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The Effect of Metacognitive-Based Contextual Learning Model on Fifth-Grade Students' Problem-Solving and Mathematical Communication Skills

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Abstract: Problem-solving and mathematical communication are essential skills needed by students in learning mathematics. However, empirical evidence reports that students' skills are less satisfying. Thus, this study aims to improve students' problem-solving and mathematical communication skills using a Metacognitive-Based Contextual Learning (MBCL) model. A quasi-experimental non-equivalent control group design was used in this study. The participants were 204 fifth-grade students; consisting of experimental (*n* = 102) and control (*n* = 102) groups selected using convenience sampling. This study was conducted in four Indonesian elementary schools in the first semester of the academic year 2019/2020. The Problem-Solving Skills Test (PSST) and Mathematical Communication Skills Test (MCST) were used as pre- and post-tests. In order to analyze the data, one-way ANOVA was used at the 0.05 significance level. The results showed that students in the experimental group had higher post-test scores than the control group in terms of problem-solving and mathematical communication skills. It can be concluded that the MBCL effectively promotes fifth-grade students' problem-solving and mathematical communication skills. Therefore, it is suggested that MBCL should be used more frequently in primary school mathematics to further improve students' problem-solving and mathematical communication skills.

Keywords: *Contextual-based learning, mathematical communication skills, metacognition, problem-solving skills.*

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Introduction

Problem-solving skills are one of the important skills in learning mathematics in the 21st century. Polya (1973) highlighted that problem-solving as an attempt to find a way out of a difficulty in order to achieve a goal. Problem-solving is recognized as an important life skill that involves a series of processes including analyzing, interpreting, reasoning, predicting, evaluating and pondering (Anderson, 2009). In addition, Kilpatric et al. (2001) argued that problem-solving provides an important context for students to learn numbers and other mathematical terms. Other studies agreed on the importance of improving problem-solving skills among students, for instance, Andrews and Xenofontos (2014) and Branca (1980) considered that these essential skills are needed by students to evaluate mathematical information and solve problems in daily life. In fact, the National Council of Teachers of Mathematics (NCTM) (2000) suggested that teachers develop students' mathematical problem-solving early on. This is important because advanced problem-solving skills encourage students to share ideas, discuss and expand mathematical discussions with their peers, and transfer their experiences to different situations, and in turn improve their problem-solving outcomes (Bostic et al., 2016; Santos-Trigo & Reyes-Martinez, 2019). In sum, mathematical problem-solving is a vital skill that students need to learn, evaluate, and solve everyday mathematical problems in order to achieve a goal. Thus, problem-solving skills should be possessed by children from the elementary school level.

Previous research reported that problem-solving skills affect mathematical abilities, school success, motivation, and individual relationships (e.g., Beyazsacli, 2016; Delice & Ergene, 2015; Moshirabadi et al., 2016; Saputro et al., 2019; Szabo & Andrews, 2017). However, Lee et al. (2014) found that many fourth-grade students had difficulty in solving mathematical problems. Supportively, in Indonesia, Demitra and Sarjoko (2018) and Parwati et al. (2018) revealed that mathematical problem-solving skills of primary and secondary school students need to be improved. Students

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generally learn to solve structured problems related to the subject matter (Johnson et al., 2011; Yu et al., 2014). Ozcan (2015) considered that routine problems are limited to exercises to test students' knowledge recently discussed. Thus, it is important to train students to solve non-routine problems using effective instructional strategies both inside and outside the classroom.

Promoting students' mathematical communication skills is one of the main goals in learning mathematics in elementary schools because communication is seen as one of the main processes in building understanding (Huang et al., 2005). NCTM (1989) stated that communication skills as the ability to express mathematical ideas through oral, written, and demonstrate them visually. In addition, John (2008) defined mathematical communication as an effort to organize and combine thinking using mathematical language. Supportively, Within (1992) argued that communication skills are important when discussions between students take place, where students are expected to be able to state, explain, describe, hear, ask and work together to deeply understand mathematics. In short, communication is seen as a way to convey ideas, thoughts, and feelings to others (van de Walle, 2008).

