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Research Article

Effectiveness of ethnomathematics-based visual thinking approach in increasing mathematics literacy and cultural motivation

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ABSTRACT

This study is aimed to increase the students' mathematics literacy and cultural motivation. The research design was a mix-method with an experiment with a nonequivalent control group design and ethnography. The research population was the junior high school students in the Siak City of Riau Province. The research sample was the students that were taken by using purposive sampling according to the research objective. The collection data techniques were interview, observation, and test. The interview with interview guidelines instrument to get information about the integration of culture with mathematics. The observation by a checklist to know the increasing motivation to learn and understand the Siak Culture. Test with an essay instrument to know the increasing the students' mathematics literacy after following the teaching process with the visual thinking method. The analysis data techniques were descriptive quantitative and t-test to know whether there was a difference between the control class and experiment class. The qualitative results show there were seven motifs of Tenun Siak that claimed in mathematics is Frieze F1 Pattern to F7 Pattern. The results show that there was a significant difference between the control class and the experiment class. The experiment class was better than the control class so it can be concluded that visual thinking can increase the students' mathematics literacy. The motivation of students to learn and understand the Siak Culture from the first and sixth meetings also increases.

Keywords: tenun motifs; visual thinking; mathematics literacy

1. INTRODUCTION

Mathematical literacy is a person's ability to understand and apply mathematics in various contexts in real life. This ability is useful for understanding the role of mathematics in making the right decisions in everyday life. By having mathematical literacy skills, students can understand the relationship of relevant mathematical concepts, then use them to solve the problems they face (Sari, 2015). This ability is needed by students, especially in the face of intense competition in the 21st century. Unfortunately, the mathematical literacy ability of Indonesian students is still relatively low. The low mathematical literacy ability of students can be seen in the results of a study conducted by the Program for International Student Assessment (PISA). PISA is a project of the Organization for Economic Cooperation and Development (OECD) designed to evaluate educational outcomes in terms of the ability of 15 year old students in math, reading, and science. The results of the 2018 PISA survey show that the level of mathematical literacy of Indonesian students is only at level 1(OECD, 2019). This level is the lowest literacy level of the 6 levels. At this level, new students are able to answer questions that have a general and familiar context and all relevant information are available with clear questions.

The results of Pakpahan's research (Pakpahan, 2017) on 15 year old students in 31 provinces in Indonesia stated that students' mathematical literacy was influenced by students' identity, socio-economic conditions, culture, ownership of computers and books. Furthermore, Mahdiansyah & Rahmawati (2014) in their research concluded that there are three factors that play a role in mathematical literacy, namely personal, instructional and environmental. Personal factors are perceptions and self-confidence of students. Instructional factors include intensity, quality and teaching methods. The characteristics of teachers and the availability of learning media in schools are environmental factors that also influence the achievement of Indonesian students' mathematical literacy. From the results of these studies, it can be said that the methods, strategies, models or learning approaches used by the teacher also affect the ability of mathematical literacy. As mentioned by Ojose (2011) that the way of teaching that is delivered also affects students' mathematical abilities. One variation of learning that can be done to overcome difficulties in mathematical literacy is the visual thinking learning

approach.

Visual thinking (visual thinking) can be an alternative for students to work in mathematics thinking becuase students can focus to think of the mathematical process (Aldalalah et al., 2019; Umbara et al., 2020). As stated by Moorman (2016) visualization can provide a simple, elegant, and powerful approach to formulating mathematical results and solving problems. Furthermore, Moeller et al., (2013) added that the Visual Thinking Strategy (VTS) strengthens students' communication skills, and critical thinking, including creative thinking. Presmeg, (2006) argues that visual thinking plays a role in understanding problems, simplifying problems, and seeing relationships. Visualization allows students to identify problems in a simpler form, find relationships in a system, understand mathematical literacy, then formalize understanding of a given problem and identify methods used for similar problems.

Problem-solving can be obtained directly without doing calculations through visual thinking. From some of these research results, it can be seen that visual thinking is an approach that is considered capable of improving communication, representation, and solving mathematical problems. These competencies are competencies that play an important role in the mathematical literacy process. Therefore, it is hoped that this visual thinking learning can improve students' mathematical literacy skills. In addition to the learning approach, according to Ojose (2011), the content of learning mathematics must be relevant to the social life of students. Mathematics learning activities should be related to life that is already known and close to students' daily lives, for example, the concept of culture in their environment. The integration of the concept of culture and mathematics is effective in improving students' mathematical abilities and love of their culture (Rezeki et al., 2020, 2021). Habits that are carried out every day will make it easier for students to understand mathematics and be motivated in learning mathematics (Amir et al., 2021).

