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# Students' Algebraic Thinking Skills Through Creative Problem Solving Learning Models

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*Skills to think algebraically, systems of linear equations in two variables, creative problem solving.*

**ABSTRACT**
Tujuan dari penelitian ini untuk mendeskripsikan kemampuan berpikir aljabar pada materi sistem persamaan linear dua variabel melalui langkah-langkah model pembelajaran Creative Problem Solving menggunakan lembar kerja peserta didik. Subjek penelitiannya adalah siswa SMP Negeri 02 Sembawa kelas VIII-7 pada tahun ajaran 2023/2024. Jenis penelitian ini adalah deskriptif kualitatif. Teknik pengumpulan datanya adalah tes tertulis dan wawancara. Indikator kemampuan berpikir aljabar meliputi indikator pada aktivitas generasional, tranformasional dan level meta-global. Setelah diterapkannya CPS dalam pembelajaran, hasil tes menunjukkan bahwa persentase kemampuan berpikir aljabar siswa untuk aktivitas generasional pada soal nomor satu ada 48% dan nomor dua ada 89%. Untuk aktivitas tranformasional, persentase siswa yang mampu mencapainya yaitu untuk nomor satu ada 38% dan untuk nomor dua juga 38%. Sementara untuk aktivitas level meta-global persentase siswa yang mampu mencapainya yaitu untuk nomor satu 45% dan untuk nomor dua 82%. Dapat disimpulkan bahwa indikator kemampuan berpikir aljabar yang paling banyak muncul ada pada aktivitas generasional.

**ABSTRACT**
This research aims to describe algebraic thinking skills in two-variable linear equation systems material through the steps of the Creative Problem Solving learning (CPS) learning model using student worksheets. The research subjects were students of SMP Negeri 02 Sembawa class VIII-7 in the 2023/2024 academic year. The type of research is descriptive qualitative. The data collection techniques are written tests and interviews. Indicators of algebraic thinking skills include indicators at generational, transformational and meta-global level activities. After implementing CPS in learning, the test results showed that the percentage of students' algebraic thinking skills for generational activities in question number one was 48% and number two was 89%. For transformational activities, the percentage of students who were able to achieve them was 38% for number one and 38% for number two. Meanwhile, for meta-global level activities, the percentage of students who were able to achieve them was 45% for number one and 82% for number two. It can be concluded that the indicators of algebraic thinking skills that appear most frequently are in generational activities.

## INTRODUCTION

With algebraic thinking skills, students are helped in creating mathematical modeling and solving problems effectively and efficiently (Utami et al., 2020), students can solve problems in everyday life related to mathematics (Silma, 2018). Because through learning algebra students are trained to improve their critical thinking skills and not only suppress their algebra activities (Sermatan et al., 2019). This is in line with research conducted by Farida & Hakim (2021) that the ability to think algebraically is an ability that really pays attention to the thinking process.. Algebra is the gateway when learning mathematics, and mathematics is a hierarchical science (Sermatan et al., 2019). Because of the importance of algebra skills, in the educational curriculum in Indonesia algebra begins to be studied in class VIII. The basic competency is that students can explain algebraic forms, carry out algebraic operations, and solve problems related to algebra (Saputro & Mampouw, 2018).

In reality, only a few junior high school students are able to meet several indicators of algebraic thinking skills (Amalliyah et al., 2022). This is in line with Indonesia's ranking in TIMSS 2011, namely only 38th out of 42 countries (Suparya et al., 2022). In TIMSS there is 30% algebra in its content (Jailani & Wulandari, 2017). This happens because students experience a quite difficult transition from elementary school which only emphasizes mastering arithmetic to middle school where they start studying algebra (Sermatan et al., 2019). Students still have difficulty carrying out calculations on algebraic operations (Septripiyani et al., 2021). Furthermore, based on research conducted by Farida & Hakim (2021), class VIII students still have low algebraic thinking abilities because they do not meet graduate competency standards, this is caused by students having difficulty applying algebraic concepts in solving problems.

