

Enhancing Mathematical Spatial Literacy through Project-Based Blended Learning with Cognitive Conflict Strategy

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Abstract: This article discusses the development of a project-based blended learning (PjBBL) module using a cognitive conflict strategy on the topic of geometric transformations to enhance mathematical spatial literacy. The objectives of this study are (1) to produce a valid, practical design of a PjBBL module with a cognitive conflict strategy, and (2) to determine the improvement in the mathematical spatial literacy of eleventh-grade senior high school students after implementing the module. This research is a design research using the Plomp model. The initial stage of the Plomp model, namely the preliminary research stage, is to identify the problems and needs required in learning. The second stage is prototyping, namely, compiling a prototype after obtaining the results of the initial investigation, followed by formative evaluation; the third stage is assessment. The data collection techniques and instruments used were interviews, observations, and mathematical spatial literacy tests. The results of the module development were evaluated based on three aspects, namely validity, practicality, and effectiveness, involving students from SMAN 1 Cicalengka as the research subjects. The research data were analyzed descriptively. The results showed that the design of the project-based learning teaching module using the cognitive conflict strategy was in the very valid category, with an obtained score of 84. Valid based on material and media experts from the results of the feasibility of content, presentation, language, contextual, and graphics (module size, cover design, and module content design). For the practicality value, a result of 86.3, including the very practical category, was obtained based on the results of the practicality test of student responses to the criteria of presentation, language, content, and time. The effectiveness of the module is evidenced by an increase in students' mathematical spatial literacy, with high N-gain and a large effect size.

Keywords: project-based learning, cognitive conflict strategy, mathematical spatial literacy.

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■ INTRODUCTION

Geometry is an essential area of the mathematics curriculum, studied from preschool to higher education. As a fundamental component of mathematics education, geometry plays a role in developing scientific reasoning skills and supporting learning both within and beyond mathematics. This demonstrates that geometry's role is not limited to the academic realm but is also relevant in everyday life involving abstract objects. This condition requires students to

visualize, interpret, and mentally represent, which are essential skills for reflecting mathematical literacy (Panaoura, 2014; Roffi et al., 2018). Mathematical literacy is crucial in equipping students to understand, use, and interpret mathematical concepts and procedures in various life contexts (Hwang & Ham, 2021; Kolar & Hodnik, 202; Genc & Erbas, 2019).

Consistent with the explanation above, de Lange (2006) argues that mathematical literacy is a comprehensive form of literacy comprising

several dimensions, including numerical, data, and spatial literacy. Spatial literacy is the ability to organize and use spatial thinking skills to visualize ideas, situations, and problems in everyday life and the world around us. Spatial literacy focuses on the context of basic abilities in understanding the two-dimensional and three-dimensional world in which a person lives and moves (Umbara & Suryadi, 2019). This aligns with Lowrie et al. (2018), who stated that spatial ability is the process of recognizing, organizing, comparing, and manipulating spatial properties and relationships among spatial concepts. Spatial literacy is an important ability for helping students understand geometric material in context. In addition, spatial literacy is one of the components of the PISA international standard assessment, which is included in the space and shape content in mathematical literacy (Lane et al., 2019). This is consistent with research by Weckbacher and Okamoto (2018) and Pujawan, Suryawan, and Prabawati (2020), which indicates that spatial ability influences the representation of geometric objects in the human mind and geometry problem-solving.

In practice, most students still experience difficulties understanding geometry. Students' geometry abilities in spatial and shape content remain relatively low. This is evident in PISA data, where the average achievement score of Indonesian students in the space and shape category is 383, compared with an OECD average of 490. Furthermore, based on observations of high school students, they have difficulty imagining an object in their minds, and data from the 2022 summative test results for 12th-grade high school students show that the average achievement in items related to geometry is the lowest compared to other mathematics topics (Sari, Priatna, & Djuandi, 2022). Likewise, a preliminary study on mathematical spatial literacy conducted on 11th grade high school students revealed that: (1) students' ability to

identify spatial relationships between objects is still weak; (2) students have difficulty using, determining, modifying, and developing mechanisms to view objects from different perspectives; and (3) many students face difficulties in representing spatial relationships cognitively, often arriving at correct answers through inappropriate processes (Sari, Priatna, & Djuandi, 2022). These findings indicate that students' mathematical spatial literacy is still inadequate and requires further development.

The development of mathematical literacy, based on the research findings of Bolstad (2020) and Freeman et al. (2015), can be enhanced by employing learning models that actively and creatively engage students by providing stimuli in the form of open-ended problems with real-world contexts. Learning models serve as valuable tools for conveying information and improving student learning success (Rohimatunisa & Sudianto, 2023). The results of research by Lutfi, Juandi, & Jupri (2021) revealed that to improve students' mathematical abilities in geometry and develop student creativity, problem-based and project-based models and methods can be applied. One innovative learning method that can develop student creativity in mathematics learning is project-based learning or Project-Based Learning (PjBL). PjBL is a learning model in which students engage in a learning environment, collaboratively designing, refining, and completing project-based tasks or specific products. PjBL engages students in complex and meaningful projects that require them to design, solve problems, make decisions, and conduct investigations (Pinho-Lopes & Macedo, 2016). This method allows students to work independently over time to produce a tangible product, report, or presentation (Husamah, 2015). The Project-Based Learning (PjBL) model has proven effective in improving mathematical skills and student engagement, as it requires active participation in producing outputs

such as project products, reports, and presentations throughout the learning process (Husamah, 2015). However, despite its advantages, Project-Based Learning (PjBL) has limitations related to time management, particularly in scheduling projects effectively to achieve learning objectives, as some students may encounter difficulties due to limited information or guidance (Chiang & Lee, 2016).

To address these challenges, e-learning integration has become a crucial need in learning. One widely implemented form of e-learning is blended learning, a model that combines face-to-face instruction with online materials and activities. Findings by Hariyono & Andrini (2020) indicate that implementing Project-Based Learning (PjBL) in a blended learning environment supported by Moodle is effective in improving mathematical literacy and student learning independence. This indicates that the combination of blended learning and Project-Based Learning models can serve as an alternative learning approach with the potential to improve Higher Order Thinking Skills (Alamri, 2021).

The development of student creativity, perseverance, and independence is not determined solely by the learning model and technology utilization; it also requires the application of contemporary learning strategies and approaches. In project-based learning, students often experience cognitive conflict, namely a state of uncertainty when working on assignments or understanding concepts that do not align with initial expectations. This occurs because PjBL requires students to reconstruct knowledge by linking new information to prior knowledge, thereby creating a more meaningful learning experience. This uncertainty indicates cognitive conflict. The results of Zetriuslita et al. (2018) indicate that cognitive conflict strategies are effective in helping students construct knowledge.

As explained previously, the Project-Based Learning (PjBL) Model places students at the

center of learning through active involvement in project planning and completion, thereby supporting the development of students' mathematical abilities. Blended learning integration provides learning flexibility by combining face-to-face and online instruction, enabling students to access information, process data, and communicate learning outcomes more independently. To optimize this process, the Cognitive Conflict Strategy is implemented at the beginning of learning to arouse attention and activate students' prior knowledge through contradictory or challenging situations.

The Project-Based Blended Learning with Cognitive Conflict Strategy (PjBBL-CCS) learning model was chosen to complement the shortcomings of each of these treatments. PjBBL-CCS refers to a constructivist view that has the following characteristics: knowledge constructivism, based on the child's cognitive developmental stage, and social constructivism, based on the given problem, meaning understanding knowledge through learning with peers. The constructivist view can improve students' learning abilities, as constructivist theory holds that students build knowledge, think, find reasons, and solve real problems with teachers as learners alongside students (Bonk & Graham, 2012; Raman, Surif & Ibrahim, 2024). Therefore, the combination of PjBL, blended learning, and cognitive conflict strategies is considered a complementary approach to improving students' mathematical spatial literacy through problem-solving activities and meaningful project development.

Referring to the explanation of the background of the problem as stated above, in general, the objectives of the research are to obtain valid, practical results of the project-based blended learning Teaching Module with cognitive conflict strategy and to determine the increase in mathematical spatial literacy abilities of high school students after implementing the project-based learning model with Cognitive Conflict Strategy. Based on the objectives above, the

specific problem formulation can be described as follows: 1. How is the design of the project-based blended learning Teaching Module with cognitive conflict strategy in improving the mathematical spatial literacy of grade XI students? 2. How is the feasibility of the design of the project-based blended learning Teaching Module with cognitive conflict strategy in improving the mathematical spatial literacy of grade XI students that has been developed? 3. How is the practicality of the project-based blended learning Teaching Module with cognitive conflict strategy in improving the mathematical spatial literacy of grade XI students that has been developed?.

