International Journal of Multicultural and Multireligious Understanding

http://ijmmu.com
editor@ijmmu.com
ISSN 2364-5369
Volume 11, Issue 8
August, 2024
Pages: 743-756

The Effectiveness of Guided Inquiry Learning with Mathigon on Problem Solving, Mathematical Connection, and Self-Efficacy

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http://dx.doi.org/10.18415/ijmmu.v11i8.6121

Abstract

This study aims to describe the difference in effectiveness between guided inquiry learning assisted by mathigon and scientific learning in terms of problem-solving ability and mathematical connections in superior student groups and students. This research is quasi-experimental research with the form of pretest-post-test non-equivalent group design. Data collection was carried out at one of the public junior high schools in Biak Numfor Regency in the 2023/2024 school year. The research sample consisted of two experimental classes that were given treatment in the form of guided inquiry learning assisted by mathigon, namely classes VIII C and VIII D and two control classes, namely VIII B and VIII E with scientific learning. In the experimental class and control class, superior students and ordinary students were selected. Data collection techniques used in the form of giving pretests and post-tests related to problem solving and mathematical connections. Hypothesis testing used independent sample t-test statistics. The results showed that guided inquiry learning assisted by mathigon was more effective than scientific learning in terms of problem solving and mathematical connections in groups of superior students and ordinary students.

Keywords: *Guided Inquiry; Mathigon; Problem Solving; Mathematical Connection; Self-Efficacy*

Introduction

Mathematics produces strategies to solve a problem by producing the right strategy so as to obtain a reasonable solution (Van De Walle et al., 2013). NCTM emphasizes the importance of problem solving skills for students, because through this ability it helps students in acquiring ways of thinking to solve problems faced outside the mathematics classroom (Mathematics, 2000). Problem solving is an effort to find a way out of a case that is not easy to solve (Polya, 2004) so that it requires a foundation of knowledge and activeness to solve it (Schoenfeld, 1985). The problem in question is a non-routine problem defined as a difficult task for someone (Schoenfeld, 1985) that requires solving but does not have a ready-made solution (De Corte et al., 2012) or the path to the solution is not immediately known (Posamentier & Krulik, 2009).

To be able to solve a problem, students need to connect all the knowledge they have. Baiduri et al. (2020) and Tasni & Susanti (2017) and revealed that connection plays an important role in the process of solving a problem. Mathematical connection is a cognitive process of connecting several ideas, concepts, definitions in mathematics with other disciplines or with real life (García-García & Dolores-

Flores, 2017) to achieve an understanding of mathematics and its applications (Alabdulaziz & Alhammadi, 2021). Through mathematical connections, students will achieve meaningful learning (Sugiman, 2008; Alabdulaziz & Alhammadi, 2021), can help students see the usefulness of mathematics in solving various problems (Son, 2022; Baiduri et al., 2020). There are 2 aspects of mathematical connection, namely intra-mathematical connection (the ability to connect the learned mathematical topics with other mathematical topics) and extra-mathematical connection (the ability to connect the learned mathematical topics with contexts outside mathematics).

In addition to cognitive abilities, in learning students also need to have good self-efficacy. Bandura (1994) defines self-efficacy as a person's belief about their ability to produce a certain level of performance. Self-efficacy affects cognitive and affective in the learning process (Goulão, 2014). Self-efficacy is a strong predictor of successful mathematical achievement (Pajares, 1995; Hackett & Betz, 1989; Liu & Koirala, 2009) because it impacts the effort put into solving the problem (Schunk, 2012). Özcan & Gümüş (2019) assumed self-efficacy as an intermediary between motivation and mathematical anxiety with student problem solving. According to Hadiat & Karyati (2019)) if mathematical connections are not supported by good self-efficacy, then efforts to improve mathematical connection skills will be ineffective. Similar research results were also revealed by Navarro et al. (2007) who found that self-efficacy significantly predicted the math-science interests of eighth grade Mexican-American students.