The importance of developing students' mathematical communication skills has been well documented; for instructors, these core competencies are related to reading comprehension, self-efficacy and scientific literacy (Hopf & Colby, 1992; Lamb et al., 1997; Spektor-Levy et al., 2009). However, recent findings showed that communication skills in mathematics curriculum are rarely trained by teachers, so students' mathematical communication skills tend to be unsatisfactory (Stoffelsma & Spooren, 2019; Yaniawati et al., 2019). In addition, student difficulties in mathematical communication and problem-solving often occur due to the lack of mathematical knowledge and metacognitive skills (Hegarty et al., 1995; Schoenfeld, 1992; Verschaffel et al., 1999). Mevarech and Fan (2018) argued that metacognition is a higher-order thinking process which involves a one's active control over cognitive processes in order to understand and control his/her own learning. Chatzipanteli et al. (2013) revealed that metacognition plays an important role in supporting student success, because students who use metacognitive abilities are able to diagnose and fix problems, and find the best way to strengthen what they have learned. Therefore, teachers need to apply effective teaching strategies to develop students' problem-solving and mathematical communication skills to a satisfactory level.

The various teaching models are necessarily used to improve students' performance. For example, Maftoon and Alamdari (2020) reported that metacognitive strategy instruction had a positive and significant impact on students' metacognitive awareness. Similarly, Hargrove and Nietfeld (2014) found that metacognitive instruction significantly encourages students' creative problem-solving. Kazeni and Onwu (2013) noted that context-based learning is significantly better than traditional teaching approaches. In addition, Podschuweit and Bernholt (2017) reported that context-based learning provides opportunities for students to develop their conceptual understanding. In a similar vein, Dori et al. (2018) determined that context-based learning (CBL) combined with metacognitive promotes conceptual understanding and the ability to regulate their learning.

Context-based learning is a student-centered approach that bridges students' real-life into the learning environment to gain knowledge and practical experiences. The empirical studies on CBL have emphasized students' active role in learning especially the sense of ownership of the subject and responsibility for their own learning (de Putter-Smits, Taconis, & Jochems, 2013). In the context-based instruction curriculum, Bennett et al. (2007) revealed that context is used as a starting point for developing scientific ideas. Thus, teachers are required to familiarize themselves with the context in the materials (de Putter-Smits et al., 2013).

However, the influence of CBL combined with metacognitive prompts on students' mathematical problem-solving and communication skills, especially in elementary schools, is rarely reported (e.g. Chung et al., 2014). Thus, we focus on exploring the effects of context-based learning integrated with metacognitive prompts to foster students' problem-solving and mathematical communication skills in elementary school. To support this goal, we design a model of "Metacognitive-Based Contextual Learning" (MBCL) for Indonesian fifth-grade students to promote their problem-solving and mathematical communication skills.

Theoretically, MBCL integrates context-based learning and metacognitive instruction (Dori et al., 2018; Hargrove & Nietfeld, 2014; Kramarski et al., 2002; Lee et al., 2014). This teaching model focuses on the student in active learning activities. In general, there are five cycles in MBCL; (1) exploring initial knowledge; (2) providing contextual problems; (3) recognizing and solving problems; (4) presenting results; and (5) reflecting on the learning process. In the first cycle, students are divided randomly into small groups, the teacher then explores the students' initial knowledge related to the topic to be studied. In the second cycle, the teacher gives contextual problems to students and invites them to discuss problems related to their daily lives. In the third cycle, students understand problems and write down what they already know using mathematical symbols; they then design procedures to solve problems; investigate the problem; draw conclusions to find a solution. In the fourth cycle, students present the results of the discussion and their peers give questions and comment on their work. In the last stage, students reflect on their mathematical problem-solving activities and the teacher provides feedback to improve the next learning process. In short, the teacher as a facilitator guides students using metacognitive-based contextual learning to solve problems both in learning, daily life and having personal responsibility for learning (de Putter-Smits et al., 2013; Dori et al., 2018). Whereas in metacognitive instruction, students work in small groups to give reason mathematically and formulate and answer metacognitive questions (Kramarski et al., 2002; Lee & Mak, 2018). Thus, metacognitive-based contextual learning not only emphasizes the elaboration in building new knowledge but also makes students aware of learning and develop their ability to use appropriate strategies (Goh, 2008; Kramarski et al., 2002).

