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Impact of the Integration of Ethno-mathematics with TPACK framework as a problem-based learning (PBL) model

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ABSTRACT

Purpose: This study aimed to see the influence of the integration of ethno mathematics with the framework of TPACK (Technological, Pedagogical, Art, Content, And Knowledge) as a problem-based learning model, in junior high school to teach social arithmetic. **Methodology**: This study used a mixed method, quasi-experimental research design with two experimental groups. The data constituted the students' posttest outcomes and the results of observation of its implementation by teachers in classroom. A sample of 128 students from 4 classes at junior high school at Jambi city was identified through a simple random sampling technique. **Findings**: Findings concluded that ethno-mathematical learning with TPACK intervention assisted by PBL models can be more effective than a simple ethno-mathematical learning model. The students who went through this experiment scored higher grades and achieved better learning outcomes. The teachers found it more holistic and supported the achievement of learning objectives. **Implications to Research and Practice:** Implications for students includes making learning less rigid because students can easily observe or imagine what is explained by the teacher; it increased their thinking and problem-solving skills. Teachers can make effective use of cultural values in maximizing students' learning potential and improve their own ability to manage the classes more effectively.

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Introduction

Learning mathematics can come out of a concrete context (Aljaberi & Gheith, 2018; Bernard & Senjayawati, 2019). Mathematical concepts can be attributed to actual situations. Diverse mathematical concepts may be explored through traditional Javanese games (Papadakis et al., 2018; Tanti et al., 2021; Zaenuri & Dwidayanti, 2018). Each student has his or her own knowledge program, realizing that the program is highly influenced by sociocultural factors. When Mathematics is used in culture, it is called ethno mathematics (Rech et al., 2017; Widada et al., 2019). The term is mathematically applied by certain cultural groups that are not just talking about ethnicity. Based on the fact obtained from a secondary school educator through an online interview that learning in schools today is not in accordance with the demands of an educational curriculum that demands cultural engagement, educators have not utilized the student knowledge scheme.

Ethno-mathematics integrates education of cultural values and character of a nation's main subjects of algebra and social arithmetic. It can train students' creativity in solving mathematical problems and make a positive impact on learning outcomes, especially in the cognitive realm of students (Hartinah et al., 2019; Schukajlow et al., 2017; Suarsana et al., 2019). Ethno-mathematics is therefore a solution that uses students' knowledge program. On the other hand, the use of the system can be made easier by the presence of appropriate technology. The help of modeling technology in mathematical learning problems for students becomes more real to achieve an ideal education.

Learning based on ethno-mathematics has been employed by many teachers. Findings of previous researchers (Sunzuma & Maharaj,2020) show that students lack knowledge of culture and the ability to observe and listen, so that in implementation they often experience obstacles. However, the past research is limited only to geometry material, without extending research to other subjects like social arithmetic. Had there been some research in other subjects like social arithmetic, it would have been possible to see how effectively ethno-mathematics integrate with mathematics learning and how it is assisted by problem-based learning models. The problem-based learning model itself aims to facilitate the development of high-level skills as well as the ability to cooperate and communicate with each other. However, there is no empirical evidence which can state that problem-based learning models can support all aspects, especially in culture. The integration of ethno-mathematics using problem-based learning is able to overcome some weaknesses; however, by integrating ethno-mathematics with problem-based learning models, it is hoped that students not only become active and are able to solve problems, but they can also preserve their cultural values.

There is a dearth of research on integrating TPACK (Technology, Pedagogic, Art, Content, Knowledge) with ethno-mathematics. Porras-Hernández & Salinas-Amescua (2013), for example, examined merely how to improve teachers' abilities in terms of micro, macro, and professional approaches. Santos & Castro (2021), though talk about TPACK but only to examine how it can build a meaningful learning experience. All these studies refer to discusses TPACK but do not examine its cultural values. Fauziah & Yusfitri (2018) show how the cultural values of the Malamang tradition were integrated with mathematics

learning, but in their research, they did not use the TPACK framework in its implementation. Likewise, Wonu & Zalmon (2019) focus on the application of ethno-mathematics for teachers; Patmara et al (2019) focus on the application of ethno-mathematics for elementary school students. In both situations, the model chosen is the problem based learning model, for its quality of being considered suitable to improve students' ability to observe and listen (Palupi et al., 2020; Ulva, 2019). The ability to observe and hear is a competence that students must possess to preserve cultural values. If this can be done optimally, the output of the usefulness of this research is not only limited to students but also it makes a real impact on the ability of teachers to teach in class. Arithmetic is one of the fields of mathematical study that is learnt because of its usefulness as a basis of knowledge in the development of critical reasoning of students (Gilmore et al., 2018; L. Mishra, 2020). Arithmetic learning is very flexible to be integrated with other variables. Sunzuma & Maharaj (2021) show that learning of arithmetic was combined with cultural values of middle school students in Zimbabwe. A similar study Orey & Rosa (2008) focused on similar issues but took algorithm material in their study. In the context of Indonesia, arithmetic material is very suitable to be integrated with cultural values.