In the integration context, the relationship between mathematics and culture is known as ethnomathematics. Ethnomathematics is a study that shows the reciprocal relationship between culture and mathematics. Ethnomathematics is described as a slice of three sets of disciplines, namely: mathematics, cultural anthropology, and mathematical modeling (Orey & Rosa, 2006). Ethnomathematics describes all cultural concepts, whether language, values, beliefs, food, clothing, or habits related to mathematics (Ambrosio, 2001). Ethnomathematics is a method used for learning mathematics through aspects of the local culture of certain communities so that it is interesting and easy to understand.

Among the cultural wealth owned by the Riau, the Malay community is Siak weaving. The Siak weaving is a traditional handicraft consisting of various Malay motifs. The Siak Malay community views this traditional dress as a cultural product that must be preserved. This woven fabric has its own motifs and patterns that contain certain meanings and philosophies as markers in life in society. The use of woven cloth and the procedure for its use is a matter of pride and shows the identity and identity of the user. However, the Siak weaving has become a culture that young people in the Siak community have started to abandon because young people prefer modern activities. The Siak weaving has lost technological sophistication where young people make android their main activity for playing games, social media, and other activities. Gradually, youth have left the Siak culture even though several cultural events were held in Siak Regency.

The low value of students' mathematics at the international level and the low interest of students in their local culture are important factors for conducting the assessment by integrating cultural values with mathematics through visual thinking learning. With this study on ethnomathematics in Siak weaving, it is hoped that the interest of the younger generation in exploring and preserving the Siak weaving culture will increase again so that the younger generation is motivated to develop it and realize the preservation of the nation's culture. Through ethnomathematics-based visual thinking learning on Siak weaving, it is hoped that it can be a bridge in improving problem-solving skills. This is in line with the opinion of Berns and Ericson (2001) who states that the use of contextual problems can also increase students' motivation to make connections between knowledge and its application in everyday life so that learning can create meaning and learning experiences. Owens (2001) shows that the use of contextual problems can increase student interest in learning from various backgrounds as well as student participation in applying understanding knowledge, connecting and applying the knowledge they have acquired. This ability can improve mathematical literacy in everyday life.

The role of ethnomathematics in learning mathematics can be built through the patterns and motifs of Siak weaving. Creative students can relate Siak weaving patterns and motifs to the concept of Geometric Transformation which consists of Reflection (Reflection), Shift (Translation), Rotation (Rotation), Multiplication (Dilation). Mathematical literacy can appear in the way students compose translation by translation, or translation by reflection. Integrating local culture in mathematics learning can make students aware of the use of mathematics in their local culture. The questions posed refer to the ethnomathematics so that students can develop a love for mathematics and culture. Therefore, in this research, it is very important and interesting to study through a combination of visual thinking and ethnomathematics approaches.

Several studies related to Malay culture and mathematics have been carried out. Hasanuddin's research, (2017) explores ethnomathematics in the Riau Malay community.The research concludes that there are various applications of mathematics to the activities of the Riau Malay community, ranging from literature, clothing, games, and carvings. In particular, research by Nurdin et al., (2018) shows that there is an application of transformation geometry, that is, reflection on Riau Malay weaving motifs. The results of this study show the relationship between Malay culture, including Malay weaving and mathematics. The novelty in this research is the involvement of visual thinking learning approaches with ethnomathematical to improve mathematical literacy skills and students' love of Riau culture which is being abandoned by the younger generation. This research will answer the problem formulation; 1) How are the motifs and patterns of Siak weaving in terms of mathematics; 2) Is there a difference in the achievement of mathematical literacy skills of students who receive learning with an ethnomathematical-based visual thinking approach with students who receive conventional learning; 3) is there an increase in motivation to learn or understand Malay culture with an ethnomathematical-based visual thinking approach?.

