Premiere Educandum JURNAL PENDIDIKAN DASAR DAN PEMBELAJARAN PE

Premiere Educandum: Jurnal Pendidikan Dasar dan Pembelajaran
Volume 14 (2) 138 – 155 December 2024
ISSN: 2088-5350 (Print) / ISSN: 2528-5173 (Online)
Doi: 10.25273/pe.v14i2.21314
The article is published with Open Access at: http://e-journal.unipma.ac.id/index.php/PE

STEM: Project based learning to enhance conceptual understanding of two-dimensional shapes and and develop the pancasila student profile

Ukhti Raudhatul Jannah ✉, Universitas Madura
Ainur Rofiq Hafsi, Universitas Madura
Sri Indriati Hasanah, Universitas Madura
Hasan Basri, Universitas Madura
Septia Nurhidayati, Universitas Madura
Akhmad Riski Rifanda, Universitas Madura
Sisca Patricia Dwi Agustin, Universitas Madura

✉ ukhti_math@*unira.ac.id*

Abstract: This study aims to explore the conceptual understanding of shapes through the integration of STEM with Project-Based Learning (PjBL) in enhancing elementary students' understanding of two-dimensional shapes and developing the Pancasila Student Profile. The research approach of this study is qualitative. Data collection techniques employed in this study include interviews, observations, and analysis of student work. The subjects of this research are three second-grade students who face difficulties in understanding the concepts of two-dimensional geometry. The research findings indicate that the STEM-integrated PjBL approach can The research findings describe that after the STEM integrated PjBL approach students can fulfill 4-7 indicators of concept understanding, namely presenting concepts in various mathematical representations, developing necessary and sufficient conditions for a concept, using, exploiting and selecting certain operations and applying concepts to problem solving Additionally, PjBL-STEM fosters character development pancasila student profile such as collaboration, critical thinking, and creativity.

Keywords: Conceptual Understanding; STEM; Project based learning; Kites-making; Profile of Pancasila Students

Received 28 November 2024; **Accepted** 20 February 2025; **Published** 26 February 2025

Citation: Jannah, U.R., Hafsi, A.R.. Hasanah,S.I., Basri, H., Hidayati, S.N., Rifanda, A.R., Agustin, S.P.D.. (2024). STEM: Project based learning to enhance conceptual understanding of two-dimensional shapes and and develop the pancasila student profile. *Premiere Educandum : Jurnal Pendidikan Dasar dan Pembelajaran*, *14*(2), 138 – 155. Doi.org/10.25273/pe.v14i2.21314

INTRODUCTION

Conceptual understanding is a foundation that must be mastered, including in mathematics education. Mathematical conceptual understanding is not only about what is done but also why it is done (Jannah, Hafsi, & Nurhidayati, 2023). Through conceptual understanding, students can grasp why and how a mathematical concept works. Students with a strong conceptual understanding tend to be more effective in solving mathematical problems, especially those requiring critical thinking and the application of diverse concepts (Kholid, Imawati, Swastika, Maharani, & Pradana, 2021). Differences in concept understanding among students are also influenced by varying cognitive styles (Kusumaningsih, Saputra, & Aini, 2019)and gender (Mahfud, Mardiyana, & Fitriana, 2021). Furthermore, the importance of teacher training focused on teaching for conceptual understanding is also crucial, using relevant methods in the learning process (O'Dwyer, Wang, & Shields, 2015).

In mathematics, understanding one concept is closely related to understanding other mathematical concepts, as true comprehension involves a deep interpretative process and the interconnection between concepts (Schaathun, 2022). Therefore, it is essential for students to grasp mathematical concepts from an early age, starting in elementary school. Several studies on elementary students' mathematical concept comprehension have been conducted by experts. Generally, these studies examine aspects of learning mathematical concepts, learning media, scaffolding, and instructional design (Herner-Patnode & Lee, 2021)(Mellroth, Bergwall, & Nilsson, 2021) (Gervasoni, Roche, & Downton, 2021)(Ziernwald, Hillmayr, & Holzberger, 2022) (Ryan & Bowman, 2022) (Naibaho, 2023). Issues with understanding mathematical concepts in geometry are common among elementary students, often acting as foundational barriers to their math achievement (Boglárka Brezovszky, Jake McMullen, Koen Veermans, Minna M. Hannula-Sormunen, Gabriela Rodríguez-Aflecht, 2019; (Jannah, Putra, Hafsi, & Basri, 2021)(Aebli, Volgger, & Taplin, 2022)(Vergnaud, 2020)(Widodo, Pangesti, Istiqomah, Kuncoro, & Arigiyati, 2020). In addition, observations and tests of students' conceptual understanding of plane geometry were conducted at an elementary school, namely SDN Pademawu Timur V. The test was administered to determine whether students could recognize various types of plane figures before the implementation of STEM-PjBL. The results revealed that 88% of students were able to identify plane figures based on their images, but only 12% could identify them based on their characteristics and properties. This indicates that students do not yet fully understand the in-depth concepts of various plane figures, as they are only able to differentiate but not explain them. In fact, students are considered to have conceptual understanding if they can restate a concept or material they have learned. The following are the 12% of students, or 3 out of 26, in this category:

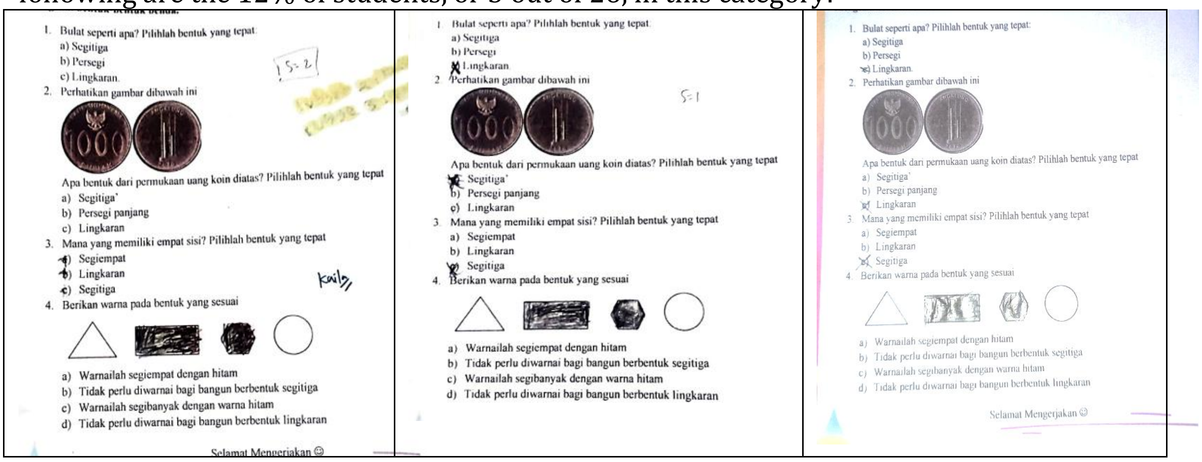


FIGURE 1. *Diagnostic test results before STEM-PjBL*

Therefore, addressing these conceptual issues in geometry is essential and urgent. The urgency of conceptual understanding skills aids students in finding meaning in learning mathematics (Nasution & Lailia, 2023). The National Council of Teachers of Mathematics (2000) states five standards of Mathematics Learning Principles, one of which is conceptual understanding, also known as understanding of concepts. Enhancing conceptual understanding in geometry can be supported through classroom learning. Geometry lessons are designed to align with the characteristics and learning needs of elementary students, beginning with concrete objects (Widodo et al., 2020)(Leton, Djong, Uskono, Dosinaeng, & Lakapu, 2020)(Raudhatul Jannah, Amiruddin, & Nurhidayati, 2022). In developing conceptual understanding in mathematics, teachers play a crucial role by using active learning methods, such as project-based learning (Widiyatmoko & Shimizu, 2018). Students' inability to comprehend concepts and solve problems often stems from conventional mathematics teaching methods (Jazuli, Setyosari, Sulthon, & Kuswandi, 2017).

