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Development of a 2D Shape E-Module Based on Project-Based Learning with Scratch to Improve Computational Thinking Skills

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Abstract

This study aims to develop a flat shapes e-module based on project-based learning (PBL) supported by Scratch to enhance computational thinking skills. The research method used is research and development with three development phases: preliminary research, prototyping, and assessment. The research subjects consisted of 30 students from class VII at SMP High Scope in the limited trial, and 32 and 35 students from SMP Negeri 5 Denpasar in field tests 1 and 2, respectively. SMP High Scope was selected for the limited trial because its student characteristics are similar to those of SMP Negeri 5 Denpasar. In addition, SMP High Scope frequently uses Scratch in its informatics lessons, making it more suitable for identifying and addressing issues with the e-module before further testing in a more general environment. The revisions and feedback from the limited trial were then followed by field tests 1 and 2 at SMP Negeri 5 Denpasar to refine the e-module. The e-module characteristics include learning objectives, estimated time, and project-based materials. The integrated support features include Scratch, learning videos, and evaluation exercises. The e-module was assessed using validation sheets, student and teacher response questionnaires for practicality, and pre-test and post-test sheets for effectiveness. The results showed that the e-module was valid with a score of 4.00, indicating it was appropriate for use. The practicality, based on student response questionnaires, was 75.34%, and for teachers, it was 75.45%. Effectiveness was tested using a t-test with a significance value of 0.00 and an N-Gain score of 0.31, categorized as moderate.

Keywords: e-Module, Project-Based Learning, Scratch, Computational Thinking, Research and Development, Field Test, Validity, Practicality, Effectiveness

INTRODUCTION

Geometry is one of the fundamental branches of mathematics, crucial for developing logical thinking, spatial visualization, and problem-solving skills (Yunita et al., 2020). In the Merdeka Curriculum, plane geometry is an essential basic concept because it serves as the foundation for students to understand more complex geometric concepts (Karunanayaka et al., 2016). Moreover, understanding plane figures plays a strategic role in supporting mastery of advanced mathematical concepts, such as area, perimeter, and the visual analysis of geometric shapes in their surroundings (Handayani et al., 2023).

Despite its importance, the implementation of plane geometry learning in schools still faces various challenges. The learning process is often delivered using conventional methods, such as lectures and practice exercises, which tend to be monotonous and less effective in building students' motivation and engagement (Resmanti et al., 2024). Based on interviews with mathematics teachers, the main challenges in teaching plane geometry include the limited availability of interactive learning media and students' low motivation toward the subject (Choeroni et al., 2021). Additionally, students find it difficult to grasp concepts related to area, perimeter, and geometric properties of plane figures, leading to low academic achievement (Fadhilah & Thahir, 2023).

To address these issues, it is necessary to introduce more interactive and student-centered learning innovations. One effective approach is Project-Based Learning (PjBL), which emphasizes designing, implementing, and evaluating projects independently by students (Maqfiroh & Munahefi, 2022). This model has been proven to enhance critical thinking, problem-solving, and collaboration skills (Wulandari et al., 2024). A study by Serevina et al. (2018), found that PjBL significantly impacts mathematics learning outcomes, particularly in improving students’ conceptual understanding and learning motivation.

With the development of technology, integrating digital media into PjBL can make learning more contextual and engaging. One promising medium is Scratch, a visual programming platform that allows students to create animations, games, or simulations of mathematical concepts independently (Lee et al., 2016). Scratch not only supports mathematical understanding but also trains students in computational thinking, a higher-order thinking skill that is highly relevant in the digital era (Darmastuti et al., 2025). Computational thinking involves processes such as problem decomposition, pattern recognition, abstraction, and algorithm development, which can be applied in various real-life contexts (Aprila et al., 2023).

In the context of mathematics learning, integrating computational thinking through technology-based media like Scratch can provide a more meaningful learning experience. A study by Andriani et al (2023) showed that the use of Scratch can enhance students' interest in learning and their creative thinking skills. However, most existing research focuses primarily on learning interest, with limited studies examining the impact of computational thinking in the context of geometry learning at the secondary education level.

