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Problem-based learning model on mathematical analytical thinking ability and science process skills

Syaiful[1], Kamid[1], Dwi Agus Kurniawan[1], Wahyu Adi Pratama[1]*
[1] Universitas Jambi, Indonesia.
✉ wahyuadipratama.wap59@gmail.com

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Abstract
This research serves as a reference for teachers to implement problem-based learning models on analytical thinking skills and science process skills in mathematics subjects. This research examines the differences and relationships between students' analytical thinking skills and science process skills with problem-based learning models in mathematics. The sample of this research consisted of 180 students. This research is a quantitative study with a questionnaire as the instrument. The obtained data were analyzed using the t-test and correlation test. The results showed a significant difference between analytical thinking skills and students' science process skills, especially on the indicators of Observation and Classification at SMPN 35 Batanghari and SMPN 8 Batanghari students who applied the problem-based learning model in mathematics. Furthermore, it was found that there was a relationship between analytical thinking skills and science process skills because students with analytical thinking skills possessed better science process skills in problem-based learning models in mathematics subjects.

INTRODUCTION

Improving the quality of human resources in terms of knowledge and morals is one educational Goal. Education is essential in developing attitudes, achievement, and quality to create national progresses (Hekmah et al., 2019; Mahendra, 2017; Rosyid et al., 2019). Creating qualify human resources in education can be done by guiding and facilitating the learning activities (Astalini et al., 2018; Sukendar et al; 2019., Hendri et al., 2020). Education aims to develop students' potential and skills so that they can be used in living life in society (Bellová et al., 2018; Diani et al., 2018; Elvanisi et al., 2018). The achievement of this educational potential can be obtained through good teaching.

Achieving educational goals is an obligation that must be carried out by teachers. A teacher has a very important role and influence in building students' character in schools to achieve these educational goals (Astalini et al., 2020; Sholihat et al., 2017; Widiana et al., 2018; Widiansyah, 2018). Generation successors who are qualified, strong, and can change the nation towards a better society can solve the problems faced by the nation (Anugrah et al., 2020; A Widiansyah, 2019; Van Den Huefel et al., 2020). Teachers can achieve educational goals using appropriate learning models.

Process skills determine students' understanding. Skills are very important for students to increase creativity and knowledge through learning activities (Vansteensel et al., 2017; Stender et al., 2018; Vartiainen & Kumpulainen, 2020). Some of the students' skills are analytical concepts and observations (Labouta et al., 2018; Solé-Llussà et al., 2020; Stylinski et al., 2020). Student skills can be obtained by experiencing, seeking, trying, and drawing

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conclusions (Kruit et al., 2018; Solé-Llussà et al., 2019; Mutlu, 2020). Apart from students' process skills, many other things affect teacher success.

Thinking in the right pattern without being careless can be done by doing analysis in thinking. Analytical thinking is one important abilities that should be controlled by the student in the mathematics learning to help them think logically about the relationship between concept and situation (Firdaus, 2019; Ilma, 2017; Kharisma, 2018). Analytical thinking can determine the cause of an event and the arguments that support a statement (Kharisma, 2018; Yanti & Prahmana, 2017;Hendriana, 2017). Analytical thinking can train students to learn the meaning by not only understanding relevant knowledge but can also use anything that has been studied (Yanti & Prahmana, 2017; Nuryanti et al., 2018; Destino et al., 2019). Through analytical thinking skills, students can have a good level of understanding in learning.

The selection of the learning model used must be appropriate to the conditions. The learning model greatly influences the learning process and outcomes (Brinus et al., 2019; Cahyaningrum et al., 2019; Hanifah et al., 2019). The problem-based learning model used by teachers in learning is useful for forming students to think critically (Trisdiono et al., 2019; Ulandari et al., 2019; Zulkarnain et al., 2019). The selection of learning models requires the teachers' competence to attract the students' learning interests (Ismawati, 2017; Aprida & Dasopang, 2017).

An understanding of important concepts and principles can be developed with a problem-based learning model. The problem-based learning model greatly influences the learning process by combining concepts (Kristanti et al., 2016; Mahasneh & Alwan, 2018; Trishchenko, 2018). A problem-based learning model can be said as a teaching that integrates the technology and the problems of everyday life (Trianto, 2013; Rati et al., 2017; Maryati, 2018). The problem-solving approach is a learning approach that allows students to gain experience using knowledge and skills that they already possess to be applied in problem-solving (Anwar & Asriani, 2017; Fauziyah, 2017). Therefore, the problem-based learning learning model is the right learning model.

