Mathematical Power's Description of Students in Grade 4th Based on The Theory of Constructivism

I. Kusmaryono[1] and H. Suyitno[2]
[1]Sultan Agung Islamic University, Semarang, Indonesia
[2]Mathematics Education Study Program, Postgraduate Program, Semarang State University, Indonesia
[1]Corresponding author: kusmaryono@unissula.ac.id
Phone: +6281575626844

Abstract

Basically every student has math skills called Mathematical Power. Obviously mathematical power which each student has been different, it is influenced by the construction of mathematical knowledge from students. Mathematical Power as a high level of mathematical thinking skills has become the focus of the development of mathematics education in the 21st century. Mathematical power can be developed from the level of children who are very young and the mathematics power has become an important goal of the mathematics learning. This paper discusses the mathematical power description of graders 4th based on the theory of constructivism. A teacher knowing mathematical power of students, it would be useful to plan learning and help students learn optimally.

Key words : mathematical power, constructivism, knowledge, thinking

1. Introduction

Construction of knowledge is mental process of a person's activity or students in finding and changing information obtained, thus forming thorough understanding or interpretation of a knowledge (Bodner, 1986). Construction of knowledge is an active, not a passive process (Ernest, 2004).

According to the constructivist ideology, knowledge is the construction of a person who knows something (schemata). Knowledge can not be transferred from the teacher to others, because each person has his own schemata of what he knows. Formation of knowledge is a cognitive process in which a process of assimilation and accommodation to achieve a balance to form a new schemata. Someone who learns meaningful form of knowledge actively and continuously (Suparno, 1997).

Philosophy of constructivism today has a great influence in mathematics education. Constructivism stream requires that students can actively use constructively ability to adjust to the demands of the development of science and technology. This philosophy prioritizes the role of students in the initiative, it is in line with the general objectives of education namely realization of qualified human resources.

In this globalization, human resource development and superior quality becomes a major challenge that must be realized, in order to be able to compete to gain a better welfare. At the APEC meeting in Tokyo on January 2006, Jan de Lange has talked in detail about the use of mathematics to equip young people for life (Stacey, 2006). The demands of globalization, the development of today's man needs to be focused on the ability of: obtaining and managing information, thinking that involves thinking reasoning, critical, systematic, logical, creative and ability to work together effectively. The thinking skills can be developed through education mathematics .

Learning in the countries on the PISA rankings increasingly focused on higher order thinking. The result of international assessment of the survey conducted by PISA, TIMSS, and PIRLS against Indonesia, we should be able to learn from the success of other countries in preparing their children with the attitudes and the skills needed to face the challenges of the 21st century (Trilling and Fadel, 2009). The best thing is when learning mathematics students should construct knowledge for themselves (Bodner, 1986). The process of building knowledge can only be done by exploration activities, justify, describe, discuss, drawing, investigate, and problem solving (Countryman, 1992).

Mathematics education reform is currently focused on the development of "mathematical power" of each child (National Council of Teachers of Mathematics, 1989), mathematical power can be developed in children are very young. In a case study (Phillips & Anderson, 1993) explained that mathematical power, problem solving, and making sense strongly related to this preschool children. It is also clear that mediation parents - is informed by a variety of perspectives mother, teacher and researcher math class, plays an important role in the development of mathematical power.

What is the mathematical power? Experts (National Council of Teachers of Mathematics, 1989,2000. Henningsen & Stein, 1997. Baroody, 2000. Romberg, Zarinnia, & Collis, 1990) state, that mathematical power is ability to explore, formulate a conjecture to provide a reason logically and to be ability to solve non-routine problems; communicate ideas about mathematics, and use mathematics as a means of communication; connect ideas in mathematics, among mathematics, and other intellectual activities. According to the Massachusetts Mathematics Framework 1996, the development of mathematical power can be done through problem solving, communication, reasoning and connections.

Mathematical power is part of higher order thinking skills (National Council of Teachers of Mathematics, 2000). At school, studying mathematics aims to have a mathematical power (Diezmann, Carmel and English, 2001. National Council of Teachers of Mathematics, 1989). The resources of mathematical power include mathematical reasoning ability, connections, problem solving and communication (National Council of Teachers of Mathematics, 1989, 2000). This mission has been initiated by National Council of Teachers of Mathematics to develop mathematical power in order to prepare young people to face the challenges of today's global era (Lubienski, 2002).