This study offers a new approach by developing an interactive e-module based on Scratch integrated with the Project-Based Learning model. The e-module is designed to facilitate independent and collaborative learning while training students in computational thinking in a contextual and enjoyable way. Compared to conventional learning media, the e-module's advantages lie in its adaptive, interactive, and user-friendly characteristics (Ismail et al., 2025). By combining Project-Based Learning, Scratch, and computational thinking concepts, this study aims to provide an innovative solution to simultaneously enhance students' understanding of geometry and computational thinking skills.

Furthermore, this research seeks to enrich the literature on technology integration in mathematics learning, in line with the educational needs of the Fourth Industrial Revolution era. The findings of this study are expected to make a practical contribution to the development of digital curricula and serve as a reference for educators in integrating technology to improve the quality of mathematics instruction. Based on the identified research problems, this study aims to gain a deeper understanding of innovative learning through an interactive Project-Based Learning (PjBL) e-module supported by Scratch. The primary objective of this research is to explore the characteristics of the e-module specifically designed to enhance students' computational thinking skills in learning two-dimensional shapes. Furthermore, this study seeks to map the learning trajectory or the learning stages experienced by students when using the e-module, ensuring that the learning process becomes more systematic, contextual, and effective. By understanding both the characteristics and the learning path, this e-module is expected to serve not only as an engaging learning medium but also as a tool to boost students' motivation and active participation in mathematics learning.

METHODS

This study employs a qualitative research approach with the primary focus on assessing the validity, practicality, and effectiveness of the developed product. It follows the Research and Development (R&D) methodology as proposed by Sugiyono (2024), which involves a systematic process of identifying problems, designing products, and testing them in the field. The final output of this research is an interactive e-module based on Scratch to enhance computational thinking skills in learning two-dimensional shapes. The chosen research method, educational design research, is dedicated to developing innovative learning tools that promote meaningful education.

The study adopts the Plomp & Nieveen development model, which consists of three main phases: (1) Preliminary research, where the initial problem analysis is conducted; (2) Development or prototyping phase, which includes product design, realization or construction, and testing, evaluation, and revision; and (3) Assessment phase, where the product is evaluated for its overall effectiveness and usability. According to Suardika (2025), design research aims to offer research-based solutions to complex educational problems while enhancing the understanding of the design and development processes. Through these structured phases, the study ensures that the developed e-module is both practical and scientifically validated.

The research will be conducted in SMP High Scope for limited trials and in SMP Negeri 5 Denpasar for broader field testing. These schools were selected due to their diverse student characteristics, adequate facilities, and strong collaboration with the researcher. Both schools have implemented technology-based learning using Scratch, making them ideal environments for this study. The research is scheduled for the even semester of the 2023/2024 academic year (January - Juny 2024). The researcher will act as the key instrument, collecting and analyzing data while also participating as an observer. This participatory role ensures that hidden aspects of the learning process can be captured and understood, enhancing the depth and reliability of the findings.