Science plays an important role in everyday life. Mathematics is one of the basic sciences that plays an important role in science, technology, and everyday life (Siagian, 2016; N. T. Anwar, 2018). Mathematics learning can hone students' abilities to think logically, analytically, critically, and systematically (Saleh et al., 2018; Kenedi, 2019; Nurlaily et al., 2019). Solving mathematics problems requires soft skills and critical thinking skills (Hendriana et al., 2018; Ambussaidi & Yang, 2019; Lin et al., 2020). Therefore, the development in the teaching and learning process of mathematics is necessary.

This research is in line with the research on process skills by (Vartiainen & Kumpulainen, 2020; Stender et al., 2018; Vansteensel et al., 2017). However, their studies only measured students' skills with one variable without a learning model. This research is in line with the analytical thinking research conducted by (Badjeber et al., 2018; Ilma et al., 2017). However, the research only has one variable without using a learning model. Therefore, this research is conducted to complement the previous studies.

Based on the description, the problem-based learning model has a relationship with students' analytical thinking skills and science process skills in mathematics. Therefore, the purpose of this research was to determine the differences and the relationship between the analytical thinking and process skills in mathematics. The urgency of this research is to help

teachers understand the differences and the relationship between problem-based learning models and students' analytical thinking skills and science process skills in mathematics.

METHODS

This research employed the associative quantitative method with a correlational research design. According to (Cohen et al., 2017), the quantitative associative method aims to determine the relationship between two or more variables. On the other hand, correlation design is a procedure in quantitative research to measure the relationship between two or more variables using statistical correlation analysis procedures (Creswell, 2016).

The research subjectS were the students of SMP 35 Batanghari and SMP 8 Batanghari selected using the purposive sampling technique. the purposive sampling technique is a sampling technique based on criteria where students ' total number is 1 to 80 students. The research samples used in this research are as follows:

Table 1. Research Sample

SMP 35 Batanghari			**SMP 8 Batanghari**		
Class			**Class**		
VIII A	VIII B	VIII C	VIII A	VIII B	VIII C
30	30	30	30	30	30

The collection of data was done through the rating instruments that are very important for attitude (Purwanti et al., 2020). The instrument used was a questionnaire to explore the attitudes and interests. A Likert scale was used with the following criteria: Strongly Agree (VA), Agree (A), Not sure (N), Disagree (D), and Strongly Disagree (SD). The values of items are SA = 5, A = 4, N = 3, D = 2, and SD = 1.

The detail of the student's process skills questionnaire instrument is as follows :

Table 2 . The Specification of Student' Science Process Skills Questionnaire

Variable	**Indicator**	**No. Statement Items**
Process skills towards mathematics	Observation	1,2,3
	Communication	4,5,6,7
	Classification	8,9,10,11,12
	Measure	13,14,15
	Conclusion	16,17,18,19
	Prediction	20,21,22,23,24
	Arrange Table	25,26,27
	Obtaining and Processing Data	28,29,30,31
	Experimental Analysis	32,33,34,35
	Creating a Hypothesis	36,37,38
	Designing Experiments	39,40,41,42,43
	Doing Experiments	44,45,46,47
Number of Statements		48

Furthermore, the intervals in each category can be seen in Table 3.

Table 3 . Categories skillss process toward mathematics

Category	Indicator Interval	
	Observation Classification	
Poor	3.0-5.25	5.0.-8.75
Low	5.26-7.50	8.76-12.5
High	7.51-9.75	12.6-16.25
Excellent	9.76-12.00	16.26-20.0

The research data was in the form of quantitative data and the analysis used was descriptive and inferential statistical analysis. According to (Cohen et al., 2017), descriptive statistics is the description or presentation of data in a number and frequency summaries (mode, mean, median, minimum, maximum). On the other hand, the inferential statistics is an inference of mathematical procedures to use probability and information about the sample to draw conclusions about the population from which the sample might be drawn (Johnson & Christenen, 2012). The assumption tests were carried out to see whether the data was normal, homogeneous, and linearly distributed. Then, a hypothesis test was carried out using the t-test to see the difference and the correlation between the two variables. The results of the questionnaire were processed using SPSS application software. The treatment was aimed at the problem-based learning model toward students' analytical thinking and science process skills.

