Jurnal Elemen, 8(2), 373-390, July 2022
https://doi.org/10.29408/jel.v8i2.4790
e- ISSN: 2442 - 4226

Check for updates

Implementation the project-based learning using the context of *Batik* art in elementary mathematics learning

Samsul Pahmi [1] *, Nanang Priatna [2], Jarnawi Afgani Dahlan [2], Arif Muchyidin [3]

[1] Elementary School Teacher Education Study Program, Nusa Putra University, West Java, Indonesia

[2] Department of Mathematics Education, Universitas Pendidikan Indonesia, West Java, Indonesia

[3] Mathematics Education Study Program, IAIN Syekh Nurjati Cirebon, West Java, Indonesia

* Correspondence: samsul.pahmi@nusaputra.ac.id

Abstract

The integration of art into mathematics is currently still carried out by paying attention to the aesthetic value of student projects. However, its use has not been found to expand artistic or cultural values knowledge. This study aims to conduct a study related to the integration of *batik* art in mathematics learning on the topic of circles in elementary schools, where *batik* art contains not only aesthetic meaning but also cultural values and is the identity of the Indonesian nation. This research is focused on content design, the use of methods, and their effect on learning outcomes. The integration of *batik* art in learning is carried out to support the development of STEAM-based learning. This study used a quasi-experimental method using the design of One group posttest only with multiple substantive posttests, which was carried out in 2 different elementary schools in grade 6 with a sample of 41 students consisting of 28 female students and 13 male students. Experimental learning uses circular *batik* motifs as an art aspect and project-based learning (PjBL) as a learning method. Data collection was carried out using three instruments: a final student ability test, interviews, and questionnaires. The results show an increase in student learning outcomes, reducing students' anxiety levels in learning, increasing student activity, and providing alternative solutions for implementing fine arts in learning, especially mathematics, on the topic of circles at elementary school. This research is expected to provide benefits of knowledge related to how art or culture can be instilled simultaneously with lessons, especially mathematics learning for educators.

Keywords: *batik* arts; elementary school; mathematics; project-based learning

Received: 20 December 2021 | Revised: 28 January 2022
Accepted: 16 February 2022 | Published: 1 July 2022

Introduction

Mathematics is an intrinsic component of science, part of its structure, its universal language, and an indispensable source of intellectual tools (Devi, 2016). This condition is, of course, inversely proportional to the ability and interest of students in mathematics. The latest survey results show that fear of mathematics reaches 82% for the level of students in grades 7 to 10 (Annual Status of Education Report [ASER], 2018). Mathematics is generally considered difficult (Fritz et al., 2019). In addition, many believe "that's okay - not everyone can be good at math" (Rattan et al., 2012). The main problems encountered in learning mathematics are students' interest in mathematics is still low (Azmidar, 2017) and anxiety about mathematics itself (Trujillo & Hadfield, 1999). It is the main focus on making the classroom atmosphere relaxed so that it can help relieve tension in learning and improve students' mathematics learning outcomes (Gregor, 2005). An art-based interdisciplinary learning approach is certainly an alternative to relieving tension/fear or reducing student stress while studying (Winner & Cooper, 2000).

The integration of art into learning has been carried out even since Plato's academy (Gutek, 2004). Since the late nineteenth century, modern educational philosophers and researchers such as Francis Parker and John Dewey have sought to provide schools with theoretical and curricular support for this comprehensive, integrative teaching approach (An & Tillman, 2014). For example, Dewey undertook a series of exploratory research studies that examined the impact on student development resulting from integrating curricular subjects into interdisciplinary pedagogical approaches (Dewey, 1938). It can be used as the basis for developing more meaningful interdisciplinary learning (Fitzgerald et al., 2021).

The integration of art in children's mathematics learning is certainly very rational considering that children are naturally curious and involved in object-based games and have sensitivity in responding to music or colors (Axel et al., 2003). As children grow up, the images or forms produced from their toys reflect artistic sensitivity and creativity, inherent aspects of their growth process (Almutlaq, 2018). It is needed because in the process of drawing shapes in mathematics, and it would be better to involve art because it can encourage their creative expression and control the class so that students stay busy in the learning process (Gude, 2009).

Using art connected to the immediate environment brings up diverse perspectives, enriching the learning process by enabling students to observe, explore, think and learn (Henriksen et al., 2019). However, the next problem is how and what the process of integrating art into learning, especially mathematics, is asked by many teachers. Even in the use of science, technology, engineering, art, and mathematics (STEAM) approaches in learning, many teachers still do not include art in the learning process (Quigley & Herro, 2016).

In the results of his research, Gerdes found that art and mathematics have a close relationship; this can be seen from the similarity in form between the art of artistic decoration of handbags, hats, mats, and other basket products from several regions in Mozambique with geometric shapes (Gerdes, 2011). On the other hand, in terms of learning, Hickman and Huckstep found that art can be integrated through examples of historical artifacts and implemented on the artistic value of mathematical forms or models (Hickman & Huckstep, 2003). Furthermore, Pumfrey et al. apply art to geometry, focusing more on design aesthetics from tile drawings using design programming (Pumfrey et al., 2002). Visual art in learning is closely related to 3D and 2D geometry (Ivins, 2013). In almost the same framework, Dietiker argues that students' mathematics learning content can be artistically created to inspire or attract students' attention (Dietiker, 2015).

Based on the literature review that has been carried out, it was found that the implementation of art in mathematics learning is carried out on aesthetic aspects, which include mathematical forms or models. Art is limited as a supporter, only focuses on mathematics, and has not integrated learning that encourages increased learning outcomes of mathematics and art. Therefore, this research offers the integration of art and mathematics in learning, aiming to improve the learning outcomes of mathematics and art together. In this study, the mathematical topic that will be taken is a circle, which is the most challenging geometry topic for elementary school students and has a geometric relationship with the art of *batik*, one of Indonesian culture.

