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Implementing Project-Based Blended Learning Model Using Cognitive Conflict Strategy to Enhance Students' Mathematical Spatial Literacy

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Abstract: High school teachers are mentors and facilitators that must be concerned about their students' formal thinking abilities. Students may not take a conservation task seriously because they perform operations without consulting. This necessitates modifying the learning process to increase student motivation. Therefore, this study aimed to examine students' mathematical spatial literacy through project-based blended learning with the cognitive conflict strategy. The study sample comprised 129 students, including 66 and 63 in the experimental and control classes, respectively, divided into the low, medium, and high levels. The findings showed that the experimental class students using project-based blended learning with the cognitive conflict strategy had higher mathematical spatial literacy than those in the control class using problem-based learning. Project-based blended learning with the cognitive conflict strategy and problem-based learning students at the high and moderate levels differed in their ability to increase their mathematical spatial literacy. However, low-level students are comparable in their ability to increase their mathematical spatial literacy.

Keywords: *Blended learning, mathematical spatial literacy, mathematics education, project-based learning.*

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Introduction

The Coronavirus disease (COVID-19) pandemic has tremendously impacted many human life aspects, particularly education. According to the Ministry of Education, Culture, Research, and Technology, implementing Limited Face-to-Face Learning is dynamic. It could be implemented while adjusting to Micro-Community Activity Restrictions in each region. The Limited Face-to-Face Learning was implemented based on a Joint Statement of Four Ministers and the instructions of the Minister of Home Affairs Number 14 of 2021. This is according to Jumeri, the Director-General of Early Childhood Education, Primary and Secondary Education under The Ministry of Education and Culture, during a virtual education talk show on Thursday, June 24, 2021. Its implementation could occur in a district or city that is declared an orange zone and meets specific criteria.

This policy restricts the days students attend school and their number in each class. For instance, students are only permitted to learn at school three times per week and study online on the remaining days. For health protocol implementation, only half the total number of students in each class are permitted to join Limited Face-to-Face Learning. As a result, principals and teachers seek appropriate and effective alternative teaching and learning methods, such as implementing a blended learning model. The model could be used with various methods and strategies relevant to the current situation (Saputri et al., 2021). According to Charman (as cited in Arifin & Abduh, 2021), blended learning mixes face-to-face education with online materials such as text, photos, diagrams, sound, and videos accessed by teachers and students over the internet. These findings support Bath and Brouke (2007) and Stein and Graham (2014) that the model combines online and face-to-face instruction, making it effective, efficient, and flexible to meet the learners' needs. Also, Bath and Brouke (2007) stated that blended learning is a teaching system that combines face-to-face with technology-mediated instruction.

Blended learning is an educator and students' collaborative effort to improve student learning experiences. Students enrich their learning experience and make it meaningful by experimenting with and evaluating different strategies and

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continuously improving through technology integration. According to Sutopo (as cited in Aslamiyah et al., 2019) blended learning improves the quality and quantity of human interaction in the classroom. It combines technology and good interaction, resulting in social support, constructive feedback, and learning experiences. Furthermore, the approach could be implemented effectively and successfully when the educator and students collaborate in achieving learning objectives (Saputri et al., 2021). The inter-complementing learning components to attain the learning system's goals create a conducive environment for students to maximize their potential (Ramadania & Aswadi, 2020).

Blended learning could help resolve the issue of learning environments that cannot adequately accommodate different student characteristics (Hapizah, 2015; Hendrik et al., 2021). Students have more flexibility in their learning time by participating in mixed learning. This strategy promotes them to exercise self-control and improve their learning abilities. In blended learning, students receive the teachers' explanation of the material and use e-learning facilities accessible from anywhere and at any time (Ramadania & Aswadi, 2020). The indirect learning process demonstrates superior qualities in student motivation, interest, and outcomes (Usman, 2019). Consequently, this strategy could be a suitable and effective alternative useful in the teaching and learning process.

So, Bonk (2010) and Pares (2016) stated that the blended learning model must incorporate five important elements. These are live events, online content, collaboration, evaluation, and reference material. In line with this, a previous study found that education quality may be improved through the learning process and thought training using appropriate models (Diani et al., 2019; Hapizah, 2015; Maskur et al., 2020; Suastika, 2017). The term project-based blended learning was coined when this study combined the concepts of blended and project-based learning. Also, it takes place in face-to-face and online settings, necessitating a systematic approach, where cognitive conflict strategy helps students construct their knowledge in learning.

In this study, project-based blended learning with the cognitive conflict strategy to increase students' mathematical spatial literacy important in mathematics learning. According to Ojose (2011), and Stacey and Turner (2015), spatial literacy is related to understanding geometric ideas that every student must have to grow their creativity. It must be developed from the start through school-based mathematics instruction. Furthermore, abstract mathematical objects and materials are difficult to understand, reducing students' learning interest (Hariyanti et al., 2021; Priatna, 2017).

