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The Effect of Guided Inquiry Learning in Improving Metacognitive Skill of Elementary School Students

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This study aimed to analyse the effect of guided inquiry learning in improving metacognitive skill of elementary school students in fractional materials. This type of research was a mixed of quantitative and qualitative methods. The subjects of this study consisted of 55 fifth grade students. Two learning models – the guided inquiry learning and conventional learning – were compared. The students' metacognitive skills were measured through fractional material problem solving tests. The quantitative data analysis used descriptive and inferential statistical tests, while the qualitative data were collected through unstructured interviews. Based on the data analysis, it was found that the sig (2-tailed) t-test from the independent post-test t-test was 0.00 ($p = <0.05$), indicating that there was significant difference. This shows that the students' metacognitive skill of the two classes were different in solving fraction problems after the application of guided inquiry. Thus, it can be concluded that there is a significant influence on the application of guided inquiry learning in improving students' metacognitive skill in solving fraction problems.

Keywords: guided inquiry, metacognitive skill, elementary school, fraction, guided inquiry learning, elementary school students

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INTRODUCTION

Metacognitive skill is an indicator that is emphasized in the achievement of learning objectives. The involvement of metacognitive skill becomes an important component in learning activities because it can encourage higher-order thinking skills (Kuzle, 2013; Biryukov, 2014; Wismath, Orr, & Good, 2014). Metacognition is defined as a part of higher-level thinking skills that includes understanding, analysis, and control of cognitive processes (Dorr & Perels, 2019; Flavell, Miller, & Miller 2002). Metacognition can also be defined as the ability to think about what has been thought which includes three activities such as awareness, regulation, and evaluation (Hastuti, Nusantara, Subanji, & Susanto, 2016).

Based on the result of a study, it was revealed that metacognitive abilities develop along with age and uniquely this development occurs continuously (van der Stel & Veenman, 2014). Therefore, it is feasible to analyze how to develop children's metacognitive skill as a key aspect of independent learning at an early stage (Winne & Hadwin, 2008). Moreover, Tarrant and Holt (2017) explain how to develop a metacognitive approach to elementary school students. According to them, students will have better metacognitive skill if they are engaged in metacognitive activities from earlier grade. Therefore, many developing countries, including Indonesia, have established policies in which metacognitive aspects become a pivotal component in the competence standard of elementary education graduates.

Some previous studies especially in Indonesian context have revealed that students' metacognitive skill is still at the lowest level (Prayitno, 2011; Suratno, 2009; Hastuti et al., 2019). Even the metacognitive skill of elementary school teacher candidates is also still at a low level (Hastuti & Haifaturrahmah, 2018). This is so ironic because metacognitive activity is a crucial indicator of student's cognitive development and a determinant in achieving learning objectives. The low metacognitive skill in elementary schools might have an impact on the low metacognitive skill in the next level of education. Therefore, the problem of the low metacognitive skill in early education needs to be solved.

One of the factors causing the students' low metacognitive skill is that learning activities that are designed are still teacher-centered and emphasize cognitive aspects. In addition, students are only involved in routine problems or problems not involving problem solving, so these routine problems have not been able to train students to think at a high level. Teacher-centered learning is believed to produce passive students; thus, there is no involvement of students' metacognitive activities (Rahmat & Chanunan, 2018). Besides, metacognition is closely related to problem solving. Metacognition arises when someone encounters unknown problems, uncertainties, questions, or dilemmas (King, Goodson, & Spiritual, 1993).

One of the solutions to improve students' metacognitive skill is through student-centered learning activities such as inquiry learning model. Inquiry learning model refers to the constructivist paradigm, in which students actively construct their own knowledge. Inquiry learning activities are designed to resemble the activities of a scientist, in which students are involved to question, analyze ideas, design strategies, and discuss the results and the meaning of the results (Ellwood & Abrams, 2018). Through inquiry activities, students build their knowledge actively so that the desired learning outcomes can be achieved. In inquiry learning activities, students are engaged in activities that are fundamentally open, student-centered, and directly based on real-life problems.

