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Developing a geogebra-based ethno-didactical module on Prambanan temple geometry to foster mathematical mindset

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***Abstract**:* This study aimed to develop a GeoGebra-assisted teaching module based on an ethno-didactical situation using the context of Prambanan Temple to foster students' mathematical mindset in geometry learning. The study employed a research and development approach using the ADDIE model, consisting of analysis, design, development, implementation, and evaluation stages. The developed module integrated the cultural context of Prambanan Temple, particularly the batur structure, with GeoGebra-based activities to support students' exploration of the surface area of a rectangular prism. Data were collected through expert validation sheets, student response questionnaires, and mathematical mindset questionnaires. The findings showed that the developed module was valid, practical, and effective for use in learning. The activities in the module helped students face mathematical challenges, try different strategies, revise their constructions, and validate their ideas through GeoGebra. The module also encouraged students to view mistakes as part of the learning process. These findings indicate that culturally grounded digital geometry tasks have the potential to support the development of students' mathematical mindset.

Keywords: ethno-didactical situation; GeoGebra; mathematical mindset; Prambanan Temple; geometry learning

Mengembangkan modul etnodidaktik berbasis geogebra tentang geometri candi Prambanan untuk menumbuhkan mindset matematika

Abstrak: Penelitian ini bertujuan untuk mengembangkan modul pembelajaran berbasis GeoGebra yang didasarkan pada situasi etnodidaktik dengan menggunakan konteks Candi Prambanan untuk menumbuhkan mindset matematika siswa dalam pembelajaran geometri. Penelitian ini menggunakan pendekatan penelitian dan pengembangan dengan model ADDIE, yang terdiri dari tahapan analisis, desain, pengembangan, implementasi, dan evaluasi. Modul yang dikembangkan mengintegrasikan konteks budaya Candi Prambanan, khususnya struktur batur, dengan aktivitas berbasis GeoGebra untuk mendukung eksplorasi siswa tentang luas permukaan prisma berbentuk segi empat. Data dikumpulkan melalui lembar validasi ahli, kuesioner respons siswa, dan kuesioner mindset matematika. Hasil penelitian menunjukkan bahwa modul yang dikembangkan valid, praktis, dan efektif untuk digunakan dalam pembelajaran. Aktivitas dalam modul membantu siswa menghadapi tantangan matematika, mencoba berbagai strategi, merevisi konstruksi mereka, dan memvalidasi ide mereka melalui GeoGebra. Modul ini juga mendorong siswa untuk melihat kesalahan sebagai bagian dari proses pembelajaran. Temuan ini menunjukkan bahwa tugas geometri melalui GeoGebra yang berakar pada budaya berpotensi mendukung pengembangan mindset matematika siswa.

Keywords: situasi etnodidaktis; GeoGebra; mindset matematika; Candi Prambanan; pembelajaran geometri

INTRODUCTION

Geometry is an essential domain in school mathematics because it supports students' spatial reasoning, visualization, representation, argumentation, and understanding of relationships among shapes, sizes, positions, patterns, and transformations (Jones & Tzekaki,

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2016; Weigand et al., 2025). However, geometry is still often experienced by students as an abstract and procedural topic. Students are frequently required to remember formulas and properties of figures without sufficient opportunities to observe, construct, manipulate, and validate geometric relationships (Na & Sung, 2025; Yahya & Hershkowitz, 2024). Such learning conditions may limit students' conceptual understanding and reduce their confidence when dealing with challenging geometry tasks. Therefore, geometry learning requires instructional designs that provide visual, exploratory, and meaningful learning experiences rather than merely emphasizing final answers or routine procedures (Tzoumpa et al., 2025).

In this context, fostering students' mathematical mindset becomes important. Mathematical mindset refers to how students perceive mathematical ability, challenges, difficulties, effort, feedback, and the success of others in learning mathematics (Boaler & Aler, 2016; Saefudin, Wijaya, Dwiningrum, et al., 2023). Previous research has shown that many junior high school students tend to demonstrate a growth mathematical mindset, but this tendency is not always strong when they face mathematical challenges and obstacles (Saefudin, Wijaya, et al., 2023b). This suggests that students need more than motivational messages about effort or intelligence. They need learning situations that allow them to experience productive struggle, revise mistakes, use alternative strategies, and reflect on their mathematical thinking (DiNapoli & Miller, 2022). Mindset interventions in mathematics are also more meaningful when they are directly connected to classroom activities and mathematical learning experiences (Bui et al., 2023; Shoshani, 2021).