Education is not ideal when teachers use conventional learning models (Asrial et al., 2021; Hendriana et al., 2017) and do not associate the learning material with students' learning outcomes, which leaves students with poor cognitive realm (Surya et al., 2017; Utami & Sayuti, 2019). Ethno-mathematics could be the answer by making use of an appropriate learning model such as problem-based learning (PBL) or a student-centered learning approach covering contextual problems and making use of creativity in problem-solving. In fact, an appropriate use of learning approaches/models and make use of adequate technology is an ideal educational scenario. It affects student learning outcomes specifically in the cognitive realm (P. Mishra, 2019; Valtonen et al., 2017; Zakaria & Syamaun, 2017), but is then integrated with TPACK to improve the knowledge patterns of learners, irrespective of their sociocultural factors that might have helped them to understand mathematical concepts. Such an initiative can also enhance the professionalism of mathematics teachers as well as their quality, while such improvements are not carried out until TPACK is integrated with ethno-mathematics, the focus of the current study. This research aimed to complement the previous research studies that recommend integration of ethno-mathematics with TPACK and make use of a problem-based learning model on arithmetic material. Specifically, this research framed the following research objectives for this study:

1. To know the learning outcomes using ethno-mathematical learning integrated with TPACK and assisted by problem-based learning models
2. To understand the learning response when ethno-mathematics is integrated with TPACK and assisted by problem-based learning models
3. To identify the differences in learning outcomes and ethno-mathematical responses when integrated with TPACK and assisted by problem-based learning models
4. To establish the relationship between learning outcomes and learning responses using ethno-mathematics integrated with TPACK and assisted by problem-based learning models

The study intended to make a comparison between two classes, one which used ethno-mathematics integrated with problem-based learning models, as in the framework and the second, that study ethno-mathematics without such integration.

Conceptual framework

Figure 1 presents a conceptual framework of the current study showing the integration of TPACK with a problem-based learning (PbL) model resulting into an integrated ethno-mathematic scenario. It appears that ethno-mathematics resulting out of the integration of TPACK with PbL can form an interesting learning concept and contribute to improving students' learning outcomes. The significance of TPACK in this framework lies in it representing the teacher's teaching ability in a classroom, since it slices with problem-based learning. This can be examined in the following way: when teachers are required to teach a material (content) with the help of technology, learning is more like a pedagogical art used by the teacher to transfer knowledge. To manages the class, the teacher might need the assistance of various models, one of which is problem-based learning.

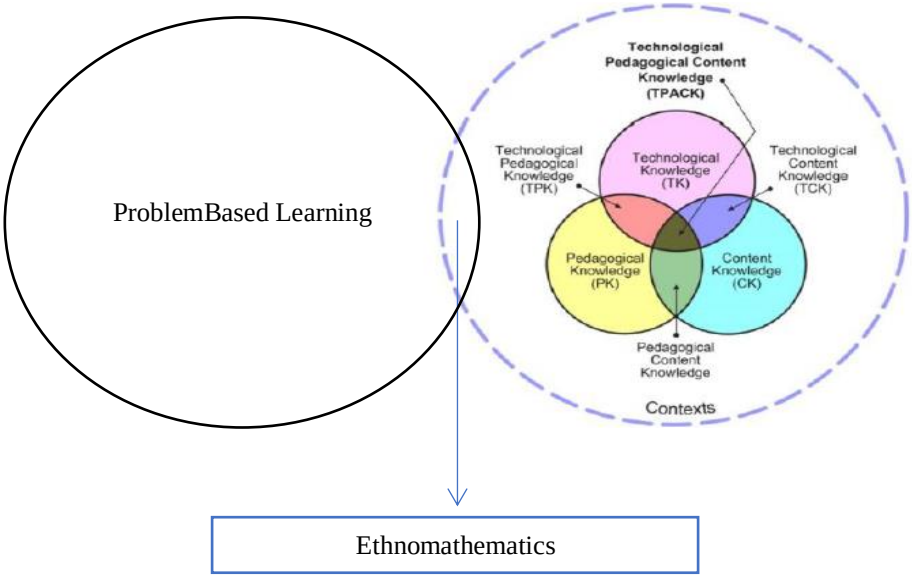

Figure 1. *Research Framework*

Figure 1 shows an interaction between TPACK and problem-based learning, which infers that for learning (ethno-mathematics) to take place, there is a need to identify the cognitive realm which can ideally improve students' learning outcomes. In other words, the integration of TPACK with the problem-based learning model will create a cognitive realm of learning where ethno-mathematics can be conveniently placed, and students' learning outcomes can be easily predicted.