Inquiry learning is divided into three types: 1) structured inquiry, 2) guided inquiry, and 3) open inquiry. The type of inquiry learning that is suitable for elementary school students is guided inquiry learning because they do not yet have much experience in inquiry learning (Suastra, 2017; Margunayasa, et al, 2018). Guided inquiry emphasizes the importance of the process of discovery by students themselves. Guided inquiry has six stages: 1) orientation, 2) problem formulation, 3) hypothesis formulation, 4) data collection, 5) verification of results/hypothesis testing, and 6) conclusion.

Some previous studies have proven that inquiry learning can improve students' critical thinking skills (Thaiposri & Wannapiroon, 2015; Prayogi, Yuanita, & Wasis, 2018). Moreover, a research conducted by Ergul et. al. (2011) also uncovers that the use of guided inquiry teaching method can significantly improve scientific process skill and attitude of elementary school students. The inquiry learning model becomes popular and plays a crucial role in supporting higher-order thinking skills in various fields, particularly in science and mathematics (Hayes, 2002; Rooney, 2009; Towers, 2010). Many researchers believe that fostering high-level thinking among students of all ages is a major educational goal and high-level thinking is an important element of life success (Gough, 1991; Zohar et. al, 2001; Sousa, 2008). Inquiry learning can also help students develop metacognitive skill (Kuhlthau, 2010; Seraphin., et. al, 2012). Anderson & Krathwohl (2001) defined three indicators of metacognitive skills as 1) plan, 2) evaluation, and 3) monitoring. The last few decades, a bunch of studies have investigated the effect of guided inquiry on higher-order thinking skills including metacognition; however, investigation on the effect of guided inquiry on the metacognitive skill of elementary school students is still limited and needs to be further researched (Suastra, 2017; Margunayasa, et al, 2018). Furthermore, this research will make a valuable contribution to the mathematics education literature especially in elementary schools in terms of the application of guided inquiry to improve elementary students' metacognitive skill in fractional material. Based on the results of previous observations, students experience a lot of concept errors in fraction material. The purpose of this research is investigate the effect of guided inquiry on the metacognitive skills of elementary school students. The expectation was that guided inquiry supported would provide significant improvement of student's metacognitive abilities and fraction concept understanding. In this study, the researchers tried to analyze different metacognitive skill between elementary school students who learned through the guided inquiry learning model and those who learned through conventional learning model.

METHOD

Population and Sample

This research was conducted in the first semester of the 2019 academic year in fractional material. The population of this research was the fifth grade students of Sandik 1 Public Elementary School in West Lombok Regency, West Nusa Tenggara, Indonesia. This study applied cluster random sampling by selecting two classes randomly, resulting one experimental class with a total of 28 students, taught using guided inquiry and control class with 27 students in total, taught using conventional learning model.

Research Design

This research used a combination of quantitative and qualitative methods (mixed method). Quantitative method was used to analyse data taken from the metacognitive skill tests of elementary school students after the application of guided inquiry. Furthermore, the qualitative method was applied to analyse data taken from observations both during class learning and group discussions, students' test results, and interview with selected students. To find out the effect of implementing guided inquiry in depth, all students in the experimental and control group were observed and interviewed related to their process of solving fraction problems. This study investigated two variables, consisting of applying guided inquiry as an independent variable and testing students' metacognitive abilities in solving fraction problems as a dependent variable.

The stages of guided inquiry in this study consisted of six: 1) orientation, 2) problem formulation, 3) hypothesis formulation, 4) data collection, 5) verification of results/hypothesis testing, and 6) conclusion. The conventional teaching model in this research refers to transferring knowledge from the teacher to students which usually starts with the teacher's brief explanation of the fractional material, continues with the student trying to answer some problems in the book or problems from the teacher and ends with the presentation of the answers. Characteristics of conventional teaching model are the tendency to dominate teaching activities, transfer of knowledge from teacher to student, monotonous learning activities, one-way communication, many exercises in problem solving and teacher-cantered teaching.

The experimental design of this study was to prepare two class groups: the experimental and the control class, which were selected by cluster random sampling and examined through pre-test and post-test using a design in Table 1

Table 1
Equivalent Pre-test and Post-test Control Group Design

Group	Pre test	Treatment	Pos test
A (n=28)	O1	X	O2
B (n=27)	O3	-	O4

Table 1 shows that A is the experimental group applying guided inquiry and B represents the control group applying conventional learning. O1 and O3 are the two groups that have the same metacognitive abilities and are tested using pre-tests. O2 is the result of the experimental group, while O4 is the result of the control group. In this study, the effect of treatment is analysed using t-test. Figure 1 shows the triangulation mode in which qualitative data are triangulated with quantitative data to find out the effects of guided inquiry in improving students' metacognitive abilities in solving fraction problems.

