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Analysis of algebraic thinking ability viewed from the mathematical critical thinking ablity of junior high school students on problem based learning

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Abstract

The aims of this research are (1) find out students critical ability in learning problem based learning achieves the minimal mastery criteria; (2) find out students algebraic ability in learning problem based learning achieves the minimal mastery criteria; (3) to describe the algebraic ability of 8th grade students of SMP Negeri 6 semarang viewed by students critical ability (high, middle, and low). The method of this research is mix method with concurrent embedded design. The population in this researchwere class 8thSMP Negeri 6 Semarang The research sample was class VIII G and the subjects were taken 9 out of 34 students of class VIII G. The results of the research showed that: (1) students critical thinking ability in problem based learning achieved the minimal mastery criteria; (2) students algebraic thinking ability in problem based learning achieved the minimal mastery criteria; (3) students who belonging to the high-critical thinking ability group, have high generationaland global meta-level capabilities, while transformational capabilities that moderate to high.Studentswho belonging to the middle-critical thinking ability group, have generational, transformational, and global meta-level capabilities that tend to be moderate. Studentswho belonging to the low-critical thinking ability group, have generational and transformational capabilities that tend to be low, while global meta-level capabilities that low to moderate.

1. Introduction

The 21st century is a different century from previous centuries. In this century, knowledge grew rapidly in all is by learning fields. The changes are increasingly felt, including in the world of education. Education is one of the determinants of a nation's civilization. One way to realize a nation's civilization mathematics.

BadanNasionalStandarPendidikan (BSNP: 2006) states that mathematics is a universal science that underlies the development of modern technology, has an important role in various scientific disciplines and advances human thinking power. Mastery of science is needed to create technology in the future. Therefore, mathematics lessons need to be given to all students from elementary school to a higher level to give provision for students with the ability to think logically, analytically, systematically, critically, creatively, carefully and consistently and the ability to cooperate. This goal places critical thinking into an important part of the mathematics curriculum.

In the process of learning and problem solving, students can gain experience using the knowledge and skills that they already have. This experience then trains students thinking power.Janah (2019) said that students who study mathematics not only need counting skills but also need skills for critical thinking and mathematical reasoning in solving new questions and learningnew ideas that will be faced by students in the future.

Mathematical critical thinking is a directed and clear process used in mental activities such as solving problems, making decisions, analyzing assumptions, and conducting scientific investigations (Van de Walle in Rochmad, 2018).Critical thinking ability can be interpreted as a person's ability to carry out activities that make

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him able to think critically. Watson (2008) composes indicators that can measure the mastery of one's critical thinking skills, which include the following: (1) Inference, is to distinguish between degrees of truth or error from a conclusion taken from the data provided. (2) Recoginition of assumptions, aware of unwritten allegations or prejudices of statements or premise given. (3) deduction, determine whether certain conclusions must follow information from the statement or premise given. (4) Interpretion, measuring evidence and deciding whether generalizations or conclusions based on the data provided are correct. (5) evaluation of arguments, distinguish between strong and relevant arguments with arguments that are weak or irrelevant to a particular issue.

Algebra is one of the material in mathematics that is important for students to learn. The importance of algebra has been revealed by Suhaedi (2013) who said that algebra is a very important material to be mastered by students, because either implicitly or explicitly algebra is used in daily life activities. This algebraic material has a close relationship with students' critical thinking skills that might often be used when learning algebra. According to Fraker as quoted by Thomas (1999), the two main reasons students lack critical thinking skills are: a) lack of training in critical thinking skills, and b) students have been "fed" with material so that they do not have to think independently. In line with the things needed to develop the ability of algebraic thinking delivered by Kieran (2004) which includes a focus on relationships, not only in calculating answers and focusing on representation and problem solving, rather than solving it.

Algebra has an association with indicators of critical thinking skills, one of which is critical thinking skills that have indicators of argument analysis and evaluation. In the argument analysis indicator, namely formulating a story problem in the form of a mathematical model and evaluating examples of giving an assessment and description of the reasons for the solution given in line with generational ability indicators in algebra which includes the formation of expressions or forms and algebraic equations.

