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Comparing The Effect of Open-Ended and Scientific Approaches on Elementary School Students' Mathematical Connection Skills

Martines✉[1], S. Prabawanto✉[2]

[1]Study Program of Basic Education, Universitas Pendidikan Indonesia, Bandung, Indonesia, [2] Department of Mathematics Education, Universitas Pendidikan Indonesia, Bandung, Indonesia

✉ [1]martinesins@upi.edu.✉ [2]sufyani@upi.edu

Abstract. Mathematical connection ability is one of the most important basic mathematical abilities. However, several reports indicate that students' mathematical connection skills are still weak and for this reason it is necessary to enhance the students' ability. The ability is necesary to prepare students to meet the global era and various situations in daily life. To enhanche the mathematical connection skills, it is necessary to apply an appropriate teaching approach, namely the open-ended and the scientific approach. This study aims to describe the comparison of the effect of teaching with an open-ended and a scientific approach on enhancing students' mathematical connection abilities. This study was a quantitative study with a pre-test post-test control design. The participants were the 4th-grade students from class IV A (treated using an open-ended approach) and from class IV C (treated using a scientific approach). The study found that open-ended and scientific approaches affected students' mathematical connection skills by 60.5% and 76.7%, respectively. This result show that the open-ended and the scientific approach give a positive effect on enhancement of students' mathematical connection skills. However, the scientific approach was found to exhibit a better effect than the open-ended approach.

Keywords: Open-Ended Approach, Scientific Approach, Mathematical Connection Skills

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INTRODUCTION ~ In the field of education, mathematics is one of the disciplines an individual should have due to its important role in technology development (Nurimani, 2016) . By learning mathematics, students are expected to be able to properly apply mathematical skills. An optimal mathematical skill may affect individuals' cognition and behavior, given that mathematics requires basic knowledge and skills that represent individuals' intellectual aspects (Lestari & Yudhanegara, 2017) Learning mathematics does not only need one's knowledge of the concept, rule, and structure, but also skill to engage with the mathematical thinking process, a process demanding reasoning, problem-solving, associating, and communication skills(Tanudjaya & Doorman, 2020). Following Indonesian Curriculum, a student should obtain five skills in mathematics learning. National Council of Teachers of Mathematics (2000), as cited in Persada (2016), highlight the importance of these five skills as a process standard in mathematics learning activities. One of the important mathematical skills an individual should have is the mathematical connection skill. This skill refers to one's skill to connect a mathematical concept to other mathematical concepts or even other disciplines or real-life application (Lestari & Yudhanegara, 2017). Mathematical connection skill is one of the skills required to understand a mathematical concept by linking one concept to another.

Despite its importance, problems related to mathematical connection skill is often found in school. This issue is often found

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in the elementary education level, where Problems occur regarding how to make students find a link among ideas to solve mathematical problems properly. This concerning problem is also proven by Indonesia's achievement in PISA 2018 (Fitriani & Salsinha, 2021). The result shows that Indonesian students performance in PISA mathematic test is still low. This condition is also found in Kenedi, Helsa, Ariani, Zainil, and Hendri's (2019) study in Singkarak Regency, where 98 students (87.6% of the total participants) obtain a score of 45 to 59 in mathematics, a score below the determined standard. A similar finding is also reported by Laili & Puspasari (2019), that elementary school students' mathematical connection skill in Banyuwangi village is low (57.8%). The findings of previous studies imply the urgency to find solutions for problems in elementary school students' mathematical connection skills. One of the potential solutions for this problem could be found by selecting the appropriate approach. It is important to apply a learning approach that encourages students to actively engage in the learning process. A learning process to encourage students' active involvement could be done through communication, logical thinking, creative thinking, critical thinking, curiosity, social development, and learning autonomy. Students tend to understand the presented concept more easily when actively engaged with the learning process (Riedy, Yu, & Zhou, 2012). Accordingly, teachers should pay attention to the learning approach.

Scientific and open-ended approaches could be applied to the mathematics learning process. Both approaches are student-centred, encouraging students to actively engage with the materials being studied (Munroe, 2015). Being actively engaged, students are likely to put their mathematical skills, especially mathematical connection skills, to solve mathematical problems during the learning process. Both approaches align with the constructivism view, where students construct their own knowledge and give meaning to their experience. As Walle, Karp, & Bay-Williams (2010) asserts, constructivism views students as creators of their own learning, not as a blank whiteboard.