Method

Research Design

A quasi-experimental research design was employed to study the impact of ethno-mathematical integration learning with TPACK framework and problem-based learning (PBL) model with students' learning outcomes in the cognitive domain. The focus of this research was therefore ethno-mathematics integration learning framework when TPACK is integrated with problem-based learning model (Figure 1). It was a mixed method research, which meant adoption of both quantitative and qualitative research methods.

Research Sample

This study was carried out at junior high school number 14 Jambi City in February 2021. The population comprised all students of grade VII junior high school number 14 Jambi City in the 2020/2021 school year. There were 128 students identified from 4 classes, grade VII A to VII D. The participants were divided into two groups, control group and experimental group. The experimental group used ethno-mathematics integrated with TPACK and assisted by problem-based learning models; while the control group used only ethno-mathematics assisted by problem-based learning.

Data collection instrument and procedure

Since this study used a mixed method research design, data collection instruments were also different for quantitative and qualitative data. The quantitative data was obtained from multiple choice questionnaires, response questionnaires and observation sheet. Table 1 to Table 5 presents details of these questionnaires.

Table 1.

Questionnaire instrument for social arithmetic material

Indicator	Conative Level	Number
– Determine profit and loss on income and expenses	C1	1, 2, 3
– Determining profit in rupiah (Indonesian currency)	C2	4, 5
– Analyze the value of profit in different conditions	C3	6, 7, 8, 25
– Determine the interest rate in n-months	C2	9, 10, 11, 12
– Determine the percentage of interest, time, and amount of money after n-months	C2	13, 14, 15, 24
– Identify and analyze gross and net values	C3	16, 17, 18
– Analyze contextual issues related to tax	C3	19, 20
– Analyze problems related to social arithmetic (discount, gross, net, and tare)	C4	21, 22, 23

There were 25 questions which were used to test reliability and validity with levels C1-C4 and 5 answer choices. The scoring range of each question can be seen in Table 2.

Table 2.

Range of categories for social arithmetic material

interval	Scoring category
0.00 – 20.00	Not very good
20.01 – 40.00	Not good
40.01 – 60.00	Pretty good
60.01 – 80.00	Well
80.01 – 100.00	Very good

Table 3 presents the learning response questionnaire intended to find out how students thought about the learning being carried out. This questionnaire was meant for the control group that was taught using the intervention of TPACK.

Table 3.

Ethno-mathematics learning response questionnaire (with TPACK)

Observed aspects	Statement number
– Students' attitudes towards ethno-mathematical learning are integrated with TPACK assisted by problem-based learning models.	1, 2, 3, 4
– Students' interest in ethno-mathematical learning is integrated with TPACK assisted by problem-based learning models.	5, 6, 7, 8
– The relationship between ethno-mathematical learning is integrated with TPACK assisted by problem-based learning models with students' mathematical representation abilities.	9, 10

For comparison, this research formed a control group who was taught only by the use of ethno-mathematics assisted by a problem-based learning model, but without the TPACK as an intervention.

Table 4.

Ethno-mathematics learning response questionnaire ((without TPACK)

Observed aspects	Statement number
– Students' attitudes towards ethno-mathematical learning assisted by problem-based learning models.	1, 2, 3, 4
– Students' interest in ethno-mathematical learning assisted by problem-based learning models.	5, 6, 7, 8
– The relationship between ethno-mathematical learning assisted by problem-based learning models and students' mathematical representation abilities.	9, 10

Both the response questionnaires, with and without TPACK had 10 statements each, measured on a 4-point Likert scale whose scoring range can be seen in Table 5.

Table 5.

Range of categories for Ethno-mathematics learning response questionnaire

Interval	Scoring category
10.00 – 16.00	Not very good
16.01 – 22.00	Not good
22.01 – 28.00	Pretty good
28.01 – 34.00	Well
34.01 – 40.00	Very good

The qualitative data of this study was in the form of observation sheets and interviews transcripts. The observation sheet comprised 10 statements that were posed to the teachers in the sampled schools. Table 6 presents statements in the observation sheet.