Therefore, mathematics learning and learning design in the classroom need to bridge arithmetic thinking skills to algebraic thinking skills which can motivate a transition of abilities (Pratiwi & Kurniadi, 2018). Choosing the right learning model can make learning more effective (Sari et al., 2020). A learning model is a design that is used as a guideline in implementing learning as well as a reference in determining the learning tools to be used (Harefa, 2020). Riskon & Rachmani Dewi (2019) in their conceptual research stated that the Creative Problem Solving (CPS) learning model is good to use to help improve algebraic thinking skills, because each stage requires students to clarify problems related to algebraic thinking activities. CPS is a type of learning that starts from a problem and is resolved through steps that require creative thinking in answering the problem (Susanti et al, 2021). Furthermore, Wahyuni et al (2018) revealed that CPS is effective for applying in mathematics learning. Anggraini, Anggraini et al (2020) also revealed that learning with CPS will make students understand Systems of Linear Equations in Two Variables (SPLDV). Based on conceptual research by Riskon & Rachmani Dewi (2019), algebraic thinking skills can be trained because students independently solve problems using CPS.

Based on the problems above and suggestions from research by Sermatan et al. (2019), namely to conduct research with other learning models besides *problem based learning* which they have researched to improve algebraic thinking skills, as well as Riskon & Rachmani Dewi (2019) who said that CPS is appropriate to help improve algebraic thinking skills, so researchers are interested in conducting research with the title " Students' Algebraic Thinking Skills Through Creative Problem Solving Learning Models". Researchers will focus on SPLDV material, because according to research by Suraji et al. (2018), when questions in the form of SPLDV stories are given, students still make many mistakes. Furthermore, Nugraha (2018) in his research showed that there were 60% of

students who had not been able to solve story questions on SPLDV material. Because the SPLDV material is very important because it is a prerequisite material for the next material, namely the System of Linear Equations with Three Variables (SPLTV), so through the CPS learning model it is hoped that it can help and make it easier for students to understand SPLDV, because according to research conducted by Sari et al (2020), stated that by choosing the right learning model, learning can be made more interesting and easier to understand.

## METHOD

### Research Design

This type of research is descriptive research with a qualitative approach. The stages in this research consist of preparation, implementation and data analysis.

1. Preparation phase

At this stage, researchers examine theories to formulate learning objectives and create research instruments which include Learning Implementation Plans (RPP), student worksheets, test questions, and interview guides. Next, the researcher made observations at the school where the research was conducted and made a research permit letter.

2. Implementation stage

At this stage, learning is carried out during two meetings which refer to the RPP. Then, a written test was carried out to measure students' algebraic thinking abilities after implementing CPS learning. After the test results were analyzed, interviews were conducted with several students.

3. Data Analysis Stages

At this stage, the researcher analyzed the written test results and strengthened the written test result data with interviews so that the reasons for whether the algebraic thinking indicators were achieved or not were known. Finally, the researcher concluded the research results.

### Research subject

The subjects in this research were students of SMP Negeri 02 Sembawa class VIII.7. Meanwhile, the object of this research is the algebraic thinking ability of class VIII students through the CPS learning model.

### Data collection technique

**4.** Written test

The test questions consist of 2 questions with the aim of knowing students' algebraic thinking abilities after learning using the CPS learning model.

5. Interview

There were three students interviewed, namely students who achieved one indicator, two indicators and all indicators of algebraic thinking ability.

### Data analysis technique

**6.** Written test

The test results were analyzed for their achievement by referring to indicators of algebraic thinking ability which were then presented in table form. Next, it is described and linked to the results of the interview.

7. Interview

The results of the interview are described in written sentences. Aims to find out more deeply the reasons for achieving or not indicators of thinking ability after implementing CPS learning.

## RESULTS AND DISCUSSION

This research aims to determine the algebraic thinking process of class VII students through CPS learning on SPLDV material. The results of this research are based on test questions given after learning using CPS steps and interviews that have been conducted. Therefore, the student worksheets used in learning uses CPS steps.

The first stage of CPS learning is problem clarification, at this initial stage students understand the existing problem by writing down the information they know and what is asked (Creative Education Foundation, 2014). The second stage is expressing opinions, at this stage students are expected to be able to express various ideas creatively in solving problems (Creative Education Foundation, 2014). Based on the Minister of Education and Culture of the Republic of Indonesia Regulation No. 37 of 2018, what students need for SPLDV material is to solve problems related to everyday life, so in SPLDV material students need to make efforts through expressing various ideas or opinions to solve problems. The next stage is evaluation and selection, at this stage students make choices based on the problem solving ideas that have been expressed (Creative Education Foundation, 2014). The final stage is the implementation stage, at this stage students solve problems by applying the ideas they have chosen to solve the (Creative Education Foundation, 2014).