2. RESEARCH METHOD

2.1 Research Design

The method used in this study is a mixed method *(mixed methods)*. According to Sugiyono (2013) the combined research method *(mixed methods)* is a research method that combines or combines qualitative methods with quantitative methods, to be used together in a research activity, in order to obtain more comprehensive, valid, reliable and objective data. Creswell (2012) suggests that mixed methods involve combining or unifying research and qualitative and quantitative data in research. This study combines qualitative *(ethnographic)* and quantitative *(quasi-experimental)* research. Data regarding the application of mathematics to Siak weaving obtained in qualitative research will be used in visual thinking learning to see its effect on students' mathematical literacy. The mixed methods research design used is exploratory sequential mixed methods. Creswell (2012) mentions that in the exploratory sequential mixed-methods approach, researchers first start with the qualitative research phase. The data is then analyzed and the information is used in quantitative research. This research begins with qualitative research, namely exploring the ethnomathematics contained in the Siak weaving motif. Research by Nurdin, Muhandez, et al. (2018) concludes that there is an application of transformation geometry to the Siak weaving motif. The application of transformation geometry on the Siak weaving motif is then used as a visual medium for learning with a visual thinking approach. The research was continued by conducting quasi-experimental research that aims to improve students' mathematical literacy through learning an ethnomathematical-based visual thinking approach. The quasi-experimental research design used was a nonequivalent control group design. The design chart in this study is as follows Sugiyono (2012):

O_1	X	O_2
O_3	-	O_4

Figure 1. Illustration of the research experiment

Information:
O1 = Pretest at Experiment Group
O2 = Posttest at Experiment Group
O3 = Pretest at Control Group
O4 = Posttest at Control Group
X = Learning with an ethnomathematical-based visual thinking approach

2.2 Sample and Data Collection

The population of this study was all students at SMP Negeri 1 Siak Sri Indrapura, Siak Regency, Riau Province. Samples were selected purposively according to the needs of the experiment. Based on the recommendations of teachers and school principals, the students of class IX.2 were selected as the experimental group and students of class IX.3 as the control group. Data collection techniques using five ways; 1) interviewed Siak weaving craftsmen to obtain data on Siak weaving motifs. The interview technique used is semi-structured, the researcher uses interview guidelines but can develop according to the conditions or respondents' answers; 2) observing the place of Siak weaving craftsmen, this is done to observe the weaving activities carried out by the craftsmen. Observations were also carried out in the experimental class to see the implementation of learning with an ethnomathematical-based visual thinking approach. Observers in this study are researchers themselves and implementers of learning activities and measure the extent to which students are motivated in learning mathematics with an ethnographic approach. Observations with a scale of 4 instruments are, invisible, quite visible, visible, and very visible; 3) Tests are given to students to see students' mathematical literacy abilities. The test was conducted at the beginning (pretest) and at the end of the lesson (posttest). The test questions consist of 6 (six) descriptive questions according to the mathematical literacy indicators consisting of 6 (six) levels; 4) Focus Group Discussion (FGD), FGD was conducted to discuss the results of observations and interviews with mathematic and cultural learning experts whether the pattern in Siak weaving can be related to the pattern in mathematics.

2.3 Analyzing of Data

Data on Siak weaving motifs were analyzed descriptively to describe the application of mathematics contained in Siak weaving motifs. Data on students' mathematical literacy skills were analyzed using statistical inferential t-test with the help of SPSS.

3. RESEARCH METHOD

3.1 Qualitative Results

Based on the results of data collection from the interview, direct and observations, it has been obtained that as many as 140 typical Riau Malay motifs have been developed to date. From this figure, 58 kinds of them are motifs made to decorate Siak woven fabrics, while others are other craft motifs. The motifs found in Siak woven are divided into groups of flora, fauna, nature, and others, where each motif develops and has various variations. From 58 kinds of motifs Siak of woven fabrics, its obtained a geometric transformation process. Art patterns and motif variations in Siak woven are the development of basic motifs that undergo a geometric transformation process, which can be the result of reflection, rotation, translation, or dilation of one basic motif that occurs repeatedly. Besides that, it is also a combination of different basic motifs that produces

a new motif so that it enriches the variety of existing motifs. The patterns of arrangement of motifs on the woven can be classified into seven types of patterns based on the theory of frieze groups. These patterns can be found in various positions on the Siak woven fabric, on the legs of the cloth, the head of the cloth, the body of the cloth, and the edges of the cloth.