Why mathematical power is important? Mathematical power is part of higher order thinking skills, has become the focus of the development of mathematics education in the 21st century (National Council of Teachers of Mathematics, 2000). Given the importance of higher-order thinking ability is needed by our young people for the challenges of the 21th century (Griffin, McGaw & Care, 2012). Mathematical power can be developed from the level of very young children and the mathematics power has become an important goal of the present mathematics learning (Diezmann, Carmel and English, 2001. Philips & Anderson, 1993. National Council of Teachers of Mathematics, 1989). Indonesian education curriculum in 2006 implicitly requires

elementary school students in to high school has a good ability in mathematics. Sudrajat research results (2013) reported that mathematical power (aspects of reasoning in problem solving) secondary school students do not achieve optimal results. This is because the teacher is not optimal in choosing the design and learning strategies that can train and while enhancing students' mathematical power.

Basically all students can be seen to have abilities in mathematical power, but the level or degree of mathematical power possessed by every students is different and construction are also different ways. This paper provides information about description of the mathematical power elementary school students in based on theory of constructivism in mathematics.

2. Method

This study is a qualitative ethnographic research that observers participate as part of the research field (Moleong, 2007). Data collection methods include : 1) In-depth interviews (depth interview) that is purposive and snowball (Miles and Huberman,1992), to the research subjects 4th graders aged 9-10 years; 2) The observation of the learning process and collect data on all the things that happen in the learning process. Observation instruments are arranged according to the indicators aspects of the ability of mathematics; 3) Study of the documentary (documentary study), to collect and analyze mathematical textbooks, student records when he joined the learning of mathematics; and 4) Pencil and paper test (achievement test) students at the end of the learning of mathematics. The focus of this study is to observe the students 'mathematical power (ability: investigation, suspect, exploration, and reasoning) in solving the problem based on the students' knowledge construction process. Learning is done with a scientific approach that is based on the inquiry, and discovery learning.

3. Result and Discussion

Learning can be defined as a change in behavior that occurs as a result of their experience and the relatively fixed nature. Piaget's theory (Dahar, 1989) regarding the study is based on four basic concepts, namely the scheme, assimilation, accommodation, and balance. Piaget sees learning as a cognitive actions, actions concerning the mind. Cognitive measures concerning the arrangement and adaptation actions on the environment .

According to Tran Vui (2001), constructivism is a philosophy of learning founded on the assumption that reflects the experience - his own experience. A student construct or build his own understanding on experience with the world in which they live. Respective students will continue to produce " mental models " on their own. Thus, learning is a process of simplification in adjusting our mental models to accommodate the experience - a new experience.

Wagenschei (1983) said: " My own experience, how mathematics can be opened by one of the teachers and closed by the other. " This quote is the starting point for thinking about the preferred ways to learn and understand mathematics to students' private person.

Mathematics learning with a scientific approach, gives a lot of positive feedback from students and teachers. This is reflected in their responses after learning of mathematics.

Nabila (student): " *saya senang belajar matematuka dengan gambar*" (I am delighted to learn mathematics with pictures).

Ridwan (student): " *guru saya selalu membuat peta konsep dan saya bias melakukannya*" (My teacher always create concept maps and I can do it).

Syla (student): " *sekarang saya mengerti cara belajar, matematika bukan rumus-rumus yang pusing*" (I now understand how to learn , not math formulas dizzy).

There are several explanations that help students understand math better. They (students) understand mathematics as what they think, they do their own knowledge construction, not what is thought by the teacher. Many students a better understanding of mathematics through pictures and other visuals rather than memorizing formulas without meaning.

Here are presented the results of the work of students in solving problems that refers to the construction of mathematical power students.

1) Conjecture is the ability to strongly suspect accompanied by the right reasons or arguments. Allegations are statements believed to be true, but it has not been proven mathematically.

