

# ANALYTICAL DESCRIPTIVE STUDY OF STUDENTS' CRITICAL MATHEMATIC THINKING ABILITY THROUGH GRADED RESPONSE MODEL (GRM)

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## ABSTRACT

Critical mathematic thinking ability is very important to solve daily problems. But in reality, junior high school students' critical mathematic thinking ability is still low. Ability measurement such as measurement of critical mathematic thinking ability cannot be measured through multiple choices test. In that case, an essay test in which graded scoring is used as scoring technique more suitable than multiple choices test. The result of the essay test will be analyzed to describe the already tested ability. There are two approaches in the measurement analysis; classical test theory and item response theory (IRT). The classical test theory has some weaknesses because it only depends on how many the right answers student could achieved. Meanwhile, the IRT technique is more suitable to analyze ability because lies on the pattern of the response and parameter of item test. Graded response models (GRM) is one of the IRT models that analyzed graded response.

The purposes of this research are to know about the result of the item parameter estimation of the test which has been developed by the researcher and to know the result of student's critical mathematic thinking ability parameter estimation through GRM (Graded Response Models). The research is a descriptive quantitative research. The population of this research are 8th grade students of MTs Al-Ishlah Bobos and of SMP N 1 Dukupuntang in the academic year of 2012/2013. Applying purposive sampling method this research took 140 students as a sample, from whom 70 students from MTs Al-Ishlah Bobos and 70 students from SMP N 1 Dukupuntang. Measurement theory used in this research is Item Response Theory (IRT) with the GRM model and the instrument used to collect data is critical mathematic thinking ability test paper.

The result of the item parameter estimation shows that in terms of the item discrimination all four items tested are less good, meanwhile in the terms of item difficulty the results vary. The first item of the test is considered to be easy, the second and the third item of the test is considered to be very difficult, and the last item of the test is considered just difficult. The result of the critical mathematic thinking ability parameter estimation shows that 4,2% of students have very high critical mathematic thinking ability, 16,4% have high critical mathematic thinking ability, 65,7% have mean critical mathematic thinking ability, 13,5% have low critical mathematic thinking ability and there is no single student with very low critical mathematic thinking ability.

Key words : critical mathematic thinking, item of the test parameter, ability parameter, IRT, GRM

## INTRODUCTION

Education is one of the most important things for the progress of a nation. Many people expect that education can give birth to the new generation with high quality by which they can realize the nation's dreams. Education is a learning process, be it formal or not. Mathematics is a science learnt and studied in every level of education, from the lowest up to the highest level of education.

Mathematics is one of the nature sciences. Mathematics is known as mother of science (Kusumaningrum and Saefudin, 2012). Mathematics has an important role in improving thinking ability. According to Sabandar (2008), learning mathematics has close connection with activity, learning process and thinking, because the basic nature of mathematics is a combination of science and human activity. It means that mathematics is about thinking pattern, organizes logic

authentication that uses accurate and clear terminology. Students who learn mathematics are expected to have a mathematical thinking ability.

In term of its depth and complexity there are two types of thinking pattern in mathematics; low order mathematical thinking and high order mathematical thinking (Sumarmo, 2010). Based on Blomm's Taksonomy, knowledge and comprehension are classified as low order thinking, while analysis, synthesis and evaluation are put into the high order thinking (Zohar and Dori, 2003).

Students are in a great need to mathematical thinking ability, especially high order mathematical thinking, because it can help them to solve their daily life problems (Noer, 2009). As such, currently the newest notion in the mathematical learning is armed of developing High Order Thinking Skills (HOTS) for students (Noer, 2009).

High order thinking skills consist of critical, creative, logic and reflective thinking. Some characteristics of the high order thinking skills are tend to be not algorithmic, more complex, the finding many alternative solutions, and involving many criteria, irregularity and self regulation (Zohar and Dori, 2003).

But, in the reality, some mathematic teachers of Junior High School declared that many students do not have good critical mathematic thinking ability. They say that students just use one of information that given by the teacher without do some confirmation whether it can be believe or not. Students also just produce one solution of the problem, they cannot wider their though about the problem and just follow the example that given by the teacher.