Methods

The focus of the study is on how the implementation and results of art-based mathematics learning on the topic of circles in elementary schools. It is intended as a more holistic pilot project in developing content and learning procedures in the classroom to determine how students respond to the learning process and review the results obtained by students during the learning process. Several substances are needed that will be measured after treatment, including learning outcomes of circle topic mathematics, results of understanding *batik* art, student responses related to the use of PjBL methods, and learning content. Thus, this study uses a quasi-experimental method using a one-group posttest-only design with multiple substantive posttests (Shadish et al., 2015). This experimental teaching methodology is taken based on the opinion of Steffe and Lipsey, who think that the use of experimental methods allows researchers as teachers to observe more broadly and have high control in observing the process that occurs from content design and teaching plans (Steffe, 1991; Lipsey, 1990). The implementation design in this study follows the following design (Shadish et al., 2015):

$$X_1 \ \{O_{1A}, O_{1B}, O_{1C}, O_{1D}\}$$

Figure 1. Posttest only design with multiple substantive posttests

The research design stages in Figure 1 were carried out without involving the control and pretest classes. All measurements were carried out after implementing art-based mathematics learning using the PjBL (X_1) method by conducting multiple substantive posttests consisting of: learning outcomes of circle topic mathematics (O_{1A}), results of understanding *batik* art (O_{1B}), student responses related to the use of PjBL methods (O_{1C}) and learning content (O_{1D}). The class experiment was carried out using the project-based learning method by following the following steps (Widiasworo, 2017): (1) Determining the basic questions; (2) Designing project plans; (3) Develop a schedule; (4) Monitor students and project progress; (5) Testing the results; and (6) Evaluating experience.

Determination of basic questions

Learning begins with essential questions, namely questions that can give assignments to students in carrying out any activity related to the real world. This stage is carried out by giving students pictures of *batik* with motifs resembling a circle to identify their relevance to the topic to be studied (Figure 8).

Design the project plan

Planning is done collaboratively between teachers and students. After the process of planting related concepts on the topic of circles with the help of GeoGebra (Figure 7), the teacher gives back pictures of circle *batik* motif(Figure 8) to be selected by each group as a *batik* drawing project task, measuring the circumference and area of each design, respectively.

Schedule

Teachers and students collaboratively arrange activity schedules for completing projects. The project activities were delivered at the first meeting and presented and discussed at the second meeting, where the second meeting was one week away from the 1st meeting.

Monitor students and project progress

The teacher is responsible for monitoring the activities of students while completing the project. At the initial activity of the second meeting, each group continued to complete the project by being monitored and given guidance by the teacher before the presentation of the results was carried out.

Test results

Assessment is done to assist teachers in measuring the achievement of the material. In this case, the teacher team assessed the results of students' mathematical abilities on the topic circle (Figures 2 and 4) using a test instrument validated by an expert (a professor of mathematics education).

Evaluating experience

At the end of the lesson, the teacher and students reflect on the activities and project results carried out. In this process, the teacher reminded again about the discovery of the formula for the circumference of a circle and the discovery of the concept of area using a rectangular approach. At this stage, the teacher also reinforces the value of *batik* art, which is the culture and identity of the Indonesian nation.

Data collection

The data used in this study are primary data and secondary data from the condition of the research subjects before and after the study (Hox & Boeije, 2005). The primary data analyzed were: (1) Observing the level of student activity during the learning process; (2) test result data related to the topic of circles conducted after the experimental learning was carried out; (3)

questionnaire data related to student responses to the application of art in mathematics learning using the PjBL method and related to content and media for delivering material and while secondary data used was a collection of students' daily math scores for the last six weeks.

Observations of the level of student activity were carried out through video recordings during the learning process for two meetings by paying attention to aspects of student involvement in discussions and project completion. The test instrument consists of 12 questions with difficulty categories, namely four easy questions, five medium questions, and three difficult questions. To ensure that the test instrument is suitable for use, the researcher conducted a content validity test conducted by one teaching teacher at the school where the experiment was carried out and one expert by a mathematics education lecturer. The test's validity results are 4.7 (very good) by the teacher and 3.9 (good) by the expert.

The questionnaire instrument used during the pre-experiment trial covered aspects of implementing the PjBL method and art-based learning content design, each of which was represented by eight statements for learning methods and seven statements for learning content. From the questionnaire validity test results, there is 1 item of invalid statements, so the total statements used are 14 with a questionnaire reliability value of 0.761. In more detail, the results of the questionnaire validity test are presented in table 1, and the reliability of the questionnaire in tables 1 and 2 below.

Table 1. Questionnaire validity test results

Instrument Number	**Type of Validity Test**	**Validity Value**	**Description**
Item1	Pearson	.616**	Valid
Item2	Pearson	.324	Invalid
Item3	Pearson	.498**	Valid
Item4	Pearson	.246	Invalid
Item5	Pearson	.389*	Valid
Item6	Pearson	.723**	Valid
Item7	Pearson	.459*	Valid
Item8	Pearson	.671**	Valid
Item9	Pearson	.504**	Valid
Item10	Pearson	.465**	Valid
Item11	Pearson	.468**	Valid
Item12	Pearson	.434*	Valid
Item13	Pearson	.384*	Valid
Item14	Pearson	.487**	Valid
Item15	Pearson	.482**	Valid
Total Respondents	**N**	**30**	

Table 2. Questionnaire reliability test results

Reliability Statistics	
Cronbach's Alpha	No. of Items
.761	15

Results

Research subject description

Data were collected to find out the initial conditions of each experimental class, which included students' views on mathematics, daily math scores for the last six weeks, and data on students' ages. The results of observations and data collection obtained the following results (Table 3).

Table 3. Data on the initial condition of the research subject

Secondary Data	Value
Students who don't like math (%)	71.43
the average daily math scores of the experimental class 1	75.17
the average daily math scores of the experimental class 2	75.03
Average age of experimental class students (years)	11.57

From the results of initial data collection (Table 3), as many as 71.43% of students stated that the most challenging subject was mathematics. It is certainly not a new problem in mathematics because, in several studies, it was found that mathematics anxiety experienced by students was also experienced by students, teachers even parents. The condition of students' mathematical abilities in the experimental class based on the daily average value of the two classes was relatively the same, namely 75.17 and 75.03, respectively. Meanwhile, based on the cognitive development aspects of students from the two samples, the age distribution is in the range of 10-12 years or with an average of 11.57 years. It means that the cognitive stage of students has reached the transition stage from concrete operations to formal operations (Piaget, 1976). so that experimental research uses four main stages: situational, referential, general, and formal, to facilitate the thinking process from concrete to abstract (abstraction) (Gravemeijer, 1994).