3.2 Quantitative Results

This section describes the experimental results of implementing ethnomathematics-based visual thinking learning. The results explained the effectiveness of the ethnomathematics-based visual thinking learning in the experiment class and the conventional learning method in the experiment class. Normality and homogeneity were required before knowing the significant difference between the experiment class and control class. **Table 1** and **Table 2** shown the normality and homogeneity analysis.

Table 1. Normality of free test and post-test of experiment and control class with One-Sample Kolmogorov-Smirnov test

		Pre_Exp	Pre_Control	Post_Exp	Post_Control
N		31	31	31	31
Normal Parameters[a]	Mean	38.8889	40.0000	55.1389	40.2778
	Std. Deviation	8.35645	7.02179	9.29726	6.91661
Most Extreme Differences	Absolute	.144	.213	.155	.227
	Positive	.144	.213	.155	.227
	Negative	-.122	-.167	-.074	-.183
Kolmogorov-Smirnov Z		.802	1.184	.860	1.263
Asymp. Sig. (2-tailed)		.541	.121	.450	.082
a. Test distribution is Normal.					

Table 1 shown four data from two groups in the normal category because four data obtained significant values of more than 0.005. This results of concluded that parametric statistics could be used for the following analysis. **Table 2** explains the student's quality or ability to master the mathematics subject. These results described whether two classes that became sample homogeny or not.

Table 2. Homogeneity of Variances Two Groups

	Levene Statistic	df1	df2	Sig.
Experiment Class	.126	1	58	.724
Control Class	.015	1	58	.902

Table 2 shown two classes become samples in this result was homogeny because significant values are obtained more than 0.05. Two classes that are declared the homogenous become requirement for conducting the experiment research.

The Pre-Test and The Post-Test of Control Class

Figure 2 explains the descriptive result of pre and post at control classes by using conventional teaching or commonly teaching used by teachers in the classroom.

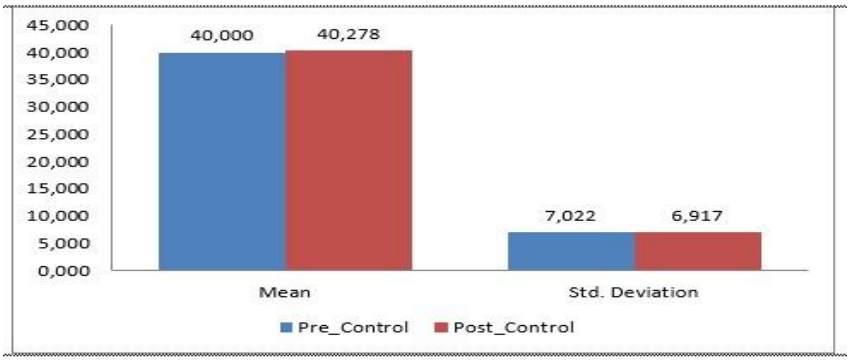

Figure 2. Descriptive statistics of Control Class

Based on **Figure 2**, it was obtained the average score of the pre-test of 40.00 with a standard deviation of 7.022. The average score of the post-test of 40.278, with a standard deviation of 6.917. The comparison of the average score shows that there was a difference between the pre-test and post-test of 0.278, but it can't claim that the different score was significant. Parametrics statictics of t-test can shown whether the comparison of pre-test and post-test was significant

Table 3. The Comparison of Pre-Test and Post-Test at Control Class

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% CI Lower	95% CI Upper			
Pair 1	Pre_Control - Post_Control	-.27778	1.49588	.26867	-.82647	.27092	-1.034	30	.309

Based on parametric t-test statistics, it was acquired the significant values of 0.309 with a mean difference of 0.27778. The significant value was obtained higher than 0.05, so it can be concluded there were no significant differences between the pre-test and the post-test in the control class that used the conventional learning method.

Pre-Test and Post-Test of Experiment Class

Figure 10 explains the descriptive result of pre and post at experiment classes using the visual thinking method. The descriptive result explains whether there was a difference between pre-test and post-test in experiment class (before and after implementing the visual thinking learning method).