Measure one's critical thinking is often to use a special test on a particular subject. The model of the test is usually multiple choice that provides two probably answers for students; true or false. Students cannot freely express their thought. As a matter of fact to measure thinking ability, we need to consider students' reasoning as well their references in answering the question. Thus, an essay test can be used to measure how students take such conclusions (Quelmalz, 1985).

The characteristics of the essay test are different from the multiple choice test in term of scoring technique, time allocation and a number of questions. In the scoring technique the multiple choice test uses a dichotomy score, 1 for the right answer and 0 for the wrong answer. Meanwhile essay test uses polytomous score in which scores must be graded into more than two categories considered to be appropriate with some categories (Budiharti, 2011).

To see the result of the test, we must apply a score test analysis. In the classical test theory, the total score achieved by students is based on how many right answers students set. This technique is very important thing to analyze item test as well as to evaluate students' achievements which usually refers to a sample analysis. Nowadays, a new method of evaluation is Item Response Theory (IRT) particularly for latent variable model. Lord and Novick are the pioneers of the IRT to

evaluate student ability and test item, including item discrimination and the differences of student ability (Matteucci and Stacqualursi, 2006).

Unlike the classical test theory, in which the test scores of the same students may vary from test to test, depending upon the test difficulty, in IRT item parameter calibration is sample-free while student proficiency estimation is item-independent. Test in the IRT, students with same scores cannot be assumed to have the same level in the ability. Instead, the IRT will firstly consider the pattern of the answer given by students before coming to take a conclusion based on the difficulty level of the answered item. So, this test does not depend on the right or wrong model of answering (Chong Ho Yu, 2012).

The Graded Response Models (GRM) is one of the IRT models for the graded scoring. GRM is the first model for graded polytomus data. This model is believed to be the best model and the newest model to the error compared to the other approaches. This model has been used globally in psychology research to measure respondents' ability based on interval scale quisioner (Sukirno and Siengthai, 2010).

From the above mentioned background, this research take the title is "Analytical Descriptive Study of Students' Critical Mathematic Thinking Ability Through Graded Response Models (GRM).

## **METODE DAN SUBJEK PENELITIAN**

### **A. Kind of Research**

The character of this research is descriptive with a quantitative approach. The purpose of this research is to describe and reveal a problem, condition and event it is expected to reveal the fact much comprehensive about students' critical mathematics thinking ability through GRM. Sukardi (2009) says that a descriptive research is a research to describe the research activity. Arikunto (2010) says that a descriptive research is a research type aimed at describing an event or phenomena.

### **B. Population and Sampling Technique**

#### **1. Population**

Target of population in this research are students of MTs Al-Ishlah Bobos, Cirebon and of SMP N 1 Dukupuntang, Cirebon. The used of two school as population in this research is not mean comparing between them. Item Response Theory (IRT) technique needs big size of sample, so this research makes those two schools as target of population. If the researcher makes a comparison between those two schools, it is not the main purpose of this research. While reached of population of this research is 8<sup>th</sup> grade students of MTs Al-Ishlah Bobos, Cirebon and of SMP N 1 Dukupuntang, Cirebon in the academic year of 2012-2013.

## 2. Sampling Technique

Arikunto (2010) says that sample is a part or representative of researched population. In a research, good sample is representative sample, means that the sample can represent the whole population. This research will use purposive sampling technique. Purposive sampling is technique sampling that based on some consideration (Sugiyono, 2012). This research took 70 students from MTs Al-Ishlah Bobos and from SMP N 1 Dukupuntang. Below is the total of the sample students.

## RESULT

### A. Prerequisite Analysis Test

Unidimensional assumption test can be done by factor analysis through software SPSS 19. The result is as follow.

Table 1

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		,559
Bartlett's Test of Sphericity	Approx. Chi-Square	36,963
	df	6
	Sig.	,000

Both KMO and Bartlett tests describe that the KMO value for the critical mathematic thinking ability is 0,559 with a significant value 0,000. It shows that variables (items) of the critical mathematic thinking ability test meet the requirement of implementing the factor analysis. Below are the results of the factor analysis of the critical mathematic thinking ability test.