Experimental Procedure

The experiments were carried out in 6 meetings, not including pre-test and post-test. The first step was to prepare two class groups: the experimental class and the control class, which were selected through purposive random sampling. Class A was the experimental group to apply inquiry learning, while class B served as the control group taught with conventional method. The second step was giving a pre-test to the two groups. The third step was validation process. There were two mathematics education experts validating the plan for implementing guided inquiry learning, student worksheets, and pre-test and post-test questions containing fraction problem solving. The fourth step was the treatment process. In this step, the researcher served as a teacher. In the experimental class, the students are involved in guided inquiry learning activities. Meanwhile, in the control class, the students were taught using conventional method. The fifth step was giving a post-test. In this step, the students' metacognitive skill was analysed.

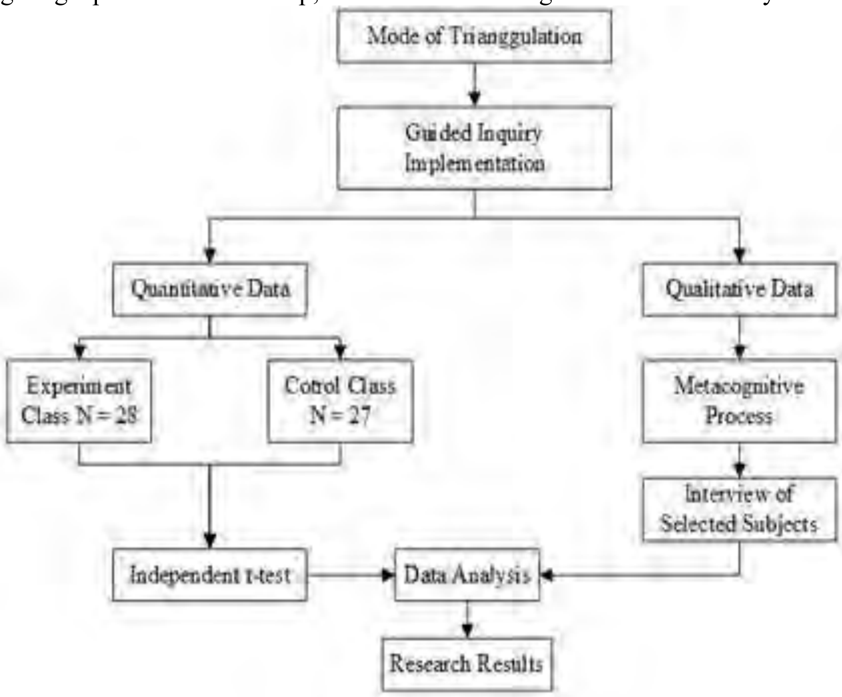

Figure 1
Mode of Triangulation

Instruments

The data of this study were obtained using some instruments such as guided inquiry lesson plan, student worksheets, mathematics problem solving test with fractions material, and interviews. Fractional material mathematics problem solving tests were used to collect students' metacognitive skill data. The fraction problem consisted of questions that integrated to metacognitive skills indicators such as planning, monitoring, and evaluation (Krathwohl, 2002). Indicators and description of metacognitive skills can be seen in Table 2.

Table 2
Indicators and Descriptions of Metacognitive Skills

No	Indicator	Description
1	Plan	• Setting goals (P1) • Enabling relevant resources (P2) • Choosing the right strategy (P3)
2	Evaluation	• Determine the level of understanding of a person (E1) • How to choose the right strategy (E2)
3	Monitoring	• Checking one's progress (M1) • Choose the appropriate improvement strategies when the chosen strategy does not work. (M2)

Metacognitive skills rubric consisted of seven scale (0-7) which includes: (1) the answer in his own words, (2) the order of a coherent answer, (3) the grammar or language, (4) the reason (analysis/evaluation, creation), and (5) answer (right/less/not really/blank) (Corebima, 2009).

