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Meta Analysis: The Effect of Contextual Teaching and Learning Model in Improving Students' Mathematical Connection Ability

A. Nurlutvia Ahmad, Fitriani Nur(*), Ahmad Farham Majid, Sitti Mania, Sri Sulasteri
Mathematics Education, Universitas Islam Negeri Alauddin Makassar
Jl. Sultan Alauddin No.63, Romangpolong, Kec. Somba Opu, Kabupaten Gowa, Sulawesi Selatan, Indonesia

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Abstract
The research was conducted to determine the effect of contextual teaching and learning in improving students' mathematical connection ability through various previous research results. The method is a meta-analysis with a quantitative approach. The research samples were the research articles in the form of theses, dissertations, and published articles from national and international journals that met predetermined criteria. The process of collecting data was conducted by following the prism flow. The data analysis technique was by determining the effect size of each study using the standardized mean difference formula. Further statistics of the effect size was the random effect model. The results of the analysis of the random-effect model show that, from the reviewed documents from various research, it can increase students' mathematical connection ability by 85% with very big categories. This indicates that the contextual teaching and learning model provides a huge contribution to the improvement of students' mathematical connection ability.

Keywords: Contextual Teaching and Learning, Mathematical Connection, Meta Analysis

(*) Corresponding Author: fitrianinur@uin-alauddin.ac.id

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INTRODUCTION

Shaping one’s character and personality is one of the aims of education as addition to humanizing intelligent humans in the field of education (Lawe, 2020). Education is needed by humans to achieve the progress of civilization. Mathematics is one of the subjects in the Indonesian education curriculum based on Permendikbud number 21 of 2016 concerning the Content Standards for Elementary and Secondary Education which must be taught at the SD/MI, SMP/MTs, and SMA/MA levels (Afriyanti et al., 2018).

Ruseffendi in Fahrurrozi & Hamdi (2017) defines mathematics as an abstract science with interconnected forms and structures. The basic aspect in mathematics is an understanding of the material concepts that exist in mathematics itself, so an ability is needed, namely good understanding ability (Afriyanti, Wardono, & Kartono, 2018). Mathematics has interrelated concepts so that to understand more complex concepts, one needs to understand basic concepts as a prerequisite for moving on to the next concept (Puspitasari & Ratu, 2019). The relationship of concepts in mathematics is called a mathematical connection.

According to Kenedi, Helsa, Ariani, Zainil, and Hendri (2019), mathematical connection is one of the abilities to connect knowledge networks with one another, in this case, basic mathematical concepts to more complex mathematical concepts. Therefore, mathematical connection skills are needed by students because through mathematical connections, the students will understand the concepts well and can improve their understanding of other sciences (Kenedi, Helsa, Ariani, Zainil, and Hendri, 2019). Hartati, Abdullah, and Haji (2017) state that the higher the mathematical connection ability of students, the better the understanding level of the mathematical concepts.

Based on the research results of Kiswanto (2019), it shows the fact that the students' mathematical connection ability in Indonesia is in the low category. The low ability of mathematical connection is caused by the students' lack of meaning and interest in learning mathematics. The low mathematical connection of students will have an impact on the process and learning outcomes. This is in line with the PISA (The Program for International Student Assessment) assessment of Indonesian Mathematics assessment since the last 15 years that has not experienced a significant increase. In 2018, the average math score was only 379, which was still far from the OECD average score of 487 (OECD, 2018). This assessment is carried out on students at the junior high and high school levels. Therefore, it can be said that the assessment on the PISA shows the low mathematical connection ability of junior and senior high school students. One of the efforts that can be done to improve the students' mathematical connection skills is that the teachers can try to create fun learning activities, as well as provide opportunities for students to be active in learning. This can be done by designing learning activities as a form of facility in increasing the students' mathematical connection ability.