Examples of the student work: " Every non-zero integers can be written as the sum of two integers ". Broadly speaking , we can indeed write numbers into the sum of two numbers, as follows :

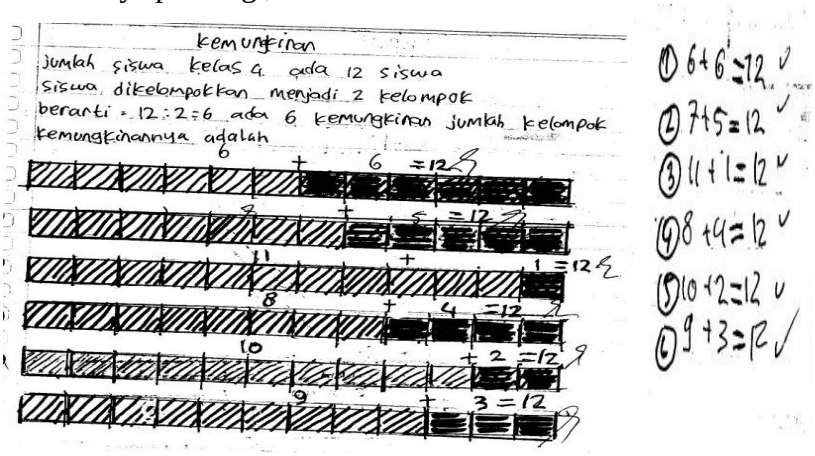

Fig. 1 Examples of student work 1

Question and answer :

Teacher: *"Apakah menurutmu yang kamu lakukan sudah tepat?"* (Do you think that you do is right?).

Wildan (student): *"ya, saya menduga, membagi dua tidak harus sama bagiannya"* (yes, I suspect, it does not have to divide two equal parts).

Based on the results of student work in Figure 1, it can be seen that the students have been able to quickly see patterns and regularities of small incidents (specializing) and then the suspect with alleged (conjecturing) strong of generalization small incidents. Marjolijn.P, et.al. (2009), confirms that the suspect with the right reasons is the use of mathematical in thinking mathematical power.

2) The ability of reasoning in mathematics is an ability to use the rules, properties or mathematical logic to obtain a correct conclusion.

Examples of problems solved by students: Write the fractions are equivalent to ¼ fractions in the form of different fractions.

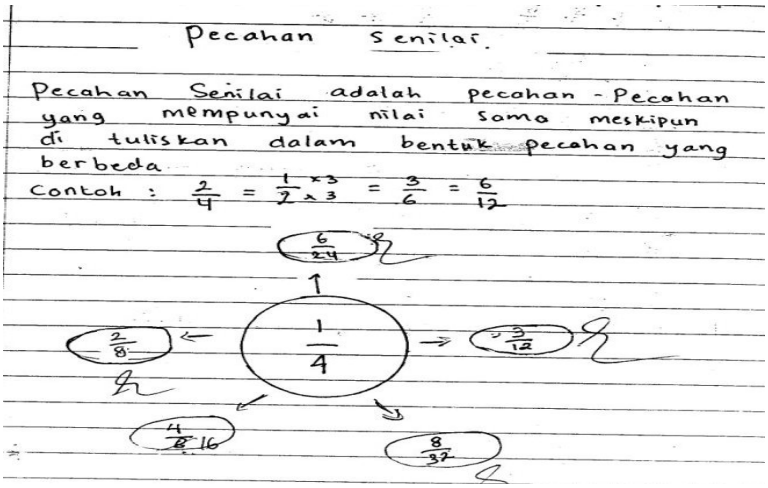

Fig . 2 Examples of student work 2

The results of the question and answer:
Teacher: "*dari mana ide jawaban ini kamu peroleh?"* (Where did the idea of the answers you get?)
Nabila (student): "*mengalikan pembilang dan penyebutnya dengan bilangan yang sama"* (multiply the numerator and denominator by the same number).
Teacher: "*bagaimana hasilnya, jika dikalikan dengan bilangan yang tidak sama?"* (what if the result is multiplied by the number that is not the same?).
Nabila (student): "*nilai bilangan pecahannya tidak akan sama"* (fractional values will not be the same).
Nabila work results show a reasonable excuse when student (Nabila) connecting prior knowledge with new knowledge, which is obtained from the exploration think with good reason .
3) The ability of mathematical investigation is related to the ability of researching or observing a simultan pattern, mathematical processes, algorithms, image - chart diagrams. Indicators investigative skills are: observing, suspect, corrected, validate, find solutions. To further encourage a better mathematical power, National Council of Teachers of Mathematics (1989) has recommended instructions into learning objectives are: meaningful, and inquiry-based so-called" investigative approach.