■ METHOD

Research Design

This study employed a Research and Development (R&D) approach. Design research in education involves designing, developing, and

evaluating instructional interventions (Plomp & Nieveen, 2010, 2013). This study uses the Plomp development model, which emphasizes iterative and reflective processes. The preliminary research phase was conducted to analyze student characteristics, analyze the needs of the learning context, and analyze the curriculum as a basis for product design. Next, the prototyping phase consisted of designing and developing rubrics. In this second phase, the product was developed through a series of formative evaluations, including self-evaluation, expert review, one-on-one evaluation, small group evaluation, and field testing. Each evaluation phase generated feedback that was used to repeatedly revise and refine the prototype. The final phase, assessment, aimed to evaluate the product's validity, practicality, and effectiveness. This iterative process ensured that the resulting product was data-driven and aligned with learning needs. The overall design of the Plomp model is illustrated in Figure 1.

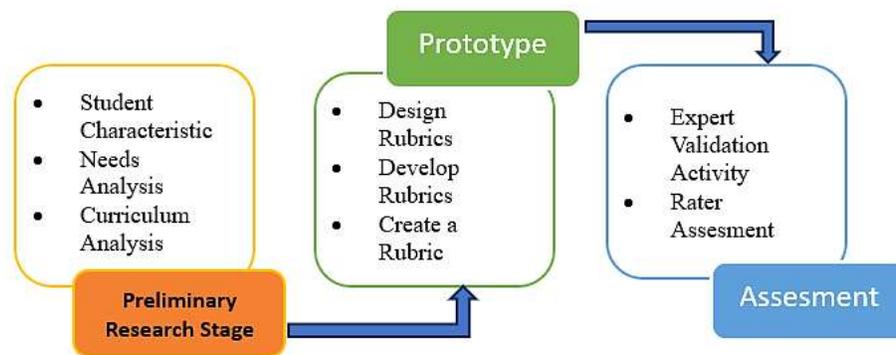


Figure 1. Plomp model

As shown in Figure 1, the preliminary research phase aims to establish a conceptual and empirical foundation for product development. At this stage, a learning needs analysis is conducted through observations and interviews to identify problems encountered in the field. Next, an analysis of the learning context and student characteristics, as well as a review of the curriculum and targeted competencies, is conducted to ensure that the product aligns with learning demands. Furthermore, a literature

review of learning theories, development models, and relevant research findings is conducted. The outcomes of this phase include the formulation of the development problem, product objectives, and initial design specifications. The process at this stage is iterative, allowing repeated analysis if the data obtained are insufficient or do not fully align with field conditions.

The assessment phase aims to comprehensively assess product quality. The assessment focuses on validity based on expert

judgment, practicality based on user responses and learning implementation, and effectiveness based on the achievement of learning objectives or measured skill improvement. If the assessment results do not meet the established criteria, further revisions are made by returning to the prototyping stage to ensure that the final product is feasible, contextual, and grounded in empirical evidence.

A one-group pretest–posttest design was employed in the small-group evaluation to assess changes in students' abilities following use of the validated learning module. This design was chosen because it was practical and appropriate for the development stage, enabling assessment of the product's initial effectiveness. However, the lack of a control group is a major weakness, as the observed improvements cannot yet be directly attributed to the use of the learning module.

Research Subjects

The subjects of this study were 36 eleventh-grade students from a high school in Bandung

Regency in the 2024/2025 academic year who had the highest average scores on the National Mathematics Examination. The schools were selected using purposive sampling, with consideration of their support for the research. This technique was used because the selected schools had characteristics that matched the research needs and supported the research process. This support encompassed the suitability of the implemented curriculum, student and teacher readiness, and the availability of facilities and infrastructure for research activities. The sampling procedure used was to meet the above characteristics. The highest average National Mathematics Examination score of Bandung Regency State Senior High Schools was used as the basis for determining school selection. The data is presented in the following table:

The characteristics of the students involved in this study were diverse. In general, students exhibited varying levels of academic achievement, ranging from low to high, as indicated by teacher

Table 1. National examination results data for mathematics for senior high schools in bandung regency

No	Educational Unit Code	Number of participants	Average Math Score
1	02100004	321	42.64
2	02100005	130	30.38
3	02100006	260	41.38
4	02100012	262	38.85
5	02100018	282	39.67

assessments and prior academic performance. Furthermore, students' socioeconomic backgrounds varied, as evidenced by differences in family circumstances and access to learning resources outside of school. However, most students were accustomed to participating in mathematics lessons in accordance with the applicable curriculum. They had prior experience with digital learning media, enabling them to participate optimally in the research.

Therefore, purposive school selection is expected to produce relevant, accurate, and appropriate data that aligns with the research objectives. The study involved several evaluation stages: one-to-one evaluation, small group evaluation, and field testing, each with a different number of participants. The one-to-one evaluation involved three students representing low, medium, and high ability levels, selected based on recommendations from the mathematics teacher.

During the implementation and data collection stages, students were grouped based on the Criteria for grouping students' Mathematical Spatial Literacy. This grouping was conducted based on the range of scores from the assessment of students' mathematical spatial literacy.

Table 2. Criteria for grouping students' mathematical spatial literacy

Score Range	Categories
0 – 20	Very Low
21 – 40	Low
41-60	Medium
61-80	High
81-100	Very High

This grouping aims to provide a more comprehensive picture of variations in student abilities and to support the analysis of the effectiveness of development products within each ability category.

Data and Research Instruments

The data collected comprised both qualitative and quantitative components. Qualitative data were obtained from interviews and field notes, while quantitative data were derived from the mathematical spatial literacy test. The instruments were used throughout the research process, from exploration to determining the effectiveness of the teaching module. The instruments were categorized into three types: (1) Validity instruments, (2) Practicality instruments, and (3) Effectiveness instruments. The following provides a detailed explanation of each instrument.

Teaching Module Validity Instrument

The validity instrument for the teaching module was used to assess the module's validity. Before the module is applied in the learning process, a validity test is conducted on all instruments. The instrument validity test for the teaching module validity sheet was conducted by

material experts comprising 2 Mathematics Education Lecturers and 1 high school mathematics teacher. The validation results for the teaching module were 0.92, meeting the validity criteria. The assessment components include the presentation of the teaching module in accordance with the needs; the language used is easy to understand and clear; the content of the teaching module meets the learning objectives; and the time allocated is in accordance with the time allocation. It can be concluded that the teaching module validity sheet is valid.

Teaching Module Practicality Instrument

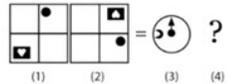
Given the practicality of the teaching module, it is necessary to have an instrument to measure it. The instrument consists of a student questionnaire on practicality and an observation sheet for the teaching module. Before the practicality instrument for the teaching module is given to students, a validity test is conducted on all instruments to ensure suitability for use. The validation results for the student response questionnaire sheet were obtained at 0.91 with valid criteria, the practicality assessment components include 1) Presentation with sub-components including the attractiveness of the appearance and content, the teaching module makes learning not 2) Language with sub-components including the use of language that is easy to understand and familiar to students' lives, 3) Content with sub-components including instructions given that are easy to understand and foster students' curiosity in learning the material, 4) Time, namely the allocation of time given according to the available mathematics lesson hours. It can be concluded that the student response questionnaire sheet can be used.

Teaching Module Effectiveness Instrument (Mathematical Spatial Literacy Test Instrument)

To assess the effectiveness of the teaching module, a specific instrument was developed: a

mathematical spatial literacy test. This test consisted of three essay questions, designed based on a combination of mathematical literacy indicators from OECD (2013) and spatial ability indicators from Maier (1998), as shown in Table 3.

Table 3. Test outline and questions for mathematical spatial literacy abilities

Mathematical Literacy Indicators (OECD, 2013)	Mathematical Spatial Indicators (Maier, 1998)	Mathematical Spatial Literacy Indicators	Question Indicator	Question
Formulate and identify mathematical aspects in real problems using appropriate symbols, pictures, or modeling.	Spatial perception: The ability to observe an object in a vertical and horizontal position	Identifying aspects of an object that are in vertical and horizontal positions in mathematical language using appropriate symbols, pictures, or models.	Students can identify the existing elements of a regular quadrilateral and describe the flat shape before and after translation.	The plane figure $A'B'C'D'$ with coordinates point A (3,3), point B (3,4), point C (-3,4), and point D (x,y) is the result of the translation of the regular quadrilateral plane figure $ABCD$ as far as 2 units towards the negative X axis, and 4 units towards the positive Y axis. Draw the plane figure
	Spatial Orientation: The ability to observe a shape in various situations/viewpoints	Observing and identifying aspects of a shape in various situations/points of view	Students can observe and identify similarities between images positioned differently with respect to the type of transformation.	Observe the position of the image below:  Identify the similarities between the images above in terms of the type of transformation, then describe the possibilities for image no. 4!
Using Applying the strategies necessary to find mathematical solutions by representation	Spatial Visualization is the ability to illustrate the process of formation or movement of a geometric shape.	Apply appropriate mathematical strategies to illustrate the process of forming or moving the arrangement of a figure using geometric representations in the process of finding a solution.	Students can classify and illustrate transformation processes in everyday problems by investigating appropriate strategies.	Four children and a coach are practicing passing a volleyball on the court, with the following formation: a coach is in the middle of the court and the four children stand in four different positions (Azis in the North, Syahrul in the South, Dimas in the East, and Ahmad in the West). Each child is 4 meters from the coach's position. Draw the standing formation of the four children and the coach according to the problem in question b. Draw the formation of the students and the coach in Cartesian coordinates, if the coach is assumed to be at the center point O (0,0)

Furthermore, before being administered to the research class, the test was validated by three Mathematics Education lecturers, one

Mathematics Education Evaluation lecturer, and one Mathematics teacher. The results of the content validity assessment were analyzed using

the Cochran Q statistic. This aimed to determine whether the reviewers assessed the learning module uniformly.