In developed countries, algebra and algebraic thinking are important topics. Because of its very important uses, algebra is one of the materials in the implementation of Trends in the International Mathematics and Science Study (TIMSS). Based on the results of TIMSS in 2015, Indonesia was ranked in the bottom 5 of 50 countries with a mean score of 397.

Algebra is a part of mathematics that is very important to help solve other mathematical problems, because in algebra studied about mathematical symbols and how to manipulate them, as Herstein argues as quoted by Paridjo (2018) which states that algebra is the study of mathematical symbols and rules for manipulating these symbols. To be able to manipulate mathematical symbols required the ability to think algebra. Algebraic thinking is not only needed in mathematics learning at school but also very useful for everyday life. Ameron (2002) reveals that the activities we do in some situations mostly require the ability to think algebraically and use symbols in solving problems. According to Kieran (2004), the term algebraic thinking appears as a representation of activities / abilities in learning school algebra.

Kieran (2004) classified algebraic thinking into three algebraic abilities, namely generational, transformational, and metaglobal abilities. Generational ability is an ability that includes the formation of expressions and algebraic equations. Then transformational ability is the ability that emphasizes the transformation (transformation) of an algebraic form or equation including factoring, expanding algebraic forms, substitution, addition and multiplication of polynomial forms, solving equations, simplifying algebraic forms, completing equivalent forms and equations. Whereas global level-meta abilities are the ability to involve algebra as a tool not only solve problems but other problems outside of algebra.

SMP Negeri 6 Semarang is one of the schools in Semarang City which in the learning process has used the 2013 Curriculum. In this 2013 curriculum, algebraic material in mathematics subjects is given from grades VII to class IX. Based on the results of observations and interviews conducted by researchers at the school in August 2018, it was found that algebra is one material that is still difficult for students to master. According to the experience of the eighth grade teacher of mathematics at SMPN 6 Semarang, there are often students who have difficulty in solving the subject matter of algebraic material, especially those related to problem solving using algebraic form operations. The results of interviews with several students also showed that most students did not like algebraic material because it was considered too complicated.

Treatment is needed to help facilitate further analysis related to the ability to think algebra and critical thinking. Treatment in this case is a learning model that can train students to bring up the potential of both thinking abilities. Providing the right learning model trains students to get used to critical thinking.A student-centered mathematics learning model is needed to overcome this. Learning that provides opportunities for students to be able to improve learning activities and develop students' algebraic and critical thinking skills. The same thing also stated by Duron et al. (2006) that it will be difficult to develop critical thinking skills when using teacher-centered learning.

Learning models that use a student-centered learning approach are suitable learning models given to students to develop their thinking skills. By using this learning, students can construct their own knowledge.In line with this Duch, Allen, White in Hamruni (2012) revealed that Problem Based Learning provides conditions for improving critical and analytical thinking skills and solving complex problems in real life so that it will bring up a "culture of thinking" in students. So that problem-based learning is considered to be able to encourage students to bring up the potential of both thinking abilities.Problem Based Learning (PBL) is a learning approach that uses real world problems as a context for students so that students can develop their own knowledge, develop higher skills, inquiry and empower students (Arends, 2007).

According to WinaSanjaya as quoted in Kusumaningtyas (2014) there are three main characteristics in the Problem Based Learning model, namely: (a) the Problem Based Learning model is a series of learning activities that emphasize student activity. Students not only just listen, record and memorize subject matter, but students are expected to actively think, communicate, search and process data and finally conclude, (b) learning activities are directed to solve problems, (c) problem solving is done by using a scientific thinking approach .

Departing from some of the above, the formulation of the problem to be carried out in this research is (1) Does the students critical ability in learning problem based learning achieves the minimal mastery criteria; (2) Does the students algebraic ability in learning problem based learning achieves the minimal mastery criteria; (3) How is the algebraic thinking ability of the 8^{th} grade students of SMP Negeri 6 Semarang Viewed from the mathematical critical thinking ability. So the purpose of this study is (1) find out students critical ability in learning problem based learning achieves the minimal mastery criteria; (2) find out students algebraic ability in learning problem based learning achieves the minimal mastery criteria; (3) to describe the algebraic ability of 8^{th} grade students of SMP Negeri 6 Semarang viewed by students critical ability (high, middle, and low).