An open-ended approach is a learning approach where the problem can be solved in various ways, allowing students to apply their unique thought to solve mathematical problems (Fatah, Suryadi, Sabandar, & Turmudi, 2016; Lestari & Yudhanegara, 2017; Munroe, 2015). Open-ended math problems encourage students to engage more actively and creatively to present their mathematical thinking (Mihajlović, A., & Dejic, 2015). n open-ended approach typically consists of four phases: open-ended problem, constructivism, exploration, and presentation (Lestari & Yudhanegara, 2017). The exploration phase allows students to find out the answer for the mathematical problems autonomously based on logical references. In the exploration phase, students may find solutions for their problems and future problems (Ollerton, 2010).

Through an open-ended approach, students can develop their self-confidence in solving mathematical problems and their creativity in presenting open-ended problems during classroom discussions and presentations

(Aras, 2018). By applying an open-ended approach, students are expected to use creative and innovative ideas to solve mathematical problems confidently during the learning process. An open-ended approach is a learning strategy that presents open-ended problems, i.e., problems with more than one possible solution (Takashasi, 2006). Various alternatives provide students with broad opportunities to find the solution, thus encouraging them to solve the problems. This is different from the scientific approach, which consists of five stages, namely: (1) identifying problems; (2) questioning; (3) experimenting; (4) associating problems with the concept; and (5) presenting the results (Safairoh, 2016). These stages are adapted from the basic principles of the scientific method. Students can improve their understanding, thinking productivity, and analysis skills (Joyce, Weil, & Calhoun, 2015).

Grounded from the description above, the present study attempted to find out the effect of open-ended and scientific approaches on the students' mathematical connection skills. This study also compares the effect of both approaches on 4th-grade elementary school students' mathematical connection skills.

METHOD

This quantitative study applied a non-equivalent control group quasi-experimental design. This study employed open-ended and scientific approaches as the stimulus variables and mathematical connection skills as the response variable. Two classes were involved in this study and treated using two different approaches. The population of the study were 4th-grade students in an elementary school in Pandeglang. The samples of the study were 28 students from class 4a and 28 students from class 4c. These two classes were recruited because they have a similar level of mathematical connection skills. Students from class 4a were treated using an open-ended approach, while students from 4c were treated using a scientific approach. The pretest and posttest results of students' mathematical connection skills were tested using inferential statistics to find out whether an open-ended or scientific approach affects students' mathematical connection more significantly. The two classes were treated using two different approaches to obtain a comprehensive depiction of how each approach affects fourth-grade students' mathematical connection skills. The data were collected through pretest and post-test on students' mathematical connection skills. The test instrument was developed based on three indicators of mathematical connection skill (NCTM, 2000) : (1) applying relationship among ideas in mathematics; (2)understanding how mathematical ideas interconnect and build on one another to produce a coherent whole; and (3) Recognizing and applying mathematics to non-mathematics and daily-life context. The test instruments had passed expert-judgment, validity, and reliability tests. The research design is displayed in figure 1. The posttest aimed to find out students' mathematical connection skill improvement after being treated using different approaches.

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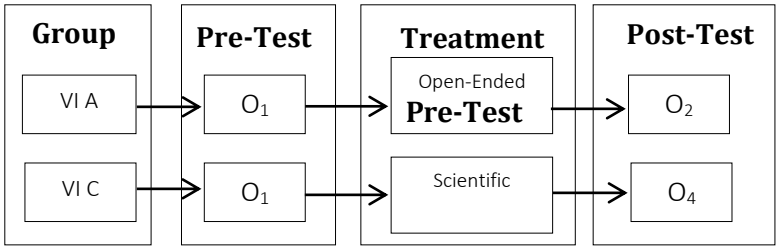

Source: (Sukardi, 2009)

Figure 1. Reseach Design

Other instruments used in this study were learning media, modules, and lesson plans developed based on indicators and stages of open-ended and scientific approaches. Lesson plans were used to keep the learning process compliant with the approach being used.