The calculation of content validity using the Cochran Q statistic yielded $Asymp. Sig. = 0.93$, or a probability greater than 0.05. This means that at a significance level of $\alpha = 5\%$, the $50\% \leq PS \leq 100\%$ is accepted. Therefore, it can be concluded that the reviewers assessed each mathematical spatial literacy item uniformly with respect to content validity.

The expert validation results for the mathematical spatial literacy ability test, using the Q-Cochran statistic, yielded a value of 0.93, indicating a valid category. This assessment component includes aspects of content validity and question language. It can be concluded that the mathematical spatial literacy ability test can be used very well with minor revisions. After the instrument was deemed to meet content validity and was deemed adequate for testing, the mathematical spatial literacy questions were administered to grade XII students to assess validity, reliability, difficulty, and discriminatory power. The results of the calculation of the validity test of the mathematical spatial literacy questions were statistically tested using the Cronbach's Alpha formula for essay questions. The results of the reliability test for mathematical spatial literacy obtained a value of 0.508, which means that the interpretation of the level of reliability of the mathematical spatial literacy test questions is in the medium category and the validity of questions number 1 and 2 is included in the high category, namely 0.731 and 0.751, and question number 3 is 0.638, included in the medium category, and all questions are valid. The reliability of the test questions is moderate, which is one of the study's shortcomings because the number of questions administered is small, resulting in low question consistency.

Product Development Analysis Techniques

The assessment of product development was conducted to determine the practicality and effectiveness of the developed teaching module. This process was conducted using instruments designed to assess the practicality and effectiveness of the module.

Teaching Module Practicality Analysis

The practicality analysis was based on data obtained from teacher and student response questionnaires, interviews, and teacher observations regarding the teaching module designed using the PjBBL model with a cognitive conflict strategy. The data from teacher and student response questionnaires were collected using a Likert scale. The results were then interpreted using the practicality classification criteria proposed by Widoyoko (2017), as shown in Table 4.

Table 4. Practicality classification

Interval (%)	Category
$85 < PS \leq 100$	Highly Practical
$70 < PS \leq 85$	Practical
$50 < PS \leq 70$	Less Practical
$0 \leq PS \leq 50$	Not Practical

Teaching Module Effectiveness Analysis

The effectiveness of the teaching module was assessed by calculating the average percentage of results from the mathematical spatial literacy test and by analyzing the magnitude of the post-implementation increase. The average test results for students' mathematical spatial literacy were analyzed by calculating the percentage of students who scored above the average. After obtaining the average percentage of student scores, a description of each indicator of mathematical spatial literacy was conducted. The goal was not only to determine the

effectiveness of the teaching module but also to understand the students' response process for each indicator of mathematical spatial literacy. Furthermore, to determine the extent of improvement in mathematical spatial literacy skills, researchers analyzed the test data using the normalized gain (n-gain) formula, which compares pretest and posttest scores. Moreover, to see the size of the effect of using this teaching module on mathematical spatial literacy.

■ RESULT AND DISCUSSION

Media Development Results

The PjBBL-CCS learning module design process for achieving spatial mathematical literacy comprises three stages of the Ploomp model: the Initial Research stage, the Prototype Development or Design stage, and the Evaluation or Assessment stage. The following describes the research results based on these stages:

Preliminary Research Stage

The preliminary research stage comprises three components: analysis of student characteristics, needs analysis, and curriculum analysis. Each stage in this section is described as follows:

The student characteristics analysis stage was conducted to provide an overview of students' abilities in geometry learning and their interest in the e-module to be developed. To obtain geometry ability data, we used test results from a geometric transformation topic taught by a teacher at one school. Test results from 152 students indicated that 65.7% scored below average. Furthermore, to clarify whether many students still scored below average, interviews were conducted with several representative students selected by the teacher. Based on the interview results, student A1 indicated that he had difficulty understanding problems and visualizing geometric concepts. In the interview, student A1

stated, "I don't understand the questions the teacher gave me. I don't know what to write on my answer sheet. So, rather than leaving blanks, I just rewrote the questions." Furthermore, an interview with student A2 stated, "I understand the questions given by the teacher and can convert the questions into the form of images to known elements, but when asked to solve the transformation concept, I forget the formula." Meanwhile, an interview with student A3 stated, "I didn't understand this material when the teacher explained it because I had difficulty visualizing geometry, so that I couldn't answer the questions." Based on the description of the student interviews above, it can be concluded that most students experience difficulty solving geometry-related problems. This is because students initially lack understanding of the problem and have difficulty visualizing geometric concepts due to inadequate learning media, which prevents them from planning solutions and ultimately prevents them from solving the problem.

Furthermore, a description of student interest in the characteristics of the e-module to be developed was obtained from the results of the questionnaire analysis of student interest in the characteristics of the e-module being developed, which revealed that 92% (140 students) prefer blended learning if the teacher provides e-modules in the lesson, and 88% (135 students) are ready to implement both online and offline learning processes. Students' interest in the e-module's appearance indicated that 94.6% (142 students) preferred a colorful design, and 97% (148 students) wanted the e-module to include challenging exercises.

In the needs and curriculum analysis phase, researchers examined existing learning materials used in a public high school in Bandung Regency. To identify problems within the school, interviews were conducted with mathematics teachers. Teacher interviews were conducted to understand

the learning process. Questions were asked about the learning process, difficulties and obstacles encountered, learning design preparation and

achievement, technology used during learning, module availability, and desired solutions. The following are the results teacher interviews:

Table 5. Teacher interview results regarding the learning process

Questions' Aspects	Teacher Response
preparation of learning design and its achievement	"Learning objectives were not achieved optimally because many students did not understand the material that had been sent to the WhatsApp group".
technology used during learning	"Sometimes it is prepared according to the learning steps in the lesson plan, but not all of them are directed at training students in problem-solving skills, and sometimes they are directly prepared according to the sequence of material in the textbook."
availability of desired modules and solutions	"We want a teaching module that supports the implementation of innovative learning that makes students motivated in learning mathematics so that they can solve problems in geometry problems."

The interviews revealed that teachers predominantly used conventional teaching methods, which were considered less effective since many students still required remedial sessions after daily tests on geometric transformations. This finding was supported by students' responses, which indicated that they found it difficult to visualize geometric transformation concepts due to limited and inadequate learning materials.

Further examination of the mathematics teacher's teaching module revealed that, although the learning activities on geometric transformations were fairly structured, the supporting media were minimal. Moreover, student engagement during lessons remained passive because the learning process remained teacher-centered. Consequently, students struggled to develop spatial imagination, resulting in low mathematical spatial literacy. This aligns with the findings of Sari & Priatna (2020), who reported that students have difficulty understanding geometry, particularly in mathematical spatial literacy.

Based on this analysis, it is necessary to develop a PjBBL module to support more effective learning and enhance students' mathematical spatial literacy. Additionally, the learning media should be readily accessible at any

time and from any location. The analysis concluded that a teaching module stimulating students' active participation through PjBL is essential. This is further supported by previous studies, which found the PjBBL model to be an effective learning approach (Tuan, Hanh & Ninh 2020). The next step in this phase was to analyze the learning content, specifically the topic of geometric transformations. During this process, the learning objectives were aligned with the curriculum, and the materials were aligned with the learning outcomes specified in the lesson plan. These materials served as the basis for designing and developing the prototype module in the next stage.