2. Methods

The method of this research is mix method. The research design used in this research is *concurrent embedded*, is a research process that combines the use of quantitative and qualitative research together, but with a different weighting method. Data collection is done by tests and interviews. The population of this researchwere class 8^{th} SMP Negeri 6 Semarang.The research sample was class VIII Gas many as 34 students. The subjects in this study were 9 students, with each of the 3 students from the high, middle, and low-critical thinking ability group and low critical thinking groups.

In this study quantitative data were analyzed first, then qualitative data analysis was carried out. Quantitative methods are used to determine whether students critical and algebraic ability in learning problem based learning achieves the minimal mastery criteria. While the qualitative method is used to obtain answers to the problem formulation in this study, how is the algebraic thinking ability of the 8^{th} grade students of SMP Negeri 6 Semarang viewed from the mathematical critical thinking ability. This qualitative data is obtained through interviews with participants depthly.

The research was conducted at SMP Negeri 6 Semarang. The subjects were taken 9 out of 34 students of class VIII G. The subjects were taken based on grouping students, that is a high-critical thinking ability group, a middle-critical thinking ability group, and a low-critical thinking ability group. The grouping is based on the results of the critical thinking ability test given. The results of the grouping show that for class VIII G of SMP Negeri 6 Semarang there are 7 students including high level groups, 24 students including middle level groups, and 3 students including low level groups.

The validity test of the data used in this study is the triangulation technique. Triangulation technique is a technique of checking the validity of data that uses something else outside the data for

checking or comparing data. Therefore, test methods and interviews aredepthly used for the same data source in order to find out the algebraic thinking skills of three students in each group of high, medium and low level students based on the results of tests of critical thinking skills and tests of algebraic thinking skills.

Data were analyzed by stages of data reduction, data presentation, and verification. Each research subject was interviewed regarding the results of his test on the matter of building a flat side space. The description of the subjects thinking ability who have been given a test and interviewed is stated by the criteria in Table 1 below.

Table 1. Criteria for Research Subjects

Group	Value Interval
High	$85{,}54 < \bar{x} \leq 100$
Middle	$66{,}42 < \bar{x} \leq 85{,}54$
Low	$0 < \bar{x} \leq 66{,}42$

3. Results & Discussions

Based on the research that has been done, the results of critical thinking tests and algebraic thinking tests are obtained.As for before the instrument was used for the test, the instrument was tested beforehand to find out whether the instrument could be used or not. The tested instruments can be used if it meets the requirements that include valid, reliable, minimal difference, and the level of difficulty of each instrument is normally distributed.

After an analysis of the test instruments, the critical thinking ability test instrument has met the requirements, namely valid, good power difference, the level of difficulty is normally distributed which means in the instrument there are questions with difficulty, easy, moderate, and difficult, and reliability of the critical thinking ability test instrument 0.755. While for the algebraic thinking ability test instrument also has met the requirements, namely 7 out of 9 questions were valid, minimal difference power was good, the level of difficulty was normally distributed which meant that there were questions with difficulty, easy, moderate, and difficult, and reliability of the algebraic thinking ability test instrument 0.713.

Furthermore, a normality test is carried out to find out that the data is normally distributed or not. Tests in this research used IBM SPSS Statistics 20 software. Normality test was carried out by the Kolmogorof-Smirnov Non-Parametric tests. The significant level used is $\alpha = 5\%$. The criteria for this normality test are accept H_0if the value of $sig. > 0.05$, and other rejects.

Analysis of tests critical thinking skills and tests algebraic thinking ability followed by hypothesis testing conducted after the normality test fulfills normal assumptions. In hypothesis 1, the minimum completeness test for the critical thinking ability test in PBL learning, using an average test of one party (right) and the proportion test for one party (right). In hypothesis 2 the minimum completeness test for testing algebraic thinking skills in PBL learning use a one-party average test (right) and test one party proportion (right).

The data obtained shows that from the 34 students who took the test of critical thinking skills in the class using the PBL learning model, there were 31 students who reached KKM more than 70 with an average score of 75.98 and the proportion of students who completed the class that is more than 75%. This is in line with Henita's research (2019), which shows that there is an increase in students critical thinking skills after learning with problem based learning learning models either by self-study or participating in teams, as indicated by the students mathematical critical thinking skills. Before learning with problem based learning, the test results did not reach classical completeness but after the study, the test results increased so that they reached classical completeness of more than 75%.