Data Analysis

Students in the experimental and control groups were given problem solving questions about fractional material during pre-test and post-test. Qualitative data were collected through unstructured interviews based on students' work result during the post-test. The statistical analysis were descriptive and inferential to analyse quantitative data. Descriptive statistic was used to show the means and standard deviations, while the inferential statistic was independent sample t-tests to test the effectiveness of guided inquiry between the experimental and the control class (Hilton et. al., 2004). The significance level used to compare the average scores of the experimental and control classes was 5% significance level.

FINDINGS

Based on the results of the interview and students' work, the percentage of students who perform the three metacognitive skills indicators during the post-test can be concluded in the following graphic.

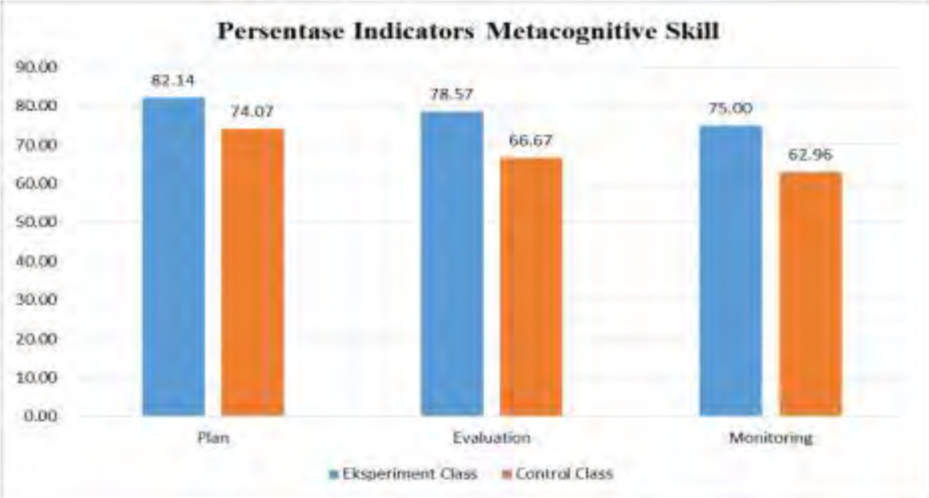

Figure 2
Percentages of Metacognitive Skill Indicators

To be more specific, Figure 3 shows the percentage of students who perform the metacognitive skills based on the description of each indicator such as setting goal (P1), enabling relevant sources (P2), choosing the right strategy (P3), determining the level of understanding of a person (E1), choosing the right strategy (E2), checking one's progress (M1), and choose the appropriate improvement strategies when the chosen strategy does not work (M2).

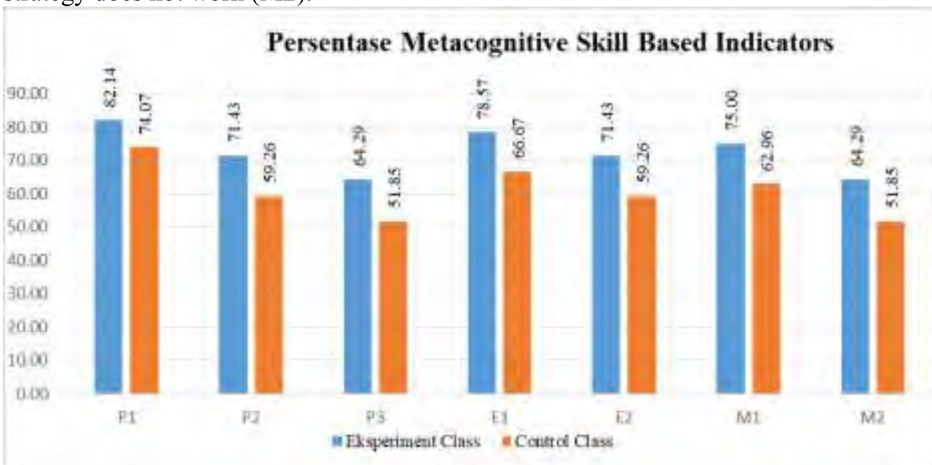

Figure 3
Percentages of Metacognitive Skill Based Indicators

Furthermore, to test the effectiveness of guided inquiry between experiment class and control class, an independent sample t-test was used. Data normality test was examined before further analysis. The number of respondents was 55 students. As can be seen in Table 3 and Table 4, the pre-test results from both the experimental class and the control class are equal or not significantly different. This assessment refers to the assessment rubric to measure the metacognitive skills developed by Corebima (2009).