Research Purpose

This study aimed to investigate whether project-based blended learning with the cognitive conflict strategy increases mathematical spatial literacy in class XI high school students. The study questions included:

1. Is there a difference in increasing mathematical spatial literacy between the students receiving project-based blended learning with the cognitive conflict strategy and those receiving problem-based blended learning?
2. Is there a difference in enhancing mathematical spatial literacy between the students receiving project-based blended learning with the cognitive conflict strategy and those receiving problem-based blended learning in terms of their initial knowledge?

Literature Review

Project-based blended learning with cognitive conflict strategy combines blended and project-based learning and cognitive conflict strategy where students work on a specific project. It has several pedagogical advantages, especially science learning (Gunawan et al., 2017; Hayati et al., 2016). This model has been adopted in secondary and higher education settings, with some scholars believing that students at that age have reached the stage of formal thinking (Priatna & Sari, 2022). The theory of Piaget states that students are considered mature at the formal operation stage when they accept renewed use of learning models, making it easier to apply this model.

Applying blended learning could improve the pedagogical aspects of students' learning and their abilities, resulting in more effective learning (Sahin, 2010). According to Sari and Priatna (2020), the six components of blended learning are face-to-face education, independent learning, application, tutorial, cooperation, and evaluation. As stated by Lewis, cited in Stein and Graham (2014), students and educators undergo three stages when engaging in blended learning. The first stage is independent online learning to gather initial information, while the second stage is active and experiential classroom learning from educators. The third stage is online learning in an environment where students participate in activities.

Using a project-based learning paradigm in mathematics could be effective by deploying blended learning (Husamah, 2015; Maryati, 2019; Wahyudi et al., 2018). This model involves students solving problems by investigating, designing, making decisions, and creating a product. The teacher's role is to supervise and guide the students' activities (Nazarenko, 2015).

The cognitive conflict strategy is applied in the project-based blended learning model at the beginning of learning. This is because some students are not ready to learn, and teachers should foster their interest and motivation by delivering something new, strange, contradictory, or complex (Zetriuslita et al., 2017).

The study aimed to increase students' mathematical spatial literacy through cognitive conflict in project-based blended learning contexts. Mathematical literacy is a fusion of numeracy as well as spatial and quantitative literacy. It embraces the concepts, methods, facts, and mathematical instruments in computations and spatial literacy. According to De Lange (2006), mathematical literacy could be divided into spatial literacy, numerical literacy (numeracy), and data literacy (quantitative). The spatial literacy aspects examined in this study were derived from De Lange's (2003) theory of mathematical literacy. This theory divides mathematical literacy into three dimensions, including spatial literacy. The other spatial literacy aspect was adopted from Maier's theory of spatial ability collaborated on in this study.

Methodology

Research Design

This is a quasi-experimental study comprising the experimental and control classes. The experimental or treatment class consists of students using project-based blended learning with the cognitive conflict strategy. In contrast, the control group or comparison class comprises students not using project-based blended learning. The quasi-experimental method was used because the independent variables used are difficult to control. The aim was to determine the effect of the teachers' treatment as measured by the pre-test and post-test. This logic is consistent with the belief that the quasi-experimental approach seeks to discover how variables are controlled to ensure that independent variables influence the dependent variable (Lodico et al., 2006).

A non-equivalent control group was used to contrast the experimental and control classes in senior high schools (Shadish et al., 2002). Therefore, the differences in students' mathematical spatial literacy were determined using the following non-equivalent control group design:

Experiment Class	: O	X	O
	- - - - - - - - - - -		
Control Class	: O		O

Description:

O: Pre-test or Post-test (Literacy Spatial Mathematics)

X: Project-based blended learning with the cognitive conflict strategy

\- - - : Subjects are not grouped randomly

Sample and Data Collection

This study sample comprised 60 male and 69 female high school students aged 16-17 from Bandung Regency, Indonesia. Every student was randomly assigned to experimental (n = 66; 32 males and 34 females) or control (n = 63; 30 males and 33 females). Furthermore, a cognitive conflict strategy was used to teach the experimental group students using project-based blended learning. The control group students were taught using problem-based blended learning. Every student had a comparable socioeconomic and educational background from upper-middle-class families living in cities. The students were led by two teachers with more than ten years of teaching experience. The teachers graduated from an Indonesian state institution with a bachelor's degree in education (S.Pd.). They were instructed to apply various learning models to eliminate teacher bias.

Study Instruments

A test was developed to assess the mathematical spatial literacy of Eleventh-grade high school students regarding matrix application on geometric transformations. Four mathematics education experts performed face and content validity on this test. The test was based on De Lange's (2003) theory of mathematical literacy that divides the literacy into three dimensions, including spatial literacy, and is combined with Maier's theory of spatial ability (1998). The theory divides spatial ability into mental dynamics and static statistics, each with several sub-indicators. First, spatial perception implies observing an object in vertical and horizontal positions. Second, spatial orientation is the ability to notice a shape under various conditions or views. Third, spatial visualization is the ability to reveal the process of forming or moving a geometrical arrangement. Fourth, mental rotation is the capacity to rotate a two- or three-dimensional object exactly and accurately. Fifth, spatial relationship is the ability to understand the spatial or part of an object and relate it to other objects. Table 1 describes the grading rubric for Mathematical spatial literacy.