In algebraic thinking skills, 30 of 34 students who took the test in the class had achieved completeness of 88.24% with the average value of the algebraic thinking ability test obtained was 76.76. So that it can be concluded that students' ability to think critically and think algebra in problem based learning has achieved minimal completeness.

The development of students' thinking abilities is the result of applying PBL with its syntax, one of which is to orient students to problems (Arends, 2012). Problem orientation that comes from students' daily lives, encourages students to think about finding solutions to solve these problems. This is as stated by (Weiss, 2017) that relevant problems will help children to be able to find suitable solutions.

After analyzing the data from the results of critical and algebra thinking tests, interviews, and triangulation on each subject including the high,

medium, and low groups, data were obtained as shown in Table 2 below.

Table 2. Algebraic Thinking Ability Viewed from Students Critical Thinking Ability

Critical Thinking Group	Subjects	Algebraic Thinking Ability		
		Generational	Transformational	Global Meta-Level
High	T1	High	Middle	High
High	T2	High	High	High
High	T3	High	High	High
Middle	S1	Middle	Middle	Middle
Middle	S2	Middle	Middle	Middle
Middle	S3	Middle	Middle	Middle
Low	R1	Low	Low	Low
Low	R2	Low	Low	Low
Low	R3	Low	Low	Middle

Based on Table 2 it can be seen that students ability tend to be better at global meta-leveland generational meta-level activities then transformational activities. This is consistent with the findings of Coles & Brown in Badawi (2015) which show that students work numerically on a given problem, after which they gain insight into the structure of the problem (global meta-level abilities) and then use symbols and arrive at their completion. the same is done by Paton and Santos in Inganah (2013), who found that visual representation is a bridge between numerical representations to algebraic representations. Through this visual representation, it can be seen that students have used familiar notation (letters and images) to denote quantity as a form of thinking algebra.

Discussion of the analysis of algebraic thinking skills viewed by critical thinking skills is as follows.

Subjects are said have a high level of critical thinking skills if the subjects have high mean scores on each indicator of critical thinking skills which include inference, recognition of assumptions, deductions, interpretation, and evaluation of arguments.

In line with the research conducted by Badawi (2015) which shows that the subjects of high critical thinking ability groups have skills that tend to be high on the inference indicators. The subject of high critical thinking ability group is able to determine the degree of truth or error correctly. In the assumption indicator, subjects in the high-level group were able to realize the unstated guesses in the form of assumptions in most of the questions of critical thinking skills. On the deduction indicator, the subject of high critical thinking ability groups showed moderate to high abilities. The subject of this group is able to determine whether certain conclusions follow the information from the statement given in part to the test questions the critical thinking ability of the deduction indicator given. The subject is able to decide whether the conclusions submitted are true or not based on the data obtained from the statement on the indicator interpretation. The subject of a high critical thinking ability group is able to distinguish between strong arguments and weak arguments precisely for indicators analyzing arguments.

In the high critical thinking ability group, subjects have generational abilities that tend to be high. In generational activities, the subject in high critical thinking abilities group is able to understand forming expressions of generalizations that arise from a problem. This can be indicated by the results of tests and interviews of subjects in high thinking skills group in algebraic ability test questions number 1 and 2a. In question number 1, subjects in the high critical thinking abilitiesgroup, T1, T2, and T3,were able to rewrite what is known to use other variables. Subjects T1, T2, and T3 can write the meaning of cuboid which has a length of 4 more than the width and if the width is l, namely $p = (4 + l)\,cm$. Subjects T1, T2, and T3 can also write variable meanings from known elements in algebraic ability test questions number 2a, one of which can be indicated by the results of tests and subject interviews.From the question number 2a it is known that a cuboid has a width measuring $\frac{2}{3}$ of the length of the cuboid, height of cuboid 5 cm. Subjects T1, T2, and T3 can write into variables namely $p = p\,cm$, $l = (\frac{2}{3}p)\,cm$, $t = 5\,cm$.