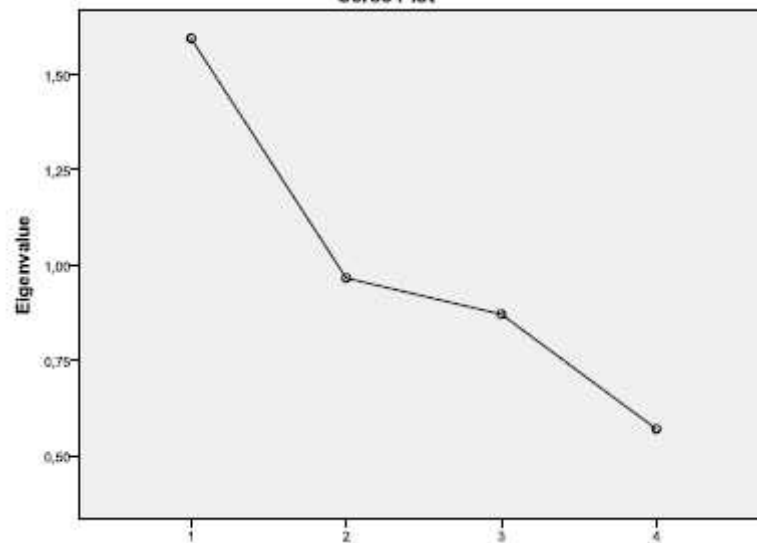
Table 2

Component	Total Variance Explained					
	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	1,594	39,860	39,860	1,594	39,860	39,860
2	,966	24,140	64,000			
3	,870	21,760	85,760			
4	,570	14,240	100,000			

Extraction Method: Principal Component Analysis.

Table 2 shows that there is only one component that has an eigen value more than 1. The first component reaches 1,594. Meanwhile the eigen value for the second component is 0,966, the third component is 0,870, and the last component is 0,570. Thus the first component is more dominant than the other components. It means that the unidimensional assumption is fulfilled as being clearly shown in the scree plot.

Table 3  
The Scree Plot of Factor Analysis of critical Mathematic Thinking Ability



**B. Result of Student Critical Mathematic Thinking Ability**

The mean ability of analysis student ability by Maximum Likelihood method is 0,000 (mean ability) with the standard of deviation is 1,000. This is the table of mean ability and standard of deviation.

Table 4

Mean and Standard of Deviation of Student Ability			
SCORE	MEAN	STANDARD	TOTAL
NAME	DEVIATION		FREQUENCIES
EAP	-0.001	0.446	140.00

Table 4 shows that mean ability of 140 students is -0,001 with the standard of deviation is 0,446. Critical mathematic thinking ability of 140 students be spreads evenly with mean ability dominant. To easier the interpretation of critical mathematic thinking ability the ability categorize based on the estimation of ability parameter below.

Table 5

Chategory of Critical Mathematic Thinking Ability	
Ability Value	Interpretation
2,00 until 3,00	Very high
1,00 until 2,00	High
1,00 until -1,00	Mean
-1,00 until -2,00	Low
-2,00 until -3,00	Very low

1. Student who have very high critical mathematic thinking ability

Critical mathematic thinking ability declared as very high ability if student has ability value among 2,00 until 3,00. The result of ability parameter analysis describe that there is 6 students who have very high critical mathematic thinking ability, they are students with number of respondent 044, 078, 083, 087, 093 and 124. Student with number of respondent 124 is student with the highest critical mathematic thinking ability with ability value 2,6783.

2. Student who have high critical mathematic thinking ability

Critical mathematic thinking ability declared as high ability if student has ability value among 1,00 until 2,00. The result of ability parameter analysis describe that there is 23 students who have high critical mathematic thinking ability, they are students with number of respondent 003, 005, 007, 012, 015, 017, 018, 019, 021, 026, 047, 072, 073, 074, 075, 076, 086, 089, 091, 098, 099, 116, and 129.