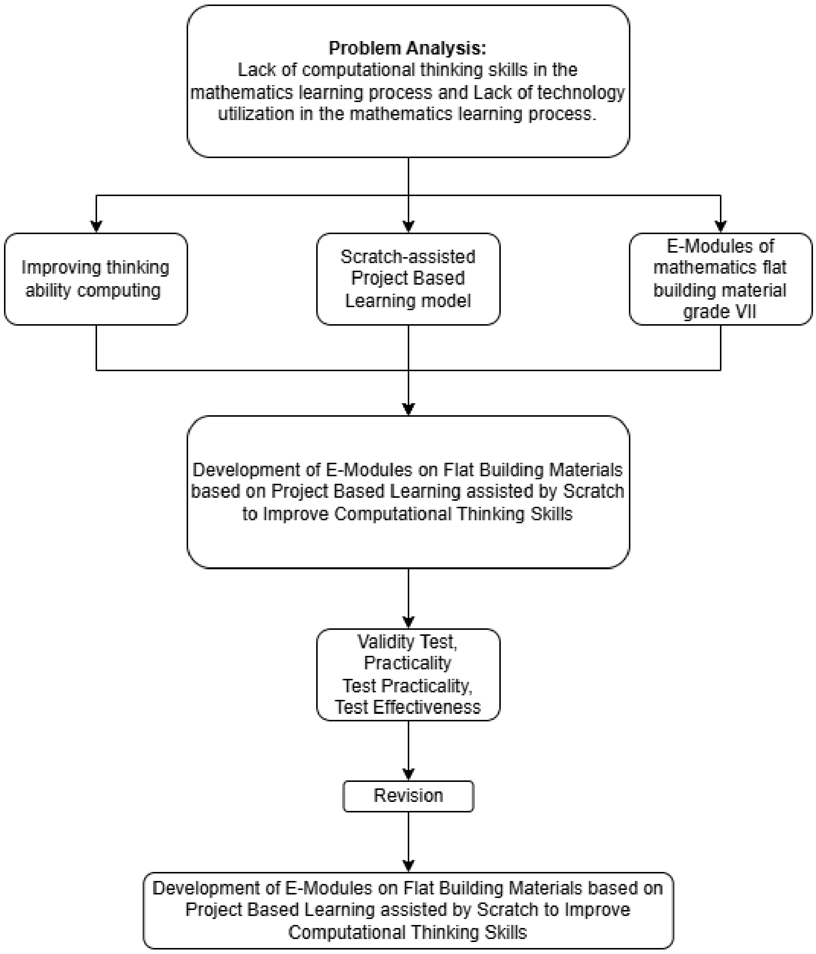


Figure 1. Conceptual Framework

RESULTS

The result of this research creates an interactive e-module with a focus on using a project-based learning model to improve computational thinking in students. The target of this research is students from grade VII of junior high school. This research was conducted using a research and development approach. This research uses three main phases of Plomp and Nieveen's development model, namely preliminary research. Prototyping phase, and assessment phase. The explanation of these stages is as follows:

1. Preliminary Research

Initial Analysis Results

To gain a deeper understanding of the learning issues, the researcher conducted classroom observations and interviews with mathematics teachers at SMP Negeri 5 Denpasar for seventh-grade classes. The interviews revealed that mathematics learning primarily relied on conventional media, which limited students' engagement and problem-solving development. According to the teacher, integrating diverse learning media is essential to enhance computational thinking skills, especially for lower-grade students. Computational thinking allows students to solve contextual problems systematically and logically. The observations, combined with a pre-test on computational thinking, showed varying levels of proficiency among students in essential aspects such as abstraction, decomposition, pattern recognition, and algorithmic thinking. Some students demonstrated sufficient computational thinking skills, but the majority still needed improvement. This finding highlighted the necessity of using interactive media to support learning and foster these critical skills.

Curriculum Analysis Results

The researcher also conducted a curriculum analysis to evaluate the Kurikulum Merdeka (Freedom to Learn Curriculum), focusing on its Learning Objectives Pathway (Alur Tujuan Pembelajaran – ATP) and Learning Outcomes (Capaian Pembelajaran – CP). This curriculum promotes a more flexible, student-centered approach, allowing students the freedom to explore and develop their understanding at their own pace.

The content presented in the e-module aligns with the learning objectives of the geometry unit, particularly focusing on two-dimensional shapes. The e-module is carefully designed to help students achieve the intended competencies outlined in the curriculum while offering an engaging and interactive learning experience. This approach encourages not just content mastery but also self-directed learning and problem-solving abilities.

Analysis of Student Characteristics

Understanding students’ characteristics is crucial for developing a meaningful and effective e-module. This phase involved observing students' learning styles, academic abilities, motivation levels, and problem-solving skills in real-world contexts. The schools selected for this research were SMP High Scope for a limited trial and SMP Negeri 5

Denpasar for broader field testing. Seventh-grade students from class C and D at SMP Negeri 5 Denpasar were observed and compared to students at SMP High Scope to identify similarities and differences in their learning patterns.

Interestingly, the two schools shared many similarities in learning habits, social factors, and peer interactions. However, a significant difference lay in students' familiarity with Scratch. Students at SMP High Scope had more experience with Scratch, making it an ideal environment for limited trials, where the researcher could collect feedback on product validity, usability, and potential improvements. Although the trial setting was more controlled, it provided valuable insights for refining the e-module.