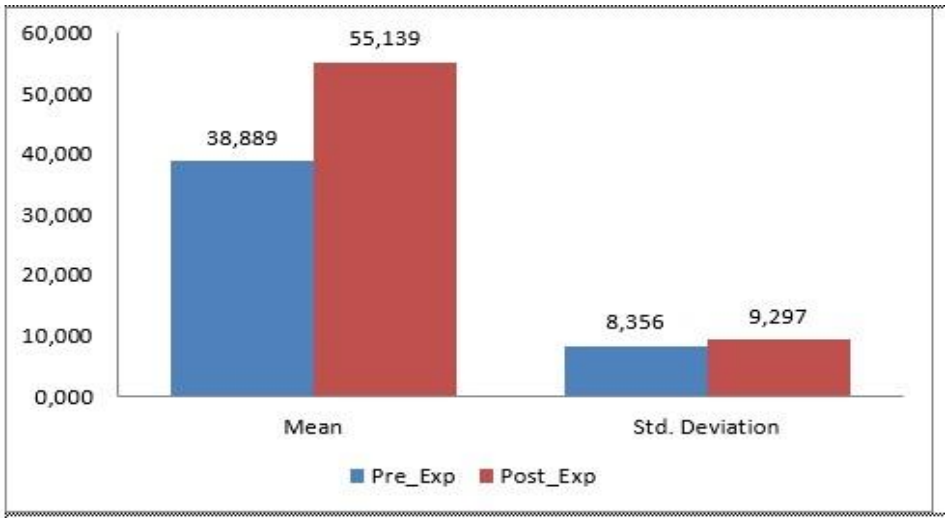

Figure 3. Results of pre and post at experiment classes using the visual thinking method

Figure 3 shown a different average score between pre-test and post-test. The average score of the pre-test was 38.889 with a standard deviation of 8.356, and the average score of post-test with the average score of 55.139 and a standard deviation of 9.297. However, the difference results pre-test and post-test can't claim significantly. Parametrics statistics by t-test proved whether the acquired difference was significant or not. **Table 4** shown the parametric test statistics for proving the differences between pre-test and post-test.

Table 4. Paired Differences of Pre-Test and Post-Test of Experiment Class

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% CI Lower	95% CI Upper			
Pair 1	Pre_Exp - Post_Exp	-1.62500E1	4.60852	.82771	-17.94042	-14.55958	-19.632	30	.0001

Based on parametric t-test statistics in **Table 4**, it was acquired the significant values of 0.0001 with a mean difference of 1.625. The significant value was obtained less than 0.05, so it can be concluded there was the significant differences between the pre-test and the post-test in the control class that using the visual thinking method. Visual thinking can increase the stu-dents' mathematics literacy of junior high schools.

Post-Test of Experiment Class and Control Class

Figure 4 explains the descriptive result of the experiment class using the visual thinking learning method and the control class using the conventional learning method based on the post-test. The descriptive result explains whether there was a difference between the experiment and conventional class at post-test.

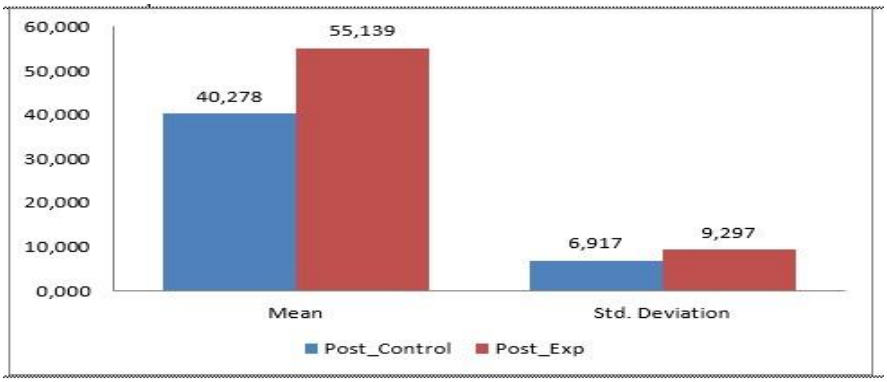

Figure 4. Average of Experiment and Control Class

Based on **Figure 4**, it was obtained the average score of the conventional class of 40.278 with a standard deviation of 6.917. The average score of the experiment class of 55.139, with a standard deviation of 9.279. It can be seen that there is a difference between the experimental class and the control class from the average score. Still, this difference cannot be declared significant before proving it with parametric t-test statistics.