In transformational activities, subjects in the high critical thinking abilitiesgroup showed abilities that tended to be high. In working on the algebraic questions given, subjects are able to determine the completion of an equation in algebra and determine the equivalent algebraic form. One of them is indicated by the results of the test and interview subjects in the high critical thinking skillsgroup in the algebraic thinking ability test questions number 2b and 5. In this question number 2b, subjects T1, T2, and T3 are able to write the formula for surface area, performing a form operation algebra with the correct result of

the known element which is a cuboid which has a width measuring $\frac{2}{3}$ of the cuboid length, cuboid height of 5 cm.Then, determine the completion of an equation in algebra if it is known that the length is 12 cm. However, there are subjects in the high critical thinking abilities group who have not been able to determine the equivalent algebraic form. One of them can be indicated by the results of the algebraic thinking ability test and interviews on the number 5 algebraic thinking ability test questions.In question number 5, subjects T1 and T2 who belong to the high level group can solve the problem in a different way. The T1 subject is almost able to determine the equivalent algebraic form. However, T1 has not been able to find the simplest form of algebra. So, for question number 5 is still wrong. While T2 subjects are still wrong in performing fractional algebraic operations.

Subjects in the high critical thinking ability group also showed capabilities that tended to be high in global meta-level activities. In global meta-level activities, subjects are able to use algebra to analyze changes, relationships, and predict problems in mathematics, and use algebra to solve problems related to everyday problems. One of them can be indicated by the results of tests and interviews of subjects for algebraic ability test number 3 which asks students to analyze changes in the volume of the cube if the edges increase in length by 4 cm with the original edge length is 4 cm. In this question, the subjects T1, T2, and T3 were able to find that the volume of the cube changed to 8 times after the length of the edges increased by 4 cm. T1, T2, and T3 answer this question number 3 by looking for the volume of the cube before and after the length increases, then comparing it.

In line with the research conducted by Badawi (2015), which showed that the algebraic thinking ability in generational, transformational, and global meta-level activities in high-level groups tended to be high. In generational activities, the subject in high algebraic thinking abilitygroup are able to determine the variable meanings of a problem, and represent problems in relationships between variables. In transformational activities, subjects are able to operate algebraic forms, and determine the completion of an equation in algebra. In global meta-level activities, subjects are able to use algebra to analyze changes, relationships, and predict problems in mathematical variables, and model problems and solve them.

In the middle critical thinking skillsgroup, in generational activities, subjects are generally able to form expressions of generalizations that arise from a problem. This can be indicated by the results of tests and interviews of subjects for algebraic ability test questions number 1 and 2a. In the number 1 problem, the subject of middle critical thinking ability, namely S1, S2, and S3, is able to rewrite what is known to use other variables.This can be indicated by the results of the test and interview subjects in the middle critical thinking skillsgroup in algebraic ability test questions number 1 and 2a. In question number 1, subjects S1, S2, and S3 are able to rewrite what is known to use other variables. S1, S2, and S3 subjects can write the meaning of cuboid which has a length of 4 more than the width and if the width is l which is $p = (4 + l)\ cm$.S1, S2, and S3 subjects can also write variable meanings from known elements in algebraic ability test questions number 2a, one of which can be indicated by test results and interviews from the subject. From the question number 2a it is known that a cuboid has a width measuring $\frac{2}{3}$ of the length of the cuboid, height of cuboid 5 cm. S1, S2, and S3 subjects can write into variables yaitu $p = p\ cm, l = \left(\frac{2}{3}p\right) cm, t = 5\ cm.$

In transformational activities, subjects in the middle critical thinking ability group showed abilities that tended to be moderate. In working on the algebraic questions of transformational activity given, the subjects in this group were able to determine the completion of an equation in algebra, but it was still wrong when determining the equivalent algebraic form. But it was also found that the subject of the middle critical thinking ability group was almost able to determine the equivalent algebraic form but still not quite right. One of them is indicated by the results of tests and interviews of subjects in the middle critical thinking skills group for the question of algebraic thinking ability number 4. The subject has not been able to solve the problem correctly, due to misconceptions when performing fractional algebraic operations. The subject made a mistake while simplifying the following fraction of the algebraic form, $t = \frac{12p-V}{6p}$.