One promising way to make geometry learning more meaningful is to connect it with cultural contexts. Ethnomathematics helps students recognize that mathematics is embedded in social practices, cultural artifacts, architecture, and local heritage (D'Ambrosio & Rosa, 2017; Rosa & Orey, 2016). In Indonesia, Prambanan Temple offers rich geometric potential through its structures, ornaments, spatial arrangements, patterns, symmetry, and proportions. Previous studies have identified geometric concepts in Prambanan Temple and other Indonesian cultural artifacts (Endaristi et al., 2023; Kusuma et al., 2024; Prahmana & D'Ambrosio, 2020). However, many ethnomathematics studies still remain at the level of identifying mathematical ideas in cultural objects (Lidinillah et al., 2022; Sunzuma & Umbara, 2025). This limitation is important because identifying cultural mathematics does not automatically result in a structured learning experience that supports students' reasoning, validation, reflection, and mathematical mindset.

Another important element is the use of digital technology, particularly GeoGebra, to support dynamic geometry exploration. GeoGebra enables students to construct, manipulate, compare, and validate geometric objects visually and interactively (Gökçe & Güner, 2022; Yohannes & Chen, 2023). Nevertheless, technology-based geometry learning is often implemented as a visualization tool without being strongly connected to cultural contexts or didactical design (Sudirman et al., 2024). Similarly, mindset-oriented learning is often treated as a motivational component rather than being embedded in students' mathematical activity. These gaps indicate the need for a module that integrates cultural context, dynamic technology, and didactical structure.

In this study, the concept of ethno-didactical situation is used to transform Prambanan Temple from a cultural object into a mathematical milieu that supports action, formulation, validation, and institutionalization in geometry learning (Artigue et al., 2014; Brousseau, 2002b). Ethno-didactical situation in this study is understood as a mathematics learning situation that transforms a local cultural context into a didactical *milieu*, so that students do not merely recognize mathematical elements in cultural artifacts but also construct mathematical concepts through the processes of action, formulation, validation, and institutionalization (Artigue et al., 2014; Brousseau, 2002a). In the context of this article, Prambanan Temple, particularly the Batur section, is not positioned merely as a cultural illustration, but as a source of geometric situations that encourages students to observe shapes, make conjectures, model objects using GeoGebra, validate their constructions, and reflect on their learning strategies. Thus, the ethno-didactical situation connects ethnomathematics, didactical design, digital technology, and the development of students' mathematical mindset within a structured learning experience.

Based on these gaps, this study aims to develop a GeoGebra-assisted teaching module based on an ethno-didactical situation using the context of Prambanan Temple to foster students' mathematical mindset in geometry learning. The module focuses on the exploration of the *Batur* structure of Prambanan Temple, which can be modeled as a rectangular prism to support students' understanding of surface area. The contribution of this study lies in designing culturally grounded digital geometry tasks that do not merely introduce local culture or use GeoGebra as a visual aid, but create learning experiences that encourage students to face challenges, make conjectures, revise constructions, validate ideas, and reflect on their mathematical strategies.

METHODS

Research Design

This study employed a Research and Development (R&D) approach using the ADDIE development model, which consists of five stages: Analysis, Design, Development, Implementation, and Evaluation (Branch, 2009; Molenda, 2003). The ADDIE model was selected because it is suitable for systematically developing instructional materials, from needs analysis to product evaluation. The product developed in this study was a GeoGebra-assisted teaching module based on an ethno-didactical situation using the context of Prambanan Temple to foster students' mathematical mindset in geometry learning. The quality of the module was assessed based on three aspects: validity, practicality, and potential effectiveness. Validity was obtained through expert judgment, practicality was obtained from teacher and student responses, as well as learning implementation, while potential effectiveness was examined from the tendency of students' mathematical mindset after using the module.

Participants and Research Setting

The study was conducted in geometry learning at the junior high school level at SMP 2 Negeri Prambanan, involving 32 students. The research subjects consisted of expert validators, a mathematics teacher, and students. The expert validators included an expert in mathematics education, an expert in instructional media/GeoGebra, and an expert in instructional design. The mathematics teacher was involved in providing an assessment of the practicality of the module, while the students were involved in a limited trial. The subjects were selected purposively by considering the suitability of the geometry material currently being studied by the students and the teacher's readiness to use GeoGebra. The geometry material used in the module covered concepts relevant to the context of Prambanan Temple, particularly the concept of polyhedra.

Development Procedure

The module was developed through the five stages of ADDIE. In the Analysis stage, the researchers analyzed learning needs, student characteristics, curriculum, geometry material, the ethnomathematical potential of Prambanan Temple, and indicators of mathematical mindset. The analysis of the Prambanan Temple context was directed toward geometric elements such as shapes, patterns, symmetry, proportion, and spatial structures that could be used as sources of learning activities (Endaristi et al., 2023). In the Design stage, the researchers designed a module that included learning objectives, GeoGebra exploration activities, the Prambanan Temple context, investigative tasks, reflective questions, and a learning assessment. The sequence of activities was designed based on the principles of the Theory of Didactical Situations, namely action, formulation, validation, and institutionalization (Artigue et al., 2014; Brousseau, 2002a). At this stage, expert validation instruments, teacher and student response questionnaires, observation sheets, and a mathematical mindset scale were also prepared.