One teaching method that can enhance conceptual understanding in mathematics is Project-Based Learning (PjBL), as projects encourage students to creatively and collaboratively apply mathematical theories and concepts, supporting deeper and more relevant learning (My Nguyen, Chau Nguyen, Hong Thai, Truong, & Nguyen, 2024). PjBL is effective in providing students with opportunities to apply mathematical concepts in real-world project contexts, which, in turn, helps reinforce their understanding and skills (Yunita, Juandi, Kusumah, & Suhendra, 2021). Project-based learning demonstrates improvements in problem-solving skills, critical thinking, and conceptual understanding in mathematics (Lazić, Knežević, & Maričić, 2021). Furthermore, this approach is well-suited for elementary school students, who are still in the concrete learning stage. To ensure PjBL's effectiveness, projects should engage students in exploration, challenge them, connect to their prior experiences, and capture their interest (Jacques, 2021). Therefore, PjBL is suitable for integration with STEM in elementary learning activities to construct students' conceptual understanding based on their initial knowledge. STEM enables students to understand how concepts from various disciplines are interrelated, helping them comprehend practical applications of theories learned in class (Thibaut et al., 2018). At the elementary level, STEM integration significantly enhances students' understanding of mathematical concepts compared to traditional teaching methods (Chine & Larwin, 2022). Some studies by (Han et al. 2016; Mayerhofer, Lüftenegger dan Eichmair 2024) highlight the importance of supporting teachers and educational institutions in studying and exploring STEM disciplines.

Incorporating students into STEM-integrated project-based learning on understanding geometric shapes can be achieved through a project like kite-making. STEM stands for Science, Technology, Engineering, and Mathematics (Sevimli & Ünal, 2022). Science involves observation, analysis, experimentation, and processes to form or explain new knowledge (Kozhuharova & Zhelyazkova, 2021). In this study, the Science aspect allows students to observe and experiment with different kite shapes to see how slight changes in form or size can affect height and stability in flight. Technology refers to tools used to achieve learning objectives. In this study, the technology aspect includes using simple tools like rulers, scissors, and materials such as paper, bamboo, or plastic to create kites. Engineering involves the design and assembly process. Here, students design kite shapes, considering proportions, angles, and balance for stability in flight. They learn to measure and cut materials precisely, build the frame, and tie strings to ensure efficient flight. Mathematics, specifically geometry, is applied to understand shapes like squares, triangles, and parallelograms that form the kite, allowing students to build experiences and construct new science and mathematics knowledge (Kelley & Knowles, 2016). Through kite-making, students can develop a deeper understanding of geometric concepts.

The STEM-integrated Project-Based Learning (PjBL) approach centers on students with practical activities, fostering teamwork, communication, and knowledge construction

(Samsudin, Jamali, Zain, & Ebrahim, 2020). This also nurtures the Pancasila Learner Profile traits, such as collaboration, critical thinking, and creativity. Studies on the Pancasila Learner Profile in Indonesian geometry learning cover aspects of character-building in mathematics education (Jamaludin, Alanur S, Amus, & Hasdin, 2022)(Tristiana & Surakarta, 2023) and the development of mathematics learning and conceptual understanding through the Pancasila Learner Profile (Putri, Efendi, & Aini, 2023)(Jannah et al., 2023). However, research on project-based learning integrated with STEM for geometry through kite-making in elementary schools to instill Pancasila Learner Profile character traits has yet to be found. Thus, the novelty of this research is STEM-integrated project-based learning for understanding geometry concepts while instilling the Pancasila Learner Profile through kite-making. This research is expected to make a positive contribution to education and the development of mathematics learning. Based on these issues, the research question is: How does understanding geometric concepts in STEM-integrated project-based learning help instill the Pancasila Learner Profile?

METHODS

Research Design

This study is a qualitative research aimed at understanding elementary students' conceptual understanding of two-dimensional shapes through project-based learning integrated with STEM, with the goal of instilling the characteristics of the Pancasila Student Profile.

Participant

The subjects of this study are three out of twenty-six second-grade students from SDN Tambaan II, who were taught using a STEM-integrated PjBL approach. The subjects were selected based on the frequency of their errors in understanding plane geometry concepts, indicating a lack of initial comprehension of these concepts.

Material

The instruments in this study include a cognitive diagnostic assessment sheet (as a pre-test) administered before implementing the STEM-integrated PjBL, a Student Worksheet (LKPD) for assembling and creating kites during the STEM-integrated PjBL learning activity, and a post-test assessment sheet provided after the PjBL-STEM learning session. Figure 2 shows examples of questions for the pretest and posttest that will be given to students. Student test results in this study were analyzed using 7 indicators of concept understanding (seen in table 1). The reflection of the Pancasila profile in students is analyzed using Pancasila profile indicators (seen in table 2)

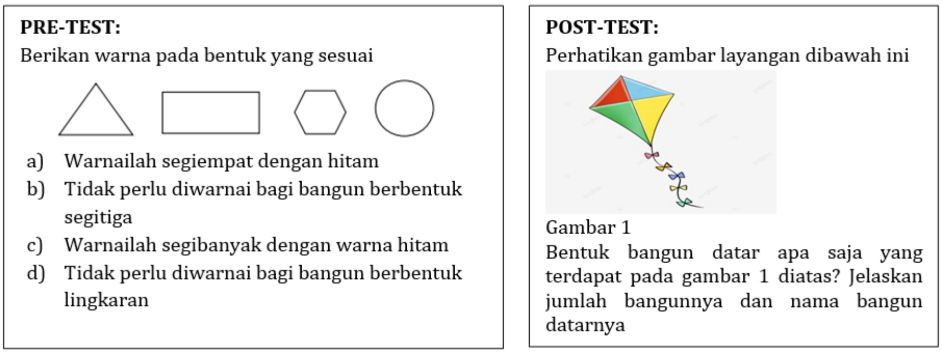


FIGURE 2. *Example of pretest and post test questions*

TABLE 1. *Indicators of conceptual understanding in STEM-integrated project-based learning through kite-making*