Table 3
The Table Displays Pre-test Results and Mean Values between the Experimental and the Control Class

Group	N	Mean	Std.Deviation	Std.Error Mean
Experimental Class	28	1.11	.832	.157
Control Class	27	1.04	.759	.146

The average score in the experimental class is 1.11 (SD = .832), while the control class is characterized by an average score of 1.04 (SD = .759). The difference in pre-test scores between the two groups is [t (55) = 0.293, p> 0.05], meaning that it is not significant at alpha .05 levels. This shows that the two groups were equal before treatment.

Table 4
The Data below Presents the Comparison of Pre-test Score of Experiment Class and Control Class Score using Independent Sample T-Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Pre test	Equal variances assumed	1.127	.293	.326	53	.746	.70	.215	-.361	.501
	Equal variances not assumed			.327	52.841	.745	.70	.215	-.360	.500

Table 5
The Table Displays Post-test Results and Mean Values between the Control Class and the Experimental Class

Group	N	Mean	Std. Deviation	Std. Error Mean
Experimental class	28	4.14	2.368	.448
Control class	27	2.07	1.615	.311

Table 5 shows the post-test results of the experimental class with the average score 4.14 (SD = 2.368), while the control class is 2.07 (SD = 1.615). Furthermore, Table 6 shows that the sig (2-tailed) t-test of the independent post-test t-test is 0.00 (p = <0.05), meaning that it is significant. This shows that the two classes are different in the metacognitive skill in solving fraction problems after the application of guided inquiry. Based on these results, it can be concluded that there is a significant influence on the application of guided inquiry learning models in improving students' metacognitive skill in solving fraction problems.

Table 6
The Data below Presents the Comparison of Post-test Score of Experiment Class and Control Class Score using Independent Sample T-Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Post test	Equal variances assumed	2.420	.126	3.771	43	.000	2.069	5.49	.968	3.169
	Equal variances not assumed			3.796	47.789	.000	2.069	5.45	.973	3.165

Based on the results of students' answers in solving fraction problems, the data about students' metacognitive skill were obtained. In the experimental class, metacognitive activities occur when students solve mathematical problems with fractions. The following is the description of metacognitive activities carried out by two selected students to get deeper analysis named as S1 and S2.

Interview Result with S1 And S2

The stages in solving problems were analysed based on Polya's problem solving stages consisting of understanding problem, planning, implementing, and evaluating. In the stage of understanding the problem, S1 did plan. In this activity, S1 thinks the fraction combination if it is added or subtracted will result $\frac{3}{4}$. Next S1 thinks over it so that S1 understands that what is asked in the problem is to find the addition and subtraction of the two fractions whose results is $\frac{3}{4}$. This fact is proven from the results of the interview transcription with S1.

Q: Okay, what was your first thought after reading question number 1?

S1: *at first, I thought about adding two fractions and subtracting two fractions that resulted* $\frac{3}{4}$ (plan)

Then in the planning stage, S1 conducts evaluation which is marked by the shaded rectangular drawing activity, with the reason to make it easier to find all the addition and subtraction of fractions that results $\frac{3}{4}$. This fact emerges from the results of interview with S1 and the following is the transcription.

Q: Why did you choose this method, drawing a shaded rectangle?

S1: <u>To make it easier, ma'am, and we can also find all the addition and subtraction of fractions that get the result</u> $\frac{3}{4}$ (evaluation)

P: Okay then what next?

S1: First I drew fractions $\frac{1}{4}$ *and* $\frac{2}{4}$*. Now if they are added, the result will be* $\frac{3}{4}$*. Then I drew another fraction* $\frac{4}{4}$*. Then if it is taken, the result is* $\frac{3}{4}$*. At the stage of implementing the plan, S1 implements the plan with illustrations of fractional images* $\frac{1}{4}$ *and* $\frac{2}{4}$ *and then added and the result is* $\frac{3}{4}$*.*

Next, in the evaluating stage, S1 does a monitoring. This monitoring can be seen from the way S1 thinks. It is related to his final decision that there are two combinations of fractions that results $\frac{3}{4}$. Then S1 thinks it over that is reassessing his decision, by convincing himself that there are two fraction combinations that result $\frac{3}{4}$ by rechecking each written step and trying to find another combination. The following are the results of S1 think aloud.