The broader field trials at SMP Negeri 5 Denpasar revealed that students generally preferred project-based learning (PjBL), which encouraged collaboration and creativity. Through collaborative projects, students were more engaged and motivated to produce meaningful outputs. However, many students faced challenges in solving mathematical problems related to two-dimensional shapes. To address this issue, the researcher integrated the findings from both schools to design a customized e-module that aligns with students' learning characteristics and fosters computational thinking in a more effective and engaging way.

2. Prototyping Results

In the prototyping phase, the researcher designed and refined the product in the form of prototypes through an iterative process involving design, formative evaluation, and revision. This phase aimed to ensure that the product met the desired quality standards and effectively supported learning goals. The detailed process is outlined as follows:

Results of Media Selection

In developing the Scratch-based e-module using a project-based learning approach, several key software tools were utilized to create an engaging and interactive learning experience. This e-module includes various exercises designed to enhance computational thinking skills in problem-solving. The exercises are implemented using Scratch, which serves as the primary platform. Scratch allows students to build programs without worrying about syntax errors, thanks to its visual programming language. Its block-based interface makes coding simple and intuitive, enabling beginners to learn programming concepts easily. The visual blocks control movements, appearances, sounds, and communication between characters, offering a wide range of interactive features. With Scratch, students can grasp basic programming concepts while integrating them into geometry lessons on two-dimensional shapes.

The second tool, Canva, plays a crucial role in designing the layout and visual aesthetics of the e-module's content slides. This design tool offers flexibility in creating visually appealing learning interfaces, making the material more attractive and accessible to students.

The third tool, GeoGebra, enhances the module by providing dynamic visualizations of mathematical concepts. Its capabilities in geometry, algebra, statistics, and calculus help students better understand abstract ideas through interactive simulations and visual representations. This integration makes the learning process more concrete and relatable.

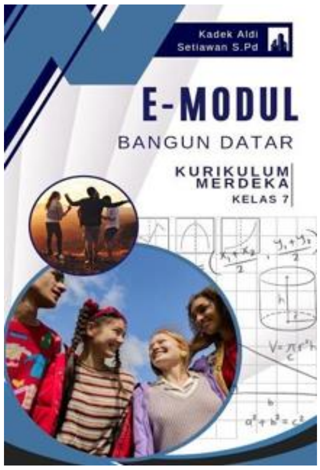
Finally, Google Forms is incorporated as an essential feature for task submission and assessment. It allows students to submit their assignments easily, making it simpler for teachers to monitor progress and provide timely feedback. This tool promotes more effective teacher-student interaction and enables personalized guidance tailored to each student's learning needs.

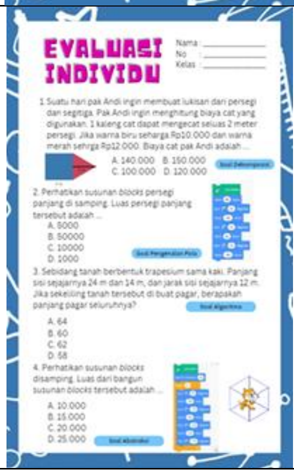
The combination of these tools is carefully designed to create a rich and engaging learning experience, helping students develop computational thinking skills while solving contextual problems. Together, they encourage collaborative learning, creativity, and meaningful exploration of mathematical concepts.

Format Selection Result

At this stage, the e-module design involves cover design, format, animation, graphics, as well as the layout of materials and questions. In general, this e-module is divided into several parts, including: 1) Material title, 2) Learning objectives, 3) Basic Competencies to be achieved, 4) Materials, 5) Learning Videos, 7) Group project, 8) Practice Questions.

Table 1. Preliminary Design of Scratch-assisted Project Based Learning E-Modules to Enhance Computational Thinking

Section	Description	Display Design
Cover E-modul	The cover of the e-module displays basic information such as title, author and images or graphics The cover page is attractive. designed as attractive as possible. The base color used is white with a combination of additional blue colors. The cover is equipped with the e-module title, independent curriculum description, class and author's name.	
List Page Contents	The table of contents section provides instructions or instructions to students regarding the sub-material to be studied. This page is designed using Canva and uses a color pattern dominated by white and blue.	
Flat Buildings Sub-Material Page	Pada sub materi pertama, disajikan pengertian garis dan sudut serta permasalahan dasar dalam penerapan konsep. Pada setiap akhir penjelasan peserta didik diberikan project yang memiliki relevansi pada materi pembelajaran.	

