The analysis of STEM-PjBL implementation and its effect on students’ metacognition skills in resolving social arithmetic problems

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Abstract. Students’ metacognition skills are expected to improve with the implementation of STEM-based learning. This research aims to analyze the implementation of STEM-based learning and its effect on students' metacognition skills in solving social arithmetic problems. The method used in this study is a mixed method, which combines qualitative and quantitative methods. The research subjects were elementary school students consisting of 11 experimental class students and 11 control class students. Both classes were given different treatments. The instruments of this study were tests, observations, and interviews. Quantitative methods are used to analyze differences in student learning outcomes in both classes, while qualitative methods are applied to analyze students' metacognition skills. The results showed that there were significant differences between the two classes applying STEM-based learning and conventional learning models. Statistical results show that the significance of the 2-tailed t-test independent sample in the post-test is 0.000 or α ≤ 0.05. It shows that the implementation of STEM-based learning significantly influences students' metacognition skills in solving social arithmetic problems. Based on the results of the phase portrait analysis, it is known that students in the control class have relatively low metacognition skills and the experimental class has relatively higher metacognition skills which can be seen from the number of indicators mastered by each student.

1. Introduction
Mathematics is one of the subjects taught to students in schools that can be used to achieve national education goals in Indonesia. Therefore, mathematics is taught at every level of education and in this case, mathematics for primary and secondary education is called school mathematics. School mathematics is the elements or parts of mathematics chosen based on or oriented to the interests of education and the development of science and technology. Hudojo [1] revealed that the mastery of science and technology must be based on the mastery of mathematics, because mastering mathematics is the main key in mastering science and technology. Thus, innovations in learning mathematics in schools are a priority in improving education in order to improve and enhance human resources. Therefore, education is currently required in order to grow and develop all the skills and talents possessed by students. One of the expected skills is a skill in thinking metacognition.
Metacognition is simply defined as thinking about what is thought. Generally, metacognition is related with two dimensions of thinking, namely (1) self-awareness of cognition, i.e. the knowledge that a person has about self-thinking, and (2) self-regulation of cognition, i.e. the ability of a person to use his consciousness to regulate his own cognitive processes [2], [3]. Both metacognitive dimensions have an independent nature that is interdependent with each other. In line with this view, in relation to problem solving, Brown divides metacognition into two broad categories, as follows: (1) knowledge of cognition, as activities that include conscious reflection on one's thinking abilities and activities, (2) regulation of cognition, as creativity paying attention to mechanisms self-regulation during the course of learning or solving problems [4].

These metacognitive skills are needed by students to help learning success. Students who know how he learns, means he is able to use his metacognition abilities. If it is like that, then the information students get when learning will go into long memory because the ability of metacognition is able to control information processing [5]. Students with metacognition skills must have 3 main indicators of metacognition, namely: (1) able to develop planning; (2) able to monitor implementation; and also (3) able to evaluate actions. Furthermore, students with metacognition skills are grouped into several levels, namely tacit use, aware use, strategic use and reflective use [6] - [8]. Fogarty [7] - [9] argues that metacognition organize the process of cognition. Highly capable students have a level of reflective use maybe also strategic use. Medium-capable students have a level of strategic use maybe also aware use. Low-ability students who have a level of aware use might also tacit use. However, sometimes it is not like that. This is due to several factors such as conditions in the process of solving problems. Therefore, this metacognition is very related to the ability of students to solve a problem, especially mathematics problems.

Problem solving in this era has various variations, one of which is being widely discussed in the world of education is STEM education. With the use of STEM education, it is expected to improve students 'thinking skills, one of which is students' metacognition skills. STEM itself stands for Science, Technology, Engineering, and Mathematics. STEM is the main focus of education for schools in various countries around the world [10], [11]. According to Breiner, et. al. [12] that there are many perspectives about what STEM itself looks like, one of which can be seen from 1) an educational perspective that STEM is a form of replacement from lecture methods (also called conventional methods) into a form of learning with more inquiry and project-based learning, 2 ) for some people, STEM can be said to be STEM when there is integration between science, technology, engineering, and mathematics curriculum which is more similar to the work of real-life scientists or engineers, 3) for others, STEM is an encouragement to graduate more students in the field of science , technology, engineering, and mathematics so that the United States can maintain its competitiveness and not be left behind from developing countries.