	Indicator	Description
1.	Restating a concept.	- Students are able to restate the definition of two-dimensional shapes. - Students are able to identify types of two-dimensional shapes based on images.
2.	Classifying objects according to certain properties (according to the concept).	- Students are able to group flat shapes based on the characteristics and properties of flat shapes.
3.	Providing examples and non-examples	- Students are able to provide examples of images of quadrilaterals and non-quadrilaterals.
4.	Presenting a concept in various mathematical representations.	- Students are able to design a kite plan that will be made according to the flat shapes presented in the student worksheets.
5.	Developing necessary and sufficient conditions for a concept.	- Students are able to use the concept of the number of sides in flat shapes to create an accurate and appropriate kite framework as desired.
6.	Using, utilizing, and selecting specific procedures or operations.	- Students are able to measure the line of symmetry on the kite so that they understand the line of symmetry in flat shapes. - Students tie the string at each corner point of the kite framework so that they are able to identify the number of corner points.
7.	Applying a concept or problem-solving algorithm.	- Students are able to shape the kite paper according to the shape of the kite framework (a combination of complex flat shapes) with accurate measurements. - Students are able to describe various types of flat shapes found in their kites (composition of complex flat shapes)

TABLE 2. *Pancasila student profile elements*

No	Pancasila student profile	Elements
1.	Believe in the fear of God Almighty	1) Religious morals 2) Personal morals 3) Morals towards humans 4) Ethics towards nature 5) State morals
2.	global diversity	1) Know and appreciate culture 2) Intercultural communication and interaction 3) Reflection and responsibility for the experience of diversity 4) Social justice
3.	Collaboration	1) Collaboration 2) Concern, and 3) Sharing
4.	Independent	1) Understanding yourself and the situation you are facing 2) Self-regulation
5.	Critical Reasoning	1) Obtain and process information and ideas 2) Analyze and evaluate reasoning 3) Reflect and evaluate one's own thinking
6.	Creativity	1) Generate original ideas 2) Produce original work and actions 3) Have flexibility of thinking in finding alternative solutions to problems

Procedure

The steps in this research include gathering data through interviews with students and teachers involved in the learning process at school, directly observing classroom learning activities, and analyzing students' work before and after STEM-based Project-Based Learning is conducted

Data Analysis

The data analysis in this study was conducted through several systematic steps to understand students' conceptual understanding of two-dimensional shapes. First, the researcher organized and analyzed data collected from various sources, including interviews, observations, and students' work documents. After gathering the data, the researcher applied a qualitative analysis method, specifically thematic analysis, to identify patterns, themes, and root issues that emerged from the data. This step aimed to gain deep insights into students' understanding of two-dimensional shape concepts. Next, the researcher synthesized relevant findings aligned with the identified issues, resulting in a clearer depiction of the effectiveness of the PjBL integrated STEM approach in enhancing students' conceptual understanding and developing the character profile of Pancasila students.

RESULTS

Three participants who exhibited the highest frequency of misconceptions regarding plane figures were purposively selected for this study and classified as having no prior knowledge of plane figures. Presented below is a diagrammatic representation of Subject 1's comprehension of plane figures before and after the implementation of STEM-integrated Project-Based Learning. In the STEM-PjBL learning process, students are presented with stimulating questions as an introduction to the material by asking about various plane figures found around the classroom. Students then respond to these questions, and the teacher provides feedback to clarify the types and shapes of plane figures. After being introduced to the different types of plane figures, students and the three selected subjects are divided into heterogeneous groups with varying abilities. Additionally, the teacher explains the kite-making project, aimed at enabling students to compose (combine) complex plane figures and decompose them into simpler forms.

The teacher distributes the materials needed for making kites (thread, bamboo, kite paper, scissors, and glue) and provides worksheets as a guide for the project. Each group is given creative freedom to design their kite's shape. During the kite-making process, the teacher observes the three selected subjects and provides scaffolding when students encounter difficulties in designing the kite shape or tying the string to the bamboo. Once the kites are completed, students work on their worksheets, which include decomposition problems to analyze the plane figures used in the kite construction. A representative from each group presents their kite in front of the class, explaining the types of plane figures involved in their kite's design and the number of sides for each figure.

After completing the group project, all students, including the three selected subjects, are given a formative assessment to be completed individually. This assessment evaluates and describes students' conceptual understanding after engaging in the STEM-PjBL learning process.

Subject 1

Based on the results of the initial understanding (diagnostic) test before the STEM-integrated PjBL learning (Figure 3.), subject 1 was only able to meet 2 out of 7 indicators of conceptual understanding. Subject one could only identify one plane figure, a circle, based on its shape characteristics and was able to identify a circle based on its image but could not differentiate between a square and a rectangle. In addition, subject 1 was less able to provide examples of other quadrilaterals such as parallelograms, trapezoids, and kites. From the initial test, it can be seen that subject 1 was only able to meet indicators (1) restating the concept of plane figures and (2) classifying plane figures based on their properties, especially circles. This low initial understanding caused subject 1 to only be able to answer 1 question during the initial test.

Based on observations conducted in the classroom during STEM-integrated PjBL with a kite-making project carried out in groups and based on the results of the given test, subject 1 was already able to meet 4 out of 7 indicators of conceptual understanding, namely (1) subject 1 already had a good understanding of mathematical concepts and could restate concepts, (2) classify objects based on certain properties, (3) provide concrete examples of the concepts learned (4) Present concepts in various mathematical representations as evidenced by the ability to arrange the kite frame well as desired through scaffolding provided by the teacher. Subject 1 carried out assimilation and accommodation of new knowledge when the group experienced difficulties in using the concept of many sides in plane figures to make the kite frame. This new knowledge was obtained when the teacher provided scaffolding in the form of an explanation of the steps for arranging the number of sides of a kite. Subject 1 was a subject who tended to be active in the group so that during scaffolding, the first subject could construct well. Figure 4 shows examples of questions for the pretest and posttest that will be given to students. Through the provided scaffolding, subject 1 will acquire new knowledge about the number of sides in a quadrilateral. STEM integrated PJBL learning activities coupled with scaffolding empower subject 1 to develop creative and collaborative thinking skills through more structured and directed learning (see table 3) and the results of subject 1's post test work can be seen in figure 5.