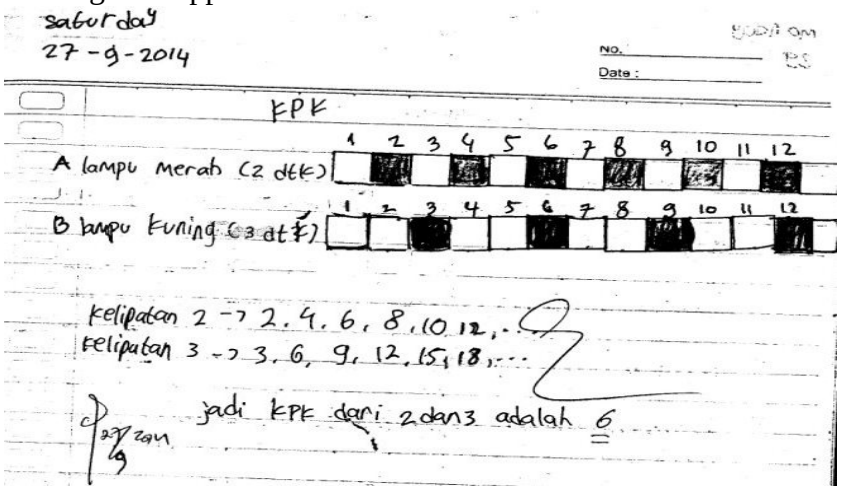

Fig . 3 Examples of student work 3

Question and answer the following :
Teacher: : "*bagaimana kamu menyelidiki pola dengan gambar ini"* (how do you investigate a pattern with this picture?).
Syla (student) : "*saya ingat ibu, saat melingkari angka di kalender setiap dua hari*" (I remember the mother, when the circled numbers in the calendar every two days).
Teacher : "*apa simpulan yang kamu dapatkan?"* (What conclusions do you get?).
Syla (students) : *"kelipatan persekutuan terkecil adalah bilangan kelipatan terkecil pertama yang sama"* (Least common multiple is the smallest multiple of the first number the same).
Figure 3. It is the work of Syla. She did the investigation find least common multiple of two numbers, she using multiple rules are created in the form of bar picture. Through the bar picture Syla find least common multiple completion of 2 and 3 is 6. Means Syla has undergone assimilation in her thinking process.
Researchers advise that what Syla has drawbacks when applied to solving the find least common multiple with a fairly large number. Therefore we need another solution method, for example, prime factorization method.
However, Syla has conducted an investigation. The investigation process can be started from the things that are very simple and easy. In this investigative approach, teachers help children build on what they already know to learn new concepts or procedures .

4) exploration capability is the ability to explore back or linking concept - rule (theorem, proposition, properties) which are known to be used in the problems faced or explore new knowledge with or without the guidance of a teacher. Indicators exploration capabilities are: remembering, linking, observe, examine, use, find.