Section	Description	Display Design
Project Page	The group project section aims to test students' understanding through the problems given.	
Evaluation Page	The individual evaluation section aims for individual practice from each learner on the material that has been learned relating to computational thinking.	

Sources: Data Processed, 2025

Results of Preparation of Initial Draft

The next step in this project is to design an engaging and interactive e-module on computational thinking. This e-module will cover three subtopics related to flat shapes, aligned with the basic competencies in the 7th grade semester 2 curriculum of the Merdeka Curriculum. The content will be creatively presented, blending computational thinking concepts with mathematical understanding.

The first subtopic, *Properties of Flat Shapes*, will guide students in understanding the characteristics of flat shapes through a more systematic and structured approach, using easy-to-understand algorithmic methods. In the second subtopic, *Types of Flat Shapes*, students will be introduced to various flat shapes, learning to recognize and categorize them using a logic-based computational approach. The third subtopic, *Geometric Shape Transformations*, will utilize computational thinking concepts to help students understand how geometric shapes can be moved, rotated, or reflected in a practical and enjoyable way.

This approach will not only teach students about flat shapes but also enhance their computational thinking skills, making learning both enjoyable and applicable.

Based on the material that has been prepared, the next step involves producing the e-module on flat shapes. This production process will include using the 7th-grade semester 2 Merdeka Curriculum textbook, Canva for creating the e-module, Filmora for video production, and Google Forms for assignment collection. The e-module will be accessible via a link (link: *https://tinyurl.com/EmodulBangun-Datar*) that will redirect users to a PDF file. This e-module, focused on mathematics education, can be accessed anywhere and anytime by opening the PDF file, making learning more flexible and accessible for students.

In this section, the research results are presented in a clear and detailed manner. Research results can be presented based on research results at each stage of research or research results that answer each problem formulation or others as long as the results of the research that have been carried out are visible. Research results should be supported by empirical evidence.

Validation Stage

The first prototype was then validated by experts, including a lecturer from the S2 Mathematics Education Program at Universitas Pendidikan Ganesha, a lecturer from the S2 Educational Technology Program, and a junior high school teacher. This expert validation aimed to refine the initial prototype for limited testing. The e-module was assessed using validation sheets for both the media and the content, where experts scored each aspect on a scale of 1-5. The average score was then converted into a validity criterion. In addition to the scores, experts also provided valuable feedback and suggestions for improvement, which guided the revision of the e-module before it could be field-tested. After undergoing revisions and assessments, the Project-Based Learning e-module, supported by Scratch, was refined into Prototype II, which is now ready for implementation in the school where the research is taking place. The product testing process will proceed in three phases: a limited trial, field test I, and field test II.

Limited Trial

Prototype II was then subjected to a limited trial, involving 7th-grade students and a mathematics teacher from SMP High Scope Denpasar. This school was chosen because it had already incorporated Scratch programming into its informatics curriculum, allowing the researcher to clearly identify the strengths and weaknesses of the e-module. The focus of the limited trial was to gather an overview of the feasibility and effectiveness of the developed e-module.

Each trial session consisted of planning, execution, observation, evaluation, and reflection to assess the practicality of the learning e-module. At the end of each session, observers conducted evaluations to address any issues immediately, ensuring that the subsequent learning sessions would proceed more smoothly. During the limited trial, surveys were distributed to both students and teachers to assess the practicality of the e-module.

The survey results were analyzed and converted into practicality criteria. The teacher's response score was 69.33%, which falls under the practical category, while the students' average response score was 68.52%, also categorized as practical. In addition to the practicality scores, the feedback and suggestions from both students and teachers were used to revise Prototype II, leading to the creation of Prototype III, which is now ready for further testing in Field Test I.

Field Test

After improvements based on the limited trial, Prototype III was tested again in what is known as Field Trial I. The main focus of this phase was to assess the quality of the product, specifically in terms of its effectiveness and practicality. Field Trial I took place with 7th-grade students from Class VII C at SMP Negeri 5 Denpasar. The trial was conducted in three key phases: implementation, observation, and reflection/evaluation.