Kurniati, Kusumah, Sabandar, and Herman (2016) state that one of the learning models that can be used to improve mathematical connection ability is using the contextual teaching and learning model. The contextual teaching and learning is a learning activity that provides opportunities for students to relate the material being studied to real world conditions. This activity will make students connect the knowledge they already know (Anwar et al., 2019). According to Musriliani, Marwan, and Anshari (2015), the stages of contextual teaching and learning create students' activity in learning, so that they do not only watch and record the material being taught, but can socialize and exchange ideas with other students. Therefore, the principle of contextual teaching and learning is the student activity with an emphasis on the application of material in everyday life. This is in line with the research results conducted by Latipah and Afriansyah (2018) that one of the factors that causes students' low mathematical connection skills is teacher-centered learning. Therefore, the contextual teaching and learning model is needed as a learning innovation to train and develop students' mathematical connection ability.

After the observations conducted by the researchers regarding the use of contextual teaching and learning model in improving students' mathematical connection ability, it was found that there have been many research reports that present comparative data for classes using the CTL model and classes using conventional models in the learning process. Some of these reports concluded that the classes with CTL learning were significantly effective in improving students' mathematical connection ability compared to the classes with conventional learning. However, there were also some research reports which revealed that there were no significant differences in the classes with the use of CTL or conventional. The results of this analysis raise a contradiction whether the use of CTL in the learning process can improve students' mathematical connection ability or not.

Based on the description, it is necessary to conduct a study that can collect and provide conclusions that are in line with the conclusions of existing studies. This is intended to produce a more accurate theory related to the use of the CTL learning model to improve students' mathematical connection ability. This research can be conducted by using the meta-analysis method.

Meta-analysis is a type of statistical research method for quantitatively synthesizing several previous studies (Utama & Kristin, 2020). The purpose of this study is to summarize and get the essence of research results from a number of previous studies (Utami, 2019). In this study, the researchers collected several reports of research results that have the same theme for analysis.

Several meta-analysis studies have been carried out in the field of education, such as the research by Pitaloka and Suyanto (2020) who conducted a meta-analysis of the effectiveness of blended learning in learning biology, physics, and chemistry. The results showed that 65.71% of blended learning was mostly done to determine the effect or the effectiveness. Likewise, the research conducted by Adiputra and Mujiyanti (2017) with the research results showing that there was a significant relationship between motivation and the students’ achievement in Indonesia.

Therefore, the researchers have an interest in carrying out meta-analysis research on CTL learning model in improving students' mathematical connection ability. Thus, the title of this article is "Meta Analysis: The Effect of CTL Learning Model in Improving Students' Mathematical Connection Ability".

METHODS

This study is a kind of a quantitative approach with the type of research used is meta-analysis, namely the research that examines previous studies to obtain systematic accurate conclusions (Retnawati et al., 2018). The population in this study is the research articles in the form of theses, dissertations, and published articles from national and international journals. Determination of the sample using purposive sampling technique that meets the following criteria: (1) The researchers in the research reports are general researchers or students; (2) The research was conducted for a decade, namely the period 2011-2020; (3) The research subjects relate to the application of the CTL learning model in improving students' mathematical connection ability; (4) The research subject is students at the junior high school (SMP) and senior high school (SMA) levels in Indonesia; (7) The research was conducted in Indonesia; (5) The type of research used is experimental research with two groups, namely the experimental group and the control group; (6) The control class used a conventional learning model; and (7) The required data are complete in the research report. The samples were collected by following the prism flow.

This research stage begins with formulating a research problem, looking for relevant research reports for formulating the problems, evaluating the studies to decide which studies should inform the review, analyzing and interpreting research reports, and presenting the review (Card, 2012).

The data were analyzed by calculating the effect size using the standardized mean difference method. The effect size is one of the data analysis methods in meta-analysis research to present the extent to which the relationship between variables in each study. The determination of the effect size value uses the following standardized mean difference formula (Retnawati, Apino, Kartianom, Djidu, & Anazifa, 2018).

$$d = \frac{t}{\sqrt{2n}}$$

Where d is the standardized mean difference, t is the independent t-test, and n is the number of samples.

Calculating the S pooled or combined standard deviation using the t test can be done using the following formula.

$$S_{pooled} = \frac{\overline{X_1} - \overline{X_2}}{\sqrt[t]{\frac{2}{n}}}$$

Determining the size of the effect of the effect size value uses the criteria proposed by Cohen, as follows (Gazali, 2017).