Project evaluation results

The learning process at meetings 1 and 2 was carried out in small groups consisting of 3 students. It facilitates the learning control process (Webb et al., 1995). At the first meeting, student activities were generally divided into two parts, namely: the first part, an introduction to shapes and elements of circles; the second, finding the concept of the value of phi, the formula for the circumference of a circle and the concept of the formula for the area of a circle.

For the stage of finding the value of phi and the concept of the formula for the circumference of a circle, the student's project task is to measure the circumference, diameter, and the ratio of the circumference to the diameter of each circular object in the class, then the students compare the measurement results with other groups. In table 4, the project results found the value of phi, and it can be seen that the accuracy of students' calculations only reached unit numbers where all groups were correct for unit numbers. As for tithes and hundredths, neither group was successful. The data from the project finding the phi value for each group is presented in table 4 below.

Table 4. Project result data find the value of Phi

Experiment Class 1	Finding the Ratio of Perimeter and Diameter (phi)	Length of Circumference	Length of Diameter
Group A	3.06	5.50	1.80
Group B	3.33	6.00	1.80
Group C	3.08	4.00	1.30
Group D	3.10	6.50	2.10
Group E	3.00	3.00	1.00
Experiment Class 2	**Finding the Ratio of Perimeter and Diameter (phi)**	**Length of Circumference**	**Length of Diameter**
Group A	3.28	8.20	2.50
Group B	3.13	5.00	1.60
Group C	3.31	4.30	1.30
Group D	3.33	5.00	1.50
Group E	3.10	6.50	2.10

Based on the final evaluation, it was found that students could identify the elements of a circle. In addition, they could use the procedure for determining the circumference and area of a circle but still found some errors in measuring the length of the diameter or radius so that the final result calculations become inappropriate (Figure 2).

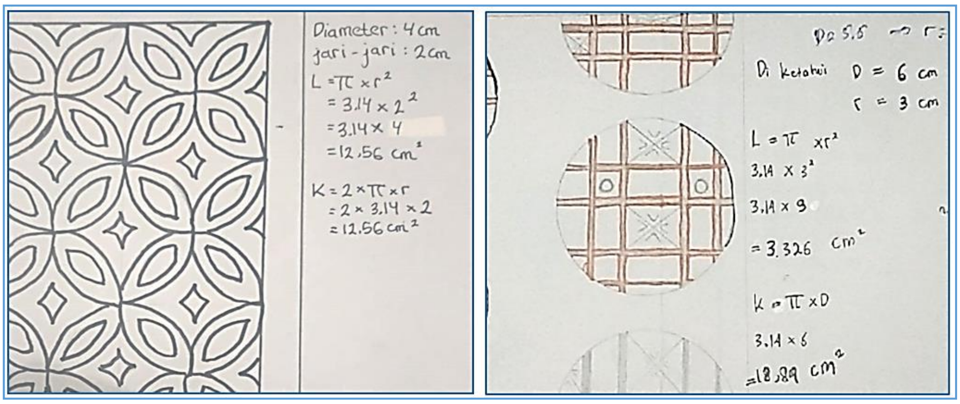

Figure 2. Sample of student calculation results

In addition, the students showed their activeness during discussions (Figures 3), especially in completing the project of finding the concept of phi value and determining the area of the *batik* design made by each group (11 and 12).

(a)

(b)

Figure 3. Student discussion activities

Circle topic math ability test results

The evaluation of learning outcomes on the topic of circles was carried out using a previously validated test instrument consisting of 12 questions on understanding and problem solving and covering material on the elements of a circle, the circumference of a circle, and the area of a circle. Based on Figure 4, it can be explained that 82.93% of students have exceeded the daily average value of mathematics for the last six weeks. In addition, 17.07% of students get scores that range from the daily average score, and 4.88% of students have to undergo remedial because they have not met the minimum score set by the school.

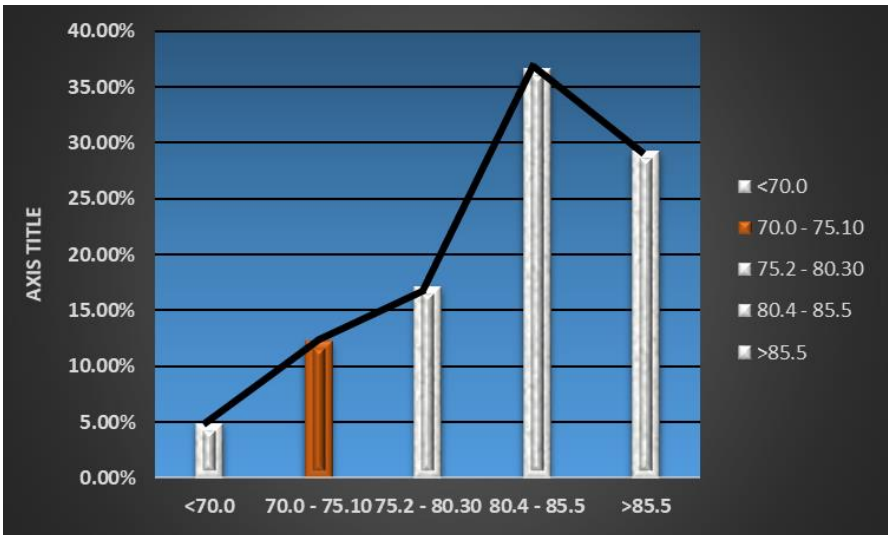

Figure 4. Data on the distribution of learning evaluation score

Assessment results and questionnaire

In a further evaluation related to the learning process and outcomes (Figure 5), the aspects of students' art skills and knowledge based on the assessment conducted by the visual arts teacher showed an average score of 78.19. From the use of learning methods and content, data was collected through a satisfaction questionnaire where the questionnaire results (Figure 5) showed that the level of student satisfaction with the PjBL method was 85.75%, and the aspect of using art content in learning is 83.25%. Although the artistic achievement is lower than the average mathematics result of 84.13, the art result is considered very good, considering that the art aspect is only used to support students' mathematics learning outcomes.