Within the curriculum, teaching modules are designed to implement the PjBBL model using a cognitive conflict strategy. Each lesson plan is structured to include an introduction, main learning materials, and a conclusion. The development of the PjBBL-CCS e-module device begins with the design of project-based learning steps. The steps in the PjBL model are adapted from The George Lucas Educational Foundation and combined with mathematics learning steps that apply cognitive conflict strategies. Based on the syntax shown above, a lesson plan using the PjBBL-CCS model was designed as follows:

Aplikasi Matriks Pada Transformasi Geometri (TRANSLASI, REFLEKSI Dan Komposisi Transformasi)

RENCANA PELAKSANAAN PEMBELAJARAN (RPP)

Nama Satuan Pendidikan : SMA Negeri 1 Cicalengka
 Pelajaran : SMA Negeri Nagreg
 Kelas/Semester : Matematika XI/1
 Materi Pokok : Aplikasi Matriks Pada Transformasi Geometri (TRANSLASI, Refleksi Dan Komposisi Transformasi)
 Alokasi Waktu : 2 x 45 menit (2 Pertemuan)

A. Kompetensi Inti

- KI-1 Menghargai dan menghormati ajaran agama yang dianutnya.
- KI-2 Menunjukkan perilaku jujur, disiplin, tanggung jawab, peduli (gotong royong), kerjasama, toleran, damai, santun, responsive, dan pro-aktif sebagai bagian dari solusi atas berbagai permasalahan dalam berinteraksi secara efektif dengan lingkungan sosial dan alam serta menempatkan diri sebagai cerminan bangsa dalam pergaulan dunia.
- KI-3 Menunjukkan kemampuan dan sikap dalam pengamatan, penemuan, dan menguji, pengetahuan faktual, konseptual, prosedural, dan metakognitif berdasarkan rasa ingintahunya tentang ilmu pengetahuan, teknologi, seni, budaya, dan humaniora dengan wawasan kemanusiaan, kebangsaan, kenegaraan, dan peradaban terkait penyebab fenomena dan kejadian, serta menerapkan pengetahuan prosedural pada bidang kajian yang spesifik sesuai dengan bakat dan minatnya untuk memecahkan masalah.
- KI-4 Mengolah, menalar, dan menyaji dalam ranah konkret dan ranah abstrak terkait dengan pengembangan dari yang dipelajarinya di sekolah secara mandiri, bertindak secara efektif dan kreatif, serta mampu menggunakan metoda sesuai kaidah keilmuan.

B. Kompetensi Dasar dan Indikator

Kompetensi Dasar	Indikator Pencapaian Kompetensi
3.3 Menganalisis dan membandingkan transformasi dan komposisi transformasi dengan menggunakan matriks	3.3.1 Menjelaskan pemakaian matriks pada transformasi geometri translasi. 3.3.2 Mengidentifikasi fakta pada sifat-sifat transformasi geometri translasi dengan matriks 3.3.3 Menganalisis dan membandingkan transformasi translasi dan komposisi transformasi dengan menggunakan matriks 3.3.4 Menjelaskan pemakaian matriks pada transformasi geometri refleksi.

3.5 Mengidentifikasi fakta pada sifat-sifat transformasi geometri refleksi dengan menggunakan matriks 3.5.6 Menganalisis dan membandingkan transformasi refleksi dan komposisi transformasi dengan menggunakan matriks (HOTS)	3.5.3 Mengidentifikasi fakta pada sifat-sifat transformasi geometri refleksi dengan menggunakan matriks 3.5.6 Menganalisis dan membandingkan transformasi refleksi dan komposisi transformasi dengan menggunakan matriks (HOTS)
4.3 Menyelesaikan masalah yang berkaitan dengan matriks transformasi geometri (translasi, refleksi, dilatasi dan rotasi)	4.3.1 Menyelesaikan masalah translasi yang berkaitan dengan matriks 4.3.2 Menyusun penyelesaian masalah yang berkaitan dengan penggunaan matriks pada transformasi geometri translasi 4.3.3 Menyelesaikan masalah refleksi yang berkaitan dengan matriks 4.3.4 Menyusun penyelesaian masalah yang berkaitan dengan penggunaan matriks pada transformasi geometri refleksi (HOTS)

C. Tujuan Pembelajaran

- Melalui pembelajaran *Project-Based Blended Learning* dengan *Cognitive Conflict Strategy*, peserta didik diharapkan dapat menemukan konsep translasi dan refleksi melalui pengamatan obyek-obyek dan memecahkan permasalahan berkaitan translasi dan refleksi dengan menggunakan matriks.
- Setelah mengamati obyek fraktal geometri, obyek esensi dan benda konkret yang ditayangkan melalui power point, siswa dapat membuat rancangan proyek dan menghasilkan produk berupa sebuah teselasi fraktal geometri yang memuat konsep translasi dan refleksi dengan tepat. (TPACK)
 - Setelah melakukan diskusi siswa dapat mengidentifikasi sifat-sifat transformasi geometri translasi, refleksi serta komposisi transformasi dengan menggunakan matriks. (HOTS)
 - Setelah melakukan diskusi siswa dapat menjelaskan pemakaian matriks pada transformasi geometri translasi, refleksi serta komposisi transformasi. (HOTS)
 - Setelah siswa berdiskusi tentang aplikasi matriks pada transformasi, siswa dapat menyusun penyelesaian masalah yang berkaitan dengan penggunaan matriks pada transformasi geometri dalam menentukan bayangan hasil translasi dan refleksi. (HOTS)

D. Penguatan Pendidikan Karakter

Nilai karakter:Religius, nasionalis, gotong royong, mandiri, integritas

E. Materi Pembelajaran

- Materi Reguler
 - ✓ Aplikasi Matriks pada Transformasi Geometri (Translasi)
 - ✓ Translasi serta refleksi titik
 - ✓ Translasi serta refleksi garis
- Materi Remedial

C. Tujuan Pembelajaran

Melalui pembelajaran *Project-Based Blended Learning* dengan *Cognitive Conflict Strategy*, peserta didik diharapkan dapat menemukan konsep translasi dan refleksi melalui pengamatan obyek-obyek dan memecahkan permasalahan berkaitan translasi dan refleksi dengan menggunakan matriks.

- Setelah mengamati obyek fraktal geometri, obyek esensi dan benda konkret yang ditayangkan melalui power point, siswa dapat membuat rancangan proyek dan menghasilkan produk berupa sebuah teselasi fraktal geometri yang memuat konsep translasi dan refleksi dengan tepat. (TPACK)
- Setelah melakukan diskusi siswa dapat mengidentifikasi sifat-sifat transformasi geometri translasi, refleksi serta komposisi transformasi dengan menggunakan matriks. (HOTS)
- Setelah melakukan diskusi siswa dapat menjelaskan pemakaian matriks pada transformasi geometri translasi, refleksi serta komposisi transformasi. (HOTS)
- Setelah siswa berdiskusi tentang aplikasi matriks pada transformasi, siswa dapat menyusun penyelesaian masalah yang berkaitan dengan penggunaan matriks pada transformasi geometri dalam menentukan bayangan hasil translasi dan refleksi. (HOTS)

D. Penguatan Pendidikan Karakter

Nilai karakter:Religius, nasionalis, gotong royong, mandiri, integritas

E. Materi Pembelajaran

- Materi Reguler
 - ✓ Aplikasi Matriks pada Transformasi Geometri (Translasi)
 - ✓ Translasi serta refleksi titik
 - ✓ Translasi serta refleksi garis
- Materi Remedial

H. Kegiatan Pembelajaran

Pertemuan Pertama (2 X 45 menit)

1. Pendahuluan (10 menit)

Tahapan Pembelajaran	Aktivitas Guru/Siswa
Orientasi	<ul style="list-style-type: none"> • Melakukan pembukaan dengan salam pembuka dan berdoa untuk memulai pembelajaran • Memeriksa kehadiran peserta didik sebagai sikap disiplin • Menyiapkan fisik dan psikis peserta didik dalam mengawali kegiatan pembelajaran.
Pemberian Acuan	<ul style="list-style-type: none"> • Memberikan/membaca materi pelajaran yang akan dibahas pada pertemuan saat ini. • Menjelaskan mekanisme pelaksanaan pembelajaran sesuai dengan langkah-langkah pembelajaran • Pembagian kelompok belajar.
Apersepsi	<ul style="list-style-type: none"> • guru memberikan gambaran awal tentang masalah transformasi yang ada kaitannya dengan kehidupan sehari – hari yang berkaitan dengan komposisi transformasi translasi dan refleksi, misalnya orang berpindah tempat atau bergeser, jam berputar, orang beracir, dll dengan memberikan beberapa pertanyaan – pertanyaan untuk kembali materi prasyarat dengan bertanya • Mengajukan pertanyaan berkaitan dengan pelajaran yang akan dilakukan.
Motivasi	<ul style="list-style-type: none"> • Memberikan gambaran tentang manfaat mempelajari materi transformasi geometri translasi dan refleksi • Apabila materi/tema/projek ini diikuti dengan baik dan sungguh-sungguh, maka peserta didik diharapkan dapat menjelaskan tentang: <ul style="list-style-type: none"> ✓ sifat-sifat translasi, refleksi berdasarkan pengamatan pada masalah kontekstual dan pengamatan objek yang berah di alam; ✓ konsep translasi, refleksi terkait dengan konsep matriks dengan benar (konseptual); ✓ konsep komposisi transformasi translasi dan refleksi dengan menggunakan matriks ✓ konsep translasi dan refleksi dari sebuah proyek yang telah dibuat. • Guru menyampaikan tujuan pembelajaran