Pimthong and Williams [13] explained that most of the teachers who were be subject of study did not specifically answer the question about how STEM was integrated but focused on the results of integration. Furthermore, Pimthong and Williams [13] argue that providing an understanding of STEM and the connections between disciplines is of utmost importance, by concluding that 1) teachers who teach STEM must understand the integration concept of STEM itself and how to teach STEM, and at least the teacher who teaches STEM has a background to one of the STEM disciplines, 2) The various objectives of STEM education must be based on educational objectives and this must be understood by the teacher, 3) required STEM teacher preparation program and this program differ from science, technology, and mathematics teacher preparation programs, because STEM teaching is representative of the integration of every discipline of science.

STEM learning influences student learning outcomes, especially in mathematics [14], [15]. STEM learning also enhances thinking skills, including critical thinking skills, creative, High-Order Thinking Skills. There are studies on STEM learning towards thinking skills, including [16], [19]. From these various things it can be concluded that STEM learning not only improves student learning outcomes, but also improves students' thinking skills. Improving thinking skills is a skill that must be possessed by every human being in facing the current era of globalization.
The STEM learning process has five steps, which is each step aims to achieve a specific process. The steps are: (1) reflection which aims to bring students into the context of the problem and inspire students to begin investigations immediately. In addition, this stage also aims to link what is known and what is learned; (2) research is a form of student research. The learning process happens more at this stage; (3) discovery is a discovery phase that involves the process of bridging research and information known in project preparation; (4) application aims to test the product or solution in solving problems; then (5) communication is the final stage in every product manufacturing project by communicating between friends and the scope of the class.

2. Research methods
The method used in this study is a mixed method that combines qualitative and quantitative research. Other studies that also use mixed methods can be seen in [20] and [21]. In this study, quantitative data is the main data obtained from tests that have been arranged based on indicators of students’ metacognition skills in solving social arithmetic problems. While qualitative data is supporting data obtained from student interviews to illustrate the portrait of students' thinking phases in solving social arithmetic problems.

2.1. Research scope
This study aims to analyze students' metacognition skills in solving social arithmetic problems. This research is aimed at elementary school students in grade V.

2.2. Research subject
The subjects of this study were 5th grade students at Pelita Hati School, Jember. Class A as a control class with a total of 11 students, and class B as an experimental class with 11 students. Both classes are given pre-test and post-test that have been arranged based on indicators of metacognition skills.

2.3. Instrument dan prosedur
Qualitative data collection instruments are pre-test and post-test which is used to analyze students' metacognition skills. Quantitative data collection instruments were conducted in the form of interviews to illustrate students' metacognition skills in the form of phase portraits.

The research design used is the form of non-equivalent control group design. Both groups were given different treatments. Conventional learning is applied in the control class while in the experimental class is applied STEM-based learning.

| Table 1. Experimental design scheme. |
|-------------------------------------|
| **Class**       | **Pre-test** | **Treatment** | **Post-test** |
| Experimental (n=11) | R₁       | STEM-PjBL    | R₂        |
| Control (n=11)    | R₃       | Conventional | R₄        |

In this study, there are three stages in accordance with the stages of the research design, namely the analysis of students' metacognition skills (quantitative research), the application of learning based on STEM-PjBL (quantitative research), and the portrait phase (qualitative research). The procedure used in this study is the same as the study conducted by [20] and [21].

2.4. Data collection and data analysis
Both classes are given pre-test and post-test that have been arranged based on indicators of metacognition skills. Quantitative analysis using independent sample t-test. Qualitative data were obtained from the interview process and analyzed from ordinal data.

Descriptive statistics and inferential statistics are used to analyze quantitative and qualitative data. Information data obtained is used to describe statistical data, especially inferential statistics to determine the effect of STEM-PjBL by using the Independent Sample T-test in both experimental and
control classes [22]. Independent sample t-test was used to compare averages between the two classes, by looking at significant differences with the 0.05 level. The data generated will be analyzed using the SPSS 17.0 program.