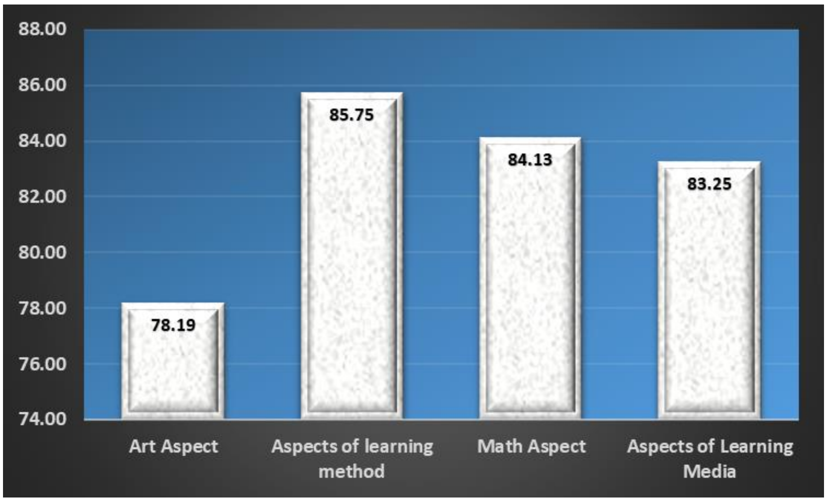

Figure 6. Data on the distribution of learning evaluation results

Discussion

General condition of research sample

The learning support facilities for the two experimental classes were adequate. Each class has a projector, geometry toolkit, and student learning reference books stored in the student's classroom cupboards and wall boards (Figures 6). In the aspect of human resources, especially teachers, interviews with teacher representatives in each school indicate that the average teacher already has a class lesson planning document (RPP). However, in using learning technology, it is still constrained. One of the teachers, when confirmed regarding the readiness of teachers to use technology in learning, hopes that in the future, more intensive training can be carried out. The research sample's broader use of technology in classroom learning is still limited. The same problem related to the use of technology was also found in the research conducted by Al-Fudail et al. (2008) found that teachers have a certain level of stress when required to use technology in learning. Furthermore, Fishman and Davis (2006) also found that many teachers are reluctant to use technology for teaching and learning.

(a) (b)

Figure 6. Facilities for textbooks and geometry tools in the classroom

Meanwhile, the condition of the mathematical ability of the two experimental classes before learning based on data collection of daily math scores in the last six weeks was relatively homogeneous, with an average score of 75.17 and 75.03 for each class. The homogeneity condition of the mathematical ability of each class is one of the supporting considerations for determining the sample in the study (Table 3). The initial condition of students in the experimental class had a fear of mathematics, reaching 71.43%. It was obtained from questions given to all students as an initial study related to the subjects they thought were the most difficult or least liked. Although this seems not good, this condition was also stated by Li and Schoenfeld in their research, finding that mathematics is often considered difficult and many students leave the disciplines of science, technology, engineering, and mathematics (Li & Schoenfeld, 2019).

Implementation of *Batik* art in learning

Description of teaching materials

Three teachers outside the researcher were involved in this study, one of whom had more than five years of teaching experience. To ensure the implementation of learning is in accordance with the research focus, instruments and lesson plans have been validated by experts in mathematics education (Lecturers of the Mathematics Education Doctoral Study Program). The three teachers involved were given training by researchers on the use of instruments and stages of integrating art in learning mathematics. The learning tools used consist of PPT materials, learning videos, project designs, project tools and materials, and animations using the GeoGebra application (Figure 7).

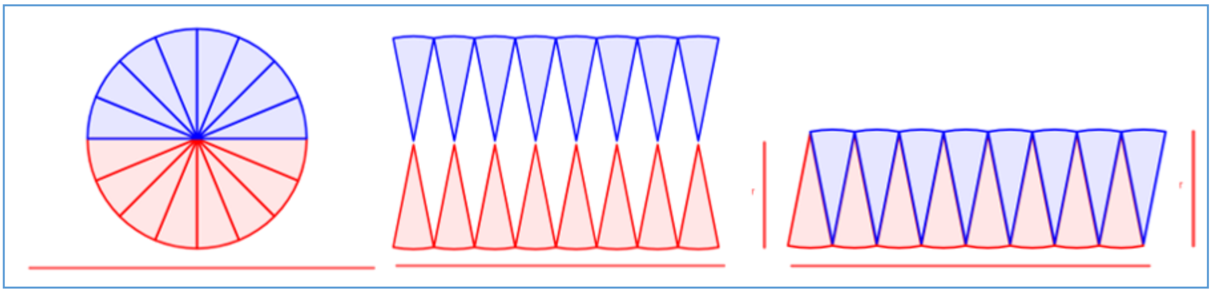

Figure 7. GeoGebra design proving the area of a circle

To deepen students' knowledge about the art of *batik*, PPT designs related to examples of circle shapes and the introduction of circle elements using *batik*-patterned pictures (Figures 8 and 9). The integration of art in this experiment is an effort to help students enjoy the learning process to reduce tension in learning mathematics. It follows Eisner's (1998) opinion that art is an aesthetic reference and makes learning mathematics more interesting. In particular, the batik art sample used as teaching material is a *batik* motif that resembles a circle (Figure 8), so it is hoped that implementing mathematical concepts in fine arts will be easier. For the circle element introduction stage, the teacher also uses images of *batik* motifs as learning media for the introduction of arcs, center points, radius (Figure 9(a)), bowstring, apothem, diameter (Figure 9(b)), cross-sectional area and area cross-section (Figure 9(c)).