2. KEGIATAN INTI

Tahapan EBL	Tahapan CCS	Aktivitas Guru dan Siswa
Fase 1 Reflection	Mengungkapkan konsepsi awal	<ul style="list-style-type: none"> • Guru membebas pertanyaan <i>ill-define problem</i> yang ditayangkan pada ppt: Pertanyaan 1 • Guru menampilkan gambar dan memberikan pertanyaan  • Apa yang dapat kalian amati dari gambar gambar di atas? Bentuk apa yang terus berulang-ulang pada gambar di atas? Apakah bentuk-bentuk tersebut memiliki kesamaan? Apakah bentuk yang memiliki kesamaan tersebut memiliki ukuran yang sama? Disebut apakah gambar-gambar di atas? Pertanyaan 2 • "Ketika kita berkunjung ke tempat penjualan keramik, terdapat berbagai jenis motif keramik yang sesuai estetika masing-masing pembuat" 1. Apakah ciri-ciri yang terdapat pada stuktur keramik yang terpasang di permukaan dinding? 2. Bagaimanakah struktur-struktur tersebut dibuat? 3. Pemasangan keramik yang menutupi semua permukaan dinding dikenal dengan sebutan apa? • Setelah mengungkapkan konsepsi awal mengenai fraktal geometri dan teselasi, Guru menyampaikan tugas proyek yang harus dibuat siswa "Teselasi Geometri Fraktal" • Setelah itu guru meminta siswa memilih konsep yang perlu dipelajari untuk memecahkan masalah. • Guru membagikan LKPD (Lembar Kerja Peserta Didik)

Fase 2 Research	<ul style="list-style-type: none"> • Guru memberikan kesempatan pada peserta didik mencari sumber-sumber informasi yang relevan • Peserta didik diberi latihan dalam menentukan rancangan yang akan dibuat serta sebagai langkah awal dalam menentukan desain proyek dengan cara: <ul style="list-style-type: none"> ✓ Mencoba • Peserta didik diminta untuk menggambar bentuk-bentuk bangun fraktal pada lembar portofolio. <ol style="list-style-type: none"> a. Menggambar bangun fraktal (segitiga Louvre) b. Menggambar bangun segitiga sierpinski c. Menggambar bangun fraktal (rubik 2x2x1) • Peserta didik diberi latihan sebagai konsep kunci dalam menentukan produk yang akan dibuat serta sebagai langkah awal dalam menentukan rancangan proyek dengan cara: <ol style="list-style-type: none"> 1. Guru menggring siswa menemukan konsep translasi dengan bantuan LKPD • Menanya Setelah siswa menunjukkan bangun yang mengalami pergeseran, siswa diberi pertanyaan mengenai: <ul style="list-style-type: none"> ✓ Cara menemukan sifat-sifat translasi berdasarkan pengamatan pada objek pada bidang koordinat (konseptual). ✓ Cara menemukan konsep translasi terkait dengan konsep matriks (konseptual). ✓ Cara menemukan konsep komposisi transformasi pada translasi (konseptual) ✓ Cara menemukan bayangan hasil translasi dengan menggunakan matriks (prosedural). 2. Guru menggring siswa menemukan pemecahan masalah pada translasi • Guru memberikan beberapa soal sebagai evaluasi pembelajaran dan meminta siswa untuk menjawab soal yang diberikan berdasarkan pengalaman belajar siswa
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<p>Fase 3 Discovery (35 menit)</p>	<p>Menciptakan ek2flik ek2stek1tual</p>	<ul style="list-style-type: none"> Setelah siswa menemukan konsep tranlasi dan refleksi melalui kegiatan yang tersusun pada LKPD, selanjutnya guru mengingatkan kembali tentang tugas proyek yang dipaparkan pada awal pembelajaran dengan: Menanya Melalui WA Grup Peserta didik diberikan pertanyaan mendasar mengenai tugas proyek yang telah diberikan pada pertemuan sebelumnya:
-----------------------------------------------------------------	-------------------------------------------------	---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

3. Penutup (10 menit) melalui GWA

Tahapan Pembelajaran	Aktivitas Guru/Siswa
Refleksi	<ul style="list-style-type: none"> Guru bertanya kepada siswa mengenai isi pembelajaran, dan masalah yang dihadapi siswa selama pembelajaran.
Penilaian	<ul style="list-style-type: none"> Peserta didik diberikan Latihan soal untuk dikerjakan setelah kegiatan pembelajaran ini ditutup pada jam aktivitas mandiri untuk mengetahui tingkat pemahaman siswa tentang materi yang dibahas. dikumpulkan melalui google clasrom (TPACK, Integritas) Guru mengingatkan peserta didik untuk membuat rancangan pembuatan proyek mengumpulkan pada papan padlet
Penyampaian materi selanjutnya	<ul style="list-style-type: none"> Guru menginformasikan bahwa pertemuan selanjutnya dilaksanakan secara tatap muka.

Figure 2. Design learning plan using the PjBBL-CCS model

During this phase, the lesson plan was validated. Validation data were obtained from two validators who assessed the feasibility and quality of the lesson plan from three aspects: content, media, and language, consisting of 15 assessment statements. The validators included one mathematics education lecturer and one mathematics teacher. During the validation of Prototype 1, several inputs and comments were provided, particularly regarding the lack of a clear reflection of cognitive conflict strategies in the core learning activities. It was also recommended that

learning objectives be explicitly stated for each session to ensure clarity of the desired outcomes. This serves as an indicator for improving the initial design to further align the learning process. This aligns with Husamah (2015), who emphasized that the development of learning media must take into account students' cognitive development levels and academic progress.

Based on input from the validators, the lesson plan was revised and adapted to a syntax that combines PjBBL with CCS, as follows:

Table 6. PjBBL-CCS syntax

Project-Based Blended Learning, Conflict Cognitive Strategy Syntax	
Project-Based Learning Phase	Conflict Cognitive Strategy Phase
1. Starts With the Essential Question	1. Exposing an alternative framework
2. Design a Plan for the Project	2. Creating conceptual cognitive
3. Creates a Schedule,	
4. Monitor the Students and Progress of the Project	3. encouraging cognitive accommodation
5. Assess the Outcome	
6. Evaluate the experience	

Based on the table above, the following explains the steps of the CCS PjBBL in implementing learning.

Starts with the Essential Questions: Exposing alternative frameworks. At this stage, the teacher introduces the topic to be studied, motivates students, and assesses students' perceptions by asking fundamental questions to guide their activities.

Design a Plan for the Project: Creating Conceptual Cognitive Skills. At this stage, students begin completing project assignments in the form of problems that present conceptual obstacles. Students develop a plan to solve the assignment with the groups they have formed.

Monitor the Students and Progress of the Project: The teacher monitors students in project implementation using a project assessment sheet

that can track overall student activity. The following is an example of a project assessment sheet.

Assess the Outcome and Evaluate the Experience. Encouraging cognitive accommodation is the final step in the learning

LEMBAR PENILAIAN PROYEK				
Judul proyek			
Waktu Pelaksana			
Kelompok			
No	Indikator Penilaian	Penilaian		
		1	2	3 4
A	PERENCANAAN			
1	Persiapan alat dan bahan			
2	Rancangan: a. Gambar rancangan b. Alur kerja dan deskripsi c. Penggunaan alat			
B	HASIL AKHIR/PRODUK			
1	Bentuk fisik			
2	Inovasi alat			
C	LAPORAN			
Laporan dibuat dengan kriteria: a. Kebermanfaatan laporan b. Sistematis laporan c. Penulisan kesimpulan				

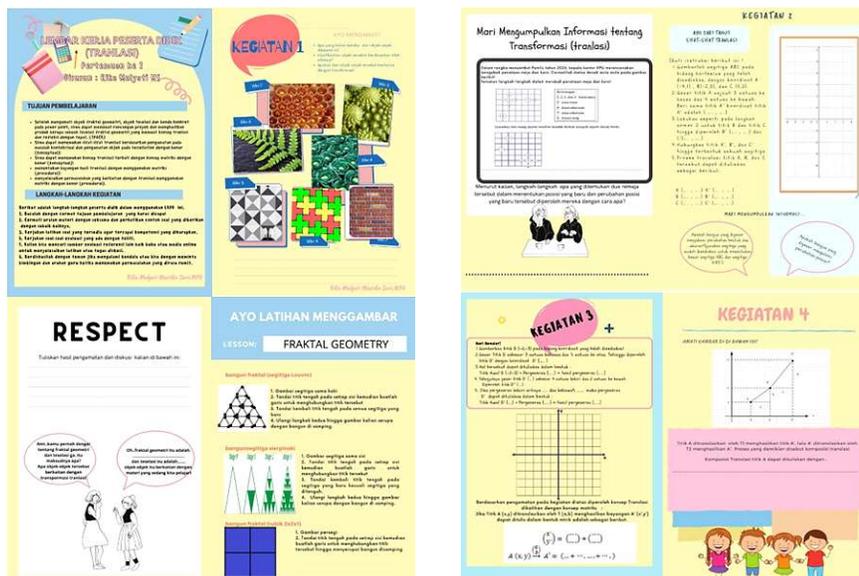
Keterangan: * berilah tanda check (✓) pada kolom yangn sesuai.