In collecting the data, the researchers chose students based on the predetermined categories. Then, the researchers distributed the questionnaire. Furthermore, the questionnaire data were processed using the SPSS application. The SPSS application analyzed the descriptive statistics of mean, min, max, percentage, and students categories (Pratama & Pramesti, 2018). THE data collection procedure of this research is contained in the following diagram :

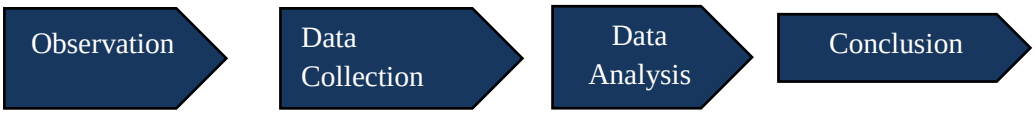

Figure 1. Research Procedure

RESULTS AND DISCUSSION

The description of the science process skills of SMP 35 Batanghari and SMP 8 Batanghari are as follows :

Table 4 . Description of Students' Process Skills On Classification Indicators

Student Responses	Interval	F	Percentage	Category	Mean	Median	Min	Max
SMP35 Batanghari	5.0 -8.75	2	6.6%	Poor	2. 32	3.00	2 .0 0	3.00
	8.85 -12.5	9	29.7%	Low				
	12.6 -16.25	19	62.7%	High				
	16.35-20.0	0	0%	Excellent				
SMP 8 Batanghari	5.0 -8.75	3	9.9%	Poor	2. 7 9	3.00	1.00	4.00
	8.85 -12.5	3	9.9%	Low				
	12.6 -16.25	20	66%	High				
	16.35-20.0	4	13.2%	Excellent				

Table 4 shows that students' skills towards mathematics in the classification indicator were high, with the percentage of 62.7 % obtained by SMP 35 Batanghari and 66% obtained by SMP 8 Batanghari. Therefore, the SMP students of both schools had the same good response in science process skills through classification indicators.

The description of students' science process skills towards mathematics at SMP 35 Batanghari and SMP 8 Batanghari on observation indicator is as follows:

Table 5. The Description of Students' Science Process Skills on Observation Indicators

Student Response	Interval	F	Percentage	Category	Mean	Median	Min	Max
SMP 35 Batanghari	3.0-5.25	0	0%	Poor	3.12	3.00	2.00	4.00
	5.26-7.50	6	19.8%	Low				
	7.51-9.75	18	59.4%	High				
	9.76-12.00	6	19.8%	Excellent				
SMP 8 Batanghari	3.0-5.25	1	3.3%	Poor	2. 75	3.00	1.00	3.00
	5.26-7.50	9	29.7%	Low				
	7.51-9.75	20	66%	High				
	9.76-12.00	0	0%	Excellent				

Table 5 displays the description of students' science process skills towards mathematics in the observation indicators was in the high category with the percentage of 59.4 % obtained by SMP 35 Batanghari and 66% obtained by SMP 8 Batanghari. Therefore, both schools had the same good response in students' science process skills through observation indicators. The description of students' analytical thinking towards mathematics in SMP 35 Batanghari and SMP 8 Batanghari is as follows:

Table 6. The Description of Students' Analytical Thinking

Student Response	Interval	F	Percentage	Category	Mean	Median	Min	Max
SMP 35 Batanghari	5.0 – 9.0	0	0%	Poor	3. 32	4.00	3.00	5.00
	10.0-13.0	1	3.3%	Low				
	14.0 – 17.0	9	29.7%	Moderate				
	18.0 -21.0	20	66%	High				
	22.0 – 25.0	0	0%	Excellent				
SMP 8 Batanghari	5.0 – 9.0	2	6.6%	Poor	2. 98	3.00	1.00	5.00
	10.0-13.0	1	3.3%	Low				
	14.0 – 17.0	8	26.4%	Moderate				
	18.0 -21.0	12	39.6%	High				
	22.0 – 25.0	7	23.1%	Excellent				

Based on Table 6, students' analytical thinking percentage obtained by SMP 35 Batanghari was 66%, and the percentage obtained by SMP 8 Batanghari was 39.4%. Therefore, both schools' proficiency levels were high.