These CPS learning stages support the achievement of algebraic thinking skills indicators. Istikomah et al. (2018) states that indicators of algebraic thinking in students consist of generational, transformational and global meta-levels. The CPS learning model is suitable for training and improving algebraic thinking skills, because each stage in the CPS learning model requires students to be able to clarify problems related to algebraic thinking activities (Riskon & Rachmani Dewi, 2019). For example, in generational indicators which include making examples and forming equations, students can make them more easily by clarifying the problem first. Then in transformational indicators which include changing equations to equivalent equations and carrying out algebraic operations, students need creativity in expressing ideas in solving problems. In global meta-level indicators which include analyzing relationships, students need to evaluate and select the ideas that have been expressed in order to choose the right solution and then apply it to solve the problem. Researchers analyzed the algebraic thinking processes of class VIII.7 students based on written test answers. In Table 4.6 below, the emergence of indicators of students' algebraic thinking abilities has been summarized.

**Table 2.** Appearance of Algebraic Thinking Process Indicators for Class VIII.7 Students.

| Test Result | Appearance of Indicators, N = 29 | | |
|---|---|---|---|
| | Generational | Transformational | Global meta-level |
| Problem 1 | 48%<br><br>(The percentage of students who can make examples and equations, the number of students who can achieve this activity are 14 students) | 38%<br><br>(The percentage of students who can change the equations to the equivalent equations and perform algebraic operations, the number of students who can achieve this activity are 11 students) | 45%<br><br>(The percentage of students who can analyze relationships, the number of students who can achieve this activity are 13 students) |

| | | | |
|---|---|---|---|
| Problem 2 | 89%<br>(The percentage of students who can make examples and equations, the number of students who can achieve this activity are 26 students) | 38%<br>(The percentage of students who can change the equations to the equivalent equations and perform algebraic operations, the number of students who can achieve this activity are 11 students) | 82%<br>(The percentage of students who can analyze relationships, the number of students who can achieve this activity are 24 students) |

The results of this research show that after implementing learning using CPS, students are able to produce indicators of algebraic thinking ability. In generational activities, most students are able to come up with these indicators by writing down what is asked and known in the problem and then making examples and equations, but some students still have difficulty. This is in line with research by Farida & Hakim (2021), amely that there are students who only guess and make up concepts. Furthermore, in transformational activities, most students still have difficulty doing them, this is in line with research by Amalliyah et al (2022), namely that students still find it difficult to carry out algebraic operations. For global meta-level activities, students are mostly able to analyze the relationship with understanding the meaning of the problem at hand. This is in line with research by Riskon & Rachmani Dewi (2019), namely that CPS can help improve students' algebraic thinking abilities. The least visible indicators are transformational activities, because students are still in the process of adapting to the use of algebraic operations. In Figure 1 below are the answers of students who only meet one indicator of algebraic thinking skills.

