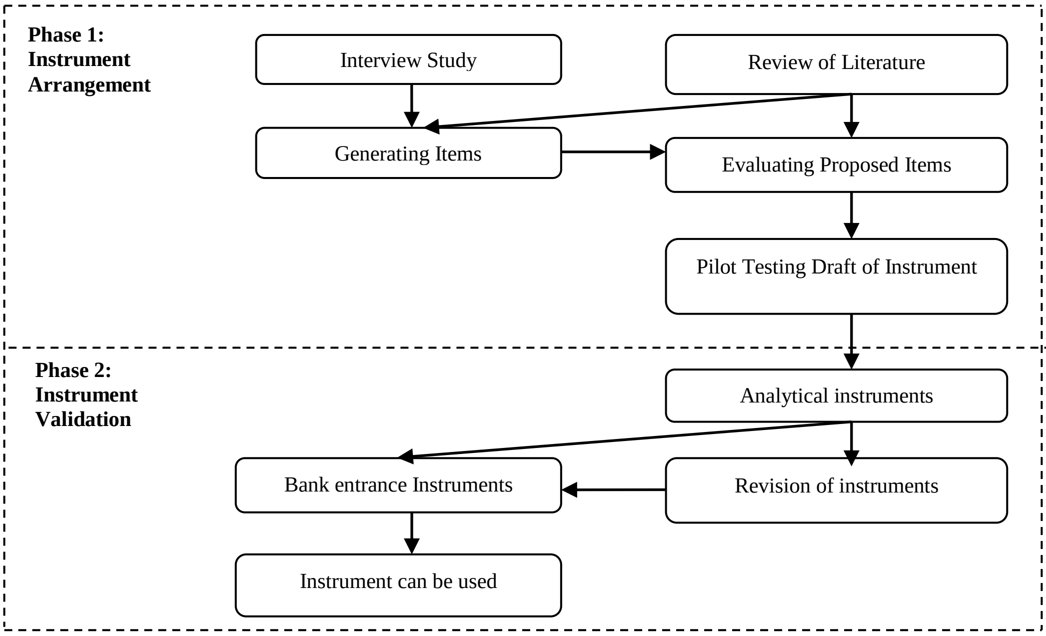


Figure 2. The Phases of Developing Instruments Modified by Beyers [1]

Phase 1. Instrument Arrangement: First phase in preparing mathematical power test items was a field study by conducting observation and interview on mathematics teachers in schools and reviewing literature on mathematical power from various sources. Then, a written test outline was prepared based on preliminary data from the teachers and relevant literature review prepared. While arranging and assembling, test instruments were re-evaluated based on peer and expert suggestion. Finally, the test was ready to be conducted in the field (school).

Phase 2. Instrument Validation: Instrument analysis technique in the first stage i.e. validation test was used to determine the validity level of test items. The formula used to determine the items' validity was *Correlation Product Moment* with variables [24]. The calculation of correlation coeffecient value was consulted to the value of *r product moment* so it could be determined if the correlation is "significant or not".

In second stage, the reliability of test items was calculated by Cronbach's Alpha formula [17]. After the coefficient value of r_{11} was obtained, it was consulted to *r product moment* value. The instruments were said to be reliable if $r_{11} > r_{table}$. The third stage was to analyze the difficulty level of the items. The item instruments were compiled with high difficulty (hard), medium and easy levels with proportionally determined percentages and considering SOLO taxonomy level criteria.

In fourth stage, it was to determine the discriminating power of the items. Discriminating powermeansan ability of a question/item to distinguish between high-ability of students and low-ability of students. To determine the discriminating power of the items, *t* test was used [17]. Value of t_{count}obtained was then consulted to t_{table} value. The test instrument was said to be significant if value of $t_{count} \geq t_{table}$with 5 % of trust level and dk = $(n_1 - n_2)$.

Besides, non-test instruments in forms of learning activity observation sheets (investigative activities) developed from the author's research [21, 23] (see appendix 2) and questionnaires (see appendix 3) were compiled with appropriate indicators [17, 18], and then were tested to students in school. The validity and reliability level of observation result data of student activities and the questionnaires were analyzed as steps conducted in test instruments development phase [4, 25].

3. FINDINGS AND DISCUSSION

After completely compiled by the authorsbefore used as a test, the instrument test should be constructively validated by the expert team consisting of Prof. Dr. Sunandar (reviewer 1), Dr. Rasiman (reviewer 2), and Dr. Isnarto (reviewer 3). The reviewers conducted assessment with a scale of 1 to 5. The assessment result was recorded on validation sheet represented in $\bar{x}$ score. The obtained average score ($\bar{x}$) shows the construction validity test of mathematical power ability implemented in learning.