Table 6.

Observation sheet on the implementation of ethno-mathematics learning (with TPACK)

Indicator	Rated aspect	No. statement
Diagnose the problem	Demonstrating examples of how to define a problem	1
	Directing students to create a problem related to the facts given by the teacher	2
	Directing students to discuss analyzing the problem	3
	Guiding students in finding concepts based on problems	4
	Encouraging students to be able to understand the concepts that have been found from the problem	5
Formulate alternative strategies	Encourage students to cooperate in gathering information from relevant sources	6
Define strategy	Guiding students to present the results of group discussions related to the problems found	7
	Guiding students in making comparisons and analysis of questions or suggestions given by other groups	8
Analyze strategic success	Evaluating discussion results and practices during discussions	9
	Guiding students to conclude the results of the discussion	10

Interview sheets were also used to collect the qualitative data, which provided situations and conditions prior to conducting research. Table 7 presents the interview guide sheets:

Table 7.

Teacher interview guide sheets

Indicator	Interview sheet number
The ease of learning offered	1
Student understanding	2
Student activity	3
Courage of students in expressing opinions	4
Student learning outcomes and cooperative attitudes	5

The research procedure began by analyzing the problem or sample to be studied. After finishing formulating the problem, the researcher carried out a plan which included preparing the instrument, preparing teaching media, and matching the research time. After the planning was complete, the next stage was to conduct research, namely teaching in class directly which then obtained data, which was analyzed, and conclusions drawn. Figure 2 summarizes the research procedure.

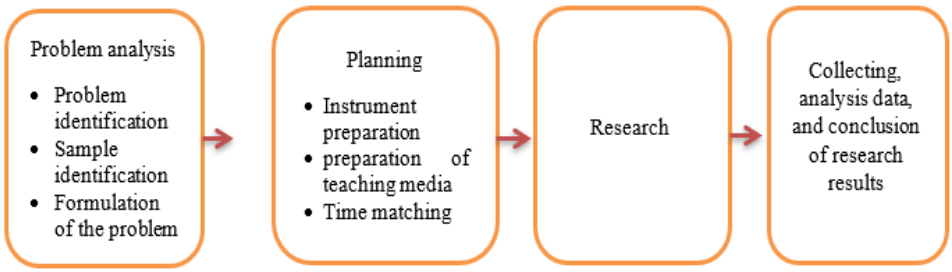

Figure 2. *Research Procedure*

Data Analysis

The sample was divided into two groups: control group and experimental group. The questionnaire items were put to reliability and validity tests prior to analyzing the data obtained. The data was comprehensively tested on SPSS v.25

Results

Before conducting the research, the author first conducted a reliability and validity test to test the validity of the questions that were later given to students. The results of the reliability test can be seen in table 8.

Table 8.

Multiple choice Reliability Test Results

Cronbach's Alpha	N of Items
.435	25

The reliability test in Table 8 shows a significance value of 0.435 for the 25 posttest questions.

Table 9.

Multiple choice test validity result

Question No	R-Arithmetic	r-table	Description
1.	0.529	0.361	Valid
2.	0.412	0.361	Valid
3.	0.424	0.361	Valid
4.	0.562	0.361	Valid
5.	0.134	0.361	Invalid
6.	0.763	0.361	Valid
7.	0.022	0.361	Invalid
8.	0.485	0.361	Valid
9.	0.109	0.361	Invalid
10.	0.406	0.361	Valid
11.	0.509	0.361	Valid
12.	0.008	0.361	Invalid
13.	0.364	0.361	Valid
14.	0.392	0.361	Valid
15.	0.032	0.361	Invalid
16.	0.412	0.361	Valid
17.	0.788	0.361	Valid
18.	0.373	0.361	Valid
19.	0.018	0.361	Invalid
20.	0.844	0.361	Valid
21.	0.371	0.361	Valid
22.	0.671	0.361	Valid
23.	0.612	0.361	Valid
24.	0.507	0.361	Valid
25.	0.414	0.361	Valid

The validity of each statement was also tested and recorded in Table 9. It can be seen here that out of 25 questions, there were only 19 valid questions where the validity was determined by finding $r_{arithmetic}$ greater than r_{table}.

After finishing testing the validity and reliability, descriptive tests of learning outcomes were conducted for students' responses. The descriptive statistical tests results are recorded in Table 10.

Table 10.