Analysis of student answers within the scope of metacognition skills for each dimension consists of (1) students reading and describing problems, (2) students can predict problem solving plans, (3) students can obtain problem solving plans, (4) students believe the chosen completion plan is true, (5) students do the correct work steps in solving problems, (6) students check the correctness of steps in solving problems, (7) students re-examine the work, (8) students can solve problems in different ways, (9 ) students are able to apply this method to other problems or problems. The metacognition skills assessment for each sub-indicator was rated "good" by 3 points, "average" by 2 points and "bad" by 1 point. Points will be changed in the form of 1-100 scale. Processing student answers, as follows: answers within the scope of metacognition skills for each dimension are categorized based on a rating scale consisting of high metacognition skills, good metacognition skills, and low metacognition skills [19]. In this study, the range of high metacognition skills scores was $67 \leq \text{SMS} \leq 100$, good metacognition skills were $34 \leq \text{SMS} < 67$, and low metacognition skills were $1 \leq \text{SMS} < 34$. SMS here stands for "Score of Metacognition Skills".

2.5. Task

The assignments that given to the students are pre-test, post-test and student worksheets that have been arranged according to indicators to measure students' metacognition skills. The control class and the experimental class were given the same test, while the student worksheets were only given to the experimental class. Students are asked to solve social arithmetic problems. The assignments that given to the students are as follows: The steps in solving social arithmetic problems in this study are as follows (1) the researcher prepares tools and materials for students to use in solving problems; (2) students understand and plan to solve social arithmetic problems contained in student worksheets in groups; (3) students try to solve social arithmetic problems with the tools and materials that have been provided; (4) students find a mathematical model of social arithmetic problems based on previous experiments that have been conducted (5) students obtain a solution to the problem of social arithmetic and then collect student worksheets; (6) students are randomly appointed to communicate the results of social arithmetic solutions obtained in front of the class; (7) researchers discuss together all the questions with the aim of giving reinforcement to students.

![Figure 1. Example of task.](image-url)
3. Research finding
The study was conducted in the experimental class and the control class by using qualitative methods to determine the metacognition skills of students. The implementation of this research was carried out after carrying out the validity and reliability tests on the research instrument. Then students in the experimental class and the control class are given a pre-test to determine the students’ initial abilities in metacognition skills.

After the pre-test is carried out in the control class and the experimental class, learning will be carried out in the experimental class using the STEM-PjBL model and the control class using conventional learning, then data will be obtained for analysis using SPSS application. The following are the results of data analysis using SPSS and Excel applications.

3.1. Instrument Validation
Before showing the results, it is necessary to test the validity and reliability of the post-test instruments. The instrument is stated valid and reliable if $r_{count} \geq r_{table}$ (2-tailed test with sig. 0.05) with degrees of freedom (df) $N-2$. The following table shows the results of the validity and reliability of the post-test instruments.

| Table 2. Validity Test Results. |
|----------------------------------|
| **Correlations** |
| Problems 1 | Problems 2 | Problems 3 | Totals Score |
| Problems 1 | Pearson Correlation | 1 | .609** | -.131 | .572** |
|          | Sig. (2-tailed) | .003 | .560 | .005 |
|          | N | 22 | 22 | 22 | 22 |
| Problems 2 | Pearson Correlation | .609** | 1 | .212 | .783** |
|          | Sig. (2-tailed) | .003 | .343 | .000 |
|          | N | 22 | 22 | 22 | 22 |
| Problems 3 | Pearson Correlation | -.131 | .212 | 1 | .682** |
|          | Sig. (2-tailed) | .560 | .343 | .000 |
|          | N | 22 | 22 | 22 | 22 |
| Totals Score | Pearson Correlation | .572** | .783** | .682** | 1 |
|          | Sig. (2-tailed) | .005 | .000 | .000 |
|          | N | 22 | 22 | 22 | 22 |

Based on table 2, it can be seen from the $r_{count}$ value of problem 1 = 0.572, problem 2 = 0.783 and problem 3 = 0.682. All items produce the value $r_{count} > r_{table}$ (0.5368) with df = N-2 = 20, so all items are valid.