Based on the results from expert team's validation on test instruments, it was obtained that score for each validation aspect was more than 4.20 and the total average score was 4.37. The results from reviewers' assessment on test construction validity showed a very good category with a percentage of 87.4%. Furthermore, it can be concluded that the test instrument is eligible for the research without any revisions.

Secondly, the instrument of written test consisting of 4 (four) items had been tested to 20 students. The results of the test instrument were recorded and analyzed for each item. The results of the test item validity used product moment correlation formula with 20 students as respondents with 5% significance level. Item number 1 has r_{xy} value = 0.985, number 2 has r_{xy} value = 0.965, number 3 has r_{xy} value = 0.970, and number 4 has r_{xy} value = 0.975.

An item is said to be valid if it showed $r_{xy} > r_{table}$, and if $r_{xy} \leq r_{table}$ then the item was invalid. The Value of r_{table} for N=20 was r_{table} = 0.444. So 100% of the items are said to be valid, meaning that all four items are in line with the criteria and not diverged from the reality. All those four items have valid criteria so they could be used as the test instruments. The items could be instantly used or inserted to items file as archieve. Calculation of realibility coefficient used Alpha formula with 5% significance level. The result showed that the value of r_{table} was 0.444, and r_{11} was 0.974. The Interpretation of realibility coefficient (r_{11}) was on interval $0.70 \leq r_{11} \leq 0.90$ meaning that the instruments has high reliability.

Third stage testing was test item difficulty. The result of the item analysis on the difficulty level of each question is the fourth question has a score between 0.25 to 0.75 with the category "medium" or "quite difficult". There were four or 100% items on 'medium' or 'quite difficult' category. The fourth stage of testing is the test of differentiation of test.

Based on the analysis that has been obtained that, the percentage of items with "satisfactory" discriminatory power was 100% . The items with "satisfactory" discriminating power were those which had discrimination index had 0.20 to 0.39. The result of this study was reinforced by the opinion of experts saying that to determine the discriminatory powerof items was very important, because one of basic guidance to arrange test items was to assume that students in class had different ability [24].

This research used four test items. These fouritems represented the types of questions on aspects of mathematical power ability: reasoning, mathematical connection, and mathematical communication. Criteria of the items used were valid, reliable, having good discriminatory power, and considering the difficulty level of each item. The following table presents the matrix of item qualification used to measure mathematical power based on SOLO taxonomy.

Table 1. Data of Item Qualification Test

No.	Mathematical Power Ability	Characteristics in SOLO Taxonomy	Dificulty Level	Validity	Reliability	Distinguishing Power
1	Mathematical Communication	Extended Abstract	medium	valid	reliable	satisfactory
2	Reasoning	Relational	medium	valid	reliable	satisfactory
3	Mathematical Connection	Realtional	Medium	valid	reliable	satisfactory
4	Reasoning	Extended Abstract	medium	valid	reliable	satisfactory

Table 1 provides data indicating that the four chosen items are qualified to be used as written test instruments to measure student mathematical power. The four items have met the aspects of mathematical power, and SOLO Taxonomy based on the grading level with a good discriminatory power, proportional difficulty level, and also high validity level and realibility level (see appendix 1).

The outline for test items which was developed for four written test items has met mathematical power ability aspects: reasoning, mathematical connection and mathematical communication, and has met characteristics in SOLO Taxonomy based on VIII grade and *intended learning outcomes* (ILO) levels: relational and extended abstract level [16]. Besides, the result of mathematical power ability test indicated that the highest score was 85, the lowest score was 50, and the average score was 67. These result indicated a fairly good category. The validity test was performed by observing construction process of arrangement mathematical power research instruments using outline (see appendix 1). In the outline, all aspects were included.They are 3 aspects of mathematical power ability.

Based on the analysis of observation sheets of activity investigation (appendix 2), all indicators of observation sheets in 20 items are valid andreliable. The reliability test showed the value of r = 0.912. That value was above r_{table} value on 0.444 with 0.05 significance level and sample n = 20. Meanwhile, the analysis on mathemathical disposition quistionnaires (appendix 3) pointed out information that all indicators of mathematical disposition in 20 items were valid and reliable. The reliability test on the questionnaires showed the value of r = 0.770. That value was above r (table) value on 0.444 with 0.05 significance level and sample n = 20. Thus, the reliability aspect of the instruments had completed. Then, a better reliability and validity test was performed in the next stage, on much greater samples and should was socialized.