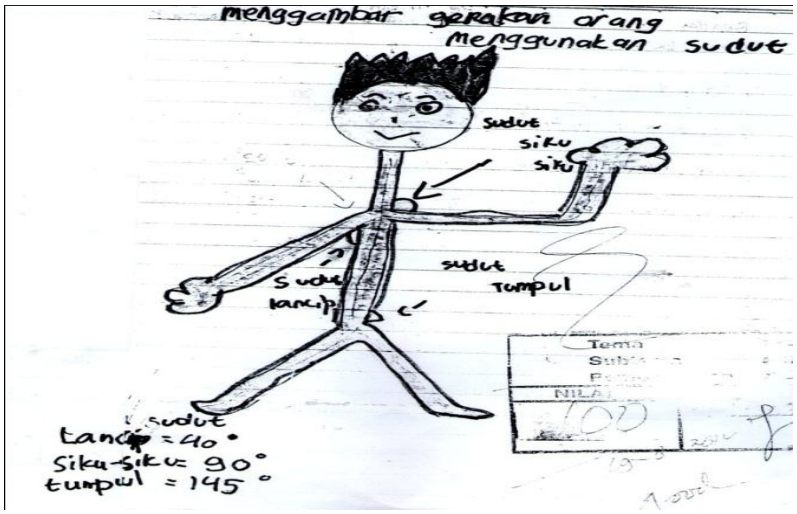

Fig . 4 Examples of student work 4

Question and answer :
Teacher : "*wah gambar kamu bagus, berapa derajat besar sudut lancip ini?"* (wow good picture,How large degree this acute angle?)
Wildan (student): "*sudut lancip kurang dari 90 derajat. Misalnya 80^0, or 25^0 and 40^0*" (acute angle less than 90 degrees. For example, 80^0, or 25^0 and 40^0) .

Teacher : *"Jika sudut siku-siku ditambah dengan sudut lancip, akan sama denga sudut apa?"* (If a right angle plus an acute angle, will be the same as what angle?).
Wildan (student) : "*sudut yang tumpul"* (obtuse angle).
Figure 4 gives an explanation that the student has been able to explore well the linking of knowledge about the concept - the rules that have been known to use the thinking for a demonstration of the concept of angle. In this case, the ability of students to connect the knowledge they already possess with new knowledge that will be built very dependent on the knowledge and experience of previous students, meaning students through the process of accommodation.

The statement was supported by the opinion of their teachers, that more students are free to pour their own ideas of the follow existing procedures. The role of the teacher becomes a facilitator so that the learning process in the class can easily help the students to construct new knowledge into cognitive framework. But some students are very heavy for making idea, since the beginning of knowledge as a form of student learning experience is still small. So that these students have problems in the process of knowledge construction. When students have problems, teachers provide assistance (scaffolding process) for the student to learn. Scaffolding is giving some assistance to students during the stage - the early stages of learning, then reduce aid and provide the opportunity to take over greater responsibility as he can do so (Slavin, 2005). Assistance in the form of guidance, encouragement, warning, describes the problem into solving steps, provide examples, and other measures that allow students to learn independently.

Piaget (Bodner, 1986) found in a person's mind (students), there have cognitive structures or cognitive framework called schema. Everyone will always try to find a balance, suitability, or a new equilibrium between what happened (new experiences) with what is on the cognitive structure. If the new experience is suitable or appropriate to that stored in the cognitive framework of the process of assimilation can occur easily, and balance (equilibrium) is not disturbed. If what is stored in the cognitive framework does not fit or do not fit in with his new experience, imbalance will occur, and students will strive to create balance again. For this necessary process of accommodation. Thus, assimilation is a process in which new information or experiences that unite themselves into existing cognitive frameworks, while the accommodation is a process of change or development of existing cognitive framework to fit the new experiences that happened.

From this discussion it can be said that they (the students) to understand the math in his own way and in a way that varies according to their learning ability of previously owned (Piaget, 1972). Piaget also argued that not only caused by the process of assimilation and accommodation, a child's cognitive development is still influenced by the maturity of the brain nervous system of the child, the child's interaction with the objects in the vicinity (physical experience), the child's own mental activity in linking experiences with cognitive framework (experience logico-mathematics), and the interaction of the child with the people around him.

According to the theory of constructivism, knowledge is built by man from the small things, the results are expanded through a limited context and not suddenly. Knowledge is not a set of facts, concepts, or rules that are ready to take and remember. Man must construct knowledge and give meaning through real experience. The followers of Piaget stated the importance of experience in the learning process. They believe that active learning experience tends to increase cognitive development, whereas passive learning experience tend to have less effect in improving the cognitive development of children.

Agree with constructivism, researchers found math skills such as math is power construction (formation) of the students who know something (schemata). Knowledge or ability can not be transferred from the teacher to the student, because every student has his own scheme of

what they know is through experience. Someone students who learn it means forming knowledge actively and continuously (Suparno, 1997).