The description of the students' responses toward the PBL model at SMP 35 Batanghari and SMP 8 Batanghari is as follows:

Table 7. The Description of the Students' Responses toward PBL Model

Student Response	Interval	F	Percentage	Category	Mean	Median	Min	Max
SMP 35 Batanghari	5.0 – 9.0	0	0 %	Poor	3. 12	3.00	1.00	4.00
	10.0-13.0	2	6.6%	Low				
	14.0 – 17.0	9	29.7%	Moderate				
	18.0 -21.0	19	62.7%	High				
	22.0 – 25.0	0	0%	Excellent				
SMP 8 Batanghari	5.0 – 9.0	0	0%	Poor	2.86	3.00	2.00	5.00
	10.0-13.0	0	0%	Low				
	14.0 – 17.0	6	19.8%	Moderate				
	18.0 -21.0	18	59.4%	High				
	22.0 – 25.0	6	19.8%	Excellent				

Based on Table 7, students' responses toward the PBL model were high, with a percentage of 62.7 % obtained by SMP 35 Batanghari and 59.4% obtained by SMP 8 Batanghari. It can be concluded that both schools provided good responses toward the PBL model in mathematics.

Assumption Tests

Normality Test

The normality results on science process skills, analytical thinking, and the PBL model can be seen in Table 8.

Table 8. Test Normality Test Results

Normality Test							
	Schools	Kolmogorov-Smirnov			Shapiro-Wilk		
		Statistics	df	Sig.	Statistics	df	Sig.
Science process skills	SMP 35 Batanghari	.053	90	.200*	.944	90	.0 9 6
	SMP 8 Batanghari	.051	90	.200*	.975	90	.575
Analytical thinking	SMP 35 Batanghari	.061	90	.200*	.976	90	.621
	SMP 8 Batanghari	.054	90	.200*	.953	90	.131
PBL model	SMP 35 Batanghari	.069	90	.200*	.979	90	.722
	SMP 9 Batanghari	.055	90	.200*	.963	90	.270

Based on table 8, it was found that the results of the normality test were normal. The obtained results of the Kolmogorov-Smirnov test were higher than 0.05.

Homogeneity Test

The homogeneity test results on science process skills, analytical thinking, and PBL model at SMP 35 Batanghari and SMP 8 Batanghari can be seen in Table 9.

Table 9. The Results of the Homogeneity Test

Test of Homogeneity of Variances					
		Levene Statistics	df1	df2	Sig.
Skills process * Analytical thinking* PBL model	Based on Mean	2,658	1	720	.091
	Based on Median	2,676	1	720	.092
	Based on Median and with adjusted df	2,676	1	717,263	.092
	Based on trimmed mean	2,662	1	720	.093

Based on table 9, it can be concluded that data were homogeneous with the obtained results higher than 0.05.

Linearity Test

The results of the linearity test can be seen in the table below :

Table 10. The Results of the Linearity Test

ANOVA Table

			Sum of Squares	df	Mean Square	F	Sig.
Analytical thinking *Science process skills * PBL model	Between Groups	(Combined)	2645.169	48	94,470	2.039	.017
		linearity	2185,264	1	2185,264	47.168	.000
		Deviation from Linearity	459,906	47	17,034	.368	.996
	Within Groups		1992.150	243	46,329		
	Total		4637,319	539			

Table 10 shows a linear relationship between science processes skills and analytical thinking using the PBL model at SMP 35 Batanghari and SMP 8 Batanghari. The results of the linearity test were higher than 0.05.

Hypothesis Testing

The hypothesis test was performed using the t-test and correlation test. The t-test aims to determine the difference in the average sample taken, while the correlation test shows whether there is a relationship between the two variables**.** The t-test result can be seen in the following table:

Table 11. The Result of T-Test

Independent Samples Test

		Levene's Test for Equality of Variances				
		F	Sig.	t	df	Sig. (2-tailed)
Analytical thinking at SMP 35 Batanghari and SMP 8 Batanghari	Equal variances assumed	.1 62	. 54 1	3.997	180	.000
	Equal variances not assumed			4.012	122.881	.000
		F	Sig.	t	df	Sig. (2-tailed)
Science process skills at SMP 35 Batanghari and SMP 8 Batanghari	Equal variances assumed	.1 32	. 73 9	2,419	180	.000
	Equal variances not assumed			2,494	132.891	.000
		F	Sig.	t	df	Sig. (2-tailed)
PBL model at SMP 35 Batanghari and SMP 8 Batanghari	Equal variances assumed	.1 87	. 72 1	2,638	180	.000
	Equal variances not assumed			2,612	121.771	.000

Table 11 shows a difference between science process skills and analytical thinking using the PBL model at SMP 35 Batanghari and SMP 8 Batanghari proven by the value sig (2-tailed) 0.000, which is lower than 0.05.

Correlation Test

The result of the correlation test is displayed in the table below.