Q: *Okay, are you sure there are only two fraction combinations that result* $\frac{3}{4}$*?*

S1: Yes ma'am

P: What makes you so sure?

S1: *<u>Yes I have checked one by one but there is no more addition and subtraction of two fractions that result</u>* $\frac{3}{4}$ (monitoring)

The results of S1 work can be seen in Figure 4.

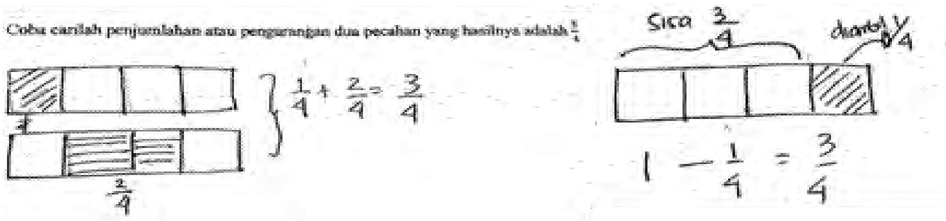

Figure 4
The Result of S1's Work

At the stage of understanding the problem, S2 performs plan activities, so S2 understands what problem is asked in question number two that is related to the price of $1\frac{1}{2}$ kg of eggs. This fact is proven with the results of interview S1. The following is the interview transcription between researchers and S1

Q: What do you think after reading question number two?

S8: <u>I must look for the price of $1\frac{1}{2}$ kg of egg if it is known that the price of 1 kg of egg is IDR 10,000.00</u> (plan).

In the planning stage, S2 performs evaluation because S2 rethinks why choosing the strategy by changing mixed fraction $1\frac{1}{2}$ to ordinary fraction $\frac{3}{2}$ then multiplying it by 10,000. The reason for choosing this strategy is to make it easy to calculate. The following is the interview transcription.

Q: Then how do you solve this problem?

S2: First, I changed the mix fraction $1\frac{1}{2}$ into a regular fraction $\frac{3}{2}$ then multiply by 10,000.

Q: Why did you choose this method?

S5: <u>Yes, I changed it to a regular fraction so that it's easy to multiply it by 10,000</u> (monitoring)

For the stage of carrying out the plan, S2 writes the decision as shown in Figure 5.

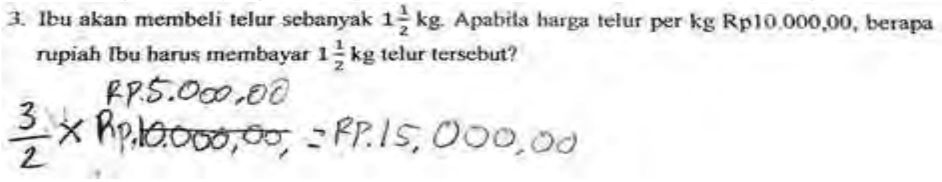

Figure 5
The Result of S2's Work

DISCUSSION

Guided inquiry learning encourages students to be more actively involved in mathematics learning activities. The stages in the guided inquiry learning model can bring up aspects of metacognitive skill. The stages of guided inquiry in this study used six stages: 1) orientation, 2) problem formulation, 3) hypothesis formulation, 4) data collection, 5) verification of results/hypothesis testing, and 6) conclusion.

In the orientation phase, the teacher made apperception and associated the material to be learned with the previous materials about introduction of fractions, simple fractions, and comparison of fractions that have been learned in fourth grade. In this stage, there were several problems confronted by the researchers. The students' initial concept of fraction material in grade four was in fact still weak, so there was a need to work hard to stimulate their background knowledge. Before discussing the material, the students received information about the basic competences and learning objectives to be achieved, the scope of the material, the learning steps, and the stages of the inquiry learning model. Most of the interactions that occurred in the orientation stage were interactions between students and the teacher (the researcher). The activity of preparing students physically and psychologically through apperception can encourage the emergence of metacognitive activities. Elbers (2003) also states that interaction in learning in class encourages reflection.