RESULTS

An open-ended approach is a learning approach developed by Japanese scholars Shigeru, Toshio Sawada, Kenichi Shibuya, and Yashimoto (Isrok'atun & Rosmala, 2018; Munroe, 2015). Meanwhile, the scientific approach is an approach implemented following the Indonesian Curriculum 2013. In this study, students' pre-test and post-test scores were tested using paired sample t-test to find out the effect of open-ended and scientific approaches on students' mathematical connection skills. The obtained data were analyzed using IBM SPSS 21. The normality and homogeneity tests were conducted as a prerequisite. The T-test would be performed if the data were normally distributed. The test of the class treated using the Open-ended approach was presented in table 1 to table 4. Meanwhile, the test result of the group treated using a scientific approach was displayed in table 4 to 8.

Table 1. Descriptive Statistic

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Open-Ended	28	2	13	7.96	2,269

Table 2. The result of Normality test

One-Sample Kolmogorov-Smirnov Test

		OpenEnded
N		28
Normal Parameters[a,b]	Mean	7.96
	Std. Deviation	2,269
Most Extreme Differences	Absolute	.145
	Positive	.145
	Negative	-.113
Test Statistic		.145
Asymp. Sig. (2-tailed)		.134

As shown in table 1, the average central tendency value was 7.96 with a standard deviation of 2.269. The result of the Kolmogorov-Smirnov normality test is

displayed in table 2. The Asymp. Sig. (2-tailed) value of 0.134 (higher than α= 0.05) indicates that the data on the Open-ended approaches group were normally distributed. The next step was conducting a paired sample t-test to find out the effect of the open-ended approach on students' mathematical connection skills. The result of the paired sample t-test is presented in table 3.

Table 3. *Paired sample T-test Result*

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre-Test	7.96	28	2,269	.429
	Post-Test	16.64	28	3,347	.632

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Pre-Test & Post-Test	28	.779	.000

Paired Samples Test

		Paired Differences							
					95% Confidence Interval of the Differences				
		Mean	Std. Deviation	Std. error Mean	Lower	Upper	t	df	Sig. (2-tailed)
Pair 1	PreTest – PostTest	-8,679	2,127	.402	-9,503	-7,854	-21,594	27	.000

The sig. (2-tailed) value, as displayed in table 3, was less than Significance level α = 0,05, indicating a significant difference in students' posttest and pretest results. The higher posttest result indicates that the open-ended approach positively affects students' mathematical connection skills. The analysis of the effect of the scientific approach on students' mathematical connection skills is presented in table 4 to table 6. The data were tested for normality prior to the paired sample t-test.

Table 4. Descriptive Statistics

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Scientific	28	3	13	7.29	2,401
Valid N (listwise)	28				

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Table 5. Normality Test

One-Sample Kolmogorov-Smirnov Test

		Scientific
N		28
Normal Parameters[a,b]	Mean	7.29
	Std. Deviation	2,401
Most Extreme Differences	Absolute	.154
	Positive	.154
	Negative	-.085
Test Statistic		.154
Asymp. Sig. (2-tailed)		.085[c]

As shown in table 4, the average central tendency value was 7.29 with a standard deviation of 2.401. The result of the Kolmogorov-Smirnov normality test is displayed in table 5. Table 5 shows that the asym. Sig (2-tailed) Value was 0.085 (> 0.05), indicating that the data were normally distributed. The next step was to carry out a paired sample t-test to find out the effect of the scientific approach on students' mathematical connection skills.

Table 6. Paired sample t-test result

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre-test	7.29	28	2,401	.454
	Post-test	15.75	28	3,204	.606

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Pre-test & Post-test	28	.876	.000

Paired Samples Test

		Paired Differences							
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
Pair 1	Pre-test - Post-test	-8,464	1,598	.302	-9,084	-7,845	-28,025	27	.000

The *Sig.*(*2-tailed*) value was lower than the significance level α = 0,05, indicating a significant difference in pretest and posttest results. The higher posttest result indicates that the scientific approach positively affects students' mathematical connection skills. The analysis results showed that both approaches positively affects students' mathematical connection skills. The following tables 7 and 8 present the comparison of effects of both approaches

on students' mathematical connection skills. Diagram 1 compare the effect of both approaches on students' mathematical connection skills.