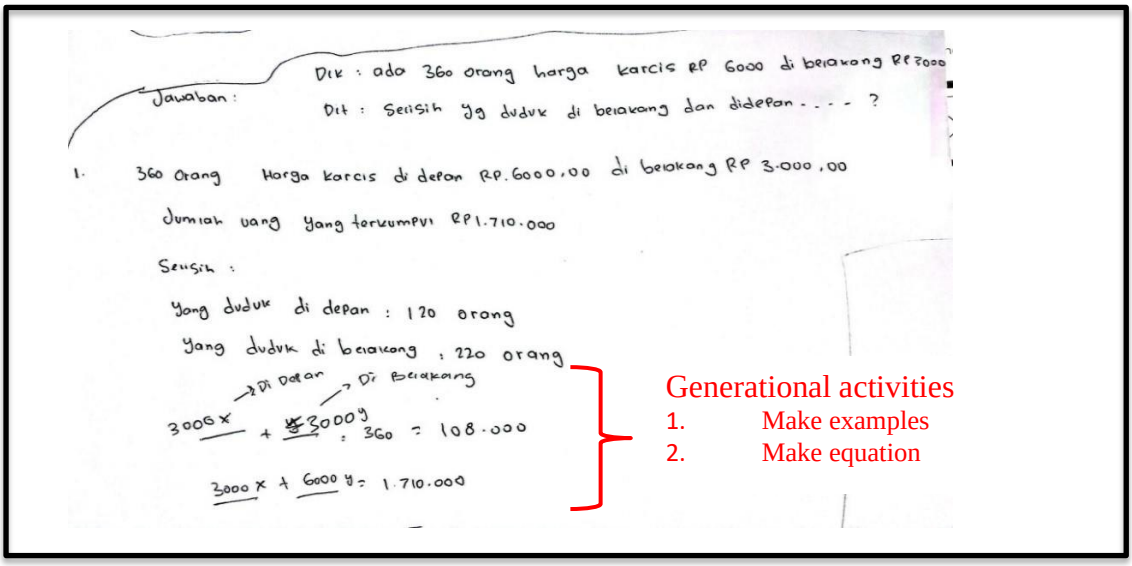


**Figure 1.** EAS Student Number 1 Answer

EAS students show the emergence of indicators in generational activities which are characterized by being able to create examples of problems and form equations. EAS still has difficulty solving equations, as can be seen in the following interview excerpt:

*Q : Why not finish it until you finish answering it?*
*EAS : Confused ma'am... I keep thinking about the equation, but I know the time is running out*
*Q : So you can actually solve this equation?*
*EAS : I don't know yet, ma'am... I'm still confused*

The equation obtained by EAS is correct, this shows that EAS is able to understand the problem in question number 1. This is supported by the following interview excerpt:

*Q : Do you often encounter problems in your daily life?*
*EAS : Yes ma'am...*
*Q : Do you understand the meaning of the question?*
*EAS : Understand, ma'am... I have mentioned what is known and asked as well as the similarities*
*Q : Why did you make an example with the letters x and y?*
*EAS : Because it's easier if you use the letters ma'am*
*Q : Does this example have a connection?*
*EAS : Yes, ma'am, you can make an equation*

In Figure 2 below are student answers that meet several indicators of algebraic thinking ability.