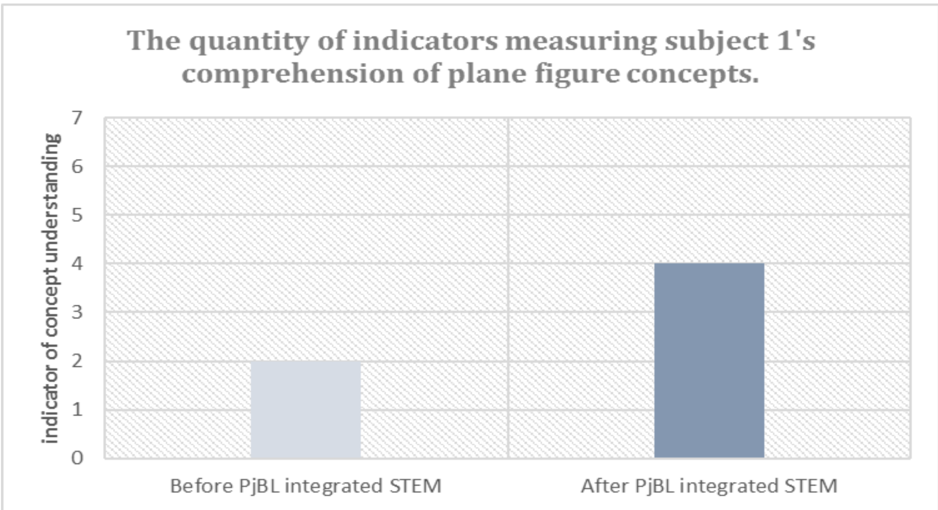
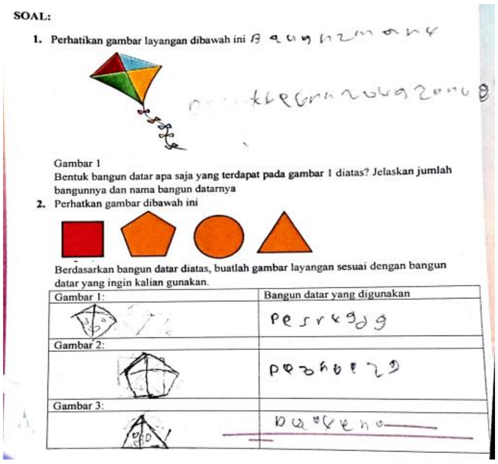


FIGURE 3. *Diagram of concept understanding for subject 1 before and after PjBL-STEM implementation*

FIGURE 4. Provision of scaffolding and results of making kites during STEM integrated PjBL activities for subject 1

TABLE 3. *Pancasila student profile characteristics demonstrated in subject 1*

Pancasila student profile characteristics embedded in STEM-integrated PjBL learning activities for Subject 1:	
Collaboration	**Creative thinking**
The teacher's scaffolding during the kite frame engineering activity encouraged more active group discussions and collaborative completion of the kite frame.	Subject 1's active participation led to active involvement in designing/engineering the kite frame according to the group's desired shape.



SOAL:

1. Perhatikan gambar layangan dibawah ini

Gambar 1

Bentuk bangun datar apa saja yang terdapat pada gambar 1 diatas? Jelaskan jumlah bangunnya dan nama bangun datarnya

2. Perhatkan gambar dibawah ini

Berdasarkan bangun datar diatas, buatlah gambar layangan sesuai dengan bangun datar yang ingin kalian gunakan.

Gambar 1:	Bangun datar yang digunakan
Gambar 2:	
Gambar 3:	

FIGURE 5. *Subject 1's formative assessment (post test) results in STEM-PjBL*

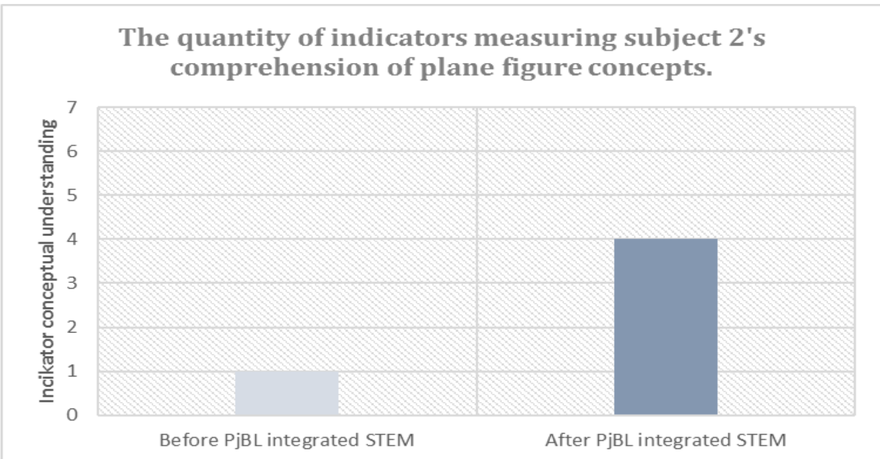


FIGURE 6. *Diagram of concept understanding for Subject 2 before and after PjBL-STEM implementation.*

Subject 2

Based on the initial test results, subject 2 demonstrated a limited initial understanding of 2D shapes. Figure 6 shows a diagram depicting the development of subject 2's conceptual understanding of 2D shapes before and after STEM integrated Project Based Learning (PjBL) intervention.

Prior to the integration of STEM in Project-Based Learning (PjBL) for understanding 2D shapes, a pre-test was conducted. This initial assessment revealed difficulties in identifying characteristics such as the number of sides and angles of each shape, as well as a lack of ability to recognize different types of 2D shapes and their properties. This lack of knowledge was evident in the students' inaccurate work and frequent errors in differentiating various types of 2D shapes, necessitating a more focused and concrete learning approach to develop a better conceptual understanding. Despite these difficulties, Subject 2 could restate their understanding of the definition of 2D shapes. However, Subject 2 was only able to meet 2 out of 7 indicators of conceptual understanding, namely (1) restating a concept.

Following the implementation of STEM-integrated PjBL, as observed in classroom observations and a final test, Subject 2 was able to meet 4 out of 7 indicators of conceptual understanding: (1) restating the definition of 2D shapes and identifying types of 2D shapes based on images, shape, and number of sides, (2) classifying 2D shapes based on their properties, (3) providing examples of quadrilaterals and non-quadrilaterals, and (4) designing a kite. However, Subject 2 required scaffolding in grouping and providing examples of kite designs, allowing them to assimilate and accommodate new knowledge. The scaffolding provided in the learning process involved the teacher explaining how to design a kite and identifying the shapes present in the kite after its construction. Through this scaffolding, Subject 2 was able to observe and accommodate their knowledge of 2D shapes and their classification to create a well-constructed kite. This teaching strategy involved direct observation and manipulation of objects to help students construct 2D shapes based on their observations of shapes and structures in their surroundings.

Figure 7 shows the provision of scaffolding and the results of making kites in the STEM integrated PjBL activity for subject 2. The use of concrete objects, such as kites, can also enhance students' understanding of two-dimensional shapes. Various effective manipulatives and how these tools help students better understand geometric concepts through direct exploration and experimentation. Although subject 2 was a passive subject, their ability to construct two-dimensional shapes was demonstrated well, as evidenced by their final test result where they could draw a kite design from several two-dimensional shape images. Pancasila Student Profile characteristics developed when subject 2 carried out the STEM-integrated Project-Based Learning (seen in Table 4) and the results of the post test by subject 1 can be seen in Figure 8.