Figure 3. Project assessment sheet

process. The teacher and students reflect on the project’s activities and outcomes. Students explain concepts underlying conflict resolution.

After the lesson plan was revised in response to the validator’s input, the next step was to develop the PjBBL-CCS module for geometric transformations. Module development followed the lesson plan structure and highlighted aspects of cognitive conflict strategies. The

module was designed for both online and offline use. In developing the e-learning materials, researchers used an existing online learning platform, Google Classroom. After the module was completed, a self-evaluation was conducted to verify the product. After the self-evaluation was completed, it was submitted for expert validation and feedback. The following is a screenshot of the validated and revised module:



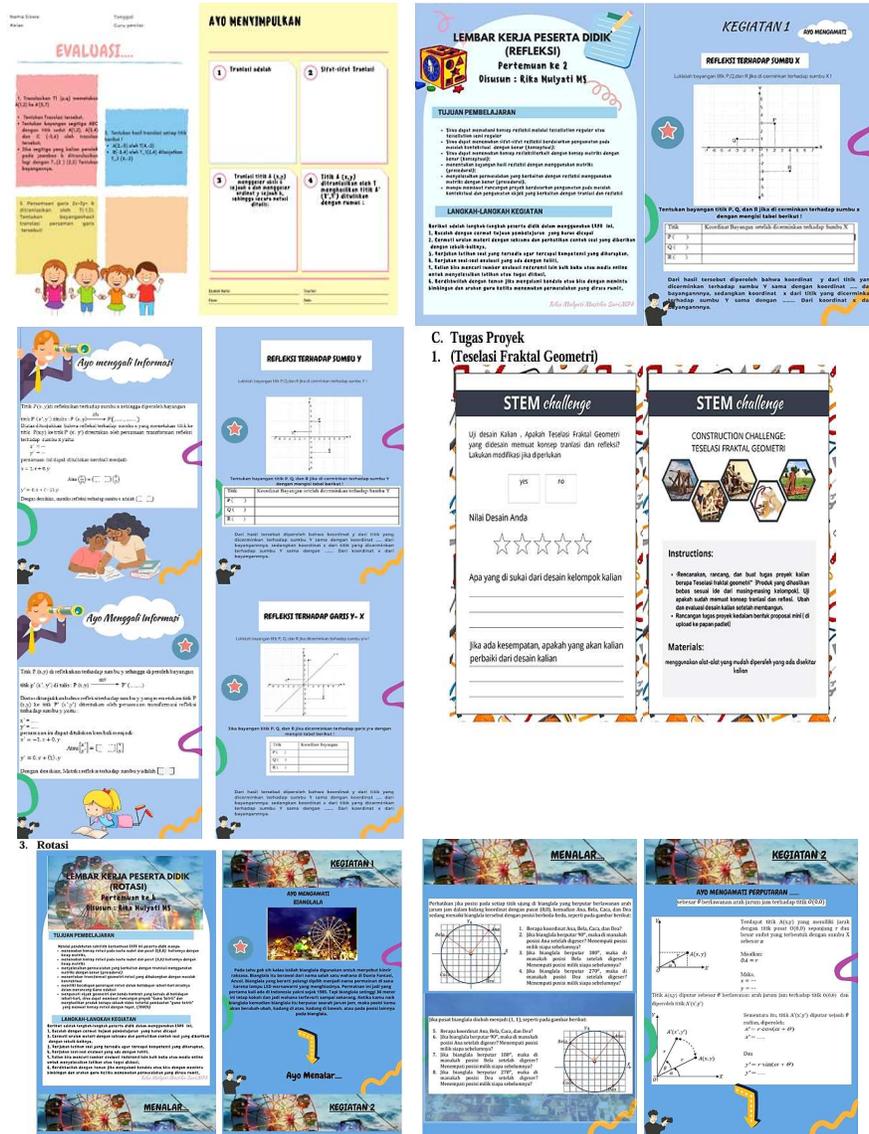


Figure 4. Example of validated PjBL-CSS module display

At the prototype stage, the module was validated by three validators (two mathematics education lecturers and a mathematics teacher), using 15 statements covering four criteria for

material experts and three criteria for media experts. The following are the validation results for the module, as assessed by material and media experts.

Table 7. Validation results of module by material experts

No	Criteria	Average Criteria	Information
1	Content suitability	0.86	Valid
2	Presentation suitability	0.82	Valid
3	Language eligibility	0.85	Valid
4	Contextual assessment	0.83	Valid
	Average	0.84	Valid

The validation of the teaching module by material experts for each component was categorized as valid. Furthermore, the results of the validation of the teaching module by media experts are presented in the following table:

Table 8. Results of validation of module by media experts

No	Criteria	Average Criteria	Information
1	Font and image size	0.82	Valid
2	Cover design	0.86	Valid
3	Content design	0.88	Valid
	Average	0.85	Valid

The table above shows that the media experts' validation of the learning module for each component is valid. The validation results from the material and media experts indicate that the learning module is valid. However, several materials and media experts provided suggestions for improvement. Table 10 presents the experts' suggestions and the resulting module revisions.

Table 9. Expert suggestions and module revision results

No	Before Revision	Validator Suggestion	After Revision
1	There are no activity steps at each meeting.	The module needs to be simplified and made consistent across meetings in its appearance to suit the characteristics.	Each meeting is equipped with clear learning objectives and activity steps.
2	The problem presented is not structured.	Illustrations, user instructions, and learning activity flows should be designed to support the implementation of the cognitive conflict strategy, namely by presenting problems that elicit students' cognitive conflicts.	After the module's learning objectives are met, reasoning activities are introduced to stimulate students and elicit cognitive conflict.
3	There are no instructions yet on where to collect project assignments.	It is recommended that project assignments be structured according to the stages of developing students' mathematical abilities, through discussion, problem solving, and the presentation of project results, and that the instructions provided be clear.	The instructions and steps in the project tasks have been revised to suit the objectives to be achieved.

The image above depicts the module design, adjusted in response to input from the validator. After implementing the validated improvement steps, the next step was to conduct one-on-one and small-group evaluations. The one-on-one evaluations were conducted with three eleventh-grade students selected by the teacher. The one-on-one and small-group evaluations are described in the Pilot Study section to test the instrument's feasibility.

Pilot Study

A pilot study was conducted to assess the initial feasibility of the Project-Based Blended Learning (PjBBL) teaching module using a cognitive conflict strategy, to identify implementation constraints, and to assess understanding of the media and research instruments. In the evaluation stage, a trial was conducted on Prototype 2 to assess the practicality and initial effectiveness of the PjBBL

model with a cognitive conflict strategy. The trial consisted of two stages: a one-on-one trial and a small group trial. The one-to-one evaluation process was conducted offline, namely, face-to-face with each student in turn. The process of implementing the one-to-one evaluation is shown in the figure below.



Figure 5. Implementing the one-to-one evaluation

The image above depicts the process of implementing a one-to-one evaluation for each student. Students were introduced to the module's purpose and objectives. The researcher asked students to understand the module's content and to read and comprehend the activities. Next, the researcher asked students to solve problems within the module. The researcher noted any obstacles encountered during the module's activities. The researcher also asked students about any sentences they did not understand. The process of implementing the one-to-one evaluation for each meeting and activity is outlined below.

In Activity 1, students were asked to observe fractal objects and determine their patterns. Activity 1 proceeded smoothly, with only one student failing to complete it.



Figure 6. Activity 1

In Activity 1, students were asked to observe fractal objects and determine their patterns. Activity 1 proceeded smoothly, with only one student failing to complete it. In Activity 2, students were asked to observe the position of a point in Cartesian coordinates and collect information on translation. In this activity, all students understood and completed the

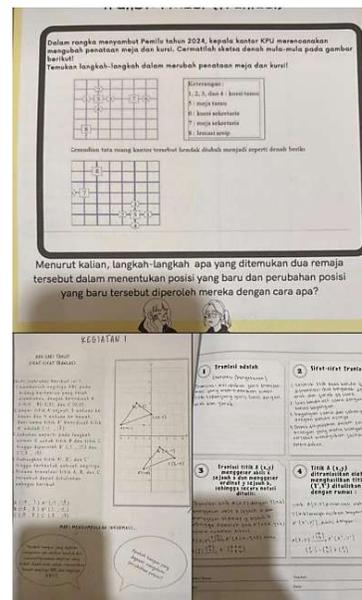


Figure 7. Activity 2

instructions. For activities 3-4, all students had no difficulty completing the instructions in the module. After completing the one-on-one evaluation, students were given a questionnaire assessing the practicality of the module. The following table presents the results of student responses to the practicality of the module:

Table 10. Student responses to the practicality of the module in the one-two-one evaluation

No	Criteria	Percentage (%)	Category
1	Presentation	88.33	Highly Practical
2	Language	86.67	Highly Practical
3	Content	83.33	Practical
4	Time	68.33	Less Practical
	Average	81.65	Practical

Based on student responses to the one-to-one and small-group evaluations of the practicality of the developed module, it can be concluded that the e-module is in the practical category, with an overall average score of 78.96%. Furthermore, a small-group trial was conducted with 10 grade XI high school students to assess

the practicality of the module using a student response questionnaire. At this stage, students were permitted to access, study, and understand the developed project-based module. The following is a description of the stages carried out in the small group trial:



Figure 8. Limited trial with eleventh-grade senior high school students



Figure 9. Main task (project task) view and project worksheet



Figure 10. Student activities and project plan design results

Figure 10 is Design a plan for the project, creating conceptual cognitive, at this stage collaborative planning is carried out between teachers and students and the design of the project plan that has been made is uploaded on the padlet

board with the aim that each group can know the project theme that will be made by other group members so that from the project assigned by the teacher several different kinds of products can be obtained.