Table 1. Guidelines for Mathematical Spatial Literacy Assessment Adapted from the Quasar General Rubric

Investigated Spatial Abilities			**Score**
(Formulating)	**(Utilizing)**	**(Interpreting)**	
Students' Response			
Failure to provide the answer, demonstrating a lack of conceptual comprehension of the assigned problem.	attempting to use problem-related information, but it is irrelevant; failing to indicate which element of the problem is appropriate; replicating some aspects of the problem without providing a solution.	Ineffective response; the answer does not reflect the problem; it may include an image that completely misrepresents the problem situation.	0
Demonstrating only a rudimentary understanding of the conceptual problem and mathematical principles.	Attempting to use problem-related information that is irrelevant; failing to identify essential elements, or exaggerating the importance of unimportant details.	Providing the final result with no reason or explanation.	1
Demonstrating an understanding of some mathematical concepts and principles and correctly formulating problems mathematically but incomplete in solving problems.	Identifying some of the key components of the problem.	Providing an illustration through a model or recognizing facts or understanding the nature and relationship of the available facts and being capable of interpreting them but lacking in the argument.	2
Correctly formulating the problem mathematically and solving it completely. Demonstrate a nearly complete understanding of the mathematical concept.	Utilizing relevant information; identifying the essential elements of the problem and demonstrating the general relationship of the parts; systematically solving the problem, and the answer is approximately correct.	Providing illustrations through models, knowing facts, understanding the nature and relationship of existing facts, or interpreting using logical and complete arguments to conclude.	3
Correct in formulating the problem mathematically and solving it thoroughly. Demonstrating a thorough understanding of mathematical concept problems.	Using pertinent information; identifying all of the critical components of the problem, and demonstrating an understanding of their interrelationships.	Providing illustrations through models or knowing facts or the nature and relation of existing facts, being able to interpret with logical and complete arguments to conclude by presenting examples and counter-examples.	4
Maximum = 4	Maximum = 4	Maximum = 4	

Source: QUASAR General Rubric

Reliability of the Test

The mathematical spatial literacy test comprised five description questions. The Cronbach's alpha formula was used to meet the reliability criteria. Decision-making was done by comparing $r_{\text{-count}}$ and $r_{\text{-table}}$. Then the question is reliable when $r_{\text{-count}} > r_{\text{-table}}$ and unreliable when $r_{\text{-count}} \leq r\text{-}t_{\text{able}}$. Table 2 shows the reliability calculation results.

Table 2. Reliability Mathematical Spatial Literacy Test

r-count	**r-table**	**Criteria**	**Category**
.85	.304	Reliable	Very high

The reliability test obtained $r_{\text{-count}}$ = .85, meaning that the question is reliable because .85 > .304 is included in the very high category. The analysis showed that the mathematical spatial literacy questions met adequate characteristics for this study.

Intervention in the Experimental Group

Teachers conducted online and offline project-based blended learning with the cognitive conflict strategy. Learning steps are compiled and defined as project-based blended learning with the cognitive conflict strategy as shown in Table 3:

Table 3. The Implementation of Project-Based Blended Learning with the Cognitive Conflict Strategy in the Learning Process

	Syntax of Project-Based Blended Learning with the Cognitive Conflict Strategy	
	Project-Based Learning Phase	**Cognitive Conflict Strategy**
Online & Offline Model	1. Starting with the Essential Question	1. Exposing the initial framework
	2. Make a Project Plan 3. Schedule Activities	2. Presenting conceptual conflict, cognitive conflict orientation, and class discussion
	4. Monitor Students Project's assignments 5. Project Result appraisal 6. Evaluating	3. Promoting cognitive flexibility

Intervention in the Control Group

In project-based blended learning with the cognitive conflict strategy, the teacher is an active facilitator, while students are expected to participate actively in the process. The learning is availed through a hybrid approach that combines online and in-person training opportunities. During the preliminary step, the teacher prayed and informed the students about the primary material, fundamental competencies, and learning objectives. Before delivering the topic, the teacher asked the students to determine their initial understanding of the subject. Groups were formed each with 5-6 students with low, medium, and high abilities. The groups presented the students' preliminary knowledge to be argued before focusing on the material provided by the teacher during the next stage. Furthermore, the teacher presented contextual difficulties to students for discussion in groups. Students communicated their ideas and perspectives in written, spoken, or visual form, referencing appropriate mathematical terms or symbols throughout their presentations. Moreover, they devised a plan based on the obstacles encountered when searching for cognitive techniques. This plan was applied to solve the problems and conclude the answers to these challenges. The next stage was student presentations, with additional information provided by other students to end the discussion. Students and teachers discussed the themes they had learned before the teacher assigned group projects in the form of mind maps for review in the next meeting.

Data Analysis

Quantitative data were collected using preliminary mathematical competency and mathematical spatial literacy tests. Preliminary mathematical competency data were related to the learning process and used to categorize students' levels as a low, medium, and high. Moreover, mathematical spatial literacy tests were administered before and after learning at the two schools. The independent variables in this study were treatment or project-based blended learning with the cognitive conflict strategy in the experimental group and problem-based blended learning in the control group. The dependent variable was mathematical spatial literacy. The exam questions were created in the form of an essay based on various spatial literacy facets. The progress in mathematical spatial literacy could be measured by conducting pretest and posttests on essays. The data were analyzed using the Statistical Package for Social Science (SPSS) version 18. The test results data were presented in a table divided into the experimental and control group sections.