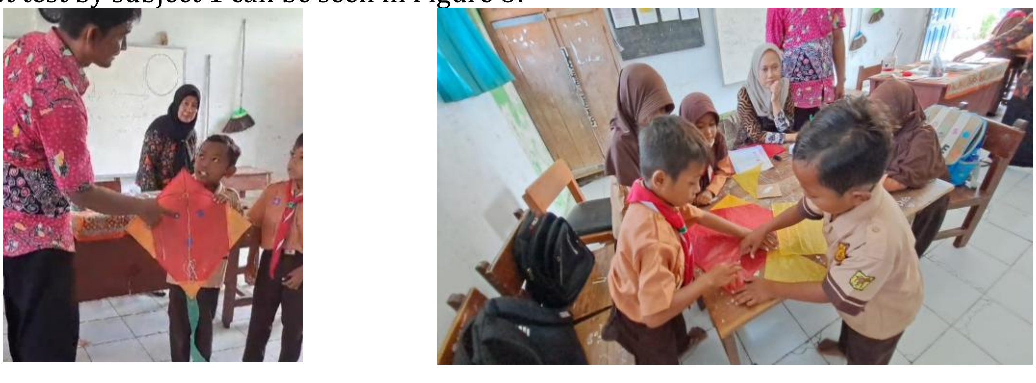


FIGURE 7. *Provision of scaffolding and results of making kites during STEM integrated PjBL activities for subject 2*

TABLE 4. *Pancasila Student Profile Characteristics Demonstrated in Subject 2*

The Pancasila student profile characteristics cultivated through STEM-integrated Project-Based Learning (PjBL) in subject 2	
Collaboration and creativity	Critical thinking
By collaboratively designing kite drawings, students exhibited a strong sense of teamwork and innovative thinking.	Students displayed their critical thinking skills through their ability to classify 2D shapes, even with some guidance.

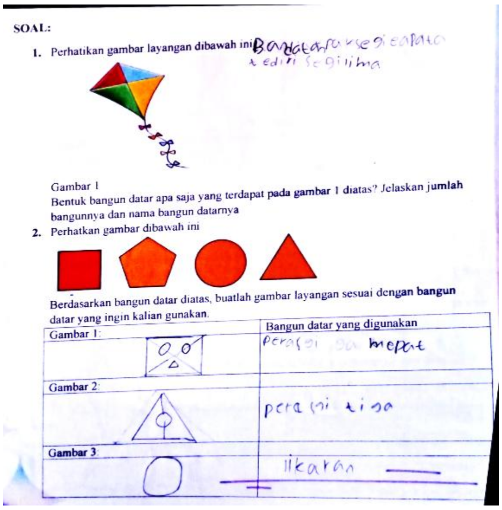


FIGURE 8. *Subject 2's formative assessment (post test) results in STEM-PjBL*

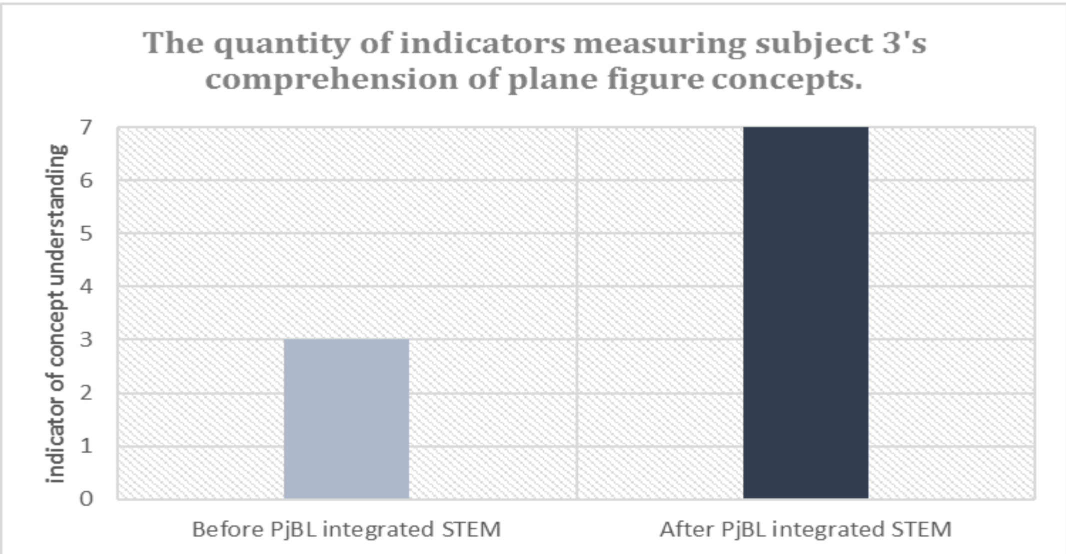


FIGURE 9. *Diagram of concept understanding for Subject 3 before and after PjBL-STEM implementation*

Subject 3

The Figure 9 illustrating the research findings for Subject 3 before and after the implementation of the STEM-integrated PjBL approach. Based on the initial test results before the implementation of STEM-integrated PjBL (Seen in Figure 9), subject 3 was able to meet 3 out of 7 indicators of conceptual understanding, namely: (1) able to restate the definition of plane figures, (2) able to classify quadrilaterals and triangles according to their properties and characteristics, and (3) able to draw examples of quadrilaterals and non-quadrilaterals. Thus, it can be seen from the test results that subject 3 was able to answer 3 out of 6 questions in the initial test.

Based on the final test results and observations during STEM-integrated PjBL learning, subject 3 was able to meet all 7 indicators of conceptual understanding, namely: (1) restating a concept as seen in the subject's ability to explain that plane figures are geometric shapes with flat sides. (2) able to classify plane figures based on their characteristics as seen in subject 3's ability to differentiate between quadrilaterals and triangles based on images and the number of sides, able to group quadrilateral shapes, such as squares and rectangles, as part of plane figures, although to be able to classify plane figures, subject 3 needed to be provided with scaffolding first, namely by the teacher introducing the types of quadrilaterals, circles, and triangles and demonstrating how plane figures can be connected to form a kite pattern (seen in Figure 10).

(3) Providing examples and non-examples, as observed in Subject 3, who can identify the shape of a kite as a combination of several quadrilaterals. (4) Presenting concepts in various mathematical representations, as seen in Subject 3, who is able to design kite models. (5) Developing necessary and sufficient conditions for a concept, as seen in Subject 3, who can apply the concept of the number of sides in a polygon to create an accurate and appropriate kite frame as desired; however, the subject must first be provided with scaffolding, with the teacher providing assistance through explanations on how to connect various shapes in a kite design. (6) Using, utilizing, and selecting specific procedures or operations, as seen in the subject's ability to calculate the axis of symmetry of a kite and tie strings at each corner of the kite frame. (7) Being able to apply the concept of polygons to solve problems, as seen in Subject 3's ability to use various types of polygons to assemble/make a kite until it is successfully completed. Figure 11 shows the results of making a kite after STEM-PjBL learning. The characteristics of the Pancasila student profile exhibited by Subject 3 in the STEM integrated Project Based Learning (PBL) activities (seen in Table 5) and the results of the post test by subject 1 can be seen in Figure 12.