In the stage of problem solving, students were given the problem of addition, subtraction, multiplication, and division of fractions through compiled student worksheets. The students were asked to make a group of 3 to 4. After that, the students were asked to learn all the instructions in the worksheet. In this stage, each group was also facilitated by transparent plastic learning media. The use of this media aims to help students deliver the concepts of addition, subtraction, multiplication, and division of fractions with different denominators. Instructions for using this media are also included in the student worksheet. It is in line with research conducted by Ellwood and Abrams (2018) stating that students' interaction especially in group discussions will give them feedback and increase students' motivation and achievement results. Hastuti, et. al. (2020) emphasize that elementary school children have not been able to think abstractly, so there is a need for learning media to deliver concepts.

At the stage of constructing hypotheses, many questioning activities occur in group members. For example, the students asked about how to add and subtract two fractions with different denominators and how to multiply and divide two fractions. Students asked one another in a group or even they also asked the teacher. After questioning, students made hypotheses about how to add, subtract, multiply, and divide fractions. At this stage, there were several difficulties in terms of students' literacy ability, which was still low. Many students preferred asking to teacher to reading and finding out themselves. However, the teacher kept encouraging the students to read over and over and to understand the worksheets given from the first meeting to the last so that students could practice their literacy skills at the same time. Interactions that occurred in this stage are interactions between students and students, students with learning resources (student worksheets, textbooks, and transparent plastic media), and students and teachers (researcher). These interactions encourage the emergence of metacognitive activities. Metacognitive activities arise, as students learn to question and evaluate the opinions of peers in groups. It is supported by Chiu and Kuo (2010), who reveal that social metacognition in group discussions can construct students' knowledge and strategies so that they can help students learn and evaluate strategies.

In the data collection stage, the members of group one began to try to do the addition, subtraction, multiplication, and distribution using transparent plastic. They also began to answer all questions in the student worksheet. When observing this activity, it was found that there were some difficulties experienced by the group. For example, the students did not understand the guidelines for using the media on student worksheets, so the teacher provided them with direction so that students understood and found it themselves. Overall, the students were enthusiastic in this activity. When they found difficulties, they directly asked the teacher. Based on observation and interview, the students were more enthusiastic about learning because they felt they were more involved in the activities of fiddling with transparent plastic and discussing one another. This finding is similar to the finding of Elbers (2003) that interactions in inquiry learning will stimulate students to construct mathematical knowledge and encourage them to do the process of reflection.

In the hypothesis testing stage, students begin to double check whether the results of the hypotheses they made related to the addition, subtraction, multiplication, and division of fractions match the results of their experiments when using transparent plastic media. In this stage, there was student-student, students-learning resources, and students-teacher interactions. These interactions stimulate the students to get involved in metacognitive activities. From the findings, to add and subtract fractions, the denominator needs to be equated at first. In this stage, the students performed metacognitive activities by evaluating input from their friends and then changed their initial answer. This is consistent with the research of Hurme, Marenluoto, and Jarvela (2009) stating that metacognition arises more when it occurs in group discussions where one group member contributes and influences other members so that other members in the group respond and develop it.

In the last stage (conclusion), students concluded that to add and subtract two different denominators is to equate the denominator at first. Furthermore, multiplication can be done by multiplying the numerator by the numerator and the denominator by the denominator. Division is the opposite of multiplication operations. Then in the reflection stage, students were asked to describe the difficulties encountered and how to overcome them. Most students revealed that they had difficulty operating fractions that had large values because in this problem they were not likely to use transparent plastic media anymore. To operate fractions of great value, students need to be guided to be able to bring from the concrete to the abstract (from the use of media to abstract concepts). Teaching and learning process which are designed by the teacher refer to three stages of children development from Bruner. They are 1) Concrete 2) Iconic and 3) Abstract. Therefore, in the first stage, the teacher needs to facilitate the students by giving teaching media in order to make the students able to learn by playing through objects directly. In the second stage, which is iconic, the teacher needs to point the students in order to be able to learn by visualization. In the last stage which is symbolic, the students are able to write the words in the form of symbol and mathematics sentence.

CONCLUSION

Based on data analysis and findings, it can be concluded that compared to conventional method, guided inquiry learning can improve students' metacognitive skill better. Each stage in inquiry learning can encourage students' metacognitive activities especially when they are involved in group discussions. It is implied that elementary school teachers need to implement media-assisted guided inquiry learning especially in mathematics learning. In addition, it is recommended that further researchers apply guided inquiry learning in other mathematical topics.

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