However, based on several previous studies, it appears that problem solving skills and mathematical connection skills are still low (Zulfah et al., 2018; Kurniyawati et al., 2019; Muhammad et al., 2018; Lubis et al., 2019; Zuyyina et al., 2018; Sari & Karyati, 2021). The low problem solving ability and mathematical connection can be overcome by implementing learning using learning with a constructivism approach (Yuanita et al., 2018) accompanied by the use of appropriate technology (Yusron et al., 2020). Therefore, guided inquiry learning combined with the use of technology, namely mathigon, was chosen. Guided inquiry is one of the levels in the inquiry approach where problems, guiding questions and materials are accompanied by appropriate directions and guidance provided by the teacher while students will determine the procedures and results (Banchi & Bell, 2008; Prahani et al., 2016). Mathigon is one of the interactive websites based on constructivism theory and aims to make math learning more active, personalized, and fun. Mathigon can be accessed online through the website https://mathigon.org/. Based on several studies, the use of technology can have a positive impact on students' cognitive and affective abilities (Psycharis & Kallia, 2017; Hohenwarte and Fuchs, 2005 in Amalia et al., 2020; Duran & Dökme, 2016; Hadi & Faradillah, 2022; Zulnaidi & Zamri, 2017; Saputra, 2016). In this study, several stages of guided inquiry include: 1) Orientation where students are faced with a problem, 2) Conceptualization, students are given questions and make temporary conjectures, 3) Investigation, students conduct exploration and experimentation using the mathigon application and interpret the results, 4) Conclusion, students make conclusions from the investigation, 5) Discussion, students communicate the results of the investigation and reflect on the learning done.

In this study there is a comparison learning that is not given special treatment, namely learning with a scientific approach. Scientific learning is an approach in learning that is designed so that students are active in constructing concepts through various processes (Daryanto, 2014) with the aim that students understand various materials using a scientific approach (Nurdyansyah & Fahyuni, 2016).

Method

The hypothesis in this study is that guided inquiry learning with mathigon is effective in facilitating students' problem solving ability, mathematical connection and self-efficacy. There are three criteria for effective learning. The criteria are the post-test score reaches the set KKM, the percentage of score improvement before and after learning (n-gain) with at least moderate criteria reaches more than

55%, and the percentage of students who reach the KKM value on the problem solving and mathematical connection variables ≥ 75% while the percentage of students who reach the KKM value on the self-efficacy variable> 60%.

The type of research used is quasi-experiment with pretest-post-test-non-equivalent group design. Data collection was carried out at one of the public junior high schools in Biak Numfor Regency, Papua in mid-February 2024 to mid-March 2024. The sample was taken using purposive sampling technique with the main characteristics of more than 80% of students in the class understand how to use technology, can access the internet using their gadgets, and students are familiar with learning based on constructivism theory. The research sample came from class VIIIC with a total of 30 students as a class given special treatment or experimental class. While the class that was not given special treatment was class VIIIE with a total of 30 students.

The independent variable in this research is the assisted guided inquiry approach. The dependent variables in this study are problem solving, metamatic connections, and self-efficacy. The data collection technique used a test technique consisting of pretest and post-test. The pretest was given before the learning was done to see students' initial abilities regarding problem solving, mathematical connection skills, and student self-efficacy. While the post-test is given after learning. The test was prepared based on indicators of the three dependent variables which were then validated using content validity based on expert assessment, namely two mathematics education lecturers. The results of this content validity show that all instruments can be used. The instruments were then tested on students who were not included in the research sample. The results of this trial were then estimated for reliability using the Cronbach Alpha formula. The instrument is said to be reliable if it reaches a minimum value of 0.65 (Ebel & Frisbie, 1991). The results showed that the pretest and post-test instruments of problem solving, mathematical connection, and self-efficacy were reliable.

Quantitative descriptive data analysis technique which includes the average value, variance, and standard deviation. Then to answer the hypothesis in this study, an effectiveness test was conducted consisting of one sample t-test, percentage n-gain test, and percentage of achievement of KKM. Before conducting the effectiveness test, assumption test and mean difference test were conducted. The assumption test consists of normality and homogeneity tests, while the mean difference test consists of the mean difference test before and after learning.

Normality test consists of multivariate normality test using Mahalanobis distance test statistic and univariate normality using Shapiro-Wilk test statistic. In the multivariate normality test, data is said to be normally distributed if the p-value <0.05 (Johnson & Wichern, 2007). In the univariate normality test, data is said to be normally distributed if the p-value> 0.05 (Cahyono, 2015). While the homogeneity test consists of homogeneity of variance using the Levene Test Homogeneity of Variances and homogeneity of the covariance matrix using Box's M test. In the variance homogeneity test, the data is categorized as homogeneous if the p-value> 0.05 (Stevens, 2009) and in the covariance matrix test the data is categorized as homogeneous if the p-value> 0.05 (Huberty & Olejnik, 2005).

After the assumption test is fulfilled, the average difference test before and after learning is conducted using Hotteling's T^2 test. Testing before learning aims to test the equality of students' initial abilities in both classes using pretest scores. While the average difference test conducted after learning aims to determine whether there is a difference in the average ability of students after learning in both classes using post-test scores. In the Hotteling's T^2 test, it is said that there is a difference in the ability of the two classes if the p-value <0.05 (Stevens, 2009).