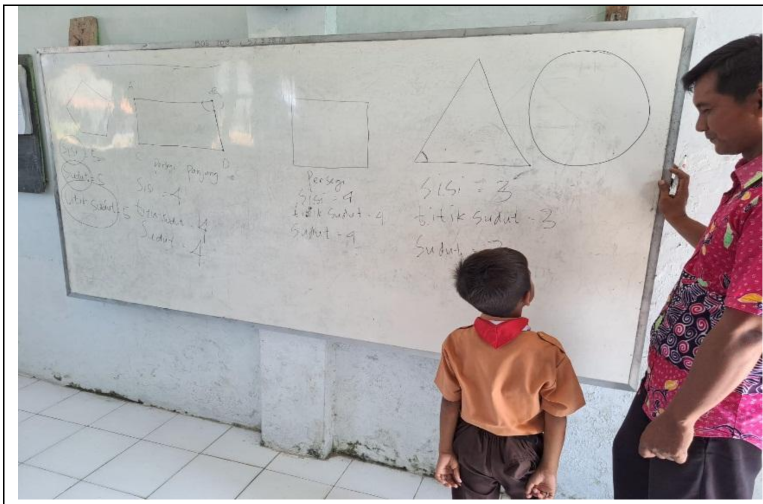


FIGURE 10. *Provision of scaffolding and results of making kites during STEM integrated PjBL activities for subject 3*

FIGURE 11. *The outcome of the kite-making project in the integrated STEM PjBL activity for Grade 2 elementary students*

TABLE 5. *Pancasila Student Profile Characteristics Demonstrated in Subject 3*

The Pancasila student profile characteristics cultivated through STEM-integrated Project-Based Learning (PjBL) in subject 3	
Collaboration and creativity	Critical thinking
The collective kite-making activity, as part of Subject 3's design curriculum, is a prime example of how group cooperation and creativity can yield tangible results.	By employing scaffolding techniques, Subject 3 will be equipped with the necessary skills to engage in critical thinking as they explore the properties of quadrilaterals, circles, and triangles, and construct kite patterns from these fundamental geometric shapes.

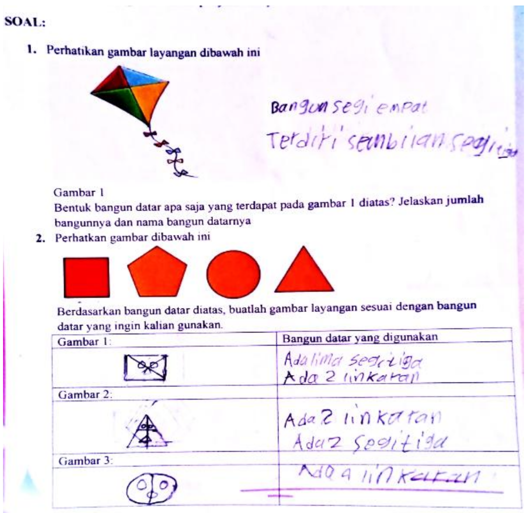


FIGURE 12. *Subject 3's formative assessment (post test) results in STEM-PjBL*

DISCUSSION

The findings of this research indicate that the STEM approach integrated with Project Based Learning (PJBL) in our research is significantly able to help students' to understanding concept of two-dimensional shapes by meeting all indicators. Apart from that, this can also be seen from the substantial increase in the number of concept understanding indicators observed before and after STEM integrated PJBL learning. Students are considered to have a good grasp of the concepts when they can meet the concept understanding indicators, which include (1) ability to explain, (2) application of concepts, (3) connections between concepts, and (4) problem-solving (Rittle-Johnson, Siegler, and Alibali 2001), implying that students demonstrate a solid conceptual understanding when they can successfully apply problem-solving algorithms. Students who initially struggled with understanding basic elements of plane geometry, such as the number of sides and angles, exhibited a significant improvement in identifying and differentiating various types of plane geometry after engaging in the project, culminating in their ability to assemble kites according to desired geometric combinations. This suggests that project-based learning integrated with STEM can be an effective medium for addressing conceptual gaps, particularly in the abstract subject of plane geometry. Several studies corroborate that PJBL can enhance students' conceptual understanding (Ahmed, Grollo, and Czech 2024; Guo et al. 2020; Parwoto et al. 2024; Remijan 2016; Viro et al. 2020).

STEM-integrated PjBL learning is conducted through group activities where students engage in small groups to find solutions, while the teacher acts as a facilitator (Sarwi, Baihaqi, & Ellianawati, 2021). By engaging students in collaborative projects that require creative thinking and problem-solving, this method promotes the development of critical thinking and communication skills (Baran, Baran, Karakoyun, & Maskan, 2021). Research findings also show that the STEM-integrated PjBL approach in kite-making projects can cultivate three of the six Pancasila student profile characteristics: mutual cooperation, critical thinking, and creative thinking. Critical thinking skills involve reasoning and logic in decision-making, problem-solving, and inference (Fuad, Zubaidah, Mahanal, & Suarsini, 2017). Creative individuals can make connections between previously unrelated things and generate new (original) ideas (Yusnaeni, Corebima, Susilo, & Zubaidah, 2017), as exemplified in this study where students assembled various types of flat shapes into a new idea: a kite. Mutual cooperation, as evidenced by the research findings, is reflected in the group activities undertaken by each subject by combining their potential, strengths, and thinking abilities, thus fostering good cooperation (Supramono & Hidayati, 2023). Therefore, it is important to instill Pancasila values in elementary school students during classroom learning activities (Lestari, Ahmadi, & Rochmad, 2021).

The findings of this study are in line with the research of (Nurmaliah, Azmi, Safrida, Khairil, & Artika, 2021), (Afriana, Permanasari, & Fitriani, 2016), and (Sarwi et al., 2021), which indicate that STEM-integrated PJBL enables students to engage in real-world projects that integrate concepts from various disciplines, such as science, technology, engineering, and mathematics, thereby providing a more comprehensive learning experience and enhancing students' critical thinking and creativity skills as they are encouraged to think across disciplines and apply theory in practical contexts, where these skills reflect the characteristics of the Pancasila student profile. The STEM-based PJBL approach not only enhances conceptual understanding but also the characteristics of the Pancasila student profile. The research of Baran et al. (2021) highlights that STEM-PJBL is effective in developing various essential 21st-century skills, such as critical thinking, creativity, collaboration, and communication. Students who participate in STEM-PJBL activities have been reported to experience improvements in problem-solving and adaptation skills, as they are confronted with situations that require them to identify problems, design innovative solutions, and collaborate with their peers to complete projects.

The implications of this research are highly relevant for educators who seek to integrate Pancasila values into STEM education. Through concrete and relevant activities, students can learn not only academic content but also character traits such as cooperation, responsibility, and creativity. This indicates that project-based learning can be an effective approach for character education alongside academic achievement, contributing to students' holistic development.

The primary limitation of this study is the limited number of subjects, which precludes the generalization of the findings to the entire student population. Furthermore, the study's narrow focus on two-dimensional shapes restricts the assessment of the impact of STEM PjBL on other mathematical concepts.