During the implementation phase, researchers, teachers, and students used Prototype III in a learning session, following a predetermined schedule. Observation was carried out by two observers: the 7th-grade math teacher and the researcher. Both students and educators completed a response questionnaire to assess the practicality of the e-module. The results were promising, with students scoring an average of 75.73%, classified as *very practical*, and the teacher's response score was even higher at 77.71%, also categorized as *very practical*. The feedback and suggestions collected during Field Trial I were then used to revise Prototype III, resulting in Prototype IV, which is now ready for further testing in Field Trial II.

3. Assessment Phase

The assessment phase continues with Field Trial II, where Prototype IV was tested. This phase took place in class VII D (30 students) and class VII C (28 students) at SMP Negeri 5 Denpasar. The primary focus of Field Trial II was to obtain a final product that is valid, practical, and effective.

As in Field Trial I, Field Trial II was carried out in three stages: implementation, observation, and reflection/evaluation. During the implementation phase, the researcher, teacher, and students conducted learning activities using Prototype IV according to the scheduled plan. Observations were made by two observers one teacher and the researcher. After each session, evaluations were conducted to identify any challenges, and solutions were provided to ensure the next session would be more efficient.

For the evaluation phase, data was gathered through response questionnaires from both students and teachers. The student response questionnaire resulted in an average score of 80%, classified as very practical, while the teacher's response questionnaire scored 85.6%, also categorized as very practical. These positive results confirmed the practicality of the e-module, marking a successful conclusion to the testing process.

Quality of the Developed Learning Emodules

Kualitas emodul berbasis Project Based Learning berbantuan Scratch dalam penelitian ini dilihat berdasarkan kriteria validitas, kepraktisan dan efektivitas.

Learning module validity

This learning module was validated by three experts who came from a lecturer of Master of Mathematics Education, a lecturer of Master of Educational Technology, and 1 mathematics subject teacher who was active as a driving teacher. The validity of the developed learning module is seen based on content validity if the design is in accordance with the systematic Plomp development model. While construct validity is seen from the existence of linkages and consistency of each component contained in the learning module. To see the construct validity and content validity of the learning modules developed, the opinions of experts have been requested, namely a Master of Mathematics education lecturer, a Master of Educational Technology lecturer and a mathematics teacher. The following is a summary of the results of the validator's assessment:

Table 2. Summary of Learning Module Validator Results

Validator	Average	Average Total	Categories
Validator 1	4.00	4.00	Very Good
Validator 3	4.00		
Validator 2	4.00		

Sources: Data Processed, 2025

Referring to the results of the table above, each validator gave a score with an average score of 4.00, namely the learning module developed met the excellent category. So it can be concluded that from all aspects of validation measured, the learning module developed has met the excellent category so it is like to be implemented.

Validitas RPP E-Modul berbasis Project Based Learning

The e-module, based on the Project-Based Learning model, was validated by a lecturer from the S2 Educational Technology Program. This expert validation aimed to ensure that the learning syntax aligns perfectly with the applied teaching model. The validation results were not only reflected in the scores, which were converted into validity criteria, but also in valuable feedback and suggestions for improving the lesson plan (RPP). The validation process yielded an impressive average score of 80%, categorized as *excellent.*

Validity of Pre-Test and Post-Test of Flat Building Materials on Computational Thinking

In knowing the ability of computational thinking in the use of e-modules, researchers validated the experts. Validation using a lecturer of Master of Educational Technology who is an expert on computational thinking ability. The indicators of computational thinking skills tested here are only at 4 stages, namely, abstraction, decomposition, pattern recognition, and algorithms. The results of this validation obtained an average of 4 with several revisions. After the researchers made revisions to the pretest and posttest questions, then this sheet will be used as a reference to determine the computational thinking ability of students.