Results

The Improvement of Mathematical Spatial Literacy Based on the Learning Model

Table 4 reviews the N-gain mean on mathematical spatial literacy according to the learning paradigm. The category is divided into two types; middle and lower. Its classification is based on the N-gain score.

Table 4. N-Gain Score of Mathematical Spatial Literacy

Class	N-gain Score	Category
Experimental	.39	Middle
Control	.27	Low

Students using the project-based blended learning with the cognitive conflict strategy improved their mathematical spatial literacy more than those taught using the problem-based blended learning model. This implies that the project-based blended learning with the cognitive conflict strategy model impacts students' mathematical spatial literacy more than learning with the problem-based blended learning model. However, the mean improvement in students' mathematical spatial literacy for groups did not reach the high-achieving category. The mean values in mathematical spatial literacy for the experimental and control classes are intermediate and low, respectively.

Increased mathematical spatial literacy among students increases the N-gain mean across all literacy components. The two learning groups achieved similar N-gain means for each mathematical literacy element, as shown in Table 5.

Table 5. N-gain Mean on Students' Mathematical Spatial Literacy based on Mathematical Spatial Aspects

Class	Mathematical Spatial Literacy			
	Spatial Perception	Spatial Orientation	Spatial Orientation	Mental Rotation
Experiment	.54	.39	.32	.28
Control	.33	.17	.26	.29
Deviation	.21	.22	.06	.010

Students' mathematical spatial literacy increased with different classifications. Table 5 shows each component's N-gain mean of students' mathematical spatial literacy. The students taught using the project-based blended learning with the cognitive conflict strategy model improved their overall proficiency more than those using the problem-based blended learning model.

A test of the difference in the mean N-gain scores was conducted using a non-parametric test (Mann-Whitney U-test). The test aimed to prove that experimental class students' N-gain score of mathematical spatial literacy is better than the control class. The non-parametric test was conducted because the normality test showed that the N-gain values of the experimental and control classes were normally distributed. Also, the homogeneity test showed that the N-gain value of one class was not homogeneous. Table 6 shows the results of the nonparametric test (Mann-Whitney U test) at the significance level = .05.

Table 6. Mann-Whitney U Result Differentiation for Mathematical Spatial Literacy Test

Statistics	Score	Description	Conclusion
Mann-Whitney U-test	408.500		
Z	-2.397	H_0 Rejected	Hypothesis accepted
Asymp. Sig. (2-tailed)	.017		
Asymp. Sig. (1-tailed)	.0085		

The Mann-Whitney U test results showed that the p-value or Sig. (one-tailed) is .0085 < .05, indicating a significant difference. The spatial thinking ability improved more in the experimental than the control class, demonstrating that hypothesis H_0 is rejected. Therefore, the students using project-based blended learning with the cognitive conflict strategy learn about mathematical spatial literacy more than those using problem-based blended learning.

The Use of Students' Initial Knowledge and Learning Models to Improve Mathematical Spatial Literacy

The difference in literacy improvement in the experimental class and the control class was reviewed based on the initial knowledge of high, middle and low students obtained from the students' mathematical spatial literacy test. Table 7 shows the average increase in mathematical spatial literacy based on initial knowledge.

Table 7. N-Gain Score for Mathematical Spatial Literacy Depending on The Category of Initial Mathematical Knowledge

Competencies Being Assessed		Mathematical Spatial Literacy		
Learning Model		Experimental Group	Control Group	Mean
Initial Mathematical Knowledge Category	High	.64	.38	.26
	Middle	.35	.25	.10
	Low	.15	.14	.01

The students taught using project-based blended learning with the cognitive conflict strategy improved more in the upper and middle categories than those using problem-based blended learning. In both learning models, students in the lowest category experienced a similar improvement in their N-gain score for mathematical spatial literacy. This is seen in the average N-gain in mathematical spatial literacy across each initial knowledge category. The results show .26, .10, and .01 for high, middle, and lower initial mathematical knowledge.

Disparities in the average increase in mathematical spatial literacy were identified for students taught using project-based blended learning with the cognitive conflict strategy and those using problem-based blended learning. There was a difference of .29, .49, and .20 between the upper and middle, upper and lower, and middle and lower categories of initial mathematical knowledge, respectively, among students receiving project-based blended learning with the cognitive conflict strategy.

There was a difference of .13 and .11 between the upper and middle, as well as middle and lower categories for students using problem-based blended learning. This shows that the stronger students' initial mathematical knowledge, the better their spatial literacy. Therefore, it indicates a relationship between students' past mathematical knowledge and spatial literacy.

The difference in increasing mathematical spatial literacy in experimental and control class students based on prior mathematical knowledge was determined by testing the difference in the average N-gain score. The prerequisite test for the normality of the two classes and the homogeneity of their categories was previously conducted on the N-gain score.