Table 5. The comparison results of t-test between experiment and control class

		Paired Differences							
			Std.	Std. Error	95% CI				Sig. (2-
		Mean	Deviation	Mean	Lower	Upper	t	df	tailed)
Pair 1	Post_Control - Post_Exp	-1.48611E1	9.95844	1.78859	-18.51390	-11.20833	-8.309	30	.000

Based on parametric t-test statistics in **Table 5**, it was obtained the significant values of 0.001 with a mean difference of 1.486. The significant value was obtained at less than 0.05, so it can be concluded there were significant differences between the control class and experiment class. The experiment class was used the visual thinking method can increase the students' mathematics literacy.

Motivation to Learn or Understand the Siak Culture of Riau Province

Motivation to learn or understand Riau Culture was the second objective of this research. Some students don't pay attention to their cultures and only focus on playing online games, so education must facilitate students through experiment research. The experiment research was a part of giving stimulus, so students interested to learn and understanding their culture. The increasing motivation to learn about the culture can be seen in **Figures 5**, **6**, and **7**. **Figure 4** explains that the motivation of students and others increased but the fluctuation happen because the third meeting in the visible category can change at the fifth or sixth meeting. For example, respondent number six in the visible category at the third meeting decreased at the fourth and fifth meeting in quite visible but in the sixth meeting in the very visible category. Fluctuations happen to almost 33% of respondents or students. **Figure 5** shows the increase of students' motivation to learn or understand the Siak of Riau Culture.

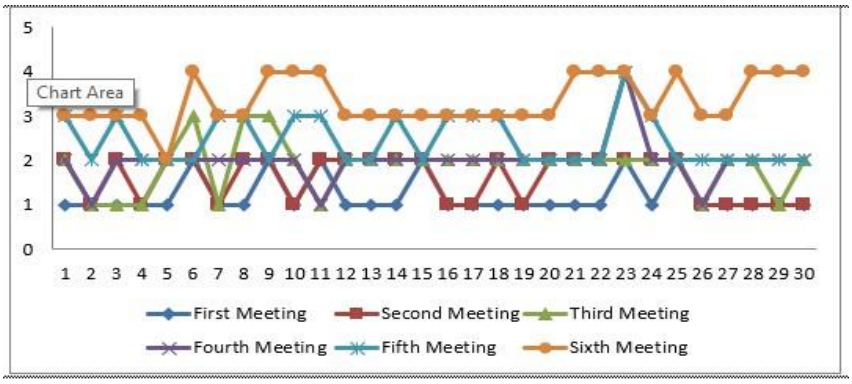

Figure 5. The Increasing of Motivation to Learn the Siak Culutre of Riau Province

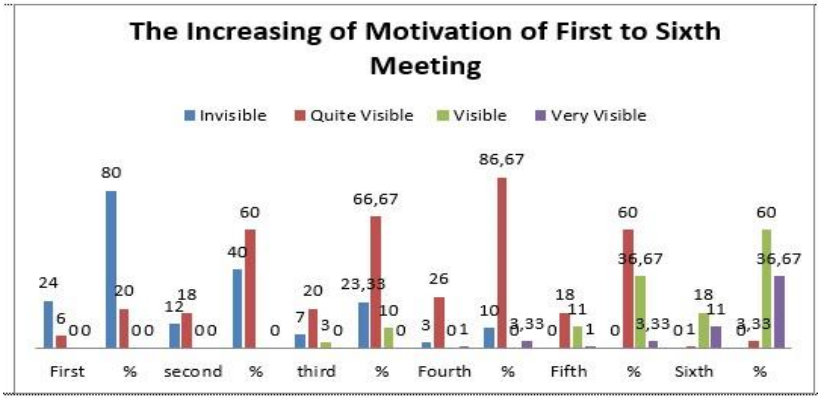

Figure 6. The increase of motivation of First to Sixt Meeting

Figure 6 explains the increase of the students' motivation from the first meeting to the sixth meeting. In the first meeting, there was 20% of students have motivation in the quite visible category and 80% in the invisible category to learn or understand the Siak Culture in the first meeting. In the second meeting, there was 40% of students have motivation in the invisible category and 60% in the quite category. In the third meeting, there was 23% of students have motivation in the invisible category, 66.67% in the quite visible category, and 10% in the visible category. In the fourth meeting, there was 10% motivation in the invisible category, 86.67% in quite a visible category, and 3.33% in the very visible category. In the fifth meeting, there was 3.33% had motivation in the quite visible category, 60% in the visible category, and 36.67% in the very visible category. In the sixth meeting, there were 3.33 who had the motivation to learn the Riau Culture in the quite visible category, 60% in the visible category, and 36.67% in the very visible category.