DISCUSSION

Development Process of Scratch-assisted Project Based Learning E-module to Improve Computational Thinking

In the development of a project-based learning (PBL) e-module, the first step is to analyze the characteristics of the students. This analysis was conducted in two schools: SMP High Scope and SMP Negeri 5 Denpasar. SMP High Scope was chosen for the limited trial due to several reasons: (1) access and availability of facilities, as private schools tend to have better and more complete technological facilities, such as computers and sufficient internet access, which are essential for testing the Scratch-based e-module; (2) conducting a limited trial at a private school provides an opportunity to identify and address shortcomings in the e-module before it is implemented in a public school, where there may be more challenges. After the limited trial was conducted to refine the developed e-module, a field trial was carried out at SMP Negeri 5 Denpasar. The reasons for conducting the field trial in a public school include: (1) demographic diversity, as public schools typically have a more diverse student population in terms of socioeconomic backgrounds, providing a more representative picture of the e-module's effectiveness across different student groups; (2) implementation on a larger scale, the field trial in a public school allows for the assessment of how the e-module can be applied on a larger scale and helps identify challenges that may not emerge during the limited trial; (3) national educational policies and standards, as public schools generally adhere to stricter national educational policies and standards. Testing the e-module in this environment ensures that it aligns with and is effective within the broader educational context and standards; (4) distribution and replication, the e-module can be more easily replicated and distributed to other public schools across the country, supporting the wider improvement of computational thinking skills.

Despite the differences between the two schools, there were several similarities in the student characteristics that led to the selection of these schools for the study. These include: (1) social and emotional needs, where adolescents in both schools require healthy social interactions with peers and support from adults to address challenges; (2) motivation and interest, as students in both schools are motivated to learn about technology and work on projects; (3) learning abilities, where both schools generally share similar foundational skills, such as the same mathematics content and basic concepts, even though teaching methods may differ. Based on the analysis of student characteristics, the development of the e-module was carried out to gain a more comprehensive understanding and create an effective module that can be widely implemented.

In building the project-based learning e-module, several software tools play a crucial role in creating an engaging learning experience. Canva serves as the primary platform for designing and organizing the e-module, making it easier to visualize content in a dynamic and engaging way for students. Scratch is used as the platform for students to create learning projects. Meanwhile, Filmora is used for producing instructional videos and creating animations that help students better understand the material. Google Forms is also used as a tool for submitting assignments, enabling teachers to track students' progress in line with the project-based learning model. These software tools work together to provide an engaging learning experience and support students' computational thinking development.

At the beginning of the e-module, users are introduced to the cover page of the developed module, designed with eye-catching visuals to attract students' attention. After viewing the cover, students are directed to the introduction section, which expresses gratitude for the completion of the e-module. The table of contents includes three main topics: properties of flat shapes, types of flat shapes, and geometric transformations. These topics are aligned with the Merdeka Curriculum. The table of contents also includes page numbers and learning objectives to help students navigate the material. After the table of contents, students are led to the learning flow, which is structured according to the Project-Based Learning model. The e-module includes 3 topics, each followed by project tasks and evaluations. Additionally, there is a guide on how to use the e-module, which includes activities to be conducted and evaluations to be performed.

The first topic, the properties of flat shapes, begins with the learning objectives and the allocated time. The e-module uses the Canva Sans font at size 12, with a white background to ensure readability and blue accents. This section covers lines and includes practice problems supported by Scratch. These problems are designed as small projects to be completed collaboratively by students and teachers. The practice problems are time-bound to enhance the effectiveness of the lesson. Students can directly access Scratch through a link provided in the module. The module then moves on to the topic of angles, explaining different types of angles, followed by Scratch-based practice problems. Additionally, video explanations are provided through clickable YouTube links.

Students are then guided to a group project, where they collaborate to solve more complex problems. The group project includes information such as group identity, learning achievements, objectives, time allocation, materials, principles, and steps for completion. Students can submit their group projects via a Google Form link provided in the module. After completing the group project, students respond to an individual evaluation to generalize the material they have learned together.

The next topic, types of flat shapes, also begins with the learning objectives and time allocation. The e-module uses Canva Sans font at size 12. The first subtopic is the rectangle, followed by practice problems supported by Scratch. Other subtopics such as squares, parallelograms, rhombuses, kites, and trapezoids are introduced, each with textual explanations, Scratch-based practice problems, and instructional videos. After completing the basic material, students are tasked with a group project. This group project includes the same components as the previous one, such as group identity, learning objectives, materials, and work steps. The project is submitted via the provided Google Form link. After the group project, an individual evaluation is given, containing 10 questions to help students summarize the material.