The Sig value was calculated based on the normality test performed on the two classes, where sig > .05 means the N-gain scores for the experimental and control classes are normally distributed in all categories. The N-gain score of students' spatial literacy in the upper and middle categories of prior mathematical knowledge comes from a homogeneous variant based on the homogeneity test. In contrast, the bottom group's prior mathematical knowledge category comes from a non-homogeneous variant. The independent sample t-test was used for the group with homogenous variance to determine the difference in the increase in students' mathematical spatial literacy for each category of prior mathematics knowledge. Additionally, a non-parametric test was used for the group whose variance was not homogeneous.

The null hypothesis and its counterpart tested are H_0: There is no difference in increasing mathematical spatial literacy between students receiving project-based blended learning with the cognitive conflict strategy and those using blended problem-based learning based on the initial top, middle, and bottom mathematics categories. H_1: There is a difference in increasing mathematical spatial literacy between students receiving project-based blended learning with the cognitive conflict strategy and those using blended problem-based learning based on the initial top, middle, and bottom mathematics categories. H_0 was accepted when $\alpha > .05$ and rejected when $\alpha \leq .05$, with a significant level $\alpha = .05$. Table 8 summarizes the test results for the difference in the average N-gain score at the significance level $\alpha = .05$.

Table 8. t-Test Results for Differences Between Mathematical Spatial Literacy Depending on Initial Mathematical Knowledge and Learning Model

Initial Mathematical Knowledge	Learning Model	N-gain Comparison	t-value	Sig.	Conclusion
High	Experimental Group: Control Group	.64: .38	3.179	.010	H_0 Rejected
Middle	Experimental Group: Control Group	.35: .25	2.046	.046	H_0 Rejected
Low	Experimental Group: Control Group	.15: .14	0.084	.936	H_0 Accepted

The data for both categories has a sig value of .010 for the upper group and .046 for the middle group. This implies that upper and middle group students have a sig value < .05 for the prior mathematics knowledge categories. It implies a significant difference in the increased mathematical spatial literacy of students receiving project-based blended learning with the cognitive conflict strategy with those using problem-based blended learning. Moreover, there is no significant difference between students using project-based blended learning with the cognitive conflict strategy and those using problem-based blended learning with inadequate initial mathematics knowledge. This is seen from the sig value obtained of .936 > .05.

The variance of one initial mathematical knowledge category is not homogeneous. Therefore, the Tamhane test was used to determine spatial literacy's initial mathematical knowledge significantly different. H_0 was accepted when sig > .05, indicating no difference in the increase in students' mathematical spatial literacy between groups (high >< middle), (high >< low) and (middle >< low). Conversely, H_0 was rejected when sig ≤ .05, implying no differences in the increase in students' mathematical spatial literacy between groups (high >< middle), (high >< low) and (middle >< low). Table 9 shows the results of the Tamhane test calculations.

Table 9. Comparison of Mathematical Spatial Literacy Differences Between Learning Models (Tamhane Test)

Learning Model	Initial Mathematical Knowledge Category	Mean Difference	Sig.	Conclusion
Experimental Group >< Control Group	High >< Middle	.21	.010	H_0 Rejected
	High ><Low	.37	.000	H_0 Rejected
	Middle >< Low	.15	.000	H_0 Rejected

The significance for the mathematical initial upper and middle groups is .010 < .05. This indicates that the N-gain score of the mathematical spatial literacy ability of students in the upper group is significantly different from the middle group students. This happens in the mathematical initial upper and lower groups, with a significance value of .000 < .05. It denotes that the N-gain score of mathematical spatial literacy students in the upper group differs from the lower group students.

The interaction between learning and initial mathematical knowledge in increasing spatial literacy was determined using two hypotheses. H_0: There is no interaction between learning and prior mathematics knowledge in the upper, middle, and lower categories on increasing students' mathematical spatial literacy. H_1: There is an interaction between learning and prior mathematics knowledge in the top, middle, and bottom categories towards increasing students' mathematical spatial literacy.

The hypotheses were tested by performing the normality and the homogeneity of variance tests. The normality calculation indicated that the data on increasing students' mathematical spatial literacy based on learning and prior mathematical knowledge categories are normally distributed. The variance calculation showed that the variance comes from a non-homogeneous population. Therefore, the non-parametric Friedman's test was used to determine the interaction between learning and the students' prior mathematics knowledge categories.

Table 10 shows the results of non-parametric calculations (Friedman's two-way ANOVA test. The test improved mathematical spatial literacy based on prior knowledge and learning.

Table 10. Ranks

	Mean Rank
Learning Process	0.383
Initial Mathematical Knowledge	0.169

Table 11. Friedman's Test

N	129
Chi-Square	88.614
Df	1
Asymp. Sig	.000

Table 10 displays average mathematical spatial literacy and early mathematical knowledge rankings. Spatial literacy shows the greatest rank after undergoing the learning process. The category factors of students' initial mathematical knowledge significantly influence mathematical spatial literacy. Similarly, learning factors significantly affect students' mathematical spatial literacy. This is seen from the Asymptotic significance value obtained at .000 < .05, indicating an interaction by increasing students' mathematical spatial literacy between learning and previous high, middle, and low mathematical knowledge.