The last test conducted was the learning effectiveness test. The one-sample t-test was used to see the achievement of KKM in the experimental class, where the average value of the measured variables was said to have reached KKM if $t_{count} > t_{table}$. Then, the percentage calculation of the n-gain value was carried out. The calculation of the n-gain percentage is done to see the percentage increase in the average score of the three variables from pretest to post-test. According to Hake (1999) in Ambarwati et al., (2022), the increase in average score from pretest to post-test is said to be effective if the n-gain percentage reaches more than 55%. Furthermore, the percentage of KKM achievement is calculated to see how many students have achieved KKM on each dependent variable. In the variables of problem solving and mathematical connection, the fulfillment of the criteria for achieving KKM if it reaches ≥ 75% (Ramdhani, 2012) in Romiyansah et al., 2020) while for self-efficacy it reaches> 60% (Arikunto, 2010).

Results and Discussion

Results

Data collection was carried out for 7 meetings with details of meeting 1 giving pretest, meeting 2-5 giving material, meeting 6 transferring understanding, and meeting 7 giving post-test. The use of mathigon was only done in the experimental class combined with the guided inquiry approach. The obstacle faced in data collection was that there were several other activities outside the schedule carried out at school which had an impact on student learning time at school. The activities in question are counseling from the local health center and activities carried out by the district government. In addition, there are also some students who are often absent from class for reasons of illness or permission so that students are not maximally able to get the subject matter. Learning activities in the classroom can also be seen from the learning implementation observation sheet. Based on the observation sheet, both in the experimental and control classes, it can be seen that the teacher and student activities carried out during learning are in accordance with the contents of the lesson plan that has been made before. The following table details the quantitative data of students' problem solving, mathematical connections, and self-efficacy.

Table 1. Description of Experimental and Control Class Problem Solving

Description	**Experimental Class**		**Control Class**	
	Pretest	***Post-test***	***Pretest***	***Post-test***
Number of Students	30	30	30	30
Average	21,8	88,7	17,7	71,3
Variance	101,3	76,5	108,7	128,4
Standard Deviation	10,1	8,7	10,4	11,3

Table 2. Description of Experimental and Control Class Mathematical Connection

Description	**Experimental Class**		**Control Class**	
	Pretest	***Post-test***	***Pretest***	***Post-test***
Number of Students	30	30	30	30
Average	30,8	84,3	26,7	61,8
Variance	232,9	128,9	247,1	188,8
Standard Deviation	15,3	11,4	15,7	13,7

Table 3. Description of Experimental and Control Class Self-Efficacy

Description	**Experimental Class**		**Control Class**	
	Pretest	***Post-test***	***Pretest***	***Post-test***
Number of Students	30	30	30	30
Average	64,9	75,7	64,5	72,9
Variance	56,2	57,9	56,1	39,6
Standard Deviation	7,5	7,6	7,5	6,3

From the table above, it can be seen that on the variables of problem solving, mathematical connections, and self-efficacy, the average value of the post-test in the experimental class is greater than the control class. In addition, there is also an increase in the average value from pretest to post-test in the experimental class and control class. After obtaining quantitative data, assumption tests, mean difference tests and learning effectiveness tests were carried out. The following are the results of the normality assumption test.

The results of the multivariate normality assumption test show that the pretest and post-test data have met the assumption of multivariate normality. The same thing is also seen in the assumption of univariate normality in pretest data and post-test data of experimental and control classes which show the results that all data are normally distributed. These two normality assumptions will be one of the requirements for the effectiveness test. In addition to the normality assumption test, homogeneity of variance and covariance will also be tested. The following are the results of the homogeneity of variance and covariance tests.

While in the assumption of homogeneity of variance in pretest data and post-test data, the results show that all data have met the assumption of homogeneity of variance, or in other words, the data come from a homogeneous population. Similar to the homogeneity of variance, the assumption of homogeneity of the covariance matrix in the pretest and post-test data also shows homogeneous results. To further strengthen the results related to whether there is a difference before and after learning in both classes, an average difference test was conducted. The following are the results of the mean difference test.

Table 4. Mean Difference Test Results

Group	**F-value**	***p-value***	**Description**
Before Learning	1,167	0,331	There is no difference
After Learning	23,303	0,000	There is a difference

Based on the table above, it can be seen that the conditions before learning, the p-value is greater than 0.05. So it can be concluded that there is no difference in initial conditions in the experimental class and control class in terms of the three dependent variables. Meanwhile, after learning, it can be seen that the p-value is <0.05. This means that there are differences in conditions after being given treatment in the form of learning in experimental and control classes in terms of problem solving, mathematical connections, and self-efficacy. After conducting the assumption test and the mean difference test, then the effectiveness test was conducted. The following are the results of the effectiveness test.