0<d≤0.20 (small effect)
0.20<d≤0.50 (medium effect)
0.50<d≤0.80 (big effect)
d>0.80 (very big effect)

Next, determining the summary effect is conducted by using the fixed random model or random-effect model. The determination of the method to be used is based on the assumption or heterogeneity test on the effect size (Retnawati, Apino, Kartianom, Djidu, & Anazifa, 2018).

RESULTS & DISCUSSION

Results

After the data collection was carried out by using the keywords "contextual teaching and learning in improving mathematical connection ability" in the database (Google scholar, Scopus, Onesearch, and ResearchGate), 29 related research articles were found. Research articles that have been found are filtered by looking at the suitability of the research sample criteria that have been determined. This analysis can be seen in the flow chart of PRISMA Flow below:

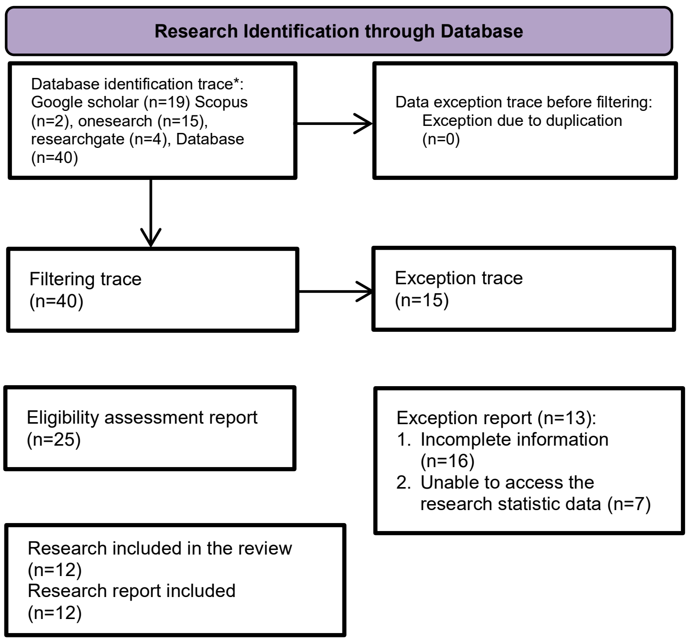

Figure 1. Data Collection Flow Based on PRISMA Flow

The research articles that have met the criteria were then analyzed by determining the mean score of the effect size. The effect size value describes the extent to which the relationship between the contextual teaching and learning model and the students' mathematical connection ability. The mean score of the effect size can be seen in the table 1.

Table 1. The Analysis Result of the Effect Size

Study	Writer/Year	*D*	*Vd*	*SEd*	Category *d*
1	Sitti Annia/2017	1.50	0.08	0.28	Very big
2	Rian Andriana/2019	-0.34	0.05	0.23	Small
3	Isro Faiz Nazalia/2017	1.31	0.12	0.35	Very big
4	Dhika Mayesti/2018	0.69	0.07	0.27	Big
5	Syahrul Anwar, heni Pujiastuti, Anwar Mutaqin/2019	0.50	0.08	0.28	Medium
6	Heris Hendriana, Ujung Rahmat Slamet, Utari Sumarmo/2014	0.63	0.06	0.25	Big
7	Maryanti, Laila Qadriah/2018	0.79	0.06	0.25	Big
8	Nurul Fajri/2015	3.74	0.17	0.41	Very big
9	Nurul Fajri, Hajidin, M.Ikhsan/2013	0.31	0.06	0.25	Medium
10	Elfira Rahmadani/2019	1.24	0.09	0.29	Very big
11	Nana Chairunnisa/2018	0.10	0.06	0.24	Small
12	Fhira Harrikant/2017	0.01	0.06	0.24	Small

Description:
d : *Effect size*
Vd : Variance of the *Effect size*
SEd : Standard Error of the *Effect size*

Based on Table 1, it can be seen that there are 33.33% of the studies that obtained the effect size value in the very big category, 25% of the studies obtained the effect size value in the big category, 16.68% of the studies obtained the effect size value in the medium category, while for the small category has a percentage of 25%. In addition, it is also seen that the standard error of the effect size obtained is below 0.5%. The results illustrate that the effect size obtained has a 95% confidence level.