The end of this discussion, that the mathematical abilities of the students in grade 4 math student can describe the power that is extraordinary. This qualitative study contributes to show that the construction of the power of mathematics students have influenced the thinking of students in problem solving. This explanation is consistent with the Borromeo (2012), which says that the mathematical thinking (visual style, analytical and integrated thinking style) is a preference to use math skills of students. But more important in the process of constructing think this has happened, understanding, and meaning that the structure found by students in an irregular manner in the formation of new knowledge, in accordance with prior knowledge. Thus, the mathematical power to be one of the central features of the higher order thinking.

Knowing the quality of the mathematical power by the time students learn mathematics, will be useful for teachers in terms of: 1) classifying providing assistance and services to students (weak or strong in mathematical power) in learning; 2) designing models, strategies, appropriate learning approach to improve and optimize the mathematical power of students; 3) become the standard assessment capabilities (mathematical power) students in learning mathematics.

In line with the thinking of experts, learning math should always be designed properly and systematically to the assessment system, in order to develop students' mathematical power into meaningful learning. As a consequence, any mathematical learning model implemented should develop mathematical power of students as recommended by the National Council of Teachers of Mathematics (Sharon, Charlene, and Denisse. 1997).

4. Conclusion

Conclusion of the research is, that a student studying mathematical ideas in a way students construct knowledge or representations of mathematical ideas of their own, so that students can relationship with the idea that the other ideas that are relevant. Grade 4^{th} elementary school students build mathematical knowledge to build strength, through the process of assimilation and accommodation and built by students little by little, the result is expanded through a limited context. Student assimilation process goes well, new information or experiences that unite themselves (as appropriate) into an existing cognitive frameworks, while grade 4^{th} elementary school students in the student accommodation experience obstacles in developing a cognitive framework that already exists. By the time the students have obstacle, teachers provide assistance (scaffolding process) for the student to learn. These obstacle are influenced by the maturity of the nervous system, the brain child, the child's interaction with the objects in the vicinity (physical experience), the child 's own mental activity in linking experiences with cognitive framework (experience logico - mathematics), and the interaction of the child with the -people around. This qualitative study shows that the construction of the mathematical power of students have influenced the thinking of students in problem solving . The results of this study are tentative , meaning that they can be changed or improved after further research deeper. This research is expected to contribute to the theory to determine the power level metematika students.

References

Baroody, J. Arthur. (2000). Does Mathematics Instruction for 3- to 5-Year Olds Really Make Sense? Research in Review article for *Young Children*, a *Journal of the National Association for the Education of Young Children*. *Journal* for *Research* in *Mathematics Education* Vol.28'.University of Illinois at Urbana-Champaign.

Bodner, G.M. (1986). Constructivism: A theory of knowlwdge. *Journal of Chemical Education.* Vol. 63 no. 10.0873-878.

Borromeo F. Rita. (2012). Mathematical Thinking Styles and Their Influence on Teaching and Learning Mathematics. *Journal 12th International Congress on Mathematical Education, COEX, Seoul, Korea*. *Journal* for Research in *Mathematics Education*, monograph series 7.

Countryman. (1992). *Hakikat Pembelajaran Matematika.* Surakarta: Departemen Pendidikan Nasional.

Dahar, R.W. (1989). *Teori – Teori Belajar*. Jakarta : Erlangga

de Lange, J. (2000). *Assessment: No Change without Problems.* Utrecht: Freudenthal institute.

Diezmann, Carmel M and English, Lyn D (2001). *Developing young children's Mathematical Power*. Developing young children's multi-digit number sense. *Roeper Review* 24(1):11-13.

Ernest, P. (2004). *The Philosophy of Mathematics Education*. The Edition Published in the Taylor & Francis e-Library.

Griffin, P., McGaw, B., & Care, E. (Eds.).(2012). *Assessment and teaching of 21st skills.* New York: Springer Publishing Company.

Henningsen, M. and Stein ,K.M. (1997). Mathematical Tasks and Student Cognition: Classroom-Based Factors That Support and Inhibit High-Level Mathematical Thinking and Reasoning.