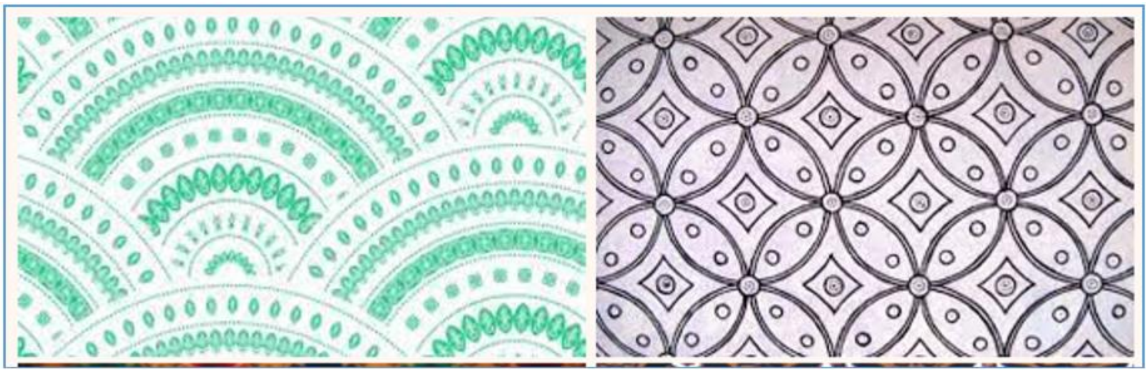

Figure 8. Introduction of circles using the *batik* art

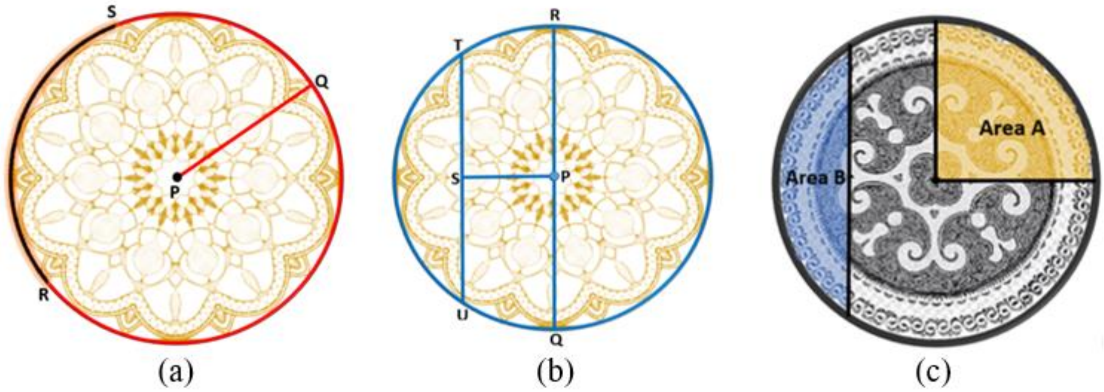

Figure 9. Circle elements learning content

Description of learning process

In general, during the learning process, the PjBL method syntax was followed at the first and second meetings. From the two meetings, there were three lessons each (JP) where 1 JP was 35 minutes each, so each meeting was 105 minutes, with a total of 210 minutes for two meetings or 3.5 hours for each class. The first meeting focused on mastering the concept of circumference and area of a circle with the help of project activities. Meanwhile, at the second meeting, it was focused on implementing the ability of the circle concept to design *batik* and determining the elements, circumference, and area of circular *batik* that had been designed in project activities.

At the first meeting, student activities were generally divided into two parts, namely: the first part, an introduction to shapes and elements of circles; the second, finding the concept of the value of phi, the formula for the circumference of a circle and the concept of the formula for the area of a circle. In the first stage, the teacher shows pictures of real objects and *batik* motifs in the form of circles. It provides an overview of the context of the circle material and an introduction to the aspects of *batik* art that will be studied (Figures 8 and 9). Based on observations, when students were asked to draw conclusions about the image's shape, three different answers were obtained, namely "round" and "circle". It is in line with Hershkowitz's (1996) opinion that when the learning process begins with an orientation in real space, students can easily recognize the basic meaning of form. Furthermore, Almutlaq (2018) reveals that children are quite interested in shapes or colors during development.

The evaluation project at the first meeting learning is a project to find the concept of the value of phi. The project evaluation results (Table 4) show that all groups of students managed to find the unit number but have not been able to accurately find the number to one-hundredth of the value of phi. From the results of the researcher's examination, it was found that the calculation of the ratio of the circumference to the diameter of each group project was correct. However, an error occurred when measuring the length. This kind of error is often found, especially in elementary school mathematics; in Masnick and Klahr's (2003) research, it was found that as many as 47% of students experienced measurement errors. In line with the study results, Mohyuddin and Khalil (2016) found that measurement errors could be caused because most students had minimal experience measuring length. To anticipate the measurement error, Masnick and Klahr (2003) further recommend that teachers can teach students to think about measurement. The activities at the second meeting had a higher artistic content than the first meeting. At this meeting, *batik*'s history and philosophical values, especially the circle motif, were presented. In the learning process, students are asked to draw a simple *batik* with a circle motif (Figures 10), which then determines the mathematical elements that can be described or measured using their knowledge (Figure 2).

In the project completion process, students are seen actively discussing (Figures 3) and are able to develop their creative ideas in completing their respective tasks (Figures 10). Due to the application of PjBL, students are accustomed to thinking creatively and conducting discussions in the completion process. Increasing student activity using the PjBL method has also been proven by several studies to increase student activity (Holubova, 2008; Hadim & Esche, 2002; Cintang et al., 2017; Krajcik & Blumenfeld, 2006). The effectiveness of the use of PjBL can also be seen from the results of the project that students as a whole can be completed well in the allotted time (Figures 10).