Figure 11. Student activities in presenting project results

The image above shows the “Assess the Outcome” and “Encouraging Cognitive Accommodation” stages. At this stage, students present the results of their discussions as each

group’s product. The teacher’s role is to evaluate student progress, provide feedback on the level of understanding, and administer assessments according to the rubric.

For the student activities in Figures 9, 10, and 11, the project assessment follows the rubric in Figure 3, covering aspects of planning, final results or products, and student reports. In general, the results show that most students can design systematically by determining basic shapes, repeating patterns, and applying geometric transformations. The application of cognitive conflict strategies encourages students to revise their initial understanding when the designs they create do not adhere to the principles of tessellation and fractals, leading to conceptual adjustments through reflection and discussion. This is reflected in the final product that meets the accuracy of shape, regularity of pattern, and

consistency of repetition. In addition, the project report shows that students can coherently explain changes in their understanding and the mathematical concepts used. However, for some students, the depth of analysis remains insufficient. Overall, the project results are in the good category and demonstrate the role of cognitive conflict strategies in supporting the development of students' mathematical spatial literacy.

After the 10 students had examined and understood the teaching module and e-LKPD, they were given a response questionnaire to evaluate the module and provide feedback. The students' responses were processed and are presented in Table 11.

Table 11. Student responses toward the learning module

Student	Actual Total Score	Criteria	Student	Actual Total Score	Criteria
Student 1	85	Practical	Student 6	86	Highly Practical
Student 2	88	Highly Practical	Student 7	88	Highly Practical
Student 3	89	Highly Practical	Student 8	87	Highly Practical
Student 4	88	Highly Practical	Student 9	80	Practical
Student 5	88	Highly Practical	Student 10	84	Practical
Average				86.3	Highly Practical

Based on Table 11, out of ten students, seven rated the module as highly practical, while the remaining three rated it as useful. Overall, the ten students obtained an average score of 86.3, indicating that the developed teaching module met the practicality criteria and was categorized as highly practical.

Consistent with the questionnaire results in Table 12, student interviews indicated that the Project-Based Blended Learning module and the e-LKPD (Worksheet) with a cognitive conflict strategy were considered easy to understand and practical to use. Students reported that the initial learning problem sparked curiosity and fostered critical thinking and group discussions throughout

the project. However, some students suggested that the instructions and the project flow be clarified to facilitate independent learning. Here are some excerpts from student interviews:

“I became more interested because I was given a problem that piqued my curiosity right at the beginning of the lesson. Group discussions helped me understand the material, although I was a bit confused about the project steps at first.” (Student S4)

“I found the module easy to understand, and the e-LKPD was helpful during group work. If the instructions were made shorter and clearer, I think it would be even easier.” (S10)

Based on the results of student responses in the one-to-one evaluation and small group evaluation of the practicality of the developed module, it can be concluded that the module is in the practical category in the one-to-one evaluation, with an overall average value of 81.65%, and the very practical category in the small group evaluation, with an overall average value of 86.3%. This means that the module can be used to implement PjBBL-CCS learning to improve mathematical spatial literacy.

Assessment (Effectiveness Test Results)

After the one-to-one and small-group evaluation stages were deemed practical and highly practical, a larger-scale effectiveness test was conducted with 36 eleventh-grade students

to assess the product's effectiveness in improving mathematical spatial literacy. The trial consisted of six sessions, including a pretest and a posttest. First, all students were instructed to complete a three-question pretest on mathematical spatial literacy. After all students completed the pretest, they used the module for four sessions. Students were able to use the teaching module independently, both online and offline, without difficulty, as each had their own smartphone and could review the material repeatedly. After completing the four sessions using the PjBBL module, students were administered a posttest on mathematical spatial literacy. The pretest and posttest results were then analyzed using SPSS, and the findings are presented in Table 12.

Table 12. Descriptive statistics of mathematical spatial literacy ability

	Data	Student Group
	N	36
<i>Pretest</i>	Minimum Value	41
	Maximum Value	62
	Mean	52.68
<i>Posttest</i>	Minimum Value	78
	Maximum Value	96
	Mean	88.66
<i>N-gain</i>	Minimum Value	0.63
	Maximum Value	0.90
	Mean	0.77

Based on the results of descriptive statistics calculations for Mathematical Spatial Literacy, there was an average difference in students' abilities from the pretest to the posttest. Referring to Table 2. Based on the criteria for grouping students' pretest results on mathematical spatial literacy, the majority of students were in the medium and high categories; however, in the posttest results, most students moved to the very high category. This improvement indicates the effectiveness of the cognitive conflict strategy, which places students in conflict between their initial understanding and the demands of problem

solving. Through reflection, discussion, and revision of solutions, students develop a more precise conceptual understanding, resulting in optimal and even development of mathematical spatial literacy skills across all ability categories. Furthermore, to demonstrate the difference, a paired-samples test was conducted to examine the relationship between students' pretest and posttest scores in mathematical spatial literacy. The results are as follows:

Based on the "Paired Samples Test" output table above, the Sig. (2-tailed) value is 0.002 < 0.05, so H_0 is rejected, and H_a is accepted. It

Table 13. Paired samples test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Pretest - Posttest	-35.972	6.876	1.146	-38.299	-33.646	-31.388	35	.000

can be concluded that there is a statistically significant difference between the learning outcomes of the Pre Test and Post Test, indicating that the PjBBL-CCS module improves mathematical spatial literacy. To find out how significant the effect of PjBBL-CCS is on students' mathematical spatial literacy abilities,

researchers used Cohen's d formula by comparing the average pretest and posttest scores. The calculation results indicate an effect size (Cohen's d) of 0.82, which falls within the large category. Furthermore, to see the linear relationship between pretest and posttest scores, this can be checked using the following scatter plot:

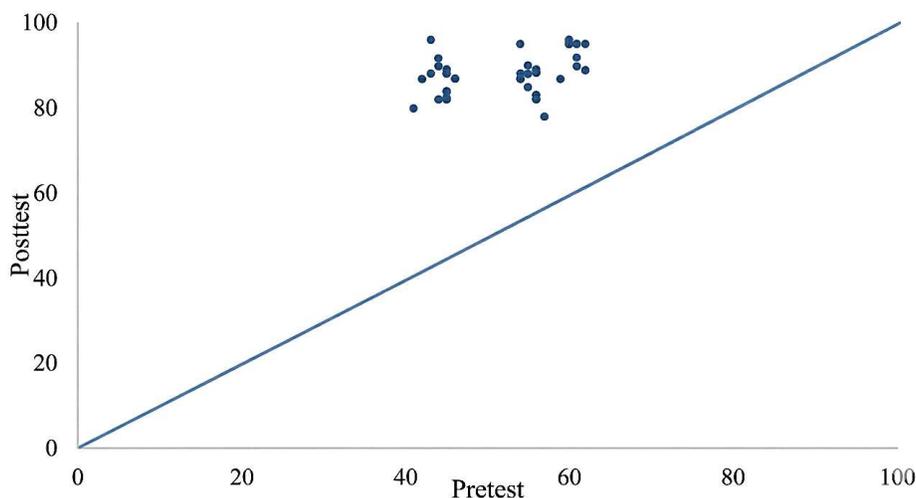
**Figure 12.** Scatterplot of pretest and posttest scores

Figure 12 shows a scatterplot of the total pretest and posttest scores. The graphs indicate that the regression slopes are similar, suggesting a moderate positive correlation between pretest and posttest scores and, consequently, agreement between them.

Next, the results of the students' mathematical spatial literacy test were analyzed based on the upper, middle, and lower categories. The findings of this study align with previous research, which concluded that project-based learning designed to elicit cognitive conflict

significantly improves students' mathematical abilities. The paired-sample test results, which showed a significant difference between pretest and posttest scores, support the findings of Madu and Orji (2025) and Prayogi et al. (2020), who emphasized that cognitive conflict strategies contribute to knowledge construction through assimilation and accommodation. During the assimilation stage, new information is integrated into students' existing cognitive structures, whereas discrepancies prompt accommodation to reconstruct conceptual understanding. The

relatively large effect size (Cohen's $d = 0.82$) also aligns with the findings of Gao and Zhang (2023), who demonstrated that project-based learning is effective in developing mathematical literacy. Through this approach, students are actively engaged in higher-order thinking processes, from problem identification to complex problem solving, thereby supporting the development of a deeper understanding of mathematics (Alenezi, 2023; Gao & Zhang, 2023). Thus, the results of this study further

strengthen the empirical evidence that integrating the PjBBL-CCS module is effective in improving students' mathematical spatial literacy, both statistically and pedagogically.