Research Purpose

This study aims to investigate the effect of the metacognitive-based contextual learning (MBCL) model to improve problem-solving and mathematical communication skills of fifth-grade students. The research questions are:

1. Is there any significant difference between students in the experimental group taught using metacognitive-based contextual learning and control group taught using traditional instruction in terms of problem-solving skills?
2. Is there any significant difference between students in the experimental group taught using metacognitive-based contextual learning and control group taught using traditional instruction in terms of mathematical communication skills?

Methods

Research Design

A quasi-experimental non-equivalent control group design was used in this study (Shadish et al., 2002). This design (see Table 1) compared two groups of participants before and after treatment without assigning participants to the experimental and control groups (Shadish et al., 2002). The intervention was conducted in four schools; three public and one private elementary school (two classes per school, of eight classes). In this study, convenience sampling was used because of the convenient location of schools and the willingness of their mathematics teachers to participate. A total of eight intact classes were divided into four classes as an experimental group and four other classes as a control group. All schools apply the same national mathematics curriculum, the 2013 Curriculum (K-13), and they have similar school facilities. The independent variable was metacognitive-based contextual learning and the dependent variables were problem-solving and mathematical communication skills. This research was conducted from September to November 2019 in the academic year 2019/2020.

Tabel 1. Pre-test and post-test control group design

Groups	Pre-tests	Treatments	Post-tests
Experimental	Problem-Solving Skills Test (PSST) Mathematical Communication Skills Test (MCST)	Metacognitive-Based Contextual Learning (MBCL)	Problem-Solving Skills Test (PSST) Mathematical Communication Skills Test (MCST)
Control	Problem-Solving Skills Test (PSST) Mathematical Communication Skills Test (MCST)	Conventional Teaching Approach (CTA)	Problem-Solving Skills Test (PSST) Mathematical Communication Skills Test (MCST)

Research Sample

The sample was 204 elementary students aged 11-12 years old (113 males and 91 females) in Nganjuk Regency, Indonesia. All students were divided into experimental groups (n = 102; 56 males and 46 females) and control group (n = 102; 64 males and 38 females) randomly selected. Students in the experimental group were taught using metacognitive-based contextual learning (MBCL) and the control group was taught using conventional teaching approach (CTA). All students have an equal socio-economic and educational background. They lived in urban areas and came from middle to upper-income families. All students were instructed by 8 teachers with similar teaching experience, more than 10 years. The teacher's degree was B.Ed from a local university. In order to avoid bias instructors, all teachers are given directions to apply different learning models.

Research Instruments

Problem-Solving Skills Test (PSST)

The Problem-Solving Skills Test (PSST) was developed by researchers to measure the problem-solving skills of fifth-grade elementary school students in mathematics. PSST has been validated face and content by four experts in mathematics education. PSST consisted of four sub-scales adapted from Polya (1973), including understanding the problem, making a solution plan, solving the problem based on the plan, and concluding. In detail, the scoring rubric for problem-solving skills is presented in Table 2.

Table 2. Problem-solving skills rubric

Sub-Scales	Score	Scoring Criteria
Understanding the problem	2	Students write what is known and what is asked from the given problem clearly.
	1	Students write what is known and what is asked but not related to the given problem that students do not understand the problem
	0	Students do not write anything down that students do not understand the meaning of the given problem
Making a solution plan	2	Students write down the plan and necessary conditions (formulas) of the problems and use all the information collected.
	1	Students write the plan to solve the problem but not coherently
	0	Students do not write plans to solve problems
Solving the problem based on the plan	4	Students solve problems based on the plan, where there are no procedural errors and calculation errors
	3	Students solve problems based on the plans, where there was no procedural error, but calculation errors occur
	2	Students solve problems based on the plans but there are procedural errors and calculation errors.
	1	Students solve problems based on plans, but there are procedural errors and calculation errors
	0	Students do not solve problems based on plans
Concluding	2	Students make conclusions based on the questions and results
	1	Students make conclusions that do not match to the questions and results
	0	Students do not make conclusions