(a) (b)

Figure 10. Student project results

In Figures 2 and 10, it can be seen that students can draw their *batik* motifs and implement the circle formula to calculate the circumference and area of a circle on their respective *batik* motifs. However, from the evaluation of the project results, students were able to use procedures to determine the circumference and area of a circle. Still, they found some errors in measuring the length of the diameter or radius (Figure 2). Based on the results of problem identification and further inspection, it was caused by several things, such as measurement error; the accuracy of the measuring instruments used by students has an accuracy of only up to a tenth, and the process of rounding the measurement results of some students only to the unit number. Errors in the measurement process are expected in the future teachers must improve students' thinking ability to measure (Masnick & Klahr, 2003) because the measurement is the main requirement in higher geometry learning (Hwang et al., 2015).

Students' concerns when learning mathematics and their impression of learning mathematics based on student opinion data collected before the experiment (Table 3) were not seen at all at the second meeting. It can be seen from students' interest in being involved when asked to solve a given circle problem (Figures 11 and 12). Increased student interest during the experimental class based on observations and limited interviews with students is the use of project-based learning methods with real objects can increase student involvement during the learning process (Holubova, 2008; Hadim & Esche, 2002; Cintang et al., 2017; Krajcik & Blumenfeld, 2006), students also argue that with the implementation of art in mathematics learning "the learning atmosphere is like not learning mathematics". This condition follows previous studies such as Nalopi's (2005) findings revealing that the implementation of art in learning can increase concentration, reduce behavioral problems, and improve academic performance. In line with these findings, Klatt et al. (2013) also found that involving the arts in learning can reduce student stress.

Figure 11. Presentation of project results

Figure 12. Students when asked to answer questions during learning

In the aspect of implementing art in mathematics, student interest seems to have increased from the first meeting, wherein the activity of completing the project of drawing *batik* with a circle motif and solving mathematical problems in the *batik* (such as elements of a circle, radius, diameter, circumference, and area), besides students completing group assignments, some students also succeeded in making their *batik* designs outside of group work. So the number of products from the project that should have been made for the two experimental classes became 24 *batik* design products (Figures 10).

Description of learning outcomes

Based on the daily average score of the experimental class in the last six weeks, it was not good at 75.10, but in Figure 4, the graph of mathematics learning outcomes on the circle material shows a slope to the right. It shows that the average student learning achievement in mathematics is quite good, namely 84.13 and an increase of 12.03% compared to the average daily value of the previous students. From the results of limited observations and interviews, students admitted that learning mathematics with the *batik* approach was "easier to understand" because they no longer felt afraid or anxious during the learning process. It follows the opinion of previous researchers (Napoli et al., 2005; Klatt et al., 2013).

In Figure 4, about 4.88% of students have not reached the minimum score. This condition is based on student attendance data; one of the students did not participate in the learning at the first meeting, so it was not easy to follow the learning at the second meeting. As for the other students who did not pass, even though they followed the whole lesson, during the process, it was pretty difficult to understand basic mathematical concepts such as multiplication and division. According to Miller & Mercer (1997), this low understanding of fundamental mathematics can increase student anxiety in learning. It is a recommendation to future teachers and researchers to provide special treatment for students with difficulty, especially regarding basic materials such as addition, subtraction, multiplication, and division.

Description of learning methods and content

The integration of art in mathematics learning based on questionnaire data (Figure 5), students feel that learning mathematics becomes more interesting (87.8%), not boring (87.8%), and eliminates the fear of learning mathematics (85.3%). It is also in line with the results of several studies. research that has been done (Napoli et al., 2005; Klatt et al., 2013; DeMoss & Morris, 2002; Winner & Cooper, 2000). Using the learning method, the highest response indicator is students' activeness in the discussion 92.6% and enthusiasm in completing project assignments 90.2%. This finding follows the results of Ferreira and Canedo's (2020) research, which found that the use of the project method can increase student activity. Although the student response to using this method is quite good, researchers and teachers need to consider the availability of project support tools and materials because, from indicators related to the availability of tools and materials, student responses are only 70.3%.

Using learning content, indicators that have a fairly high response are the suitability of the content with daily life by 87.8% and ease of understanding by 85.4%. It is because the learning content used in the abstraction process is examples of circle-patterned *batik* designs that students often encounter, and project designs that involve surrounding objects allow students to interact directly with the learning object. The use of real object-based learning, according to Widada et al. (2018), in their research can improve students' understanding of mathematical concepts; the enthusiasm and activeness of students also confirm this during the learning process (Figures 11 and 12).

Conclusion

The study has succeeded in integrating art into the mathematics learning of circle topics. The results of this study indicate increasing student learning outcomes based on the comparison between daily scores and the results of evaluating circle abilities during implementation, reducing students' anxiety levels in learning, increasing student activity, and being able to provide alternative solutions on how to implement art in learning, especially mathematics. This research also succeeded in providing knowledge and skills related to *batik* art so that the use of art not only supports mathematics learning but also instills understanding and skills at the same time. The use of the PjBL method in experimental learning has increased activeness in discussions during learning and the enthusiasm of students in doing assignments. Apart from being an example of how to integrate art into learning, the results of this study are also expected to provide an example of how art or culture can be instilled simultaneously with lessons in other fields of study.

The limitation of this study is that it has not been able to design evaluation instruments in detail related to art aspects, which are carried out directly by art teachers. In addition, the art used is only limited to *batik* art with circle material, so the results of this study cannot be generalized to a broader topic. Suggestions for further research are expected to involve experts in the field of art to develop assessment instruments so that the possibility of errors in interpreting the value of art can be reduced. It is hoped to be developed on mathematical topics or broader aspects of art.

Acknowledgment

We would like to express our gratitude to all parties who have helped both in the process of implementing and funding this research. As for the parties, including Nusa Putra University as the party that funds research needs; Dr. Kohar Pradesa, M.Pd and Dr. Barkah, M.Pd as a validator of teaching instruments and questionnaire instruments; Andini Hukma Salmin, Gias Nuraliah, and Fariz Alparuq as members of the teaching team.

Conflicts of Interest

Stating that there is no conflict of interest regarding the publication of this manuscript. In addition, ethical issues, including plagiarism, infringement, falsification and/or falsification of data, publication and/or double submission, and redundancy have been fully borne by the authors.