Discussion

This study found that the project-based blended learning with the cognitive conflict strategy model increases students' mathematical spatial literacy more than problem-based learning. The hypothesis tests showed that students receiving project-based blended learning with the cognitive conflict strategy increased their mathematical spatial literacy more than those receiving problem-based blended learning. This implies that project-based blended learning with the cognitive conflict strategy improves mathematical spatial literacy in mathematics more than problem-based blended learning. However, the improvement category in the experimental class is moderate, while the average increase in the control class is low. In this case, the effectiveness of project-based blended learning with the cognitive conflict strategy could be demonstrated by meeting students’ needs to solve math problems. According to Ambarwati et al. (2015) and Thomas (2000), project-based blended learning with the cognitive conflict strategy motivates students to develop and makes their mindsets wider and comprehensive, and the ability to foster collaboration between students in applying knowledge and attitudes. The model develops student problem-solving skills by creating projects or products when building concepts.

Project-based blended learning with the cognitive conflict strategy begins with challenging problems that students investigate to obtain a concept related to the material. It teaches students how to solve problems through an exploratory process. The teacher designs an investigative process in which students solve a problem in several stages. The project-based learning encourages student creativity, makes them more active, and challenges their learning.

Project-based blended learning with the cognitive conflict strategy develops students' mathematical spatial literacy. This literacy is the ability to provide a logical answer based on previously collected data. Students' mathematical spatial literacy could be improved through project-based blended learning with the cognitive conflict strategy, though at a less significant rate than in previous studies. According to Almulla (2020) and Anita (2017), the approach allows students to discover principles, concepts, and procedures or construct knowledge based on their findings.

Implementing the project-based blended learning with the cognitive conflict strategy allows students to participate actively throughout the learning process. They participate in education and learning through involvement in activity sheets, group and class discussions, and completion of group project assignments. According to Piaget's concept of activity (Shadiq, 2009), a person's cognitive development is influenced by physical and logical-mathematical activities and social transmission. Consequently, it is appropriate when a teacher creates a learning environment that allows students to participate in mentally and physically demanding activities. Individuals construct their knowledge based on their experiences. Therefore, project-based blended learning with the cognitive conflict strategy model increases student and student-teacher interaction, boosting their confidence in learning (Erdogan & Bozeman, 2015).

A well-managed project-based blended learning model provides a conducive pedagogical feel for students with upper and middle abilities in developing mathematical capabilities and affective values (Tsai et al., 2015). The learning approach is used because of the teacher's encouragement of group communication and direct feedback to students individually and in groups. Furthermore, the model minimizes knowledge gaps caused by forced or optional absenteeism in class. Teachers could also identify the students' strengths and weaknesses in understanding a subject matter presented in project-based blended learning with the cognitive conflict strategy. Students learn at their pace and location using problem-based learning and mixed methods. Engaging students and teachers benefit from the cognitive conflict strategy with the project-based blended learning. Although students' experience is limited compared to teachers, they are prepared to take on their assigned roles by learning about self-regulation. This helps achieve the strategic goals, especially in educational activities in this pandemic.

Conclusion

Project-based blended learning with the cognitive conflict strategy improves students' mathematical spatial literacy. Students taught using this model improve their mathematical spatial literacy more than those using the problem-based blended learning model. Based on the initial knowledge, there is a difference in the improvement of mathematical spatial literacy between students taught with the two models in the high and middle categories. This study found no difference in improving mathematical spatial literacy in the two learning approaches based on prior mathematical knowledge. The improvement in mathematical spatial literacy in the high group students taught by project-based blended learning with the cognitive conflict strategy and those taught by problem-based blended learning was greater than in the middle and lower groups. Additionally, there was no association between the learning model and students' prior mathematics knowledge in the high, moderate, and poor categories.

This study has several implications. First, the project-based blended learning with the cognitive conflict strategy model could be an alternative method to help high school pupils develop their spatial literacy abilities in mathematics. Second, the model creates a conducive pedagogical environment when managed adequately by the teacher. This particularly applies to students in the high and middle categories in developing mathematical abilities and affective values. Third, the project-based blended learning with the cognitive conflict strategy model increases student as well as student-teacher interaction, boosting confidence in learning.

Recommendations

Project-based blended learning with cognitive conflict strategy could be used to assess other mathematical abilities and implemented by teachers of other subjects. Teachers should provide students with sufficient basic knowledge for the model to run smoothly. Further studies should develop other mathematical abilities required of high school students in line with industrial needs. Additionally, studies should develop project-based blended learning with a cognitive conflict strategy for learning mathematics in primary or secondary schools.

Limitations

This study used few samples, making the conclusion unable to describe mathematical spatial literacy in general. It did not conduct a more in-depth investigation because the project-based blended learning with the cognitive conflict strategy did not improve spatial literacy in lower category students.

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Authorship Contribution Statement

Sari: Conceptualization, design, data collection, analysis, writing original draft. Priatna: Writing—review and editing, supervision, final approval. Juandi: Writing—review and editing, supervision, final approval.