Initially, PSST consisted of 10 items in the form of a description. Each question has been adjusted to basic competencies and indicators in the Indonesian elementary school curriculum (Ministry of Education [MoE], 2006). Then, PSST was validated by four experts; one professor and three senior lecturers in mathematics teaching and learning technology. the validation relates to (1) the suitability of the questions with the indicators, (2) the level of difficulty of the questions, (3) the use of language, (4) the truth of the concept. After validation, PSST was tested to 30 fifth-grade students at Aisyiyah Elementary School in the pilot study. As a final version, four questions were valid and six questions were invalid (see Table 3). At the significance level of 0.05 and the degree of freedom of 28, the r_{table} value was 0.361. These six questions were declared valid because they had r_{observed} higher than r_{table}; so that PSST is suitable to be used as pre- and post-tests. After being analyzed, the Cronbach's alpha reliability coefficient was found at 0.72.

Table 3. Item validity of problem problem-solving skills

Items	r_{observed}	p	Criteria
Question 1	0.535	0.002	Valid
Question 2	0.183	0.334	Invalid
Question 3	0.684	0.000	Valid
Question 4	0.184	0.331	Invalid
Question 5	0.718	0.000	Valid
Question 6	0.095	0.618	Invalid
Question 7	0.578	0.001	Valid
Question 8	0.345	0.062	Invalid
Question 9	0.317	0.088	Invalid
Question 10	0.356	0.054	Invalid

Mathematical Communication Skills Test (MCST)

In order to evaluate students' mathematical communication skills, the Mathematical Communication Skills Test (MCST) was designed by researchers. MCST was modified from NCTM (2000). MCST has been validated face and content by four experts in mathematics education. The scoring rubric for students' mathematical communication skills is presented in Table 4.

Table 4. Indicators of mathematical communication skills assessment

Sub-scales	Indicator	Score	Scoring Criteria
The ability to connect contextual problems into mathematical ideas	Students can write what is known and asked based on the problem	2	Students write what is known and asked correctly and correctly
		1	Students write what is known and asked but not right
		0	No answer
The ability to express daily events into mathematical symbols or languages	Students can use mathematical symbols when writing information obtained from problems and completing the problem	2	Students use mathematical symbols when writing information obtained from problems and when solving problems correctly and correctly
		1	Students use mathematical symbols when writing information obtained from problems and when solving problems but not right.
		0	No answer
The ability to understand, interpret, and evaluate mathematical ideas in writing.	Students can write the concept of the formula used in solving daily problems, and do the calculation process correctly	4	Students write down the concept of the formula used in solving daily problems, and do the calculation process correctly and correctly
		3	Students write the concept of the formula used in solving daily problems correctly but are wrong in doing the calculation process.
		2	Students incorrectly write down the concept of the formula used in solving daily problems and do the calculation process incorrectly.
		1	Students incorrectly write down the concept of the formula used in solving daily problems and do not carry out the calculation process at all.
		0	No answer
Suggestions to draw a conclusion based on the questions.	Students can write conclusions of the results of the settlement based on the problem	2	Students write the conclusions of the results of the settlement based on the problem correctly and correctly
		1	Students write the conclusions of the results of the settlement based on the problem but not right
		0	No answer

Initially, MCST consisted of 10 items in the form of a description. Furthermore, MCST was tested on 30 fifth-grade students at Aisyiyah Elementary School, Indonesia. The trial results were analyzed using the Product Moment correlation. Rubric validity test results were valid if r_{observed} higher than 0.361. Based on the trial, four questions were valid and six other questions were invalid (see Table 5). These six questions were declared invalid and dropped from the test because have a r_{observed} value less than 0.361 (r_{table}); so that MCST contained four questions that were appropriate for measuring mathematical communication skills as a final version. In addition, the Cronbach's alpha reliability coefficient was found at 0.74. Thus, MCST was declared a valid and reliable test.