CONCLUSION

Based on the research findings and discussion, it can be concluded that the STEM approach integrated with Project-Based Learning (PjBL) can enhance second-grade students' conceptual understanding of two-dimensional shapes, as evidenced by their ability to apply these concepts in the creation of a kite. Through the kite-making project, students demonstrated improvements in their understanding of two-dimensional shapes as well as in their problem-solving skills. Additionally, the STEM-integrated PjBL approach positively impacted students' character development, aligning with the Pancasila Student Profile. By fostering collaboration, critical thinking, and creativity, PjBL empowered students to become active learners and responsible citizens. These findings suggest that educators can incorporate Pancasila values into the learning process through STEM-based PjBL activities, creating a holistic learning environment that enhances conceptual understanding and instills Pancasila values.

ACKNOWLEDGMENTS

Thank you to Universitas Madura for the financial support through the internal grant with decision letter 049/E.03/UNIRA/VIII/2024 and contract number 188/E.02/LPPM-UNIRA/X/2024; to all academic staff and LPPM of Universitas Madura; and to SDN Tambaan II Sampang for their willingness to be partners.

REFERENCES

1. Aebli, A., Volgger, M., & Taplin, R. (2022). A two-dimensional approach to travel motivation in the context of the COVID-19 pandemic. *Current Issues in Tourism*, *25*(1), 60–75. https://doi.org/10.1080/13683500.2021.1906631
2. Afriana, J., Permanasari, A., & Fitriani, A. (2016). Project based learning integrated to stem to enhance elementary school's students scientific literacy. *Jurnal Pendidikan IPA Indonesia*, *5*(2), 261–267. https://doi.org/10.15294/jpii.v5i2.5493
3. Baran, M., Baran, M., Karakoyun, F., & Maskan, A. (2021). The Influence of Project-Based STEM (PjbL-STEM) Applications on the Development of 21st-Century Skills. *Journal of Turkish Science Education*, *18*(4), 798–815. https://doi.org/10.36681/tused.2021.104
4. Boglárka Brezovszky1, Jake McMullen1, Koen Veermans1, Minna M. Hannula-Sormunen1, 2, Gabriela Rodríguez-Aflecht 1, N. P. E. L. & E. L. (2019). *Effects of a Mathematics Game-Based Learning Environment on Primary School Students' Adaptive Number Knowledge*. *11*(1), 1–14.
5. Chine, D., & Larwin, K. (2022). The Impact of STEM Integration on Student Achievement Using HLM: A Case Study. *Journal of Research in STEM Education*, *8*(1), 1–23. https://doi.org/10.51355/jstem.2022.108
6. Fuad, N. M., Zubaidah, S., Mahanal, S., & Suarsini, E. (2017). Improving junior high schools' critical thinking skills based on test three different models of learning. *International Journal of Instruction*, *10*(1), 101–116. https://doi.org/10.12973/iji.2017.1017a
7. Gervasoni, A., Roche, A., & Downton, A. (2021). Differentiating Instruction for Students

Who Fail to Thrive in Mathematics: The Impact of a Constructivist-Based Intervention Approach. *Mathematics Teacher Education and Development*, *23*(3), 207–233.

8. Han, S., Rosli, R., Capraro, M. M., & Capraro, R. M. (2016). The effect of Science, technology, engineering and mathematics (STEM) project based learning (PBL) on students' Achievement in four mathematics topics. *Journal of Turkish Science Education*, *13*(Specialissue), 3–30. https://doi.org/10.12973/tused.10168a
9. Herner-Patnode, L., & Lee, H. J. (2021). Differentiated instruction to teach mathematics: Through the lens of responsive teaching. *Mathematics Teacher Education and Development*, *23*(3), 6–25.
10. Jacques, L. A. (2021). What does Project-based Learning (PBL) Look like in the Mathematics Classroom? *American Journal of Educational Research*, *5*(4), 428–433. https://doi.org/10.12691/education-5-4-11
11. Jamaludin, J., Alanur S, S. N. A. S., Amus, S., & Hasdin, H. (2022). Penerapan Nilai Profil Pelajar Pancasila Melalui Kegiatan Kampus Mengajar Di Sekolah Dasar. *Jurnal Cakrawala Pendas*, *8*(3), 698–709. https://doi.org/10.31949/jcp.v8i3.2553
12. Jannah, U. R., Hafsi, A. R., & Nurhidayati, S. (2023). Conceptual Understanding of Students with Special Needs in Two-dimensional Shapes Based on Pirie Kieren's Theory. *Jurnal Tadris Matematika*, *6*(2), 219–230. https://doi.org/10.21274/jtm.2023.6.2.219-230
13. Jannah, U. R., Putra, F. P. E., Hafsi, A. R., & Basri, H. (2021). Pengembangan Sekolah Inklusi dengan Pemanfaatan Media Visual Scratch dan Alat Peraga Manipulatif. *Wikrama Parahita : Jurnal Pengabdian Masyarakat*, *5*(1), 89–96. https://doi.org/10.30656/jpmwp.v5i1.2653
14. Jazuli, A., Setyosari, P., Sulthon, & Kuswandi, D. (2017). Improving conceptual understanding and problem-solving in mathematics through a contextual learning strategy. *Global Journal of Engineering Education*, *19*(1), 49–53.
15. Kelley, T. R., & Knowles, J. G. (2016). A conceptual framework for integrated STEM education. *International Journal of STEM Education*, *3*(1). https://doi.org/10.1186/s40594-016-0046-z
16. Kholid, M. N., Imawati, A., Swastika, A., Maharani, S., & Pradana, L. N. (2021). How are Students' Conceptual Understanding for Solving Mathematical Problem? *Journal of Physics: Conference Series*, *1776*(1). https://doi.org/10.1088/1742-6596/1776/1/012018
17. Kozhuharova, D., & Zhelyazkova, M. (2021). What Is STEM Education. *Педагогически Форум*, *9*(3), 19–29. https://doi.org/10.15547/pf.2021.016
18. Kusumaningsih, W., Saputra, H. A., & Aini, A. N. (2019). Cognitive style and gender differences in a conceptual understanding of mathematics students. *Journal of Physics: Conference Series*, *1280*(4). https://doi.org/10.1088/1742-6596/1280/4/042017
19. Lazić, B. D., Knežević, J. B., & Maričić, S. M. (2021). The influence of project-based learning on student achievement in elementary mathematics education. *South African Journal of Education*, *41*(3), 1–10. https://doi.org/10.15700/saje.v41n3a1909
20. Lestari, F. P., Ahmadi, F., & Rochmad, R. (2021). The implementation of mathematics comic through contextual teaching and learning to improve critical thinking ability and character. *European Journal of Educational Research*, *10*(1), 497–508. https://doi.org/10.12973/EU-JER.10.1.497
21. Leton, S. I., Djong, K. D., Uskono, I. V., Dosinaeng, W. B. N., & Lakapu, M. (2020). Profile of Elementary School Teacher in Concept Understanding of Geometry. *Infinity Journal*, *9*(2), 133–146. https://doi.org/10.22460/infinity.v9i2.p133-146
22. Mahfud, M. S., Mardiyana, M., & Fitriana, L. (2021). Bagaimana Pemahaman Konsep Matematika Siswa Pada Pembelajaran Online? *AKSIOMA: Jurnal Program Studi Pendidikan Matematika*, *10*(2), 1190. https://doi.org/10.24127/ajpm.v10i2.3681
23. Mayerhofer, M., Lüftenegger, M., & Eichmair, M. (2024). The development of mathematics expectancy-value profiles during the secondary–tertiary transition into STEM fields. *International Journal of STEM Education*, *11*(1).