References

Almutlaq, Z. (2018). *Understanding creativity: The nature of children's creativity and the development of creativity*. The University of Toledo. https://www.proquest.com/openview/c9df86de32af5afabba6c85b86c3b7f3/1?pq-origsite=gscholar&cbl=18750&diss=y

Al-Fudail, M. & Mellar, H. (2008). Investigating teacher stress when using technology. *Computers & Education*, *51*(3), 1103-1110. https://doi.org/10.1016/j.compedu.2007.11.004

An, S. & Tillman, D. (2014). Elementary teachers’ design of arts based teaching: Investigating the possibility of developing mathematics-music integrated curriculum. *Journal of*

Curriculum Theorizing, *30*(1), 20–38. https://journal.jctonline.org/index.php/jct/article/view/511

Center, A. S. E. R. (2018). *Annual status of education report*. ASER Center. https://img.asercentre.org/docs/ASER%202018/Release%20Material/aserreport2018.pdf

Axel, E. S. & Levent, N. S. (Eds.). (2003). *Art beyond sight: A resource guide to art, creativity, and visual impairment.* American Foundation for the Blind. https://books.google.co.id/books?id=B4ioCFic7m0C&pg=PA12&lpg=PA11&ots=YniB5kEFzN&focus=viewport&dq=Axel#v=onepage&q=Axel&f=false

Azmidar, A., Darhim, & Dahlan, J. A. (2017, September). Enhancing students' interest through mathematics learning. *Journal of Physics: Conference Series, 895*(1), 012072. https://doi.org/10.1088/1742-6596/895/1/012072

Cintang, N., Setyowati, D. L., & Handayani, S. S. D. (2017). Perception of primary school teachers towards the implementation of project based learning. *Journal of Primary Education*, *6*(2), 81-93. https://journal.unnes.ac.id/sju/index.php/jpe/article/view/17552

Cook, T. D., Campbell, D. T., & Shadish, W. (2002). *Experimental and quasi-experimental designs for generalized causal inference*. Houghton Mifflin. https://www.alnap.org/system/files/content/resource/files/main/147.pdf

Cox, D. C. & Lo, J. J. (2019). Measurement and decomposition: Making sense of the area of a circle. *Proceeding of the 41st Annual Meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education*, University of Missouri. https://eric.ed.gov/?id=ED606937

DeMoss, K. & Morris, T. (2002). *How arts integration supports student learning: Students shed light on the connections*. Chicago Arts Partnerships in Education (CAPE). http://capechicago.org/wp-content/uploads/2016/11/How-Arts-Integration-Supports-Student-Learning-Full-Report-CAPE.pdf

Dewey, J. (1986). Experience and education. in the educational forum. *Informa UK Limited, 50*(3), 241–252. https://doi.org/10.1080/00131728609335764

Dietiker, L. (2015). What mathematics education can learn from art: The assumptions, values, and vision of mathematics education. *Journal of Education, 195*(1), 1-10. https://doi.org/10.1177/002205741519500102

Eisner, E. W. (1998). Does experience in the arts boost academic achievement? *Arts Education Policy Review, 100*(1), 32-40. https://doi.org/10.1080/10632919809599448

Ferreira, V. G., & Canedo, E. D. (2020). Design sprint in classroom: Exploring new active learning tools for project-based learning approach. *Journal of Ambient Intelligence and Humanized Computing*, *11*(3), 1191-1212. https://doi.org/10.1007/s12652-019-01285-3

Fishman, B. J., & Davis, E. A. (2006). *Teacher learning research and the learning sciences*. Cambridge University Press. https://doi.org/10.1017/CBO9780511816833.033

Fitzgerald, S. L., Popa, C., Fitzgerald, C., & Vesa, A. (2021). Interdisciplinary learning for pre-service teachers. *Revista Romaneasca pentru Educatie Multidimensionala*, *13*(1Sup1), 101-122. https://doi.org/10.18662/rrem/13.1sup1/387

Fritz, A., Haase, V. G., & Rasanen, P. (2019). *International handbook of mathematical learning difficulties*. Springer. https://doi.org/10.1007/978-3-319-97148-3

Gerdes, P. (2011, July). African basketry: Interweaving art and mathematics in Mozambique. *Proceedings of Bridges 2011: Mathematics, Music, Art, Architecture, Culture* (pp. 9-16). https://archive.bridgesmathart.org/2011/bridges2011-9.html

Gravemeijer, K. (1994). *Developing realistic mathematics education*. CD [beta] Press. https://research.tue.nl/nl/publications/developing-realistic-mathematics-education

Gregor, A. (2005). Examination anxiety: Live with it, control it or make it work for you?. *School Psychology International*, *26*(5), 617-635. https://doi.org/10.1177/0143034305060802

Gude, O. (2009). The 2009 lowenfeld lecture: Art education for democratic life. *Art Education*, *62*(6), 6-11. https://doi.org/10.1080/00043125.2009.11519039

Gutek, G. L. (2004). *The Montessori method: The origins of an educational innovation: including an abridged and annotated edition of Maria Montessori's The Montessori method*. Rowman & Littlefield Publishers. https://books.google.co.id/books?hl=id&lr=&id=ixh0_T43eXgC&oi=fnd&pg=PP11&dq=Gutek,+G.+L.+(2004)

Hadim, H. A. & Esche, S. K. (2002). Enhancing the engineering curriculum through project-based learning. *The 32nd Annual Frontiers in Education*, IEEE. https://doi.org/10.1109/FIE.2002.1158200

Henriksen, D., Mehta, R., & Mehta, S. (2019). Design thinking gives STEAM to teaching: A framework that breaks disciplinary boundaries. In *STEAM education* (pp. 57-78). Springer, Cham. https://doi.org/10.1007/978-3-030-04003-1_4

Hershkowitz, R., Parzysz, B., & Dormolen, J. (1996). Space and shape. *In international handbook of mathematics education* (pp. 205–237). Springer Netherlands. https://doi.org/10.1007/978-94-009-1465-0_7