Table 5. Experimental Class One Sample T-test Results

Variable	**t_{count} value**	**t_{table} value**	**Description**
Problem Solving	12,986	1,699	Reached the KKM
Mathematical Connection	7,886	1,699	Reached the KKM
Self-Efficacy	5,029	1,699	Reached the KKM

Table 6. N-gain test results and percentage of achievement of KKM Experimental Class

Variable	**N-gain percentage**	**Percentage of achievement of KKM**
Problem Solving	100%	100%
Mathematical Connection	100%	90%
Self-Efficacy	60%	83%

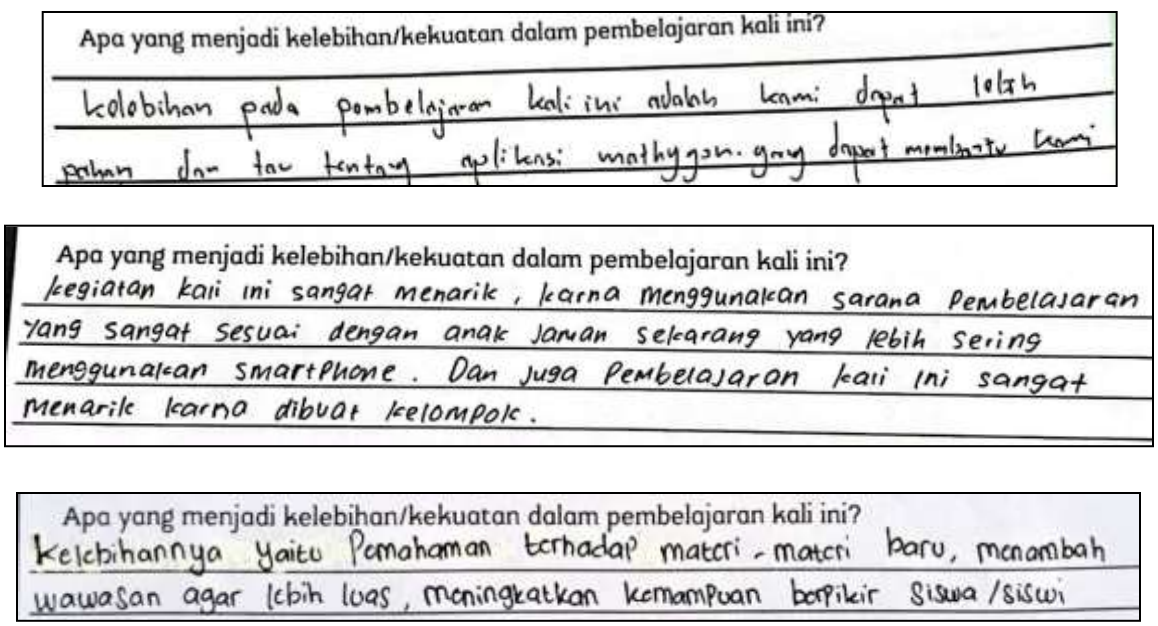
Based on the one sample t-test, it was found that for the variables of problem solving, mathematical connection, and self-efficacy showed the value of $t_{count} > t_{table}$. This means that the average post-test score on the three variables has reached the specified KKM value. Furthermore, based on the n-gain value, it can be seen that for the variables of problem solving, mathematical connection, and self-efficacy, the percentage of students who reach the n-gain value criteria is greater than 55%. Then the number of students who have reached the KKM in the experimental class of problem solving and mathematical connection variables has reached ≥75% while the self-efficacy variable is > 60%. Because the three criteria for learning effectiveness have been met, it is concluded that guided inquiry learning assisted by mathigon is effective in terms of problem solving, mathematical connections, and self-efficacy.

Discussion

The effectiveness of guided inquiry learning assisted by mathigon is influenced by student activeness during learning activities in the classroom. Lestari & Prahmana (2017) in their research wrote that guided inquiry learning is learning that involves student activeness so that students do not just sit and listen but can create meaningful learning. In addition, according to Rochana (2016) guided inquiry learning is well used to improve students' higher order thinking skills. Prahani et al. (2016) also obtained results from their research that guided inquiry learning is effectively used to facilitate students' problem solving skills in high school.