After obtaining the research results described above, the researchers then analyzed the achievement of each indicator of mathematical spatial literacy among students in the moderate, high, and very high groups. The percentage achievement of each indicator is presented in the following table.

Table 14. Results of students' achievement of mathematical spatial literacy indicators

No	Indicator	Very low	Low	Medium (2 Students)	High (3 Students)	Very High (31 Students)
1	Identify aspects of an object in vertical and horizontal positions in mathematical language using appropriate symbols, images, or models.	-	-	50 %	66.6 %	100 %
2	Observing and identifying aspects of a structure in various situations/viewpoints	-	-	0 %	33.3 %	83.8 %
3	Applying appropriate mathematical strategies to illustrate the process of forming or changing the arrangement of a figure using geometric representations in the process of finding a solution.	-	-	50 %	66.6 %	96.7 %

Based on the table of the percentage distribution of spatial literacy indicator achievement by student category, a 100% stacked bar chart will be presented to illustrate the percentage distribution of students in each category for each indicator.

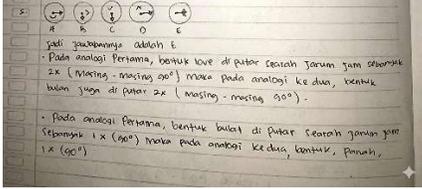
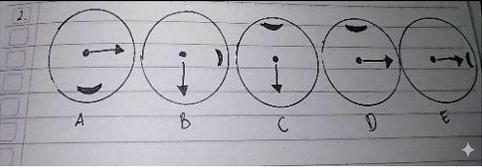
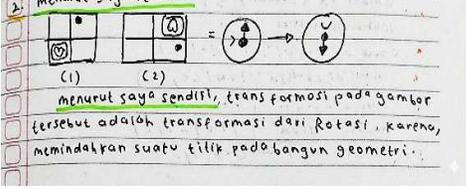
Moreover, the results of the analysis of the achievement of mathematical spatial literacy indicators indicate a strong relationship with the stages of cognitive conflict strategies: revealing alternative frameworks, creating conceptual cognitive conflict, and encouraging cognitive accommodation. In Indicator 1, the achievement of students in the very high group of 31 students (100%) and students in the high group of 2 students (66%) indicates that students can revise

their initial framework after conceptual conflict, thus successfully accommodating the concept of vertical and horizontal positions into appropriate mathematical representations. In contrast, the achievement of students in the medium group is only 1 student (50%), indicating that accommodation is not optimal. In Indicator 2, the achievement of students in the very high group (26 students; 83.8%) reflects the success of conceptual conflict in challenging initial perceptions of various points of view. However, the achievement of students in the high group is only 1 student (33.3%), indicating limitations in integrating the conflict results into a comprehensive understanding. Furthermore, in Indicator 3, the achievement of students from the

very high group was 30 students (96.7%) and students from the high group were 2 students (66.6%) which confirmed the role of the cognitive accommodation phase in the application of geometric strategies and representations, while the medium group (50%) still needed reinforcement at the conceptual adjustment stage.

Based on Table 16, the achievement of Indicator 2 in the very high and high groups showed a tendency to be lower than the other two indicators. Therefore, the researchers conducted further analysis of student responses in the very high, high, and medium groups as samples for an in-depth study.

Table 15. Results of the spatial literacy test indicator no 2

Group	Example of students' answer
Very High	 <p>Students in the very high group can internalize abstract concepts in depth; namely, they can test, generalize, and reflect on the concept of transformation geometry across various contexts and representations.</p>
High	 <p>Students in the high group have demonstrated a strong ability to understand abstract concepts; they are also more consistent in associating visual representations with geometric principles.</p>
Middle	 <p>Students in the medium group continue to have difficulty constructing abstract concepts, particularly in understanding the geometric concept of rotational transformation.</p>

Analysis of student responses indicated alignment with theory and prior research on spatial literacy and project-based learning employing cognitive conflict strategies. Students in the medium group demonstrated a gradual development of spatial abilities, from visual experience to abstract understanding (Siagian et al., 2019; Madu & Orji, 2025). In the high group, student responses demonstrated the ability to revise initial understanding through structured cognitive conflict, consistent with findings that PjBL containing conceptual conflict is effective in improving spatial visualization and reasoning (Nadzeri et al., 2024). Meanwhile, the representational flexibility and strategic accuracy

of the very high group reflected deeper conceptual accommodation and spatial generalization (Mandala, 2025).

Differences in the quality of spatial literacy problem-solving across ability groups indicate varying levels of students' spatial thinking skills. Students in the upper group were able to present appropriate illustrations or models, understand relationships among spatial elements, and provide logical interpretations and conclusions supported by examples. Students in the middle group tended to focus on the final result without providing adequate explanation or rationale, thereby preventing the explicit communication of the reasoning process. Meanwhile, students in the

lower group demonstrated limited understanding of the problem context, as evidenced by less effective answers and inaccurate use of visual representations.

Implications for Practice

This research suggests that learning with the PjBBL-CCS module can serve as an alternative, with instruction delivered both online and offline. Learning through this module will provide experience and train students to develop mathematical spatial literacy skills, particularly in geometric transformations. Furthermore, the developed module can serve as a tool for teachers and researchers to develop and train students' abilities to achieve mathematical spatial literacy. Theoretically, this research implies that the resulting learning module is valid, practical, and effective because it undergoes preliminary research, prototyping, and evaluation, thereby supporting meaningful learning designs that improve students' mathematical spatial literacy.

Based on the findings obtained from the research, the authors recommend the following: the learning module needs to be tested in madrasas and private schools to determine its effectiveness for use in these schools; the developed learning module needs to be adapted to the students' conditions, both in terms of supporting facilities and students' skills in using technology; and teachers are required to be prepared in terms of pedagogical aspects, time management, and assessment of student learning outcomes.

Limitations of the Study

This study has several limitations. First, the pilot study was conducted in only one class, so the findings cannot be generalized to the entire population of high school students in Bandung Regency. Second, the mathematical spatial literacy test used comprised only three questions, thereby not fully covering all indicators of spatial literacy. Furthermore, qualitative data were collected through semi-structured interviews with teachers

and students, the depth of which depended on respondents' ability and willingness to share their experiences and perspectives. These limitations indicate that while this study provides a meaningful initial picture of students' mathematical spatial literacy abilities at SMA Negeri 1 Cicalengka, the results are not fully representative of conditions in other schools. Therefore, further research is recommended to include more schools, examine student characteristics in greater depth, and employ a wider range of mathematical spatial literacy questions to develop a more comprehensive understanding of the factors influencing these abilities.

■ CONCLUSION

Based on the data collection process, analysis of research results, and discussion referring to the problem formulation, the following conclusions can be drawn: 1) The PjBBL-CCS module was developed in line with the achievement of students' spatial literacy abilities. The module design accounts for students' spatial literacy characteristics and the needs of teachers and students in learning, to minimize students' learning difficulties, particularly in geometric transformation materials. 2) The evaluation results show that the developed learning module is suitable for use, as reviewed from the criteria of validity, practicality, and effectiveness. The validity of the module is based on assessments by material and media experts covering content, presentation, language, context, and design. Practicality is demonstrated by students' responses regarding presentation, language, content, and learning time. The effectiveness of the module is demonstrated by an increase in students' spatial literacy, with high N-gain and a large effect size. 3) The developed learning module can be used as a learning and research facility for teachers and researchers to train and improve students' spatial literacy abilities. 4) This module has implications as an innovative learning product that can be implemented flexibly in mathematics learning, both

online, offline, and blended, as well as being a learning resource and supporting tool for teachers and researchers in designing learning oriented towards strengthening mathematical spatial literacy.

This research also has several challenges that occur during the development and implementation process, namely the limited data that truly shows the real conditions in the classroom, as well as the implementation of the module in real classes, namely the limited learning time, teacher and student readiness, and control of external variables that can affect the practicality and effectiveness of the module. However, this research is novel in integrating Project-Based Blended Learning (PjBBL) with the Cognitive Conflict Strategy (CCS) approach to develop a learning module that improves mathematical spatial literacy, thereby making theoretical and practical contributions to mathematics learning, particularly in geometric transformation.

■ DECLARATION OF GENERATIVE AI USAGE IN THE WRITING PROCESS

During the writing of this manuscript, the author employed Generative AI to assist with proofreading. The authors have reviewed and edited the content generated by this tool and assume full responsibility for the content of the published article.

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