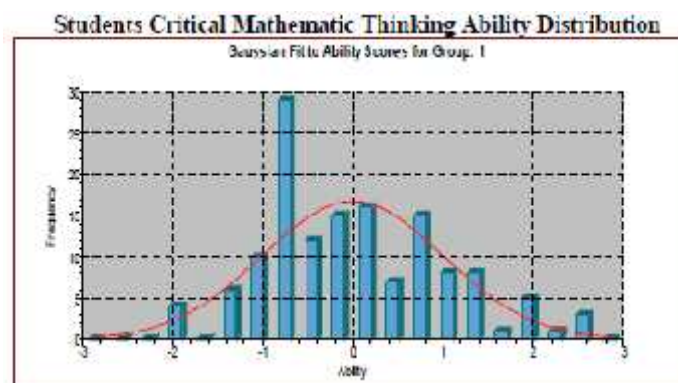
3. Student who have mean critical mathematic thinking ability

Critical mathematic thinking ability declared as low ability if student has ability value among 1,00 until -1,00. The result of ability parameter analysis describe that there is 92 students who have mean critical mathematic thinking ability, they are students with number of respondent 001, 002, 003, 004, 006, 008, 009, 010, 011, 014, 016, 020, 023, 024, 025, 027, 028, 030, 031, 032, 033, 034, 035, 036, 037, 038, 039, 041, 042, 043, 045, 048, 049, 050, 051, 052, 053, 055, 056, 057, 059, 060, 061, 062, 064, 065, 066, 067, 068, 069, 070, 071, 077, 078, 079, 080, 081, 084, 085, 088, 090, 092, 094, 096, 098, 100, 101, 102, 103, 104, 105, 106, 109, 111, 114, 115, 117, 118, 120, 121, 122, 126, 128, 131, 132, 133, 135, 136, 137, 138, 139, and 140.

4. Student who have very low critical mathematics thinking ability

Critical mathematic thinking ability declared as very low ability if student has ability value among -2,00 until -3,00. After analysis, there is no student who declared has very low ability. Below is the histogram of 140 student critical mathematic thinking ability.

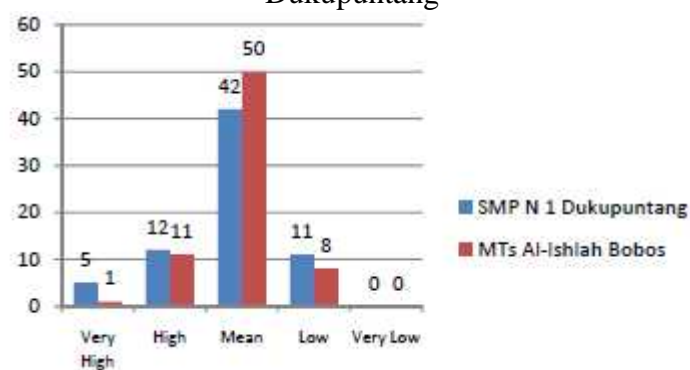
Table 5



Afterwards if we see 70 students of MTs Al-Ishlah Bobos, it just one students who has very high critical mathematic thinking ability. And 11 students have high critical mathematic thinking ability, 50 students have mean critical mathematic thinking ability, and 8 students have low critical mathematic thinking ability. There is no single student of MTs Al-Ishlah Bobos who has very low critical mathematic thinking ability.

Whereas 70 students of SMP N 1 Dukupuntang, 5 students who have very high critical mathematic thinking ability. Then 12 students have high critical mathematic thinking ability, 42 students have mean critical mathematic thinking ability, and 11 students have low critical mathematic thinking ability. There is also no single student of SMP N 1 Dukupuntang who has very low critical mathematic thinking ability. This is the chart of student critical mathematic thinking ability in MTs Al-Ishlah Bobos and SMP N 1 Dukupuntang.

Chart 1  
Student Critical Mathematic Thinking Ability in MTs Al – Ishlah and SMPN 1 Dukupuntang



## DISCUSSION

Curriculum based on competent (Mulyasa, 2002) hoped that Junior High School alumnus has ability to: (1) faith, understand, and carry out the teachings of their religion, (2) understand and carry out their rights and obligation to create and make use of environment responsibility, (3) logically, critically, and creatively thinking, solve problem, and communicate with any media, (4) likes and appreciate art, (5) carry out clean, fresh and healthy life style, (6) participate in livelihood as love reflection and proud of nation and fatherland. The result of research describe that many 8th grade of MTs Al-Ishlah Bobos and SMP N 1 Dukupuntang students have mean critical mathematic thinking ability. Means that students have good enough critical mathematic thinking ability.