After knowing the value of the effect size for each analyzed study, the next step is calculating the summary effect. The summary effect is a summary of the effects or average effects of various studies. In this study, the determination of the summary effect method used was based on the heterogeneity effect size test to avoid erroneous conclusions obtained. The heterogeneity test was carried out in the JASP 0.14 Windows 10 software which obtained the following results. The heterogeneity test was carried out on the original JASP software version 0.14, the results obtained which can be seen in table 2.

Based on Table 2, it is known that the value of I^2 is 92.811%. This result is greater than the 25% limit of the proportion of the variance measure which is said to be low. Therefore, there is heterogeneity that is not only caused by the sampling error or in other words the "true" effect size in all studies is not the same, so to interpret the summary effect with the fixed-effect model to be inaccurate, but to use random-effect model. Assuming this method is used because the study population analyzed is different.

The differences are usually caused by the differences in the characteristics of the observed samples, and how the treatment is applied to the samples (Retnawati, Apino, Kartianom, Djidu, & Anazifa, 2018).

Table 2. Test Results of Heterogeneity

Residual Heterogeneity Estimates

		95% Confidence Interval	
	Estimate	**Lower**	**Upper**
τ^2	0.931	0.430	3.094
τ	0.965	0.656	1.759
I^2 (%)	92.811	85.640	97.722
H^2	13.909	6.964	43.897

The results of the summary effect analysis using the random-effect model method using the JASP 0.14 Windows 10 software can be seen in the following table 3.

Table 3. Statistic Results of the *Random-Effect Model*

Mean and Precision		
Mean effect	M	0.843
Variance	V_M	0.076729
Standard error	SE_M	0.277
Confidence Intervals		
Lower limit (95%)	LL_M	0.300
Upper limit (95%)	UL_M	1.385
Test of the null that M=0		
Z for test of null	Z	3.045
p-value (1-tailed)	P_1	0.002

Based on Table 3, the z-value is 3.045 and the p-value is 0.002. These results show that the p-value is smaller than the significance value used, which is 5% (0.002 <0.05). If it is seen that the value of M = 0.843 obtained shows the extent to which the effect that is classified as very big. The mean effect shows a value of 0.843 which means that the effect of applying the contextual teaching and learning model in learning is 84.3%. Thus, the conclusion obtained is that the use of CTL in learning has a significant effect on students' mathematical connection ability compared to the learning using conventional models.

In meta-analysis research, the bias publication is one of the weaknesses that researchers must avoid. The publication bias is a situation where there are studies that are not included, and the research results show different results from the sampled research. Therefore, to avoid the publication bias, it can be seen in the funnel plot in Figure 2.

In Figure 2, it can be seen that the meta-analysis research conducted did not indicate the occurrence of bias publication. It can be seen in the funnel plot that symmetry. As for the forest plot, it can be seen that the RE Model value is 0.85 which indicates that the average influence of the contextual teaching and learning model on students' mathematical connection ability is 85% which is included in the very big category, while the other 15% is influenced by other variables.