Subjects in the middle critical thinking ability group showed abilities that tended to be moderate for global meta-level activities. In global meta-level activities, subjects in the middle critical thinking ability group are able to use algebra to

analyze changes, relationships, and predict problems in mathematics. However, subjects have not been able to use algebra to solve problems related to everyday problems. One of them can be indicated by the results of tests and interview subjects in the middle critical thinking skills group for algebraic ability test questions number 4 which asks students to determine the height of the increase in water in the vessel after the object is inserted into the vessel. In this problem, the subjects of S1, S2, and S3 work on the problem using inappropriate methods.

In the group of low critical thinking abilities, have generational abilities that tend to be low. This is in accordance with the results of Tjalla's research (2009) which found that one of the factors that caused the weakness of Indonesian students regarding algebraic material was the lack of ability to generalize mathematical models in algebra, which in this study included generational activities.. In generational activities, it is found that subjects in the low critical thinking abilities group are able to form expressions of generalizations that arise from a problem. However, not for some subjects other groups of low critical thinking abilities. One of them can be indicated by the results of the test and interview subjects in the low critical thinking ability group for the number 1 algebraic ability test questions. In question number 1, the subjects in the critical thinking ability group were low, R1 and R2, had not been able to express relationships between length, width, and cuboid height in algebraic form.

In transformational activities, subjects in the low critical thinking ability group showed abilities that tended to be low. In working on the algebraic questions of transformational activity given, subjects in the low critical thinking ability group have not been able to operate algebraic forms and determine equivalent algebraic forms. One of them is indicated by the results of tests and interviews of subjects in the low critical thinking ability group for the question of algebraic thinking ability number 5 which asks students to change the equation to another algebraic form. Subjects R1 and R3 have not been able to solve the problem correctly, because they have not been able to apply operations to the algebraic form to find factors from the given equation. However, it was found that subjects in the low critical thinking ability group, namely R2, were able to determine the algebraic form that was appropriately equivalent. The low transformational ability in this subject is in accordance with the results of a study by Badawi (2015), which found that junior high school students tend to be able to use symbols more quickly but then stop in transformational work.

In global meta-level activities, subjects in the low critical thinking ability group showed low to moderate abilities. In this activity, most subjects in the low critical thinking ability group have not been able to analyze changes, relationships, and predict a problem in mathematics and use algebra to solve problems related to everyday problems. This can be indicated by the results of the test and interview subjects in the low critical thinking ability group for algebraic ability test questions number 3 and 4, which asks students to use algebra to analyze changes and can solve problems related to everyday problems. In question number 3, students are asked to analyze changes in the volume of the cube if the edges increase 4 cm in length with the original edge length of 4 cm, the subject R1 and R2 have not done a complete and only write what is known. Likewise for question number 4 which asks students to find the height of the increase in water in the vessel after the object is inserted in the vessel, the subject R1, R2, and R3 do not work completely just write what is known.

4. Conclusion

Based on the results of the research and discussion, it was concluded that: (1) students critical thinking ability in problem based learning achieved the minimal mastery criteria; (2) students algebraic thinking ability in problem based learning achieved the minimal mastery criteria; (3) Based on the analysis of algebraic thinking skills in terms of the ability to think critically mathematically students in each group in solving the problem description, it can be concluded as follows.(a) The high Critical Thinking Ability Group, having the generational ability tends to be high, fulfilling indicators forming expressions of generalization that arise from a problem. The transformational ability is moderate to high, fulfilling indicators of operating algebraic forms and determining equivalent algebraic forms. The global meta-level capabilities tend to be high, fulfilling indicators of solving problems related to everyday problems and using algebra to analyze changes, relationships, and predict problems in mathematics. (b) The Medium Critical Thinking Ability Group, having the generational abilities tend to be moderate, not fulfilling all the indicators forming expressions of generalization that arise from a problem. The

transformational ability tends to be moderate, fulfilling the indicators of operating algebraic forms but not fulfilling the indicators of determining equivalent algebraic forms. The global meta-level capabilities tend to be moderate, not fulfilling indicators of solving problems related to everyday problems but fulfilling indicators using algebra to analyze changes, relationships, and predict problems in mathematics.(c) The Low Critical Thinking Ability Group, having generational ability tend to be low, not fulfilling indicators forming expression of generalization that arises from a problem. The transformational ability tends to be low, does not fulfilling the indicators of operating algebraic forms and determining equivalent algebraic forms. The global meta-level ability is low-to-moderate, meeting indicators of solving problems related to everyday problems but not yet fulfilling indicators using algebra to analyze changes, relationships, and predict problems in mathematics.