Ability to build basic skill aspect has one indicator, it is ability to consider whether the source of the data can be proof or not. This indicator show that student can consider and check out the source of the theory critically. Student does not accept a theory categorically. They will look for about the source of the theory and then consider whether they accept or refuse the theory. Result of

research describe that student critical mathematic thinking ability in this aspect is low. This signed by 60,9% of 164 students cannot answer or give wrong answer (grade 1). But from item difficulty side, the item which representative this aspect declared as very difficult item with item difficulty value 3,295.

Make a conclusion aspect has one indicator, it is ability to make a conclusion from a problem and make a settlement of the problem. Student will collect the source which have correlation with the problem, listen for some opinion about the problem, then student will make a conclusion from those sources. Result of research describe that student critical mathematic thinking ability in this aspect is low. This signed by 68,9% of 164 students cannot answer or give wrong answer (grade 1). But from item difficulty side, the item which representative this aspect declared as very difficult item with item difficulty value 4,186.

Ability to give a systematic explanation, it is ability to identify assumption. Student has ability to identified an assumption, whether the assumption proper to believed or not. Result of the research describe that critical mathematic thinking ability in this aspect is good enough. This signed by 55,5% of 164 students can answer reach grade 2, grade 3, and grade 4, and just 44,5% students cannot answer or give wrong answer (grade 1). But from item difficulty side, the item which representative this aspect declared as difficult item with item difficulty value 1,976.

While arrange strategy and technique aspect has one indicator, it is ability to decide a solution of the problem and write down the solution clearly. Student can decide solution of a problem and write down the solution clearly, student is also write down the reason why they make a conclusion and the solution. Result of the research describe that student critical mathematic thinking ability in this aspect is good. This signed by only 20,7% of students cannot answer or give wrong answer, and the other can answer until grade 2, grade 3, and grade 4. But from item difficulty side, the item which representative this aspect declared as easy item with item difficulty value -0,726.

Then critical mathematic thinking ability of MTs Al-Ishlah Bobos student, many students have low and mean critical mathematic thinking ability. There is 11 students who have high ability and 1 student who have very high ability. While student at SMP N 1 Dukupuntang, many students also have low and mean critical mathematic thinking ability. But SMP N 1 Dukupuntang has 12 students who have high ability and 5 students who have very high ability.

Critical thinking was not nature from born, and cannot develop by itself, but it must trough learning process and exercise (Muijs and Reynolds, 2011). Critical thinking can easy get by someone if the person has high motivation or tendency and ability which judge as characteristic critic thinker. Beside that critical thinking can also influenced by emotion factor on make a conclusion. Rath in (Sudaryanto, 2008) says that one of factor that influence critical thinking



development is interaction between teacher and student. The interaction can be influenced by math teacher competence and method which use to deliver the lesson.

## **CONCLUSIONS**

Referring to the result of the research and discussion above, it is a time to conclude. There are two conclusions:

1. Based on the analysis using GRM, the instrument developed in this research to measure critical mathematic thinking ability is declared as not a good enough instruments because in terms of the item discrimination of all four items of the test are considered to be not good enough. While in term of item difficulty, the item 1 is considered to be easy item, both the item 2 and 3 are considered to be very difficult item, and the item 4 are considered to be difficult item.
2. Based on the analysis using GRM, 65,7% of students have mean critical mathematic thinking ability, only 4,2% students who have very high critical mathematic thinking ability, 16,4% have high critical mathematic thinking ability, and 13,5% have low critical mathematic thinking ability. There is no single student who has very low critical mathematic thinking ability. Furthermore students critical mathematic thinking ability both in the field of building basic skills aspect indicated by the ability to consider whether the source of the data can be proven or not and the ability to make a conclusion aspect indicated by the ability to make a conclusion from a problem or make a settlement of the problem is still low. Yet in the case of item difficulty, two of the four items representing the two above aspects and indicators are considered to be very difficult item. While critical mathematic thinking ability in giving a systematic explanation aspect that is indicated by the ability to identify an assumption is good enough. Yet in the case of item difficulty, one of the four items representing this aspect and indicator is considered to be difficult item. And critical mathematic thinking ability in arrange strategy and technique that indicated by the ability to find problem solving and write it down clearly is good. Yet in the case of item difficulty, one of the four items representing this aspect and indicator is considered to be easy item.

## **SUGGESTIONS**

1. Teachers and other learning instructors since the inception have to pay more attention to the development of their student thinking ability, especially high order thinking ability because thinking ability is very important in daily life.