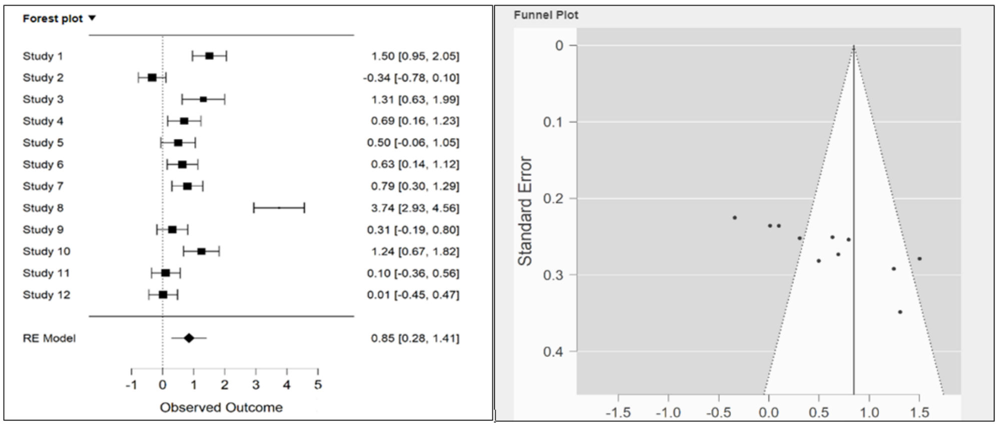

Figure 2. *Forest plot* and *Funnel Plot*

Discussion

The results obtained are supported by the research conducted by Anwar Anwar, Pujiastuti, and Mutaqin (2019); Silalahi (2018) (Anwar et al., 2019) that learning with contextual teaching and learning model affected the students' mathematical connection ability. Likewise, the results of the research conducted by Maryanti and Qadriah (2018) also concluded that there was a significant difference in the mathematical connection ability of the students using the contextual teaching and learning model with groups of students using conventional learning. The two results of this study confirm that learning with CTL is able to improve students' mathematical connection ability. In addition, learning with the CTL model also shows a positive increase in the ability to understand students' mathematical concepts (Chotijah & Susanto, 2019).

The success of contextual learning in improving mathematical connection skills certainly cannot be separated from the ability of students to connect their initial knowledge with new knowledge that will be obtained. This condition is created through a series of components that are carried out when implementing contextual learning. Kunandar (Zulkifli, 2018) states that there are 7 main components of contextual learning, namely constructivism, inquiry, questioning, community learning, modeling, reflection, and meaningful assessment. This is in line with what was expressed by Susilaningsih, Drastisianti, Lastri, Kusumo, & Alighiri (2019) state that the ideal learning condition is a process in which interaction and communication activities occur between teachers and students to achieve learning objectives. Thus, it can be seen that the components of contextual learning in general create interactive interactions between teachers and students so that learning feels more meaningful for students. In line with this, Hasanah (2022) states that contextual teaching and learning creates participatory and multidirectional learning.

One of the advantages of CTL learning is that it can provide meaningful learning situations (Ghiast, 2017). As stated by Winadi (2019) that learning mathematics requires a meaningful learning process to show the benefits of mathematics in solving various problems in life. Seeing the advantages of the CTL learning model with Badjeber's expression (Manik & Saija, 2019) who reports that meaningless learning is one of the causes of low mathematical connection ability. If students can connect the material learned from previous subjects or with other subjects, then mathematics learning becomes more meaningful (Kenedi, Helsa, Ariani, Zainil, and Hendri, 2019). Rahmah dan Ermawati (2022) explains that learning factors that are less than optimal cause students' mathematical connection skills to be low, so according to Susanti dan Faradiba (2022) that students' mathematical connections are obtained through a continuous learning experience process by creating an active and participatory learning atmosphere.

In the CTL model there are stages where the teacher gives contextual problems to students to solve (Maryanti & Qadriah, 2018). The problem-solving process will provide opportunities for students to gain new knowledge by linking previously known knowledge to solve the problems they face, either in groups or alone. This is in line with what was expressed by Anwar, Pujiastuti, & Mutaqin (2019) that linking the material studied with everyday life through concepts discovered by students will provide a high concept understanding. In other words, CTL requires students to experience rather than memorize, think, and be active. As a result, they are able to build knowledge based on their own experiences (Bustami et al., 2018). Likewise expressed by Rahmah dan Ermawati (2022) that by applying contextual teaching and learning can develop students' abilities in understanding teaching materials by linking real-life contexts so that students gain knowledge in solving problems obtained in learning materials.

The application of contextual learning requires accuracy and hard work. This was revealed by Nursamsi et al., (2020) that in its application encountered obstacles that could trigger inefficient learning, namely at the learning community stage when students had discussions. There is a gap between the willingness to share and the ability to master the material, besides that there are always students making noise in class, causing chaos and obstacles during discussion. Research (Dayani & Hasanuddin, 2020) also reveals the same thing. Student activity in the learning community phase is quite low, even though the teacher has maximized the learning process. Thus, the learning community phase should be an important point that needs to be considered when implementing contextual learning.

CONCLUSION

Based on the results of the analysis and discussion of this study, it can be concluded that the use of contextual teaching and learning models contributes significantly positively to improving students' mathematical connection abilities. Thus, contextual teaching and learning models can be applied if they want to improve students' mathematical connection abilities.

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