4. CONCLUSION

Based on the testinthe field andthe analysis of instrument qualification, it could be concluded that: (1) the steps in the model (scheme) to assess mathematical power could be performed well without any obstacles, so it could be said that this assessment scheme model could be used as a tool to assess mathematical power, (2) test and non-test instruments are valid and reliable, and (3) prototypes of test and non-test instruments could be used as a measurement in mathematical power assessment. Result of this study could be instantly used by teachers as well as students at school, or as a reference in the assessment in order to develop mathematical power.Then, if the model (scheme) will be used as a measurement, the author suggest as follows: (a) Assessment on student mathematical power should be performed thoroughly,including cognitive, psychomotor, and affective aspects; (b) Test items should be in forms of non-routine problem solving referring to development of student mathematical power and considering characteristic competence in SOLO Taxonomy based on grade level; (c) Teacher should be optimal as a facilitator in the learning; (d) Usage of instruments in investigative activity observation should be performed repeatedly in order to obtain accurate and representative data.

ACKNOWLEDGEMENTS

A big gratitude is addressed to Prof. Dr. Sunandar (reviewer 1), Dr. Rasiman (reviewer 2), and Dr. Isnarto (reviewer 3) who have been willing to be the reviewers of this research instruments. Next gratitude will be for Mrs. Lana, S.Pd. and Mr. Nur Cholis, S.Ag as teachers in Sultan Agung Islamic Junior High School 4 Semarang, Indonesia, and for all students of Mathematics Education program in Sultan Agung Islamic University who have helped the research.

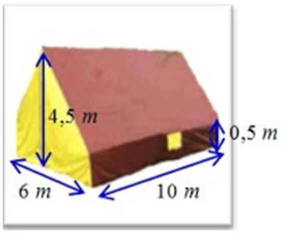
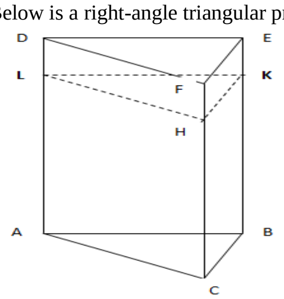
REFERENCES