Table 12. The Result of Correlation Test

Correlations		
		RESULT
Analytical thinking at SMP 35 Batanghari and SMP 8 Batanghari	Pearson Correlation	.690**
	Sig. (2-tailed)	.033
	N	180
Science process Skills at SMP 35 Batanghari and SMP 8 Batanghari	Pearson Correlation	.884**
	Sig. (2-tailed)	.000
	N	180
PBL model SMP 35 Batanghari and SMP 8 Batanghari	Pearson Correlation	.729**
	Sig. (2-tailed)	.023
	N	180

Table 12 shows a relationship between science process skills and analytical thinking using the PBL model at SMP 35 Batanghari and SMP 8 Batanghari proven by the Sig. Value of (2-failed) 0.023 which is higher than 0.05.

Descriptive statistics are types of statistics that process statistical analysis by classifying the processed data. In this research, the researchers examined the science process skills and analytical thinking using the PBL model at SMP 35 Batanghari and SMP 8 Batanghari. The classification indicators were in the high category with a percentage of 6 2.7 % obtained by SMP 35 Batanghari, and SMP 8 Batanghari obtained a percentage of 66%. Therefore, both schools had good responses. Furthermore, the observation indicators were in the high category with 59.4 % obtained by SMP 35 Batanghari and a percentage of 66% obtained by SMP 8 Batanghari. Therefore, both schools had good responses.

The students' analytical thinking skills were high, with a percentage of 66 % obtained by SMP 35 Batanghari and 39.4% obtained by SMP 8 Batanghari. It can be concluded that both schools' proficiency levels were high. The students' PBL model was high, with a percentage of 62.7 % obtained by SMP 35 Batanghari, and SMP 8 Batanghari obtained 59.4%. Therefore, both schools had good responses.

The normality test of science process skills and analytical thinking using the PBL model in mathematics at SMP 35 Batanghari and SMP 8 Batanghari was normally distributed. The results of the Kolmogorov-Smirnov test were higher than 0.05. The homogeneity test results on science process skills and analytical thinking using the PBL model at SMP 35 Batanghari and SMP 8 Batanghari were homogeneous with a significant value higher than 0.05. The linearity test on science process skills and analytical thinking using the PBL model showed a linear relationship proven by the Sig value that was higher than 0.05. Hypothesis testing can be carried out since the data met the requirements, namely normally distributed, homogeneous, and linear.

The t-test on science process skills and analytical thinking using the PBL model at SMP 35 Batanghari and SMP 8 Batanghari showed a difference proven by the Sig. Value of (2-tailed) 0.000 which is lower than 0.05. The correlation test of science process skills and analytical thinking using the PBL model showed a relationship proven by the Sig. Value of (2-failed) 0.023 which is higher than 0.05.

This research is in line with the research on process skills (Vartiainen & Kumpulainen, 2020; Stender et al., 2018; Vansteensel et al., 2017). However, their research only measured students' skills with one variable and without using a learning model. This research is in line with the analytical thinking research conducted by (Ilma et al., 2017). However, their research only has one variable and without using a learning model. Therefore, this research was conducted to complement the previous research.

In this research, researchers examined the problem-based learning model with variables of analytical thinking ability and science process skills of junior high school students in learning mathematics. It can be seen that the problem-based learning model used has a relationship with students' science process skills and analytical thinking in mathematics. The science process skills and good analytical thinking can develop students' knowledge and skills regarding mathematics lessons. The science process skills and analytical thinking with the PBL model can evaluate problems related to mathematics subjects. Therefore, good science process skills and analytical thinking are formed to produce good impacts.

The urgency of this research is to help educators understand the differences and relationships between students' analytical thinking skills and science process skills in mathematics subjects using a problem-based learning model. The drawback of this research is that it only measures the variables of analytical thinking and science process skills in the PBL learning model and has not been tested with other variables such as self-efficacy, attitudes, interests, motivation, and others. Therefore, it is possible to read or do further research with different variables.

CONCLUSIONS

Based on the analysis and research results, it can be concluded that based on the t-test, there was a significant difference between the analytical thinking skills and the science process skills of students at SMP Negeri 35 Batanghari and SMP Negeri 8 Batanghari in mathematics, especially on the indicators of Observation and Classification. Furthermore, in the correlation test, it was found that there was a relationship between analytical thinking skills and science process skills because students who have analytical thinking skills will have better science process skills in problem-based learning models. It is hoped that further research can be carried out using different variables, populations, and learning models.

AUTHOR CONTRIBUTIONS STATEMENT

This article was conceptualized and original written by ADK. ES participated in the methodology, validation and data curation. For review and editing carried out by all authors.

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