| Table 3. Hasil Uji Realibilitas instrumen. |
|-------------------------------------------|
| **Reliability Statistics** |
| Cronbach's Alpha | N of Items |
| .998 | 3 |

Based on table 3, it can be seen that the overall reliability value is 0.997. $r_\alpha$ (table) with a significance level of 5% is 0.997, because $r_{count} (0.998) > r_{table} (0.997)$, it can be concluded that the test instrument is reliable.
3.2. Result
The research began with a pre-test of 29 students in the control class to determine the level of metacognition skills. Based on the pre-test results in diagram 1, in the control class it was found that 10% of students were in the very good category in metacognition skills, 37% of students were in the good category in metacognition skills and 53% of students were in the poor category of metacognition skills. Student pre-test results in the control class are depicted in diagram form as follows.

Figure 2. Distribution of Pre-test metacognition skills of students in the control class.

Furthermore, the pre-test was tested on 11 students in the experimental class to determine the students' initial ability in metacognition skills. Based on the pre-test results in the experimental class (diagram 2), it was found that 12% of students were in the very good category in metacognition skills, 36% of students were in the good category in metacognition skills and 52% of students were in the poor category in metacognition skills. Student pre-test results in the experimental class are depicted in the form of a diagram as follows.

Figure 3. Pre-test distribution of students' metacognition skills in the experimental class.
Data from the pre-test results obtained from the experimental class and the control class, then analyzed using the homogeneity test, normality test and independent test t-test with the application of SPSS version 17.0. Homogeneity test aims to determine whether the variance in the control class and experimental class are different or the same. Normality test aims to see the distribution of data and as initial conditions in the independent t-test. The independent t-test aims to find out the difference in the mean of the data that is independent of the experimental class and the control class. In this study, the data is said to be homogeneous if the significance value or Sig. > 0.05.

Table 4. Test Results Homogeneity pre-test in the control class and experimental class.

| Marginal Homogeneity Test | Pre-Test & Post-Test |
|---------------------------|----------------------|
| Distinct Values           | 17                   |
| Off-Diagonal Cases        | 11                   |
| Observed MH Statistic     | 583.000              |
| Mean MH Statistic         | 603.500              |
| Std. Deviation of MH Statistic | 23.393             |
| Std. MH Statistic         | -.876                |
| Asymp. Sig. (2-tailed)    | .381                 |

Based on table 4, the homogeneity test of pre-test in the control class and the experimental class is sig 0.381. This is significant and greater than 0.05 (0.381 > 0.05), so the variance of pre-test data from the experimental class and the control class is homogeneous. The next data analysis is the normality test as a prerequisite in the independent test.

Table 5. Test Results Normality Pre-test in the control class and the experimental class.

| Tests of Normality | Class          | Kolmogorov-Smirnov^a Statistic | df | Sig. | Shapiro-Wilk Statistic | df | Sig. |
|--------------------|----------------|-------------------------------|----|------|------------------------|----|------|
|                    | Pre Test       |                               |    |      |                        |    |      |
|                    | Eksperimental Class | .158                        | 11 | .200*| .945                   | 11 | .577 |
|                    | Control Class  |                               |    |      |                        |    |      |
|                    | .140           |                               | 11 | .200*| .934                   | 11 | .448 |

Based on table 5, the shapiro-wilk pre-test normality test in the control class was 0.448 and the experimental class got a sig. 0.577. This is significant and greater than 0.05, so the variance of pre-test data from the experimental class and the control class is normality. The next data analysis is the independent t-test using the SPSS application with learning outcomes data from the pre-test.
Based on Table 6, the statistical test results show the average in the control class group is 53.7273 and the experimental class is 56.0000. These results indicate that the average in the control class is lower and the experimental class is higher. Then the next analysis is the analysis of independent test results in both classes. In this study, the results are said to be significant if the Sig. (2-tailed) is greater than 0.05.