Table 5. Item validity of problem mathematical communication skills

Items	r_{observed}	p	Criteria
Question 1	0.108	0.571	Invalid
Question 2	0.080	0.673	Invalid
Question 3	0.320	0.084	Invalid
Question 4	0.318	0.087	Invalid
Question 5	0.579	0.001	Valid
Question 6	0.176	0.353	Invalid
Question 7	0.724	0.000	Valid
Question 8	0.331	0.074	Invalid
Question 9	0.681	0.000	Valid
Question 10	0.672	0.000	Valid

Procedures

Before treatment, the researchers developed metacognitive-based contextual learning (MBCL), lesson plans, teacher books, and student books. Then, four experts (one professor and three senior lecturers in mathematics teaching and learning technology) validated all teaching materials. After obtaining feedback from the experts, the teaching material was revised and tested in the pilot study to obtain an appropriate learning model and tool.

After officially permitted by the Education Office of Nganjuk regency and all school principals, students and parents were given consent forms. All students participated voluntarily and could withdraw at any time. After they signed the consent form, a pre-test was carried out. Then, experimental and control group students participated in learning activities for five meetings (5 x 105 min = 525 min in total). Students in the experimental group were instructed to use the metacognitive-based contextual learning, and students in the control group used the conventional learning approach.

Intervention in the Experimental Group

In the preliminary stage, the teacher started the lesson by praying and informed the main material, basic competencies, and learning objectives. The teacher gave students the question to know their preliminary knowledge and presented information. At this stage, students made small groups (4-6 students based on their ability level; low, medium, and high), conveyed initial knowledge to discuss, and then paid attention to the information given by the teacher. Further, the teacher gave contextual problems, students paid attention, and students discussed it in their group. Then, students expressed their ideas and thoughts in written, oral, or picture form with language or mathematical symbols appropriately. Students made plans by looking for cognitive strategies based on the problem, solving problems with the strategies, concluding the answers to those problems. Students then presented their discussion result and other students gave input. Finally, students and the teacher reflected concepts they have learned and finally, the teacher gave group assignments to be discussed at the next meeting.

Intervention in the Control Group

In this method, the teacher was the active facilitator but students as passive listeners. The teacher led the prayer, checked students' attendance, gave apperception, and conveyed the learning objectives. Then, the teacher gave information and explained the material on the board, and students took notes. The teacher gave lower-order thinking skills questions and students worked on the problems individually. Next, students answered the questions and the teacher asked other students to correct. Finally, the teacher concluded the topic and gave individual assignments to be discussed at the next meeting.

Data Analysis

Before using inferential statistics, normality and homogeneity tests were done first. In this study, the Kolmogorov-Smirnov and Shapiro-Wilks tests were used to check the assumption of normality (Hair et al., 1995). The analysis showed that the data were normally distributed due to the *p*-value was higher than 0.05 (see Table 6).

Table 6. Kolmogorov-Smirnov and Shapiro-Wilk test results

	Groups		**Kolmogorov-Smirnov**			**Shapiro-Wilk**		
			Statistic	**df**	**p**	**Statistic**	**df**	**p**
Problem-Solving Skills	Experimental	Post-test	0.072	102	0.200	0.981	102	0.145
		Pre-test	0.073	102	0.200	0.983	102	0.229
	Control	Post-test	0.071	102	0.200	0.977	102	0.079
		Pre-test	0.063	102	0.200	0.988	102	0.493
Mathematical Communication Skills	Experimental	Post-test	0.078	102	0.130	0.989	102	0.565
		Pre-test	0.073	102	0.200	0.983	102	0.198
	Control	Post-test	0.076	102	0.165	0.983	102	0.205
		Pre-test	0.070	102	0.200	0.989	102	0.567

Based on the results of the matrix covariance test, it showed that the Box's *M* values in both variables had a significant number greater than 0.05 (see Table 7). Therefore, it could be concluded that the variance-covariance matrices of the dependent variable were assumed equal.

Table 7. Box's M test results

Dependent Variables	**n**	**Box's M**	**F**	**df1**	**df2**	**p**
Problem-Solving Skills	102	5.708	1.882	3	7344720.0	0.130
Mathematical Communication Skills	102					

Next, the homogeneity test of variance between groups used the Levene's Test of Equality of Error Variance (Hair et al., 1995). The analysis showed that the homogeneity of the variance was not violated (see Table 8). Thus, the assumption test has been fulfilled.