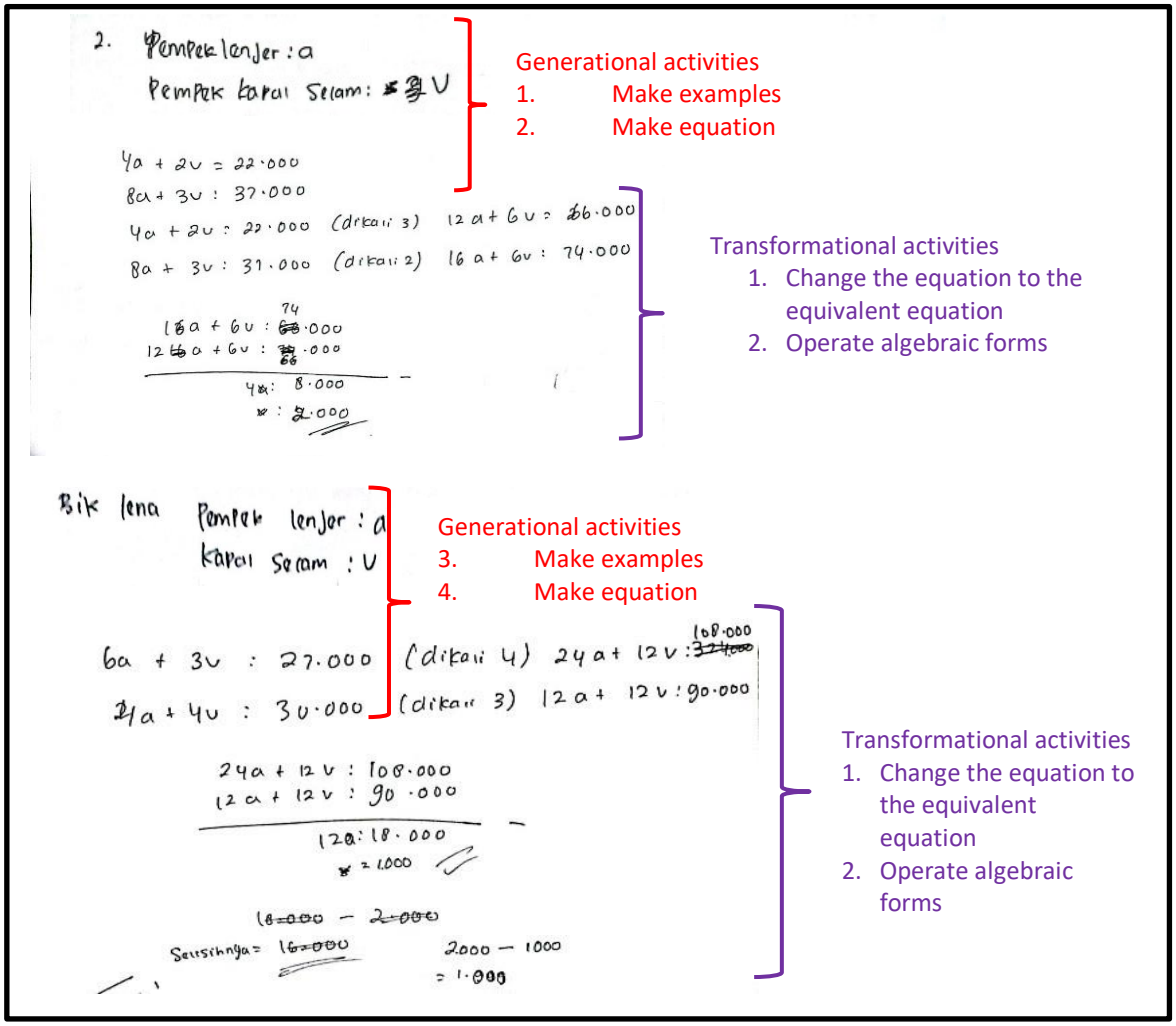


**Figure 2.** CS Student's Answer Number 2

CS students show the emergence of indicators in generational activities and transformational activities. The emergence of indicators in generational activities is characterized by CS being able to create examples of problems and form equations. The emergence of indicators in transformational activities is characterized by CS being able to change equations to equivalent equations and being able to solve equations. CS has difficulty finding relationships that can be used to find what is being asked. CS only looked for the price of pempek lenjer and this did not match what was asked which required students to also look for the price of pempek submarine to find out the difference between the prices of pempek between sellers. CS was able to understand the meaning of the question by making equations and trying to solve it, but CS had difficulty finding relationships that could be used to find what was being asked. This is supported by the following excerpt from the interview between the researcher and CS:

*Q : Do you often encounter problems in this matter in life?daily?*
*CS : Yes ma'am...*
*Q : Do you understand the meaning of the question?*
*CS : Understand ma'am...*
*Q : What do you need to look for in this problem?*
*CS : Proof that Nanda's words are true and the price difference for each pempek lenjer and pempek submarine between sellers, ma'am*
*Q : Why don't you look for it?*
*CS : Still confused, ma'am*
*P : You've been looking for the price of pempek lenjer, why ship pempek Have you ever looked for a way to solve the problem?*
*CS : Forgot how to look for it, ma'am...*

It can be seen in the interview excerpt above that CS only memorized how to do the SPLDV, but did not fully understand it, including understanding the questions.

In Figure 3 below are the answers of students who only meet all the indicators of algebraic thinking skills.