Table 7. Independent Pre-Test Test Results in the control class and experimental class.

| Test         | Levene's Test for Equality of Variances | t-test for Equality of Means | 95% Confidence Interval of the Difference |
|--------------|----------------------------------------|------------------------------|------------------------------------------|
| Pre Test     | F = 0.959, Sig. = 0.339                 | t = -0.96, df = 20, Sig. (2-tailed) = 0.331 | Mean Difference = -3.72727, Std. Error = 3.74188, Lower = -11.53269, Upper = 4.07815 |
| Equal variances assumed |                           |                              |                                          |
| Equal variances not assumed |                         |                              |                                          |

Based on Table 7, the Sig. (2-tailed) is 0.331 > 0.05, then H₀ is accepted, which means there is no significant difference in the mean pre-test values of the control class and the experimental class.

The research was then continued by carrying out learning using conventional learning models in the control class and STEM-PjBL learning models in the experimental class, then continued with the post-test at the end of the learning. Based on the results of research conducted in the control class on 11 students after a post-test, it was found that 33% of students are in the very good category in metacognitive thinking skills, 52% of students are in the good category in metacognition thinking skills, and 15% of students are in poor category in metacognitive thinking skills. The results of the post-test of students in the control class are depicted in diagram form as follows.
Furthermore, post tests were conducted on 11 students in the experimental class to find out the students’ metacognition skills after applying STEM-PjBL based learning. Based on the post-test results, it was found that 40% of students were in the very good category in metacognitive thinking skills, 45% of students were in the good category in metacognitive thinking skills, and 15% of students were in the poor category in metacognitive thinking skills. The post-test results of students in the experimental class are depicted in diagram 4 as follows.

Figure 4. Post-test distribution of students' metacognition skills in the control class.

After giving treatment in the experimental class with the STEM-PjBL method and the control class using the conventional method, the data obtained from the post-test results were further analyzed using the normality test and independent test. Normality test aims to determine whether the distribution of
post-test data in the experimental class and the control class are normally distributed or not. In this study, the data distribution will be said to be significant if the value is greater or equal to 0.05.

**Table 8.** Normality Test of Post-test Results in the control class and experiment class.

|                 | Tests of Normality |
|-----------------|--------------------|
| Class           | Kolmogorov-Smirnov<sup>a</sup> | Shapiro-Wilk |
|                 | Statistic | df  | Sig. | Statistic | df  | Sig. |
| Post Test       | Experimental Class | .194 | 11   | .200<sup>*</sup> | .921 | 11   | .324 |
|                 | Control Class     | .156 | 11   | .200<sup>*</sup> | .964 | 11   | .824 |

Based on table 8, the Shapiro-Wilk value of the experimental class was 0.324 ≥ 0.05 and the Shapiro-Wilk value of the control class was 0.824 ≥ 0.05. So, it can be concluded that the experimental class and control class data are normally distributed. The next data analysis is an independent t-test using the SPSS application with learning outcomes data from the post-test.

**Table 9.** Mean Test of Post-Test Results in The Control Class and Experimental Class.

|                 | Group Statistics |
|-----------------|------------------|
|                 | N    | Mean       | Std. Deviation | Std. Error Mean |
| Post Test       | Experimental Class | 11  | 74.0000 | 6.91375 | 2.08458 |
|                 | Control Class    | 11  | 68.8182 | 4.11869 | 1.24183 |

Based on Table 9, the statistical test results show that the average of each control class group is 68.82 and the experimental class is 74.00. These results indicate that the average in the control class is lower and the experimental class is higher. Then the next analysis is the analysis of independent test results in both classes. In this study, the results are said to be significant if the Sig. (2-tailed) is greater than 0.05.
Table 10. Independent test results of post-test in the control class and experimental class.

|                      | Levene's Test for Equality of Variances | t-test for Equality of Means | 95% Confidence Interval of the Difference |
|----------------------|----------------------------------------|-----------------------------|----------------------------------------|
|                      | F   | Sig. | t   | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | Lower | Upper |
| Post Test            |     |      |     |    |                |               |                       |       |       |
| Equal variances      |     |      |     |    |                |               |                       |       |       |
| assumed              | 4.781 | .041  | 2.136 | 20  | .045           | 5.18182        | 2.42644               | .12036 | 10.24328 |
|                      |     |      |     |    |                |               |                       |       |       |
| Equal variances      |     |      |     |    |                |               |                       |       |       |
| not assumed          | 2.136 | 16.304 | .048  | 5.18182 | 2.42644 | .04578           | 10.31786 |

Independent test results of post-test in the control class and experimental class in table 8 show that the Sig. (2-tailed) is 0.045 <0.05, then H₀ is rejected, which means there is a significant difference in the average post-test scores of the control class and the experimental class.