References

Almulla, M. A. (2020). The effectiveness of the project-based learning (PBL) approach as a way to engage students in learning. *Sage Open*. Advance online publication. https://doi.org/h74x

Ambarwati, R., Dwijanto, & Hendikawati, P. (2015). Keefektifan model project-based learning berbasis GQM terhadap kemampuan komunikasi matematis dan percaya diri siswa kelas VII [The effectiveness of GQM-based project-based learning model on mathematical communication ability and self-confidence of class VII Students]. *Unnes Journal of Mathematics Education, 4*(2), 180-186. https://bit.ly/3dPfNBp

Anita, I. W. (2017). Implementasi pembelajaran berbasis proyek untuk menumbuhkan kemampuan berpikir kreatif matematis mahasiswa [Implementation of project-based learning to improve students' mathematical creative thinking ability]. *Journal of Mathematics Research and Learning, 10*(1), 125-131. https://doi.org/h74z

Arifin, M., & Abduh, M. (2021). Peningkatan motivasi belajar model pembelajaran blended learning [Improved learning motivation blended learning model]. *Jurnal Basicedu, 5*(4), 2339-2347. https://doi.org/h742

Aslamiyah, A. T., Setyosari, P., & Praherdhiono, H. (2019). Blended learning dan kemandirian belajar [Blended learning and independent learning]. *Jurnal Kajian Teknologi Pendidikan, 2*(2), 109-114. https://doi.org/h743

Bath, D., & Brouke, J. (2007). *Getting started with blended learning*. Griffth University.

De Lange, J. (2003). Mathematics for literacy - quantitative literacy: why numeracy matters for schools and colleges. In B. L. Madison, & L. A. Steen (Eds.), *National Council on Education and the Disciplines* (pp. 75-89). National Council on Education. https://bit.ly/3zaEBMk

De Lange, J. (2006). Mathematics literacy for living from OECD-PISA perspective. *Tsukuba Journal* of *Educational Study* in *Mathematics*, *25*(6), 13-35. https://bit.ly/3IHnaWM

Diani, R., Herliantari, H., Irwandani, I., Saregar, A., & Umam, R. (2019). The effectiveness of the SSCS learning model: Its impact on the students' creative problem-solving ability on the concept of substance pressure. *Journal of Physics Research and Its Applications*, *9*(1), 65-77. https://doi.org/h744

Erdogan, N., & Bozeman, D. (2015). Models of project-based learning for the 21st century. In A. Sahin (Ed.), *A practice-based model of STEM teaching: STEM students on the stage (S.O.S.)* (p. 31-42). Sense Publishers. https://doi.org/h745

Gunawan, Sahidu, H., Harjono, A., & Suranti, N. M. Y. (2017). Project-based learning with virtual media assistance affects students' creativity in physics. *Jurnal Cakrawala Pendidikan, 36*(2), 167-179. https://doi.org/h746

Hapizah. (2015). *Peningkatan kemampuan penalaran matematis, komunikasi matematis, dan kemandirian belajar mahasiswa calon guru matematika melalui blended learning dengan strategi probing-prompting* [A Probing-prompting strategy for blended learning to improve prospective mathematics teachers' mathematical reasoning capability, mathematical communication, and independent learning] [Unpublished doctoral dissertation]. PPs Universitas Pendidikan Indonesia.

Hariyanti, S., Arjudin, A., & Baidowi, B. (2021). Efektivitas media pembelajaran terhadap prestasi belajar matematika siswa kelas XI SMAN 10 Mataram [The impact of learning media on mathematical learning achievement of SMAN 10 Mataram class XI Students]. *Mandalika Mathematics and Educations Journal*, *3*(1), 19-29. https://doi.org/gkcsp8

Hayati, W. I., Utaya, S., & Astina, I. K. (2016). Efektivitas student worksheet berbasis project-based learning dalam menumbuhkan kemampuan berpikir_kritis siswa pada materi pelajaran geografi [The efficacy of project-based learning-based student worksheets in developing students' critical thinking skills in geography]. *Jurnal Pendidikan, 1*(3), 468-474. https://bit.ly/3QIdxdP

Hendrik, B., Masril, M., & Putra, U. (2021). Meningkatkan kemandirian belajar mahasiswa melalui penerapan blended learning pada mata kuliah algoritma dan pemrograman I [Improving student learning independence in algorithms and programming courses by using blended learning I]. *Jurnal Ilmu Pendidikan Edukatif*, *3*(4), 2192-2198. https://doi.org/h747

Husamah, H. (2015). Blended project-based learning: Metacognitive awareness of biology education new students. *Journal of Education and Learning 9*(4), 274-281. https://doi.org/gp5dk5

Lodico, M. G., Spaulding, D. T., & Voegtle, K. H. (2006). *Methods in educational research: From theory to practice*. Jossey Bass.

Maier, P. H. (1998). Spatial geometry and spatial ability – how to make solid geometry solid? In E. Cohors-Fresenborg, K. Reiss, G. Toener, & H.-G. Weigand (Eds.), *Selected papers from the annual conference of didactics of mathematics* (pp. 63-75). Osnabrueck.

Maryati, I. (2019). *Peningkatan kemampuan literasi statis, penalaran statis, dan disposisi statis siswa madrasah tsanawiyah melalui pembelajaran berbasis proyek modifikasi* [Improving static literacy, static reasoning, and static disposition of madrasah tsanawiyah students through modified project-based learning] [Unpublished doctoral dissertation]. PPs Universitas Pendidikan Indonesia.