Based on observations made by researchers, it can be seen that students in the experimental class are active students in learning and show curiosity in learning. In learning using the worksheet, students were enthusiastic in trying and using mathigon. Students prepared themselves by bringing laptops and cellphones that can access the internet. They also actively discussed, expressed ideas and helped each other in the group. Students seemed to pay close attention to the lessons given. When asked to make presentations in front of the class, they did so with full responsibility, although there were some complaints. They also did not hesitate to ask the researcher when they found obstacles in learning or in using mathigon.

In addition to being active in learning activities, discipline and responsibility in working on worksheets and using the mathigon were also seen. All worksheets were done carefully and fully. The worksheets were not done carelessly. In using mathigon, students showed their interest and enthusiasm. They took the initiative to explore further the features contained in mathigon, beyond the lessons given. Below are some results of students' reflection.



Apa yang menjadi kelebihan/kekuatan dalam pembelajaran kali ini?
kelebihan pada pembelajaran kali ini adalah kami dapat lebih paham dan tau tentang aplikasi mathygon. yang dapat membantu kami

Apa yang menjadi kelebihan/kekuatan dalam pembelajaran kali ini?
kegiatan kali ini sangat menarik, karna menggunakan sarana pembelajaran yang sangat sesuai dengan anak jaman sekarang yang lebih sering menggunakan smartphone. Dan juga pembelajaron kali ini sangat menarik karna dibuat kelompok.

Apa yang menjadi kelebihan/kekuatan dalam pembelajaran kali ini?
Kelebihannya yaitu Pemahaman terhadap materi-materi baru, menambah wawasan agar lebih luas, meningkatkan kemampuan berpikir siswa/siswi

Picture 1. Experiment Class Students' Reflection Results on Worksheets

From some of the reflection results above, it can be seen that through guided inquiry learning carried out in groups, students become more helpful because they have discussion partners who are the same age as them. The use of mathigon that utilizes technological advances and cellphones that are close to students' lives also contributes to the level of student efficacy. Students feel that their insights and experiences are increasing. Students can also build their own knowledge so that they are more confident in themselves.

Mathigon used with guided inquiry learning causes multi-directional interactions between teachers and students, students with students, and students with the environment (Kurniawati & Rizkianto, 2018). In some interviews and reflection results, students are quite happy and interested in learning using technology. This is a new and fun thing for students. Through mathigon, students can explore and find various types of nets of flat-sided spaces and find formulas for surface area and volume of flat-sided spaces. This finding is similar to previous research conducted by Hadi & Faradillah (2022) that the use of technology, namely GeoGebra online, can develop students' independence and activeness in completing the assigned tasks so that it has an impact on improving students' problem solving skills. Zulnaidi et al. (2019) also obtained research results showing that the use of technology in learning can increase student interaction so that students are more active in learning.

One of the benefits of guided inquiry learning for students is that students can construct their own meaning and gain independence in learning (Kuhlthau et al., 2007). In addition, in guided inquiry learning, researchers provide guidance in the form of oral and/or written directions regarding key steps that are important for students to take to obtain answers. This precise guidance allows each student to have the same opportunity to understand the problems given (Lestari & Prahmana, 2017) so as to facilitate students' problem solving skills (Prahani et al., 2016). Sihotang et al. (2019) in their research found that the use of teaching modules with an inquiry approach can improve students' mathematical connection skills because it requires students to actively think and reason until it has an impact on improving students' mathematical connection skills. In addition, according to Zengin (2019), implementing learning with technology contributes to connecting conceptual and procedural knowledge, examining different representations, and connecting real-world conditions with mathematics. According to Hadi & Faradillah (2022), the use of technology can motivate students to complete tasks given independently. The use of technology can help students become more responsible for learning through a more creative and interesting exploration approach (Zulnaidi & Zamri, 2017). The use of technology can also increase interaction between students and teachers so that students become more active in the learning process (Zulnaidi & Zamri, 2017). In a study conducted by Moma (2014), it was found that generative learning that emphasizes freedom in constructing and integrating new knowledge with old knowledge can increase student self-efficacy.

Conclusion

The conclusion of this research is that guided inquiry learning assisted by mathigon is effectively applied to facilitate students' problem-solving ability, mathematical connection, and self-efficacy. This can be proven from the results of inferential static tests using the one sample t-test, n-gain test, and the percentage of achievement of KKM. Suggestions that can be given to future researchers are to use other abilities or other materials to see the effectiveness of guided inquiry learning assisted by mathigon. In addition, the use of mathigon can be juxtaposed with other learning approaches or models as a reference for other researchers or teachers.

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