The next step is the analysis of the results of observations on STEM PjBL conducted in the experimental class. Based on Diagram 5, it was found that 58% of students were very active in STEM-PjBL, 17% of students were active in STEM-PjBL, 9% of students were fair in STEM-PjBL, 7% were poor students in STEM-PjBL, and 9% of students are very poor in STEM-PjBL. Thus, STEM-PjBL have an impact on students in solving social arithmetic problems. The results of observations from STEM-PjBL in the class experiment are described in the form of a diagram as follows.

Figure 6. The observation result distribution of all subject in the experimental class.
3.3. Portrait phase

The difference in metacognition skills of elementary school students is influenced by a number of things, such as their prior knowledge and experience, also the treatment given during the study. Their metacognition skills in solving social arithmetic problems can be explained in the portrait phase. The portrait phase is taken to describe the stages of the students' metacognition skill process with the implementation of STEM-PjBL. By using the interview method, we can explore students' metacognition skills in the problem solving process given from the first step to the last step. The results of student work can be seen as follows:

![Figure 7. The Result of student 1(very good).](image)

The analysis of student1 (S1) on social arithmetic problem given has reached level 3 (very good). Based on the analysis of the work of S1 it is understood that S1 can solve problems with appropriate steps and can be seen in Figure 2. This S1 skill is clearly demonstrated by the results of the interviews are as follows:

R : What do you get about the from the question?
S1 : About social arithmetic problem, isn’t it?
R : Yes, it is. Do you get it?
S1 : Yes I do, I know how to solve the problem and it is easy for me.
R : Would you like to explain, how do you solve the problem?
S1 : Firstly, I worked on the problem. I am fully confident with my working. then I think again, whether the steps I have done are correct or not.
R : Then?
S1 : I worked on the problem. I am fully confident with my working. Next, I think again, whether the steps I have done are correct or not.
R : Did you double-check what you have done?
S1 : Yes I did.
R : Do you have another way to do the problem?
S1 : Yes, In addition to counting manually, I have also tried using a calculator and the results turned out to be the same.
R : If I give another question, can you do it?
S1 : Yes, of course I can, that's easy

![Figure 8. The portrait of phase S1.](diagram)
From the portrait phase in figure 3, it can be seen that S1 has done the problem solving in accordance with the steps, and fulfilled all indicators of metacognition skills. And they are (1) students reading and describing problems (P1), (2) students can predict problem solving plans (P2), (3) students can obtain problem solving plans (P3), (4) students believe the chosen completion plan is true (M1), (5) students do the correct work steps in solving problems (M2), (6) students check the correctness of steps in solving problems (M3), (7) students re-examine the work (E1), (8) students can solve problems in different ways (E2), (9) students are able to apply this method to other problems (E3).

**Figure 9.** The Result of student 2 (poor).

The analysis of Student2 (S2) on social arithmetic problem given has reached level 1 (poor). Based on the analysis of the work of S2 it is understood that S2 can not solve the problems with appropriate steps and can be seen in Figure 5. The skill of S2 is clearly demonstrated by the results of the interviews are as follows:

R : What do you get about the question?
S2 : oh, about finding the long of calculator?
R : Yes, it is. Do you get it?
S2 : I understand a little bit.
R : Would you like to explain, how do you solve the problem?
S2 : when I get a question, I read the problem and immediately work on it.
R : Then, did you double check what you have done?
S2 : No I did not.
R : If I give another question, can you do it?
S2 : I don't know if I can do it.