Descriptive statistics of student learning outcomes

Class	Gender	Category	F	%	Mean	Median	Min	Max
VII A	Male	Very Good	5	16.67				
		Good	8	26.67				
		Enough	5	1 6.67	74.5	77.5	55	85
		Bad	0	0				
		Very Bad	0	0				
	Female	Very Good	7	23.33				
		Good	2	6.67				
		Enough	3	10	73	75	60	90
		Bad	0	0				
		Very Bad	0	0				
	Total		**30**	**100**				
VII B	Male	Very Good	8	46.67				
		Good	3	10				
		Enough	6	20	76	80	55	95
		Bad	0	0				
		Very Bad	0	0				
	Female	Very Good	6	20				
		Good	5	16.67				
		Enough	2	6.67	77.5	78.5	60	90
		Bad	0	0				
		Very Bad	0	0				
	Total		**30**	**100**				
VII C	Male	Very Good	3	10			60	85
		Good	7	23.33				
		Enough	4	1 3.33	72.5	75		
		Bad	0	0				
		Very Bad	0	0				
	Female	Very Good	5	16.67	71.5	73.5	55	80
		Good	5	16.67				
		Enough	6	20				
		Bad	0	0				
		Very Bad	0	0				
	Total		**30**	**100**				
VII D	Male	Very Good	3	10	71	70	50	85
		Good	5	16.67				
		Enough	5	16.67				
		Bad	0	0				
		Very Bad	0	0				
	Female	Very Good	6	20	73.5	72	55	85
		Good	11	36.67				
		Enough	0	0				
		Bad	1	3.33				
		Very Bad	0	0				
	Total		**30**	**100**				

The data obtained from response questionnaire was tested in 4 classes, out of which 2 classes, VII A and VII B, used integrated ethno-mathematics with TPACK assisted by problem-based learning models. The other 2 classes, VII C and VII D integrated ethno-mathematics assisted by problem-based learning models without the TPACK. The results revealed that the first set of students, Class VII A and VII B, which had used ethno-mathematics assisted by problem-based learning models and integrated with TPACK, had much better and superior learning outcomes than the other 2 classes, VII C and VII D, which did not use the TPACK method.

Table 11 depicts the responses to e- learning questionnaire in ethno-mathematics of the group, VII A and VII B, that was experimented with TPACK and assisted by a problem-based learning model

Table 11 .

Description of the results of the questionnaire response to experimental Group with TPACK

Class	Gender	Category	F	%	mean	median	Min	Max
VII A	Male	Very good	8	2 6.67	35.2	2 9 , 5	16	36
		good	3	10				
		Enough	1	3.33				
		Bad	0	0				
		Very bad	0	0				
	female	Very good	12	40	36	28	16	32
		good	5	16.67				
		Enough	0	0				
		Bad	1	3.33				
		Very bad	0	0				
	Total		30	100				
VII B	Male	Very good	13	4 3.33	3 4 , 5	2 8 , 5	20	32
		good	5	1 6.67				
		Enough	0	0				
		Bad	0	0				
		Very bad	0	0				
	female	Very good	15	50	33	29	12	32
		good	3	10				
		Enough	0	0				
		Bad	0	0				
		Very bad	0	0				
	Total		30	100				

Table 12 depicts the responses to e- learning questionnaire in ethno-mathematics, of the group, VII C and VII D, simply assisted by a problem-based learning model and not experimented with TPACK.

Table 12.

Description of the results of the questionnaire response to experimental Group without TPACK

Class	Gender	Category	F	%	mean	median	Min	Max
VII C	Male	Very good	8	2 6.67	33.5	24	14	36
		good	3	10				
		Enough	2	6.67				
		Bad	2	6.67				
		Very bad	0	0				
	female	Very good	7	23.33	32	22.5	13	33
		good	5	16.67				
		Enough	3	10				
		Bad	0	0				
		Very bad	0	0				
Total			30	100				
VII D	Male	Very good	8	26.67	34.5	26.5	17	38
		good	4	13.33				
		Enough	0	0				
		Bad	0	0				
		Very bad	0	0				
	female	Very good	10	33.33	31	31.5	15	34
		good	8	26.67				
		Enough	0	0				
		Bad	0	0				
		Very bad	0	0				
Total			30	100				

Form another questionnaire on learning outcome, the data was also collected in the same manner from both sets of classes, one set experimented with TPACK and the other set without it. Table 13 presents the T-test results to see how the differences in student learning outcomes in each set of classes.

Table 13.