Hickman, R., & Huckstep, P. (2003). Art and mathematics in education. *Journal of Aesthetic Education*, *37*(1), 1-12. https://doi.org/10.2307/3527417

Holubova, R. (2008). Effective teaching methods project-based learning in physics. *Online Submission*, *5*(12), 27-36. https://eric.ed.gov/?id=ED504949

Hox, J. J. & Boeije, H. R. (2005). Data collection, primary vs. secondary. *Encyclopedia of social measurement*, *1*(1), 593-599. https://doi.org/10.1016/b0-12-369398-5/00041-4

Hwang, W. Y., Lin, L. K., Ochirbat, A., Shih, T. K., & Kumara, W. G. C. W. (2015). Ubiquitous geometry: Measuring authentic surroundings to support geometry learning of the sixth-grade students. *Journal of Educational Computing Research*, *52*(1), 26-49. https://doi.org/10.1177/0735633114568852

Ivins Jr., W. (2013). *Art & Geometry*: A Study in Space Intuitions. Harvard University Press. https://doi.org/10.4159/harvard.9780674184565

Jungnickel, P. W., Kelley, K. W., Hammer, D. P., Haines, S. T., & Marlowe, K. F. (2009). Addressing competencies for the future in the professional curriculum. *American Journal of Pharmaceutical Education*, *73*(8). https://doi.org/10.5688/aj7308156

Klatt, M., Harpster, K., Browne, E., White, S., & Case-Smith, J. (2013). Feasibility and preliminary outcomes for Move-Into-Learning: An arts-based mindfulness classroom intervention. *The Journal of Positive Psychology*, *8*(3), 233-241. https://doi.org/10.1080/17439760.2013.779011

Krajcik, J. S. & Blumenfeld, P. C. (2005). *Project-based learning*. In The Cambridge Handbook of the Learning Sciences (pp. 317–334). Cambridge University Press. https://doi.org/10.1017/cbo9780511816833.020

Li, Y. & Schoenfeld, A. H. (2019). Problematizing teaching and learning mathematics as “given” in STEM *education. International Journal of STEM Education*, *6*(1), 1-13. https://doi.org/10.1186/s40594-019-0197-9

Lipsey, M. W. & Aiken, L. S. (1990). *Design sensitivity: Statistical power for experimental research.* Sage. https://books.google.co.id/books?hl=id&lr=&id=NXb5SbaMrXMC&oi=fnd&pg=PA7&dq=Lipsey,+M.+W.,+%26+Aiken,+L.+S.+(1990)

Masnick, A. M. & Klahr, D. (2003). Error matters: An initial exploration of elementary school children's understanding of experimental error. *Journal of Cognition and Development, 4*(1), 67-98. https://doi.org/10.1080/15248372.2003.9669683

Miller, S. P. & Mercer, C. D. (1997). Educational aspects of mathematics disabilities. *Journal of learning disabilities, 30*(1), 47-56. https://doi.org/10.1177/002221949703000104

Mohyuddin, R. G. & Khalil, U. (2016). Misconceptions of students in learning mathematics at primary level. *Bulletin of Education and Research, 38*(1), 133-162. https://eric.ed.gov/?id=EJ1210348

Napoli, M., Krech, P. R., & Holley, L. C. (2005). Mindfulness training for elementary school students: The attention academy. *Journal of applied school psychology, 21*(1), 99-125. https://doi.org/10.1300/J370v21n01_05

Piaget, J. (1976). Piaget's theory. *In Piaget and His School* (pp. 11–23). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-46323-5_2

Pumfrey, E., & Beardon, T. (2002). Art and Mathematics--Mutual Enrichment. *Micromath*, 18(2), 21-26. https://eric.ed.gov/?id=EJ654565

Quigley, C. F. & Herro, D. (2016). "Finding the joy in the unknown": Implementation of STEAM teaching practices in middle school science and math classrooms. *Journal of Science Education and Technology*, *25*(3), 410-426. https://doi.org/10.1007/s10956-016-9602-z

Rattan, A., Good, C., & Dweck, C. S. (2012). "It's ok—Not everyone can be good at math": Instructors with an entity theory comfort (and demotivate) students. *Journal of experimental social psychology, 48*(3), 731-737. https://doi.org/10.1016/j.jesp.2011.12.012

Steffe, L. P. (1991). The constructivist teaching experiment: Illustrations and implications. *In Radical constructivism in mathematics education* (pp. 177-194). Springer, Dordrecht. https://doi.org/10.1007/0-306-47201-5_9

Trujillo, K. M., & Hadfield, O. D. (1999). Tracing the roots of mathematics anxiety through in-depth interviews with preservice elementary teachers. *College student journal, 33*(2), 219-219. https://link.gale.com/apps/doc/A62839422/AONE?u=anon~9820beb3&sid=googleScholar&xid=22427800

Webb, N. M., Troper, J. D., & Fall, R. (1995). Constructive activity and learning in collaborative small groups. *Journal of educational psychology, 87*(3), 406. https://doi.org/10.1037/0022-0663.87.3.406

Widada, W., Herawaty, D., & Lubis, A. N. M. T. (2018). Realistic mathematics learning based on the ethnomathematics in Bengkulu to improve students' cognitive level. *Journal of Physics: Conference Series*, *1088*(1), 012028. https://doi.org/10.1088/1742-6596/1088/1/012028

Widiasworo, E. (2017). *Strategi dan metode mengajar siswa di luar kelas (outdoor learning) secara aktif, kreatif, inspiratif, dan komunikatif [Strategies and methods of teaching students outside the classroom (outdoor learning) are active, creative, inspiring, and communicative]*. Ar-Ruzz Media. https://opac.perpusnas.go.id/DetailOpac.aspx?id=1138120

Winner, E., & Cooper, M. (2000). Mute those claims: No evidence (yet) for a causal link between arts study and academic achievement. *Journal of Aesthetic Education*, *34*(3/4), 11-75. https://doi.org/10.2307/3333637