Table 8. Levene's test results

Dependent Variables	F	df1	df2	p
Problem-Solving Skills	0.003	1	202	0.958
Mathematical Communication Skills	0.328	1	202	0.567

Furthermore, to investigate the effect of metacognitive-based contextual learning models on students' problem-solving and mathematical communication skills, a one-way analysis of variance (ANOVA) was performed. In the current study, SPSS version 25 was used to analyze data at a significance level of 0.05.

Results

Instructional Model Development

The developed products consist of MBCL and learning tools (lesson plans, teacher books, student books) on the topics of Time, Distance, Speed, Debit, and Comparison. In this phase, MCBL was validated by four experts, including one professor and three senior lecturers in mathematics teaching and learning technology. Feedback from experts included; book covers and layouts need to be designed more interestingly, problems and questions related to students' daily life need to be enriched, the use of fonts should be consistent, and learning outcomes and learning activities need to be specified in detail. After receiving expert feedback, the MBCL model was then revised. The final instructional product is visualized in Figure 1.

Figure 1. Implementation guide of MBCL

Effects on Problem-Solving and Mathematical Communication Skills

One-way ANOVA is used to determine the difference between pre-test mean scores between experimental and control groups in terms of problem-solving and mathematical communication skills. The results are shown in Table 9.

Table 9. One-way ANOVA results for pre-test mean scores

Dependent Variables	Groups	M	SD	df	F	p
Problem-Solving Skills	Experimental	59.02	9.79	1	2.113	0.148
	Control	57.04	9.94			
Mathematical Communication Skills	Experimental	59.94	10.66	1	1.761	0.186
	Control	57.84	11.98			

*Note: *p < 0.05*

According to Table 9, there are no significant differences in pre-test scores between the experimental and control groups in terms of problem-solving (F = 2.113, p > 0.05) and mathematical communication skills (F = 1.761, p > 0.05). This indicates that both groups have equal initial skills.

Furthermore, ANOVA is employed to explore univariate main effects of learning models on the dependent variables to test the first and second research questions. The results of the analysis of the influence of instructional models on students' problem-solving and mathematical communication skills are presented in Table 10.

Table 10. One-way ANOVA results for post-test mean scores

Dependent variables	Groups	M	SD	df	F	p
Problem-Solving Skills	Experimental	75.99	10.46	1	67.687	0.000
	Control	63.55	11.06			
Mathematical Communication Skills	Experimental	75.65	11.17	1	56.151	0.000
	Control	64.30	10.42			

*Note: *p < 0.05*

Based on Table 10, the mean score on the problem-solving skills post-test shows that students in the experimental group (M = 75.99; SD = 10.46) has significantly higher mean scores than control group (M = 63.55; SD = 11.06). In addition, students in the experimental group (M = 75.65; SD = 11.17) has significantly higher mean scores than their counterparts (M = 64.30; SD = 10.42) in terms of mathematical communication skills. In short, there is significant difference mean score in mathematical problem-solving [F (1,202) = 67,687; p < 0.05] and communication skills [F (1,202) = 56,151; p < 0.05] between the two groups. This finding implies that treatment differences affect the mean post-test scores between experimental and control group students.

Discussion

This study aims to investigate the effect of MBCL on fifth-grade students' problem-solving and mathematical communication skills compared to traditional instruction. After being analyzed, the ANOVA test results showed that students taught using context-based instruction had better post-test scores than students received the traditional teaching approach. This indicates that metacognitive-based contextual learning is effective in increasing student learning. This may result in problems related to students' daily lives during the intervention. Significantly, Ultay (2017) noted that contextual problems effectively involve students in the learning process and promote their problem-solving skills. The previous research agrees that a learning environment designed using context-based approach can overcome problems in traditional instruction (Irwanto et al., 2019; Pilot & Bulte, 2006; Westbroek, 2005).