*Journal for Research in Mathematics Education.*Vol. 28, No. 5 (Nov., 1997), pp. 524-549 Published by: National Council of Teachers of Mathematics. Article Stable URL: http://www.jstor.org/stable/749690

Lubienski, Sarah Theule.(2002). *Are We Achieving "Mathematical Power for All?" A Decade of National Data on Instruction and Achievement*.PUB DATE 2002-04-00NOTE 42p.; Paper presented at the Annual Meeting of the American Educational Research Association (New Orleans, LA, April1-5, 2002).

Marjolijn Peltenburg, et.al.(2009)**. "**Mathematical power of special-needs pupils: AnICT-based dynamic assessment format to reveal weak pupils' learning potential" . *British Journal of Educational Technology Vol 40 No 2 2009 p.*273–284 doi:10.1111/j.1467-8535.2008.00917.x

Miles, Matthew .B. And Huberman, A. Michael. (1992). *Qualitative Data Analysis. A Sourcebook of New Methods.* London : Sage Publication. (Terjemahan oleh Tjetjep R.) Jakarta : UI Press.

Moleong, J.L.(2007). *Metodologi Penelitian Kualitatif*. Bandung : Remaja Rosda karya

National Council of Teachers of Mathematics (1989). *Curriculum and Evaluation Standards for School Mathematics.* Reston, VA: NCTM.

National Council of Teachers of Mathematics (2000a). *A Vision of Mathematical Power And Apresciation For All.* Available at http://www.sde.ct.gov/sde/lib/sde/PDF/ Curriculum/Curriculum_ Root_Web_Folder/mathgd_chpt1.pdf (March 29, 2014)

National Council of Teachers of Mathematics (2000b). *Principle and Standards of school Mathematics.* Available at http://www.fayar.net/east/teacher. web/math/standards/previous/CurrEvStds/evals4.htm (March 29, 2014).

Piaget, J. (1972). *To Understand Is to Invent*. New York: Grossman. Piaget, J. (1972). *To Understand Is to Invent*. New York: Grossman.

Phillips E. & Ann Anderson.(1993). Article. "Developing mathematical power: A case study". *Journal of Early Development and Care* .Vol.96 (1) 135-146. 1993. DOI: 10.1080/0300443930960111. Published online: 07 July 2006. Available at. http://www.researchgate.net/publication/247499348_Developing_mathematical_power_A_case_study

Romberg. A.T. (1992). Mathematics Assessment and Evaluation : Imperatives for Mathematics Educators. SUNY series. Reform in Mathematics Education. (p.259).1992

Romberg. A. T. (1995). Reform in School Mathematics and Authentic Assessment. ISBN.0-7914.2161.9 . Albany. State University of New York Press.

Romberg. T.A., Zarinnia, E.A.,& Collis, K.F. 1990. A new world view of assessment in mathematics. In G.Kum (Ed.), Assesing higher order thinking in mathematics (p. 21-38). Washington DC : American Association for the Advancement of Science.

Sharon L. Senk, Charlene E. Beckmann, *and* Denisse R. Thompson, *1997.* Assessment and Grading in High School Mathematics Classrooms. *Journal for Research in Mathematics Education.* Available at : *math.coe.uga.edu/olive/.../JRME1997-03-187a.p*

Slavin E. Robert. (2005). *Cooperative Learning: theory, research and practice.* London: allymand bacon, 2005.

Stacey, Kaye. (2006). What is mathematical Thinking and Why is it Important? *Journal of Mathematical Behavior. Vol.24. pp.314-350.University of Melbourne, Australia.*

Sudarjat, Akhmad.(2013). *Pendekatan Saintifik dalam Proses pembelajaran.* Available at. https://akhmadsudrajat. wordpress.com/2013/07/18/pendekatan-saintifikilmiah-dalam-proses-pembelajaran/ (20 November 2014).

Tran Vui (2001). *Practice Trends and Issues in the Teaching and Learning of Mathematics in the Countries*. Penang: Recsam.

Trilling, B., & Fadel, C. (2009). *21st century skills: Learning for life in our times.* San Fransisco: Jossey-Bass.

Wagenschein, M. (1983). *Erinnerungen für morgen.* Beltz Taschenbuch. *Weinheim* und Basel 2002, ISBN 3-407-22752-3, S. 22. Available at. *de.wikipedia.org/wiki/Martin_Wagenschein*.