Maskur, R., Sumarno, Rahmawati, Y., Pradana, K., Syazali, M., Septian, A., & Palupi, E. K. (2020). The effectiveness of problem-based learning and aptitude treatment interaction in improving mathematical creative thinking skills on curriculum 2013. *European Journal of Educational Research, 9*(1), 375-383. https://doi.org/h748

Nazarenko, A. L. (2015). Blended learning vs. traditional learning: What works? (A case study research). *Procedia - Social and Behavioral Sciences, 200*, 77-82. https://doi.org/gf7jxr

Ojose, B. (2011). Mathematics Literacy: Are we able to put the mathematics we learn into everyday use. *Journal of Mathematics Education*, *4*(1), 89-100. https://bit.ly/3awJtSz

Pares, P. (2016). B-learning quality: Dimensions, criteria, and pedagogical approach. *European Journal of Open, Distance and E-Learning, 17*(1), 56-75. https://doi.org/h749

Priatna, N. (2017). Students' spatial ability through an open-ended approach aided by Cabri 3D *Journal of Physics: Conference Series, 895,* 1-4. https://doi.org/gh5zzx

Priatna, N., & Sari, R. M. M. (2022). Analyzing students' mathematical spatial literacy using a project-based blended learning model. *Kreano Jurnal Matematika Kreatif Inovatif, 13*(1), 78-87. https://doi.org/10.15294/kreano.v13i1

Ramadania, F., & Aswadi, D. (2020). Blended learning dalam merdeka belajar teks eksposisi [Blended learning in merdeka learning exposition text]. *STILISTIKA: Jurnal Bahasa, Sastra, dan Pengajarannya, 5*(1), 10-21. https://doi.org/10.33654/sti.v5i1.1014

Sahin, M. (2010). Blended learning in vocational education: An experimental study. *International Journal of Vocational and Technical Education, 2*(6), 95-101. https://bit.ly/3oXDJ83

Saputri, S. I., Tasriah, S., & Rahmaiswianti, I. (2021). Kajian literatur tentang efektivitas implementasi penilaian autentik dalam blended learning method pada mata pelajaran akuntansi [Authentic assessment implementation in blended learning methods for accounting subjects: A literature review]. In T. R. Izzalqurny, A. Priyono, P. M. Nagari, S. Fauzan, R. F. Harahap, & R. Zulkha (Eds.), *Prosiding national seminar on accounting, finance, and economics* (pp.59-67). Finance.

Sari, R. M. M., & Priatna, N. (2020). Blended learning: A strategy of current mathematics learning*. Journal of Physics: Conference Series, 1663,* 1-6. https://doi.org/h75b

Shadiq, F. (2009). *Aplikasi teori belajar* [Learning theory application]. Depdiknas, P4TK Matematika Yogyakarta.

Shadish, W. R., Cook, T. D., & Campbell, D. T. (2002). *Experimental and quasi-experimental designs for generalized causal inference.* Houghton Mifflin.

So, H.-J., & Bonk, C. J. (2010). Examines the roles of blended learning approaches in computer-supported collaborative learning (CSCL) environments: A Delphi study. *Educational Technology & Society, 13*(3), 189-200. https://bit.ly/3uFN6fU

Stacey, K., & Turner, R. (2015). *Assessing mathematical literacy*: *The PISA experience.* Springer. https://doi.org/h75c

Stein, J., & Graham, C. R. (2014). *Essential for blended learning: A standards-based guide*. Routledge.

Suastika, K. (2017). The mathematics learning model of open problem solving develops students' creativity. *International Electronic Journal of Mathematics Education, 12*(3), 569-577. https://doi.org/10.29333/iejme/633

Thomas, J. W. (2000). *A review of research on project-based learning*. The Autodesk Foundation.

Tsai, C. W., Shen, P. D., & Lin, R. A. (2015). A quasi-experimental study of digital storytelling explores the effects of student-centered project-based learning with initiation on students' computing skills. *International Journal of Information and Communication Technology Education, 11*(1), 27-43. https://doi.org/10.4018/ijicte.2015010102

Usman, U. (2019). Komunikasi pendidikan berbasis blended learning dalam membentuk kemandirian belajar [Educational communication through blended learning in the development of independent learning]. *Jurnal Jurnalisa, 4*(1), 136-150. https://doi.org/h75d

Wahyudi, Anugraheni, & Winato. (2018). Pengembangan model blended learning berbasis proyek untuk menunjang kreatifitas mahasiswa merancang pembelajaran matematika [Developing project-based blended learning models to encourage student creativity in mathematics instruction]*. Jurnal Ilmiah Pendidikan Matematika, 6*(2), 68-81. https://bit.ly/3pfvSmq

Zetriuslita, Z., Wahyudin, W., & Jarnawi, J. (2017). Mathematical critical thinking and curiosity in problem-based learning and cognitive conflict strategy: A study in number theory course. *International Education Studies, 10*(7), 65-78. https://doi.org/10.5539/ies.v10n7p65