2. The active participation of parents is also pivoted in improving students thinking ability. Their parent supports could take a form in facilitating their children with all kind of supportive media in order to endorse the development of their children's thinking ability.
3. Students are encouraged to sharpen their high order thinking ability, whether inside or outside schools because high order thinking ability is very useful for daily life.
4. Other researcher to use Item Response Theory (IRT) analysis, in addition to item focus analysis is strongly advised, this analysis technique is also describing parameter estimation which more focus and detail.
5. Finally, it is better for the measurement for thinking ability to use an essay test instrument explore students' answers to know and evaluate how far students' ability is.

### **BIBLIOGRAPHY**

1. Anggrayani, Arie. 2009. *Penerapan Teori Uji Klasik dan Teori Respon Butir Dalam Mengevaluasi Butir Soal. Thesis*. Unpublished. Bogor: Institut Pertanian Bogor
2. Arikunto, Suharsimi. 2010. *Prosedur Penelitian Suatu Pendekatan Praktik*. Jakarta: Rineka Cipta
3. Ariyanti, Melda. 2010. "*Pengaruh Kompetensi Pedagogik Guru Terhadap Prestasi Belajar Maematika Siswa Kelas XI SMA Di Kabupaten Kuningan*". Thesis. Unpublished. Cirebon: IAIN Syekh Nurjati Cirebon
4. Azwar, Saifudin. 2012. *Metode Penelitian*, Yogya: Pustaka Pelajar
5. Browne, M. Neils and Keeley, Stuart M. 2007. *Asking The Right Question; A Guide to Critical Thinking (Eighth Edition)*. New Jearsey: Pearson Prentice Hall
6. Budiharti, Rini. 2011. *Kemampuan Mahasiswa Prodi Fisika Dalam Mengembangkan Test Essay Materi Pembelajaran Fisika Sekolah Menengah*. Thesis. Unpublished. Surabaya: Universitas Negeri Surabaya
7. Cagnone, Silvia and Ricci, Roberto. 2005. *Student Ability Assessment Based on Two IRT Models*. Journal of Methodology.
8. Dawber, T., Rogers, W.T., and Carbonaro, M. 2004. Robustness of Lord's Formulas for Item Difficulty and Discrimination Conversation Between Classical and Item Response Theory. Paper presented at the annual meeting of AERA, the American Education Research Association, April 12, 2004, San Diego, California. PDF copy possibly available via: [www.education.ualberta.ca/educ/psych/crame/research.htm](http://www.education.ualberta.ca/educ/psych/crame/research.htm).
9. Echols, John M. and Shadily, Hasan. 2003. *An English-Indonesian Dictionary*. Jakarta: Gramedia

10. Embretson, Susan E. 1996. *The New Rules of Measurement*. University of Kansas: Psychology Assessment Journal
11. Fisher, Alec. 2009. *Berpikir Kritis; Sebuah Pengantar*. Jakarta: Erlangga
12. Hambleton, Ronald K. and Jones, Russell W. 2005. *An NCME Instructional Module on Comparison of Classical Test Theory and Item Response Theory and Their Applications to Test Development*. Jurnal of University of Massachusetts at Amherst.
13. Hambleton, Ronald K. and Swaminathan, Hariharan. 1985. *Item Response Theory Principles and Applications*. Canada: Published by John Wiley and Sons, Inc.
14. Hassoubah, Zaleha. 2008. *Mengasah Pikiran Kreatif dan Kritis Disertai Ilustrasi dan Latihan*. Bandung: Nuansa
15. Hidayati, Kana. 2002. *Keakuratan Hasil Analisis Butir Menurut Teori Tes Klasik dan Teori Respon Butir Ditinjau dari Ukuran Sampel*. Thesis. Unpublished. Yogyakarta: Universitas Negeri Yogyakarta. <http://bahasa.kemdiknas.go.id>; diunduh pada tanggal 02 November 2012, pukul 20:24
16. Klein, R. B. 2005. *Principles and Practice of Structural Equation Modelling (2nd ed.)*. New York: Guildford Press
17. Kusumaningrum, Maya and Saefudin, Abdul Azis. 2012. *Mengoptimalkan Kemampuan Berpikir Matematika Melalui Pemecahan Masalah Matematika*. Prosiding. ISBN: 978-979-16353-8-7.
18. Lawshe, C. H. 1975. *A Quantitative Approach to Content Validity*. Personnel Psychology Journal
19. Lestari, Sartika. 2012. *Penerapan Generalized Partial Credit Model Dalam Teor Respon Butir Untuk Menduga Kemampuan Hasil Tes Uraian*. Thesis. Unpublished. Bogor: Institut Pertanian Bogor.
20. Marrapodi, Jean. 2003. *Critical Thinking and Creativity; An Overview and Comparison of The Theories*. Paper. Unpublished. Ravenswood Avenue.
21. Matteucci, M. and Stracqualursi, L. 2006. *Student Assessment Via Graded Response Model*. Statistics Journal.
22. Muijs, Daniel and Reynolds, David. 2011. *Effective Teaching: Evidence and Practice*. California: Sage Publication. Available via: [www.amazon.com](http://www.amazon.com)
23. Mulyasa, E. 2002. *Kurikulum Berbasis Kompetensi*. Bandung: Remaja Rosdakarya
24. Noer, Sri Hastuti. 2009. *Peningkatan Kemampuan Berpikir Kritis Matematis Siswa SMP Melalui Pembelajaran Berbasis Masalah*. Prosiding.
25. Ostini, Remo and Nering, Michael L. 2006. *Polytomus Item Response Theory Models*. California: Sage Publications.