**Figure 10.** The portrait of phase S2.

From the phase portrait in figure 5 it can be seen that S2 has done problem solving not according to the right steps and does not meet all indicators of metacognition skills. S2 only takes two steps: (1)
students reading and describing problems (P1), (2) students believe the chosen completion plan is true (M1).

![Image of a worksheet with a problem and solution]

**Figure 11.** The Result of student 3 (good).

The analysis of student 3 (S3) on social arithmetic problem given has reached level 2 (good). Based on the analysis of the work of S3 it is understood that S3 can solve the problem correctly but not all steps are done in sequence. There are several steps that are passed, it can be seen in Figure 6. The skill of S3 is clearly demonstrated by the results of the interviews are as follows:

R : What do you get about the question?
S3 : Questions about pricing and changing calculation problems?
R : Do you get it?
S3 : Yes, I do.
R : Would you like to explain, how do you solve the problem?
S3 : When I get a problem, I read it and I find a way to solve it.
R : Then?
S3 : I think that the working that I have taken is right. Therefore I do what is in my mind and I think is right.
R : Then, did you double check what you have done?
S3 : Yes I did.
R : If I give another question, can you do it?
S3 : I don't know, maybe I can do it, maybe I can't.

![Phase portrait of S3]

**Figure 12.** The portrait of phase S3.

From the phase portrait in figure 7 it can be seen that S3 has done problem solving correctly but not all steps are done in all indicators of metacognition skills. S3 only takes 5 steps: reading and outlining the problem (P1), getting the problem solving plan (P3), believing the problem solving plan chosen is correct (M1), doing the right work steps and also crosschecking the work. (1) students reading and describing problems (P1), (2) students can obtain problem solving plans (P3), (3) students believe the
chosen completion plan is true (M1), (4) students do the correct work steps in solving problems (M2), (4) students re-examine the work (E1).

4. Discussion
STEM-PjBL Learning aims to improve student metacognition skills, especially in solving social arithmetic problems. The syntax of this learning are five steps, namely reflection, research, discovery, application, and the last one is communication. In the reflection phase, students try to understand the problems given by the teacher. Furthermore, at the research stage, based on the understanding gained at the previous phase, students device a mathematical model of the social arithmetic problems provided. After that, based on the mathematical model that has been created, students find answers in the form of numbers from the problem through the calculations that have been done. Step four is the students applying the results obtained in the form of numbers from the calculations a form the conclusion of the appropriate answer. Next, at the last stage students converse the outcome of the answer in a presentation in front of the class.

The learning device used in this research is a students worksheet based STEM-PjBL that improving the skills of students’ metacognition. At the first meeting, the teacher gave pre-test question of social arithmetic. Afterwards, discuss the social arithmetic material that was learned earlier using STEM-PjBL-based learning for the experimental class. As for the control class get re-explanation with conventional learning. The purpose of this learning is to remind students of social arithmetic material that has been studied at the previous meeting. In addition, it is also aimed at improving the skills of students’ metacognition. At the second meeting, students were given post-tests on social arithmetic for the purpose of learning the improvement of their skills.

In this study, there were results related to the analysis of students' ability to solve social arithmetic problems. By using the test-t researchers analyze the normality and homogeneity of the data obtained from the results of pre-test class of control and experimental class. Based on the results pre-test can be known that both classes have the same level of variant. Thus, both classes are said to be homogen. Furthermore, researchers also have tested the results of data normality in results of post-test. From the test results, it is known that both classes of both control and experimental classes have the results of a test post with a normal distribution. Once that is followed by checking the average test post results from both classes. The results showed that the average experiment-class test post results were higher than the average post-test results in the control class. This indicates that STEM-PjBL-based learning is better able to improve student's ability to study than conventional-based learning. Based on the discussion in Part 3 is also known from the SPSS calculations that there is a significant influence of the implementation of the STEM-PjBL learning

5. Conclusion
This paper discusses the application of STEM-PjBL based learning and its effect on students' metacognition skills in solving social arithmetic problems. The results show that the application of learning based on STEM_PjBL has a big influence on learning, in this case it is able to improve students' metacognition skills in solving social arithmetic problems.

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