Table 7. The effect of Open-ended approach

Measures of Association

	R	R Squared	Eta	Eta Squared
Pretest * Posttest	.779	.606	.932	.869

Table 8. The effect of scientific approach

Measures of Association

	R	R Squared	Eta	Eta Squared
Pre-test * Post-test	.876	.767	.934	.872

Diagram 1. Comparison of Open-ended and scientific approaches

The R-squared value of the open-ended approach was 0.606, meaning that the open-ended approach may affect student's mathematical connection skills by 60.6%. Meanwhile, the r-squared value of the scientific approach was 0.767, meaning that the scientific approach may affect student's mathematical connection skills by 76.7%. Thus, in this study, the scientific approach exhibited a more significant effect on students' mathematical connection skills than the open-ended approach. However, both approaches positively affect students' mathematical connection skills. The next step was conducting further analysis of both approaches by performing an unpaired sample t-test. Prior to the t-test, prerequisite tests, i.e., normality and homogeneity tests were conducted. The normality, homogeneity, and t-test results are presented in table 9 to table 12, respectively.

Table 9. Descriptive Statistics

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Open-ended Approach Post-test	28	7	21	16.64	3,347
Scientific Approach Post-test	28	9	21	15.75	3,204
Valid N (listwise)	28				

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Table 10. Normality test of posttest data

One-Sample Kolmogorov-Smirnov Test

		Open-ended Approach Post-test	Scientific Approach Posttest
N		28	28
Normal Parameters	Mean	16.64	15.75
	Std. Deviation	3,347	3,204
Most Extreme Differences	Absolute	.157	.152
	Positive	.117	.100
	Negative	-.157	-.152
Test Statistic		.157	.152
Asymp. Sig. (2-tailed)		.073[c]	.099[c]

As displayed in the table above, the central tendency of the post-test result of students' mathematical connection treated using open-ended approach was 16.64 and those treated using scientific approach was 15.75. The standard deviation of students treated using open-ended and scientific approaches was 3.347 and 3.204, respectively. The normality test result showed Asym. Sig (2-tailed) values of 0.073 and 0.99 (>0.05), meaning that the data were normally distributed.

Table 11. Homogeneity Test of Open-Ended and Scientific Approaches

Test of Homogeneity of Variances

post-test

Levene Statistic	df1	df2	Sig.
.064	1	54	.801

The p-value (sig.) was 0.064, meaning that the data were homogeneous. The next step was to carry out a t-test to see the magnitude of effects of both approaches on the student's mathematical connection skill. The result of the t-test was presented in table 12.

Table 12. Unpaired sample t-test of Open-ended and Scientific Approaches

Independent Samples Test

	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

Mathematical connection skills	Equal variances assumed	.064	.801	1,020	54	.312	.893	.876	-.863	2,648
	Equal variances not assumed			1,020	53,898	.312	.893	.876	-.863	2,649

The mean difference in the t-test for equality of means column was 0.893 on equal variances not assumed, and equal variances assumed. The result indicates that the open-ended approach exhibited lower mean values than the scientific approach. The mean difference value indicates that the scientific approach affects students' mathematical connection skills more significantly than the open-ended approach.

DISCUSSION

Previous studies report the positive effect of the open-ended approach on students' mathematical connection skills (Fitriani & Salsinha, 2021; Hartati, 2017). The open-ended approach is also reported to be able to encourage students to develop creativity in connecting mathematical concepts to other concepts or in applying the mathematical concept to real-life contexts (Lubis, Harahap, & Nasution, 2019). The analysis result showed that open-ended and scientific approaches positively affect students' mathematical connection skills by 60.6% and 76.7%, respectively. However, the success of the learning process does not rely on the learning approach alone but is also affected by the suitability between learning strategies, models, and methods and students' characteristics (Isrok'atun & Rosmala, 2018). The learning approach could be combined with various learning models, stages, environment, and classroom management (Afandi, Chamalah, & Wardani, 2013). A proper combination of learning approach and model is likely to improve students' mathematical connection skills.

CONCLUSION

This study concludes that open-ended and scientific approaches positively affect 4th-grade elementary students' mathematical connection skills. The scientific learning approach exhibited a more significant effect on students' mathematical connection skills than the open-ended approach. Both approaches can be applied to enhance students' mathematical connection skills, especially in mathematics learning at the elementary school level. This study opens new possibilities to investigate other mathematical approaches to improve students' mathematical connection skills. Future studies are recommended to collaborate learning approaches with various learning models, methods, and strategies to further improve students' mathematical connection skills.

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