T-Test Results of both groups

	Class				t-test for equality of means		
					t	df	Sig. (2-tailed)
Learning Outcomes	VII B	A*VII	*Equal assumed*	*varieties*	1. 42	30	.0 14
			Equal assumed	*variances*	1. 43	29.5	.0 14
	VII D	C*VII	*Equal assumed*	*varieties*	2.23	30	.0 23
			Equal assumed	*variances*	2.23	29.25	.0 23

The T test results reveal differences in learning outcomes between the two sets of classes, the first set of class A and B, and second set of class C and D, which is because the significant value obtained is less than 0.05.

The correlation test was also conducted to see the relationship between the learning methods tested and their learning outcomes. Table 14 presents the results of the correlation test.

Table 14 .

Correlation test results

Class	Variable		Learning outcomes
VII A	Ethno-mathematical learning integrated with TPACK assisted by problem based learning model	Correlation	0.723
		Significance (2-Tailed)	0.001
		df	30
VII B		Correlation	0.743
		Significance (2-Tailed)	0.003
		df	30
VII C	Ethno-mathematical learning model assisted by problem-based learning (without TPACK)	Correlation	0.613
		Significance (2-Tailed)	0.039
		df	30
VII D		Correlation	0.608
		Significance (2-Tailed)	0.003
		df	30

Table 14 results show the significance level of both sets of learning methods as strong and positive with learning outcomes. These results are supported by qualitative data, presented in Table 15 and Table 16 obtained from observation for both sets of classes.

Table 15.

Observation results of the implementation of ethno-mathematics learning assisted by problem-based learning models (with TPACK)

Indicator	Rated aspect	Answer
Diagnose the problem	Demonstrating examples of how to define a problem	The teacher is quite capable of demonstrating problems in everyday life
	Directing students to create a problem related to the facts given by the teacher	The teacher has been able to direct students in making a problem
	Directing students to discuss the problem analysis	The teacher is enough to direct the discussion in class
	Guiding students in finding concepts based on problems	The teacher has been very good at guiding students in finding a problem concept
	Encouraging students to be able to understand the concepts that have been found from the problem	The teacher is a little difficult because some problems are quite difficult
Formulate alternative strategies	Encourage students to cooperate in gathering information from relevant sources	The teacher is good enough to encourage cooperation in class.
Define and define strategy	Guiding students to present the results of group discussions related to the problems found	The teacher has been quite successful in guiding the presentation of the results of the discussion
	Guiding students in making comparisons and analysis of questions or suggestions given by other groups	The teacher is very good at analyzing the opinions of other groups
Analyzing strategy success	Evaluating discussion results and practices during discussions	The evaluation carried out is probably in terms of time that is not maximized
	Guiding students to conclude the results of the discussion	The teacher is good enough to guide students in inferring the results of the discussion

From the results obtained, it appears that the teacher is quite good in carrying out the learning offered, however, for the sake of comparison, there is a need to look at the other set of classes, that only used ethno-mathematical learning assisted by problem-based learning models, without TPACK model. Table 16 presents those results.

Table 16 .

Observation results of the implementation of ethno-mathematics learning assisted by problem-based learning models (without TPACK)

Indicator	Rated aspect	Answer
Diagnose the problem	Demonstrating examples of how to define a problem	The teacher is quite capable of demonstrating problems in everyday life
	Directing students to create a problem related to the facts given by the teacher	The teacher has been able to direct students in making a problem
	Directing students to discuss analyzing the problem	The teacher is quite difficult in directing the discussion in class
	Guiding students in finding concepts based on problems	The teacher has been very good at guiding students in finding a problem concept
	Encouraging students to be able to understand the concepts that have been found from the problem	Teachers are quite difficult in encouraging students' understanding of concepts
Formulate alternative strategies	Encourage students to cooperate in gathering information from relevant sources	The teacher is good enough to encourage cooperation in class
Define and define strategy	Guiding students to present the results of group discussions related to the problems found	The teacher has been quite successful in guiding the presentation of the results of the discussion
	Guiding students in making comparisons and analysis of questions or suggestions given by other groups	The teacher is good enough in analyzing the opinions of other groups
Analyzing strategy success	Evaluating discussion results and practices during discussions	The evaluation carried out is the discussion time and the concept is not maximized
	Guiding students to conclude the results of the discussion	The teacher is good enough to guide students in inferring the results of the discussion

From the results obtained above, the teacher is quite difficult compared to the first method, but in terms of implementation it is quite good. However, to further strengthen the findings, it was necessary to conduct an interview with the teachers at the school. The interview results are presented as follows.