[1] S. Supandi dan Farikhah, "Analisis butir soal matematika pada instrumen uji coba materi segitiga," *Jurnal Kependidikan*, vol.*44*(1), pp. 26–38, 2014.
[2] NCTM, " *Principles and standards for school mathematics,"Reston. VA:NCTM*, 2000.
[3] I. Kusmaryono, & D. Dwijanto, "Pengaruh Aktivitas Investigasi Terhadap Daya Matematis Siswa Dalam Pembelajaran Matematika Saintifik,"*Jurnal Cakrawala Pendidikan,*Vol. *35*(6), pp. 91–102, 2016. Retrieved from https://journal.uny.ac.id/index.php/cp/browseSearch/sections/view?sectionId=3&searchPage=5
[4] H. Makhfud, & L. Lestari, "Pengembangan Instrumen Penilaian Pendidikan Karakter Terpadu," *Jurnal Paeagogia*, vol. *18*(2), pp. 1–9, 2015.
[5] M. K. Potter, & E. Kustra, "A Primer on Learning Outcomes and the SOLO Taxonomy," in. *Course Design for Constructive Alignment*, (Winter), pp. 1–22, 2012.
[6] BSNP, " Salinan Permendikbud R.I. Nomor 64 Tahun 2013: Tentang Standar Isi Pendidikan Dasar dan Menengah," in *Kemendikbud RI*. Pub. L, 2013 pp. 1–114. Retrieved from https://luk.staff.ugm.ac.id/atur/bsnp/Permendikbud64-2013StandarIsi.pdf
[7] G. O'Neill, & F. Murphy, "*Guide To Taxonomies Of Learning,".in UCD Teaching and Learning: Dublin.* 2010. Retrieved from: *www.ucd.ie/t4cms/ucdtla0034.pdf*
[8] OECD, "PISA 2015 Results in Focus," pp. 1–16, 2016. Retrieved from https://www.oecd.org/pisa/pisa-2015-results-in-focus.pdf
[9] C. A. Feldhaus, "How Pre Service Elementary School Teachers' Mathematical Dispositions are Influenced by School Mathematics,"*American International Journal of Contemporary Research*, Vol. *4*(6), pp. 91–97, 2014.
[10] S.Yeşildere, & E.Türnüklü, "An investigation of the components affecting knowledge construction processes of students with differing mathematical power," *Egitim Arastirmalari - Eurasian Journal of Educational Research*, vol.(31), pp.151–169, 2008.
[11] J. W. Creswell, " *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches,"* SAGE Publications, Inc. 2455 Teller Road Thousand Oaks, California 91320, 2014.
[12] NCTM, "NCTM Evaluation Standard 10: Mathematical Disposition", 1989. Retrieved December 15, 2017, http://webapp1.dlib.indiana.edu/virtual_disk_library/index.cgi/4273355/FID3542/DOCS/ENC2280/28023310.
[13] J. Beyers, "Development and evaluation of an instrument to assess prospective teachers ' dispositions with respect to mathematics," *International Journal of Business and Social Science*, vol. *2*(16), pp. 20–33, 2011.
[14] N. Bikić, S.M. Maričić, & M. Pikula, "The effects of differentiation of content in problem-solving in learning geometry in secondary school," *Eurasia Journal of Mathematics, Science and Technology Education*, vol. *12*(11), pp. 2783–2795. https://doi.org/10.12973/eurasia.2016.02304a
[15] I. Kusmaryono, & H. Suyitno, "The Effect of Constructivist Learning Using Scientific Approach on Mathematical Power and Conceptual Understanding of Students Grade IV," *Journal of Physics: Conference Series*, vol. *693*(1), 2016. https://doi.org/10.1088/1742-6596/693/1/012019
[16] B. Panjaitan,"Karakteristik Metakognisi Siswa," *Jurnal Ilmu Pendidikan*, vol. *21*(1), pp. 19–28, 2015.
[17] D. Zingaro, "*Group Investigation: Theory and Practice*," in *Ontario Institute for Studies in Education, Toronto, Ontario.* Vol. 7, 2008. Retrieved from www.danielzingaro.com/gi.pdf
[18] J. L. Blanco, E. Guerrero, C. Carrasco, & B. Ana, "The Mathematics Enthusiast Cognition and Affect in Mathematics Problem Solving with Prospective Teachers Cognition and Affect in Mathematics Problem Solving with Prospective Teachers," *The Mathematics Enthusiast*, vol. *10*(10), pp. 334–364, 2013.
[19] P. Pilten, "Evaluation of mathematical powers of 5th grade primary school students," *Procedia - Social and Behavioral Sciences*, Vol. *2*(2), pp. 2975–2979, 2010.
[20] J. P. Mairing, "Kemampuan Siswa Kelas VIII SMP Dalam Memecahkan Masalah Matematika Berdasar Tingkat Akreditasi," *Jurnal Kependidikan: Penelitian Inovasi Pembelajaran*, vol. *46*(2), pp. 179–192., 2016. Retrieved from https://journal.uny.ac.id/index.php/jk/article/view/9655/pdf
[21] Y. W. Purnomo, "Pengembangan Desain Pembelajaran Berbasis Penilaian Dalam Pembelajaran Matematika," *Cakrawala Pendidikan*, vol. *2*(2), pp. 115–142, 2015.
[22] S.M. Şahin, & A, Baki, "A new model to assess Mathematical Power," *Procedia - Social and Behavioral Sciences*, vol. *9*, pp. 1368–1372, 2010. https://doi.org/10.1016/j.sbspro.2010.12.336
[23] P. Sullivan, B. Doug, & B. Clarke, "Teaching with tasks for effective mathematics learning : Review Book," *Research in Mathematics Education*, vol. *15*(3), pp. 309–323, 2013.
[24] J. Biggs, & C. Tang, "*Teaching For Quality Learning At University" Fourth Edition*. In *The Society for Research into Higher Education*. Berkshire: McGraw Hill and Open University Press. pp.1-418, 2011.

[25] J.M. Mueller, & A. Hindin, "An analysis of the tactors that influence preservice elementary teachers' developing dispositions about teaching all ahildren," *Issues in Teacher Education*, vol. *20*(1), pp. 17–34, 2011. https://doi.org/10.1080/08878730.2010.489992

Appendix 1:

Table 7. Outline of essay (written) test items

Mathematical Power Ability	Intended Learning Outcomes	Examples of Test Items	Item Number
Mathematical Communication	SOLO 4 Level: *Extended Abstract* Students have the ability to think conceptually, and can generalize in a new area.	In a village, there is a water reservoir with 6 m length, 5 m width and 4 m height. The reservoir is full of clean water and will be distributed to people's homes. There are 40 homes. Each house gets 500 liters of water per day. How many times do the PDAM refill the water in order to meet the needs of 40 homes within 1 month?	1
Reasoning	SOLO 3 Level: *Relational* At this level, students understand how to construct the whole and the relationship between structures that construct the whole.	Abdullah wants to make a tent of fabric with the model and size as shown in the picture below.  What is the area of fabric in square meters (m^2) required by Abdullah to make 1 (one) tent along with its base?	2
Mathematical Connection	SOLO 3 Level: *Relational* At this level, students understand how to construct the whole and the relationship between structures that construct the whole.	The roof of a traditional house is pyramid-shaped. The side of the pyramid is rectangular with 18 m length x 10 m width and 12 m heightIn order to prevent leaks, a large plastic cover should be installed on rooftiles. Each 1 m^2 plastic cover is Rp 5,250.00. What price should be paid to buy that plastic cover for the roof?	3
Reasoning	SOLO 4 Level: *Extended Abstract* Students have the ability to think conceptually, and can generalize in a new area.	Below is a right-angle triangular prism ABC.DEF.  The prism contains water as CH height. Comparison of CH : HF length = 3 : 1. The base ABC has a right angle on C. Length of AC = 8 cm while AB = 10 cm, and height of AD = 16 cm. If the water inside the prism is moved to a cuboid with 16 cm base length, 6 cm base width and 8 cm on its height, what is the length of water inside the cuboid?	*4*

Appendix 2:
Table 8. Checklist sheet of observation on investigative activities

Stages of Investigation	No.	Student Activities	Score					Note
			1	**2**	**3**	**4**	**5**	
Grouping	1	Students listen to explanations and instructions (presentation of problems from teachers)						
	2	Students are excited to join with their group to learn the topics chosen based on their interest						
Planning	3	Students prepare notebooks, resource books, and learning equipments						
	4	Students perform group work assignments						
	5	Students read the lesson/learning resources and work instructions in the worksheet						
Investigation	6	Students take note of important points in the investigation						
	7	Students conduct discussions and question and answer section in the investigation group						
	8	Students help each other understand the lesson						
	9	Students are excited and persistent to do investigation						
	10	Students can illustrateproblem of investigation form of figure, sketch, tables, graphs etc.						
Organizing	11	Students deliver opinions and ideas for presentation materials						
	12	Students actively in discussions make decisions about the subjects to be presented						
	13	Students prepare reports to be presented well						
Presenting	14	Students present topic presentation that was studied before in a coherent and systematic way						
	15	Students perform a presentation of group investigation result with confidence						
	16	Students perform positive attitude and pay attention to the presentation from other groups						
Evaluating	17	Students compile reports which are easily understood by others						
	18	Students record feedback and suggestions from teachers, or friends of other groups						
	19	Students make a summary note / conclusion with their own words						
	20	Students provide suggestions and evaluation on the learning topic and on the effectiveness of experiences in investigative activities.						

Appendix 3:
Table 9. Outline of Questionnaire for Mathematical Disposition

Modes of Mental Functioning	Subcategory of dispositional function	Statement of Questionnaire	Number
Dispositional cognitive function	Connections	I believe that, in mathematics, there is a relationship between topics or lessons each other	1
		I am not able to relate ideas or topics in and across mathematics	11
	Argumentation	I believe that, by correcting or re-examining my work, the result will be more satisfying	2
		I can give a good reason for the result of my task	12
Afektif disposisional	Nature of Mathematics	I do not believe that mathematics consists of systematic concepts or rules or procedures	3
		I am currently solving mathematical problems based on mathematics concepts or procedures	13
	Usefulness	I am convinced that the mathematics I learned is useful for improving school achievement and succeeding future goals	4
		I use mathematics knowledge in everyday problem solving	14
	Worth Whileness	I believe that my mathematics task assessment resultis appropriate and qualified for me	5
		I consider my mathematics achievement to be a valuable experience	15
	Sensibleness	I believe that mathematics consists of ideas that can be interpreted	6
		I communicate mathematical ideas through symbols, tables, graphs, or diagrams to explain mathematical problems	18
	Mathematics Self-Concept	I feel confident that I can develop various ways to solve mathematics problems	7
		I do not care if I do not understand or not good at mathematics	20
	Attitude	I consider that mathematics lessons are not fun to learn	8
		I feel that mathematicsdoes not fulfil my needs	16
	Math Anxiety	I feel anxious when I will have a test or mathematicsexam	9
		I am shy (low self confidence) if my mathematics score is not good	19
Dispositional conative function	Effort/Persistence	When I get to have a difficult mathematical problem, I feel challenged to work hard to find a solution	10
		I seek for and read lessons from other sources to extend my knowledge and understanding on mathematics	17