References

Ameron, B. A. V. (2002). *Reinvention Of Early Algebra*. Tesis. Universiteit Utrech, Nederlands.

Arends, R. (2012.)*Learning To Teach 10th edition*. New York: McGraw-Hill Education.

Badawi, A., Rochmad, & Agoestanto, A. (2015). Analisis Kemampuan Berpikir Aljabar dan Kemampuan Berpikir Kritis dalam Matematika pada Siswa SMP Kelas VIII. *Unnes Journal of Mathematics Education*, 5 (3), Page 182-189.

BSNP. (2006). *Standar Isi untuk Satuan Pendidikan Dasar dan Menengah, Standar Kompetensi dan Kompetensi Dasar SMP/MTs*. Jakarta.

Duron, R., Limbach, B., & Waugh, W., (2006). Critical Thinking Framework For Any Discipline. *International Journal of Teaching and Learning in Higher Education* 17(2), 160-166.

Hamruni. (2012). *Strategi Pembelajaran*. Yogyakarta:InsanMandiri.

Henita, H., Mashuri, M., & Margana, M. (2019). Penerapan Model Problem Based Learning untuk Meningkatkan Kemampuan Berpikir Kritis Matematis dan Rasa Ingin Tahu Siswa Kelas XII IPA 2 SMAN 5 Semarang. *PRISMA, Prosiding Seminar Nasional Matematika*, *2*, 79-83. Retrieved from https://journal.unnes.ac.id/sju/index.php/prisma/article/view/28875.

Inganah. (2013). *Semiotik dalam Proses Generalisasi Pola*. Himpunan Matematika Indonesia.

Janah, S. R., Suyitno, H., & Rosyida, I. (2019). Pentingnya Literasi Matematika dan Berpikir Kritis Matematis dalam Menghadapi Abad ke-21. *PRISMA, Prosiding Seminar Nasional Matematika*, 905-910. Retrieved from https://journal.unnes.ac.id/sju/index.php/prisma/article/view.

Kieran, C. (2004). *Algebraic Thinking in the Early Grades: What Is It?. The Mathematics Educator*, 8(1): 139-151.

Kusumaningtyas, E. (2014). Penerapan Model *Problem Based Learning* dalam Pendekatan Saintifik untuk Meningkatkan Efektivitas Pembelajaran Matematika Materi Aritmetika Sosial pada Siswa Kleas VIII SMP. *Prosiding Seminar Nasional Matematika 2014*. Surabaya: Universitas Negeri Surabaya.

OECD. (2015). *International Students performance (PISA 2015)*. Retrieved from http://oecd.org

Paridjo. (2018).Kemampuan Berpikir Aljabar Mahasiswa Dalam Materi Trigonometri Ditinjau Dari Latar Belakang Sekolah Malalui Pembelajaran Berbasis Masalah.*PRISMA, Prosiding Seminar Nasional Matematika*, *1*, 814-829. Retrieved from https://journal.unnes.ac.id/sju/index.php/prisma/article.

Rochmad, Kharis, M. & Agoestanto, A. (2018). Keterkaitan Miskonsepsi dan Berpikir Kritis Aljabaris Mahasiswa S1 Pendidikan Matematika. *Unnes Journal of Mathematics Education*. *PRISMA, Prosiding Seminar Nasional Matematika, 1*, 216-224.

Sugiyono.(2016). *Metode Penelitian Kombinasi (Mixed Methods)*. Bandung: Alfabeta.

Suhaedi, D. (2013). *Peningkatan Kemampuan Komunikasi Matematis, Berpikir Aljabar, dan Disposisi Matematis Siswa SMP Melalui Pendekatan Pendidikan Matematika Realistik*. Disertasi. Bandung: Universitas Pendidikan.

Thomas, P. E. (1999). *Critical Thinking Instruction in Selected Greater Los Angeles Area High Schools*. Disertasi. California: Azusa Pacific University.

Tjalla, A. (2009). *Potret Mutu Pendidikan Indonesia Ditinjau dari Hasil-hasil Studi Internasional*. Jakarta: Universitas Negeri Jakarta. Retrieved from pustaka.ut.ac.id/-pdfartikel/TIG601.pdf