26. Pritasari, Ajeng D. C. 2011. "*Upaya Meningkatkan Kemampuan Berpikir Kritis Siswa Kelas XI IPA 2 Sekolah Menengah Atas Negeri 8 Yogyakarta Pada Pembelajaran Matematika Melalui Pembelajaran Kooperatif Tipe Group Investigation (GI)*". Thesis. Unpublished. Yogyakarta: Universitas Negeri Yogyakarta
27. Quelmalz, Edys S. 1985. *Needed: Better Methods for Testing High-Order Thinking Skills*. Educational Leadership Article.
28. Sabandar, J. 2008. *Pembelajaran Matematika Sekolah dan Permasalahan Ketuntasan Belajar Matematika*. Bandung: Universitas Pendidikan Indonesia
29. Samejima, F. 1969. *Estimation of Latent Trait Ability Using a Response Pattern of Graded Scores*. Psychometric Monograph No.17.
30. Sudaryanto. 2008. Pembelajaran Kemampuan Berpikir Kritis. Education Journal. PDF copy possibly available via: <http://www.scribd.com/doc/36173841/Pembelajaran-Kemampuan-Berpikir-Kritis>
31. Sugiyono. 2011. *Metode Penelitian Pendidikan Pendekatan Kuantitatif, Kualitatif, dan R & D*. Bandung: Alfabeta
32. Sukardi. 2009. *Metodologi Penelitian Pendidikan*. Jakarta: PT Bumi Aksara
33. Sukirno and Siengthai. 2010. The Comparison of Graded Response Model and Classical Test Theory in Human Resource Research: A Model Fitness Test, Research and Practice in Human Resource Management. Article. 18(2). PDF copy possibly available via: <http://rphrm.curtin.edu.au/2010/issue2/comparison.html>
34. Sulistyono-Basuki. 2006. *Metode Penelitian*. Jakarta: Wedatama Widya Sastra dan Fakultas Ilmu Pengetahuan Budaya Universitas Indonesia
35. Sumarmo, Utari. 2010. *Berpikir dan Disposisi Matematik: Apa, Mengapa, dan Bagaimana Dikembangkan Pada Peserta Didik*. Jurnal FMIPA UPI
36. Suryabrata, Sumadi. 2011. *Psikologi Pendidikan*. Jakarta: PT Rajagrafindo Persada
37. Susongko, Purwo. 2009. *Perbandingan Keefektifan Bentuk Tes Uraian dan Testlet Dengan Penerapan Graded Response Models (GRM)*. Thesis. Unpublished. Tegal: UPS.
38. Yu, Chong Ho. 2012. *A Simple Guide to the Item Response Theory (IRT) and Rasch Modelling*. Jurnal.
39. Zohar, Anat and Dori, Yehudit J. 2003. *Higher Order Thinking Skills and Low Achieving Students: Are They Mutually Exclusive*. The journal of the learning sciences.