Interview results

Q. How easy is it to use the two learning methods offered, one integrated ethno-mathematical learning with problem-based learning models with TPACK; and the second, ethno-mathematical learning simply integrated with problem-based learning models, without TPACK?
A. Both methods are equally good, but our group prefers the first method because it is more complete and includes all the learning objectives that have been formulated.
Q. Can both learning methods, with and without TPACK, check students' understanding in group discussions?
A. Of course, each method describes everyday problems, so students understand the learning material better.
Q. Did the first learning methods, with TPACK intervention, make students more active in the learning process?
A. Of course, it did. The students after the experiment looked more enthusiastic than usual. They seemed to be more active in finding sources and submitted opinions on the problems.
Q. Can the learning offered by the first learning method, with TPACK intervention, make students more daring in expressing their opinions in the class?
A. I think there have been improvements, but some are students are still not. It is likely that over time the rest will also dare to express their opinions in class forums.
Q. How are the learning outcomes and student collaboration in both the learning methods with and without TPACK experiment?
A. The learning outcomes have increased, but I think the first method is more effective because it looks like students are a little more active in discussing and working together in class.

Discussion

The purpose of this research was to obtain information about the achievement of student learning outcomes by integrating TPACK (Technology, pedagogic, art, content, knowledge) into the learning process. The data in this study was obtained from the questionnaire instrument of student learning outcomes and student response questionnaires. The descriptive results for each instrument in each class were distinguished by gender in each class. For the student learning outcomes questionnaire, the results obtained are presented in Table 9, which shoes that the highest average score is in class VII A, which is 76 for male students with a minimum score of 55 and a maximum value of 95 while the average student learning outcomes for female students is 77.5 with a minimum score of 60 and a maximum value of 90. On the other hand, the student response questionnaire received mixed results. Table 10 presents the findings for both sets of classes.

It is seen that the set of classes that used TPACK (Class VII A and VII B) received the highest average score for male of 35.2 with a minimum score of 16 and a maximum score of 36; while the female average score was 32. with a minimum score of 16 and a maximum value of 36. However, the classes that did not use the TPACK model, (VII C and VII D), as shown in Table 12, the average score obtained by male students was 34.5 with a minimum score of 17 and a maximum score of 38. The average score for female students in this group was 32 with a minimum score of 13 and a maximum value of 33. Based on these descriptive results, it was concluded that better learning outcomes are obtained in classes using TPACK, which is also supported by the results of student learning responses. The learning responses results also showed that the class that used TPACK received a higher average value. These results are also supported by the results of observations of teachers, who were found to be able to guide students quite well by using the TPACK model.

Having obtained the descriptive results for each class, the hypotheses test was carried out with the condition that the assumption test should be met. The assumption test in this study was also fulfilled, so the study continued with hypothesis testing comprising t-test and correlation test. The objective of t-test was to obtain information about whether there are differences in learning outcomes in each set of classes, one which used TPACK and the other which did not. The t-test results showed a significant value of 0.014 for the class that used TPACK and the class that did not use TPACK scored 0.023. The significance value was smaller than 0.05 (sig < 0.05) which suggests that there was a difference in the average value in each class, whether using TPACK or not. The correlation test results revealed the relationship between student learning outcomes and the learning method used. The correlation results showed both groups in strong category with a significance of 0.723, 0.743, 0.613, and 0.608. However, the highest correlation was seen in the class that used ethno-mathematical integrated learning with a problem-based learning model using the TPACK intervention, having a significance value of 0.743.

The results of this study provide an overview of the integration of ethno-mathematics using TPACK and PBL models in improving students' learning outcomes. Student learning outcomes in this study were obtained from students' understanding of the material taught by integrating ethno-mathematics, namely social arithmetic material. This material was important to learn and understand because it formed the basis of knowledge and also developed students' reasoning and critical thinking abilities (Gilmore et al., 2018; L. Mishra, 2020). These results are consistent with the results of Usman et al (2021), who stated that difficulty encountered in social arithmetic material was due to the lack of student mastery in understanding prerequisite materials such as algebraic operations. Hence, the application of ethno-mathematics can be a solution to improve students' learning outcomes.

The findings of this study also suggest that the integration of ethno-mathematics in learning can be used as an alternative to improve students' understanding in learning mathematical concepts. Fouze & Amit (2018) stated that this ethno-mathematics provides a great contribution for students, so it can help them understand the material, increase motivation, and improve their learning achievement. These findings are supported by

research conducted by Sunzuma & Maharaj (2019) which stated that the integration of ethno-mathematics into the learning process made understanding of geometry material better, but the challenge remains in the teacher's lack of ability to understand content and knowledge in the teaching process. Hence, there is a need to make innovations in learning methods such as TPACK. This is in line with the research conducted by Baser et al (2015), where the integration of technology in the form of TPACK in English language learning improved the way teachers taught and improved the quality of teaching outcomes. Furthermore, research conducted by Muir et al (2016) concluded that the use of technology as part of TPACK in learning can provide meaningful learning for students and improve their understanding. However, this study also suggested that, apart from TPACK, learning can also be assisted by using the PBL model. This is in line with the research conducted by Hmelo-Silver et al (2007) that the PBL model can help prepare students to become students who can solve problems and are ready for future challenges.