The ANOVA results also imply that students taught using context-based instruction show significantly higher scores on problem-solving skills than those who are taught conventionally. One possible reason is that the teacher creates a metacognitive-based contextual learning environment that attracts attention where students are given the opportunity to ask relevant questions. In turn, these activities stimulate students to develop their problem-solving skills through context-oriented questions or problems related to everyday situations. In line with this argument, Ultay (2017) stated that problems allow students to analyze, synthesize, and evaluate are claimed to improve their problem-solving skills. This finding is consistent with previous studies which reported that context-based instruction promotes students' problem-solving skills in primary and secondary schools (e.g., Kopparla et al., 2019; Yu et al., 2014).

Another explanation is that MBCL emphasizes active student learning activities and interactions among them. The teacher only acts as a facilitator who provides questions and problems for students. In addition, the problems presented are consistent with daily situations, so that mathematical knowledge becomes more meaningful. Furthermore, in solving problems, students are directed to use the ability of metacognition, where students are stimulated to think about what appropriate steps are used to solve their problems related to real life. O'Neil and Brown (1997) agreed that metacognition is seen as a thought process for solving problems. In fact, Jacobse and Harskamp (2009) believe that students can improve strategies in the process of solving mathematical problems using metacognitive skills. In the MBCL environment, students are also facilitated and motivated to improve problem-solving through hands-on activities.

In addition, the ANOVA results show that students taught using context-based instruction show better scores on mathematical communication skills than students taught using traditional instruction. The reason might be during treatment, MBCL provided students with opportunities to increase peer interaction in order to construct student communication skills. Additionally, metacognitive prompts encourage students to understand the main concepts and answer complex questions during treatment (Dori et al., 2018). Specifically, Chung et al. (2014) and Fadli and Irwanto (2020) contended that peer interactions can promote students' communication skills. In order to find a solution, students in small groups express their ideas, opinions, and thoughts verbally and in writing (Shield & Galbraith, 1998). Students then communicate the findings in a whole class and other students provide input. A series of activities are pursued so that students use mathematical representation under the guidance of the teacher. As mentioned by Brenner et al. (1997), mathematical communication is closely related to how students use mathematical representations (i.e., words, graphs, tables, and equations). This means that students who are proficient in using mathematical representation during group work tend to have good mathematical communication. In another study, Allen (2012) revealed that discussions in small groups also improve students' mathematical communication. The current findings are in accordance with several other studies that have documented the positive effects of CBL on students' mathematical communication skills (e.g., Chung et al., 2014; Yoo, & Park, 2014).

In short, students' high post-test scores in this study may be due to MBCL facilitating students to learn mathematical concepts by connecting topics with the context of everyday life (Johnson, 2002). Supportively, Dugger (2010) argued that context-based learning gives students opportunities to communicate, do teamwork, and solve problems. In this study, students' problem-solving skills develop well when teachers associate learning with their real-life (Irwanto et al., 2018; Wright, 2001). In addition, the success of their communication is related to opportunities obtained by students and interactions between students and the learning environment during the intervention (Olteanu & Olteanu, 2013). In order to make mathematics more meaningful for students, Gilbert (2006) even emphasized the importance of real-world contexts to be designed in such a way as to engage students in teaching and learning.

Conclusions and Recommendations

In conclusion, the mean post-test scores of students taught using the metacognitive-based contextual learning model (MBCL) were significantly higher than in another group in terms of problem-solving and mathematical communication skills. Our study confirms previous findings related to the effectiveness of context-based teaching on student learning in mathematics. This study provides evidence that the metacognitive-based contextual learning model is effective in increasing elementary school student achievement. To improve students' abilities in developing problem-solving and mathematical communication skills, mathematics teachers need to pay attention to these findings and to utilize strategies that support the use of context-based instruction in the twenty-first century. Therefore, it is suggested that MBCL should be used more frequently in primary school mathematics to further improve students' problem-solving and mathematical communication skills.

Although the developed models and tools are effective in increasing student learning, there are some limitations found. First, the topics taught are limited to material time, distance, speed, discharge, and comparison. Second, the intervention was carried out for six sessions, so long-term research needs to be done to study changes in student achievement over time. In addition, the current research investigates students' problem-solving and mathematical communication skills, further research needs to evaluate the effect of contextual based learning on other variables; for instance, attitudes, achievements, motivation, and higher-order thinking skills, both quantitatively and qualitatively.

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