The final topic, geometric transformations, starts with learning objectives and time allocation. The first subtopic is translation, followed by practice problems supported by Scratch. Other subtopics such as rotation and reflection are also covered. Afterward, students are assigned a group project with the same components as in previous projects. The project is submitted via a Google Form link, and an individual evaluation is provided after the project is completed.

Several studies have been conducted on the development of e-modules, such as Afitra (2020), who created a basic programming module to improve computational thinking skills. However, Afitra's module could only be accessed offline and lacked interaction between media, teachers, and students after the class. Handayani (2023) developed a problem-based learning e-module with Scratch to improve computational thinking. However, the e-module had limited projects to help improve computational thinking. The developed e-module has several advantages, including the provision of both textual and video explanations to help students understand challenging concepts, Scratch-based practice problems that encourage active learning and collaboration, individual evaluations that aid in generalizing knowledge, direct interaction in group projects, and the inclusion of clickable Scratch links to assist students who face challenges with the projects.

Despite its strengths, the e-module has some limitations, such as the need for an internet connection to access Scratch, the absence of correction features for project practice problems, and limited time for learning. These limitations highlight the importance of providing additional guidance outside of class for students who may not be familiar with Scratch. The validity of the project-based learning e-module was assessed through expert evaluations, with an average score of 4.00, categorized as excellent. The e-module is considered valid and effective for improving students' computational thinking.

Learning Trajectory Using Project Based Learning E-Modules based on Scratch to Improve Computational Thinking Skills

After the developed e-module is validated as valid, practical, and effective, a learning trajectory needs to be designed for students during the learning process using the e-module with a focus on the Project-Based Learning (PBL) model. A learning trajectory refers to the pathway or process of providing experiences to students to achieve a change through stimulus and response interactions. A learning trajectory has a starting point (student experience and condition), a pathway (staggered activities), and an endpoint (learning goals). The learning trajectory designed by the teacher should guide students to achieve the learning objectives step by step.

The development of a Hypothetical Learning Trajectory (HLT) for each learning activity is a crucial part of designing student learning activities. This design is inseparable from the learning trajectory, which contains the lesson plan for the material to be taught. In this context, the learning trajectory serves as the concept map that will be traversed during the learning process. The learning trajectory used in this study is the understanding of flat shape concepts through the use of the e-module to enhance computational thinking skills. HLT consists of three components: learning objectives, learning activities, and hypotheses about the learning process that predict the development of students' thinking (Putri, 2020). One way to achieve this is by creating a clear and easily understandable learning trajectory for the teacher.

The HLT is designed to ensure that students progress through the learning activities with increasing levels of understanding, starting from basic concepts related to flat shapes and gradually moving to more complex ideas related to geometric transformations. Through this step-by-step approach, students will not only acquire knowledge but also develop critical computational thinking skills, as outlined in the Project-Based Learning model. The teacher plays a pivotal role in guiding students through the learning trajectory, helping them to make connections between the content, activities, and real-world applications, while providing scaffolding as needed to support student learning and growth.

CONCLUSION

In conclusion, the development of the Project-Based Learning (PBL) e-module supported by Scratch has proven to be effective in enhancing computational thinking skills among students. The e-module features an intuitive interface, easy access via multiple devices, and engaging elements such as videos, Scratch integration, and self-assessment tools, which have positively impacted student motivation and learning outcomes. The e-module underwent rigorous validation, practicality, and effectiveness testing, with results indicating a high level of practicality and a significant improvement in students' computational thinking, as evidenced by N-Gain and T-test analyses. The learning trajectory designed through this approach provided a structured path that guided students through understanding and solving complex geometric problems in a step-by-step manner.

For future research and development, it is recommended to expand the e-module by incorporating more creative and engaging elements, such as interactive discussions or a collaborative online forum where students can share ideas and provide feedback. Additionally, providing a basic Scratch tutorial for students unfamiliar with the platform would enhance accessibility and user experience. This can be implemented through videos, text, or images, further supporting students' learning and ensuring that they can fully engage with the e-module. These improvements will strengthen the overall learning process and facilitate a more dynamic and interactive educational environment.

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