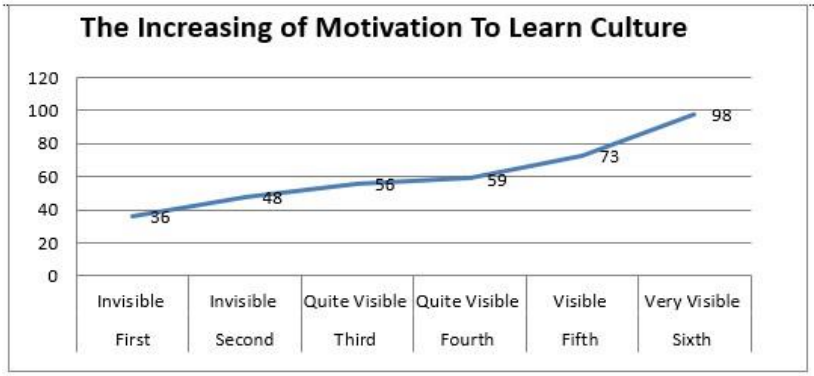

Figure 7. The increasing of motivation of Average Score

Figure 7 concludes that students' motivation was increased from the first to the sixth meeting based on observation with four scales of observation *(invisible, quited, visible, and very visible).* **Figure 7** explains the increasing category from the first to the sixth meeting. Although the increasing still small, the increase occurs from the first to the sixth meeting. The first and second meetings were in the invisible category. The third and fourth meetings were in the quite category. The fifth meeting was in the visible category and the sixth meeting was in the very visible category. The acquired increase in students' motivation shows that ethnomathematics-based visual thinking learning can increase the students' motivation to learn their culture so they can maintain the Siak culture of Riau in the future.

3.3 Discussion

The results show the increase occurs in mathematics literacy after junior high school students learn mathematics through ethnomathematics-based visual thinking learning. The ethnomathematics-based visual thinking learning that is used in the experiment class gives a significant impact on improving students' mathematics literacy. The integration of mathematics learning with certain methods became one of the best ways to preserve the culture of a particular area (Rezeki et al., 2020, 2021). The integration of the learning method with the culture can give the best practice because the teachers can introduce their culture to students that almost leave their cultures (Mak et al., 2020; Prastiwi, 2013; Supeni, 2020). The learning activities that run every day make a good habit for students to understand their subject (Al-husseini & Elbeltagi, 2018; Amir et al., 2021; Greenhow & Lewin, 2016; Saputra, 2013). The integration of mathematics learning and the cultures in a particular area was the best promotion to every student the important thing in maintaining their culture (Albanese & Perales, 2015; Emin, 2013; Valero, 2017). The interested way to introduce the culture and mathematics to students was through the integration of media or learning material (Hodge & Cobb, 2016). Cultural aspects designed in learning mathematics can increase the commitment of teachers and students to jointly maintain or care for culture from the pace of development of the times (Louie, 2017). The learning mathematics that integrate with culture can motivate students to learn dan love their culture but the teaching that far from the students daily life will make students didn't interested with their culture (Pathuddin et al., 2021). The culture and mathematics integration produced the great skill of students because they

got two great skills simultaneously.

4. CONCLUSION

There was a significant difference between the experiment class is used the ethnomathematical-based visual thinking approach with the control class with the conventional learning approach. The ethnomathematical-based visual thinking approach gave a positive impact on the increasing students' mathematics literacy and their love of the Siak Culture of Riau Province.

RECOMMENDATION & LIMITATION

It is hoped that further researchers can explore the new learning method to increase the students' mathematics literacy and motivate students to learn and understand their culture. The development of research can be carried out to increase students' mathematics literacy because literacy in mathematics was one of the important aspects that should be increased by stakeholders in Indonesia. This study was experimental research only used two schools to implement in experiment class and control class so the ability of the research results to generalize was still weak. Measurements are only carried out in junior high schools, so they cannot be generalized to different school levels in Indonesia.

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AUTHOR'S CONTRIBUTIONS

The authors discussed the results and contributed to from the start to final manuscript.

CONFLICT OF INTEREST

There are no conflicts of interest declared by the authors.

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