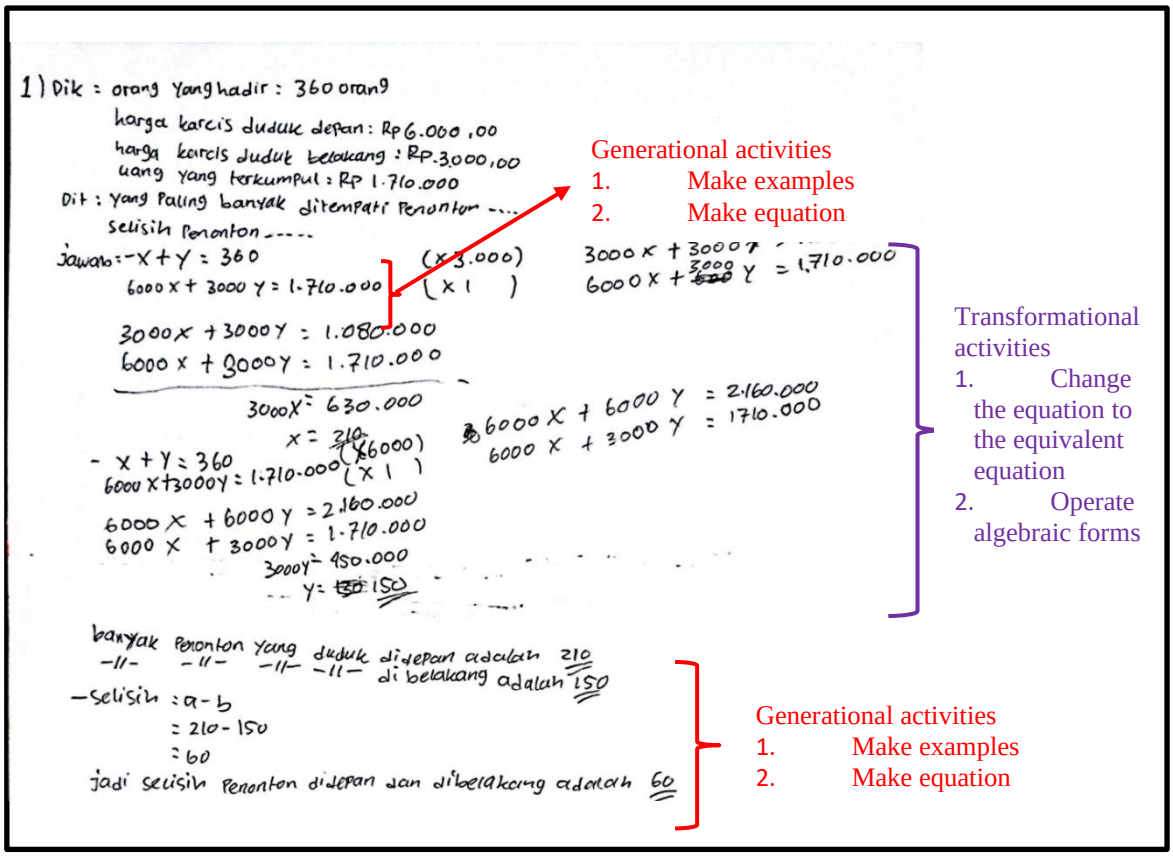


**Figure 3.** AN Student's Answer Number 1

AN students show the emergence of indicators in generational activities, transformational activities, and global meta-level activities. The emergence of indicators in generational activities is characterized by AN being able to create examples of problems and form equations. The emergence of indicators in transformational activities is characterized by AN being able to change equations to equivalent equations and being able to solve equations. The appearance of indicators in global meta-level activities is characterized by AN being able to analyze relationships in solving problems. AN experienced a slight error when working on the questions. It can be seen in the following interview excerpt.

*Q : Why not use elimination and substitution? Isn't it true that after we get a result from doing elimination, we can substitute it into the existing equation to find what we are looking for next?*

*AN : Ohhiya ma'am... didn't think about it ma'am...*

*Q : Why didn't you calculate the difference between each pempek?*

*AN : Ohhyes, ma'am, I forgot... I wanted to finish quickly because time was about to run out yesterday ma'am...*

From the interview excerpt above, AN understands the method for solving SPLDV even though AN is confused about determining the solution method and lacks time.

Based on data analysis from written tests and interviews, it was found that through the CPS learning model, students were able to produce indicators of algebraic thinking ability. However, in transformational activities, only a few students showed indicators of algebraic thinking ability because students had difficulty operating algebra. This is in line with research conducted by Sermatan et al (2019) which states that junior high school

students have difficulty learning algebra because when students are in elementary school, mathematics learning places more emphasis on arithmetic.

## CONCLUSION

After learning using the CPS learning model, it was found that the algebraic thinking ability of class VIII students was highest in the generational indicator, where many students were able to make examples and formulate them into equations. Meanwhile, in transformational activities, most students are not yet able to change equations to other equivalent equations and have difficulty operating algebraic forms. For global meta-level activities, many students are still confused about analyzing relationships in solving problems. It is hoped that future researchers will conduct research using other learning models.

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