https://doi.org/10.1186/s40594-024-00491-6
24. Mellroth, E., Bergwall, A., & Nilsson, P. (2021). Task design for differentiated instruction in mixed-ability mathematics classrooms: Manifestations of contradictions in a professional learning community. *Mathematics Teacher Education and Development*, *23*(3), 78–96.
25. My Nguyen, H. T., Chau Nguyen, G. T., Hong Thai, L. T., Truong, D. T., & Nguyen, B. N. (2024). Teaching Mathematics Through Project-Based Learning in K-12 Schools: A Systematic Review of Current Practices, Barriers, and Future Developments. *TEM Journal*, *13*(3), 2054–2065. https://doi.org/10.18421/tem133-33
26. Naibaho, D. P. (2023). Strategi Pembelajaran Berdiferensiasi Mampu Meningkatkan Pemahaman Belajar Peserta Didik. *Journal of Creative Student Research*, *1*(2), 81–91.
27. Nasution, M., & Lailia, H. (2023). "Animated Video Media": Improved Conceptual Understanding and Solving Mathematical Problems. *AKSIOMA: Jurnal Program Studi Pendidikan Matematika*, *12*(1), 1344. https://doi.org/10.24127/ajpm.v12i1.6892
28. Nurmaliah, C., Azmi, T. N., Safrida, Khairil, & Artika, W. (2021). The impact of implementation of STEM integrating project-based learning on students' problem-solving abilities. *Journal of Physics: Conference Series*, *1882*(1). https://doi.org/10.1088/1742-6596/1882/1/012162
29. O'Dwyer, L. M., Wang, Y., & Shields, K. A. (2015). Teaching for conceptual understanding: A cross-national comparison of the relationship between teachers' instructional practices and student achievement in mathematics. *Large-Scale Assessments in Education*, *3*(1). https://doi.org/10.1186/s40536-014-0011-6
30. Putri, S. R., Efendi, R., & Aini, N. (2023). Pengembangan Media Video Animasi Terintegrasi Profil Pelajar Pancasila Pada Mata Pelajaran Matematika Kelas IV Sekolah Dasar. *INNOVATIVE: Journal Of Social Science Research*, *3*(4), 5987–5998.
31. Raudhatul Jannah, U., Amiruddin, M., & Nurhidayati, S. (2022). Profile of the Concept Understanding of Two-Dimensional Figure Based on Pirie Kieren's Theory Reviewed from Learning Motivation in Elementary School. *Jurnal Pendidikan MIPA*, *23*(3), 1135–1148. https://doi.org/10.23960/jpmipa/v23i3.pp1135-1148
32. Ryan, J., & Bowman, J. (2022). Teach cognitive and metacognitive strategies to support learning and independence. *High Leverage Practices and Students with Extensive Support Needs*, *3*(3), 170–184. https://doi.org/10.4324/9781003175735-15
33. Samsudin, M. A., Jamali, S. M., Zain, A. N. M., & Ebrahim, N. A. (2020). The effect of STEM project based learning on self-efficacy among high-school physics students. *Journal of Turkish Science Education*, *17*(1), 94–108. https://doi.org/10.36681/tused.2020.15
34. Sarwi, S., Baihaqi, M. A., & Ellianawati, E. (2021). Implementation of Project Based Learning Based on STEM Approach to Improve Students' Problems Solving Abilities. *Journal of Physics: Conference Series*, *1918*(5). https://doi.org/10.1088/1742-6596/1918/5/052049
35. Schaathun, H. G. (2022). On Understanding in Mathematics. *Teaching Mathematics and Its Applications*, *41*(4), 318–328. https://doi.org/10.1093/teamat/hrac016
36. Sevimli, E., & Ünal, E. (2022). Is the STEM Approach Useful in Teaching Mathematics? Evaluating the Views of Mathematics Teachers. *European Journal of STEM Education*, *7*(1), 1–11. https://doi.org/10.20897/ejsteme/11775
37. Supramono, A., & Hidayati, K. (2023). Constriction of Pancasila Student Profile Assessment for 21st Century Students in Elementary School. *Proceedings of International Conference on Research in Education and Science*, *9*(1), 224–239.
38. Thibaut, L., Ceuppens, S., De Loof, H., De Meester, J., Goovaerts, L., Struyf, A., … Depaepe, F. (2018). Integrated STEM Education: A Systematic Review of Instructional Practices in Secondary Education. *European Journal of STEM Education*, *3*(1), 1–12. https://doi.org/10.20897/ejsteme/85525
39. Tristiana, V., & Surakarta, U. M. (2023). *IMPLEMENTASI PROGRAM SEKOLAH SEKOLAH DASAR ELSE (Elementary School Education*. *7*(2).

https://doi.org/10.30651/else.v7i2.16924

40. Vergnaud, G. (2020). A classification of cognitive tasks and operations of thought involved in addition and subtraction problems. *Addition and Subtraction: A Cognitive Perspective*, 39–59. https://doi.org/10.4324/9781003046585-4
41. Widiyatmoko, A., & Shimizu, K. (2018). An overview of conceptual understanding in science education curriculum in Indonesia. *Journal of Physics: Conference Series*, *983*(1). https://doi.org/10.1088/1742-6596/983/1/012044
42. Widodo, S. A., Pangesti, A. D., Istiqomah, Kuncoro, K. S., & Arigiyati, T. A. (2020). Thinking Process of Concrete Student in Solving Two-Dimensional Problems. *Mathematics Education Journal*, *14*(2), 117–128. https://doi.org/10.22342/jpm.14.2.9460.117-128
43. Yunita, Y., Juandi, D., Kusumah, Y. S., & Suhendra, S. (2021). The effectiveness of the Project-Based Learning (PjBL) model in students' mathematical ability: A systematic literature review. *Journal of Physics: Conference Series*, *1882*(1). https://doi.org/10.1088/1742-6596/1882/1/012080
44. Yusnaeni, Y., Corebima, A. D., Susilo, H., & Zubaidah, S. (2017). Creative thinking of low academic student undergoing search solve create and share learning integrated with metacognitive strategy. *International Journal of Instruction*, *10*(2), 245–262. https://doi.org/10.12973/iji.2017.10216a
45. Ziernwald, L., Hillmayr, D., & Holzberger, D. (2022). Promoting High-Achieving Students Through Differentiated Instruction in Mixed-Ability Classrooms—A Systematic Review. *Journal of Advanced Academics*, *33*(4), 540–573. https://doi.org/10.1177/1932202X221112931