The use of ethno-mathematics is executed by applying cultural elements in learning indoors or outdoors in the surrounding environment. This can help students understand better the concept and application of learning, if carried out on culture or the environment. Widada et al (2019) stated that a student's ability to solve problems between classes increased after implementing ethno-mathematical-based outdoor learning. The problem-solving abilities after integrating ethno-mathematics became higher. This finding is supported by Amidi et al (2021) which states that there is a positive effect after integrating ethno-mathematics with the PBL model on students' problem solving abilities. However, there are still problem-solving steps that have not been achieved. This is because the PBL model is expected to help students solve problems, which is in line with the research conducted by Bilgin et al (2009), that the approach to the problem based learning model can help students to develop the problem solving ability. Tarhan & Ayyildiz (2015) also state that PBL is a learning model that is useful in making learning more active and effective so that it can help build knowledge and improve students' social skills.

This research was carried out is to see how students compared the use of two different learning methods and how each learning method was related to students' learning outcomes Previous researches used only one learning method, as in Akturk & Ozturk (2019), which examined how teachers' TPACK levels could affect student learning outcomes or in Abiam et al (2016),who examined the effect of ethno-mathematical learning on students' learning outcomes. This is also in line with the research of James & Tertsea (2021) who conducted a similar study but added the effect of the COVID-19 pandemic. Additionally, social arithmetic material is rarely taken as a variable in previous studies or sued with limitations. For instance, Passolunghi et al (2019) used social arithmetic material to evaluate the state of the relationship between cognitive and emotional students in the classroom. In another study, Fitria et al (2020) used social arithmetic material for the preparation of student worksheets and integrated it with problem based learning. Çankaya & Dag (2017) examined general arithmetic material, instead of social arithmetic. The current research has added a new avenue to this domain.

Conclusion, Recommendations, and Implications

This research study has concluded that ethno-mathematical learning with TPACK (Technology, pedagogic, art, content, knowledge) intervention and assisted by problem-based learning models can be more effective than a simply planned ethno-mathematical learning using a problem-based learning model. The set of classes that used the integrated model with TPACK intervention reported higher scores and better learning outcomes. As for the teacher's response, the ethno-mathematical learning method integrated with TPACK and assisted by the problem-based learning model was also found more effective. The reason is that this method was found completer and more holistic and supported the learning objectives formulated for the courses. The study faced certain limitations. First, there were 4 classes which were divided into two experimental groups, one for each teaching method. It was rather a challenge to implement the two teaching methods when both groups were experimental. Second, this research also did not use any pretest, so no comparison of the test result was available. The material used was also limited to mathematics subjects, namely social arithmetic, so further research may be carried out with other materials. Owing to these limitations, the conduct of research in 4 classes with two different learning methods, the difference was not too significant. Additionally, with the use of multiple-choice questionnaire, it was rather difficult to assess students' thinking skills optimally. It is recommended that future research should be carried out on a bigger sample size, with more groups and more schools; the questions should also be more varied, such as combination of open-ended and closed-ended questions or a combination of multiple choice and descriptive questions.

The implications of this research are divided into two, namely for students and teachers. For students, this research would increase students' comfort in classroom learning. The use of learning methods when integrated with local cultural values makes learning less rigid because students can easily observe or imagine what is explained by the teacher (Rohaeti et al., 2020; Wardono et al., 2021). Moreover, a cultural or value-based learning method included in teaching can foster a sense of pride and love for their respective nation. In addition, using a problem based learning model also increases students' thinking skills in solving problems (Duda et al., 2019; Suryawati et al., 2020). This makes a greater impact on students' learning outcomes which can later help them get satisfactory grades. For the teachers, this research can assist them to choose the appropriate learning method in their class. By using the appropriate method, teachers can achieve the learning objectives. The teachers can also make an effective use of cultural values is in maximizing students' learning potential. Cultural values are known to improve thinking and affective aspects such as cooperation in classrooms (Asif et al., 2019; Immordino-Yang & Gotlieb, 2017). Apart from that, using the appropriate learning method can improve the teacher's ability to manage the class which includes mastery of the material, situation, and emotional students.

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