In the Development stage, the module design was developed into a prototype. The module contained learning activities based on the Prambanan Temple supported by GeoGebra as a tool for exploring, constructing, and validating geometric objects. The module prototype was then validated by experts to assess the aspects of content, didactical design, media, language, layout, and alignment with mathematical mindset indicators. Revisions were made based on the scores and suggestions from the validators. In the Implementation stage, the revised module was tested in a limited geometry learning setting. During the implementation, students used GeoGebra to explore geometric shapes and patterns inspired by Prambanan Temple. The teacher facilitated learning according to the stages of the ethno-didactical situation, from exploration, conjecture formulation, and validation to the development of formal concepts. In the Evaluation stage, the researchers evaluated the validity, practicality, and potential effectiveness of the module. Formative evaluation was conducted at each stage of development, while the final evaluation was conducted after the limited trial to determine the overall quality of the module.

Research Instruments

The instruments used in this study included: expert validation sheets to assess the feasibility of the module in terms of content, instructional design, GeoGebra media, language, layout, and mathematical mindset; learning implementation observation sheets to observe the learning process using the module; teacher and student response questionnaires to assess the practicality of the module; and a mathematical mindset scale to measure students' tendencies toward mathematical ability, challenges, difficulties, effort, feedback, and the success of others. The mathematical mindset scale was developed by referring to the dimensions of mathematical mindset proposed by Saefudin, et al. (2023a), namely mathematical ability and intelligence, challenges, obstacles, effort, criticism or feedback, and the success of others, with Aiken's V values of 0.91 and 0.89, respectively. The mathematical mindset questionnaire showed acceptable internal consistency (Cronbach's $\alpha = 0.87$), while the student response sheet yielded $\alpha = 0.82$.

In the mathematical mindset scale, the mathematical ability aspect refers to students' beliefs about whether mathematical competence can grow through learning and practice. The challenges aspect concerns students' willingness to engage with demanding mathematical tasks, while the difficulties aspect reflects how students interpret obstacles during learning. The effort aspect captures students' beliefs about the role of persistence, strategies, and hard work in mathematics learning. The feedback aspect measures students' openness to criticism and corrective input, whereas the success of others aspect reflects how students perceive peers' success as either a threat or a learning resource (Saefudin, et al., 2023).

Data Collection Techniques

Data were collected through document analysis, expert validation, learning observation, tests, and questionnaires. Document analysis was used to analyze the curriculum, geometry material, and the geometric potential of Prambanan Temple. Expert validation was conducted after the module prototype had been developed. Observation was conducted during the limited trial to examine the implementation of learning. The mathematical mindset scale was administered before and after learning, while the response questionnaire was administered after the module implementation had been completed.

Data Analysis

Data were analyzed quantitatively and qualitatively. The validity of the module was analyzed using Aiken's V based on the assessments of expert validators. Aiken's V was used because it is appropriate for analyzing content validity based on ratings from several experts (Aiken, 1985). The module was considered valid if it obtained a validity score in the high category and was feasible for use after revision. The practicality of the module was analyzed from teacher responses, student responses, and observations of learning implementation. Questionnaire scores were converted into percentages. The percentages were then categorized as highly practical, practical, fairly practical, less practical, or impractical.

The development of students' mathematical mindset was analyzed by comparing pretest and posttest scores. Descriptive analysis was conducted by calculating the mean and standard deviation for each dimension of mathematical mindset, namely, mathematical ability and intelligence, challenges, obstacles, effort, criticism, and the success of others. Furthermore, the mathematical mindset scores were categorized into four levels: Fixed-Fixed, Fixed-Growth, Growth-Fixed, and Growth-Growth, by adapting the mathematical mindset categories from (Saefudin, et al., 2023b). To determine the difference in mathematical mindset scores before and after the use of the module, the data were first tested for normality using the Shapiro–Wilk test. Subsequently, the analysis was continued using a paired-sample t-test at a significance level of 0.05. Qualitative data in the form of validator comments, observation notes, and students' open-ended responses were analyzed descriptively to support the quantitative findings and to serve as the basis for module revision.

RESULT AND DISCUSSION

Development Rationale of the Mathematical Mindset-Oriented Module

The development of this module was grounded in the need to provide geometry learning that not only emphasizes conceptual understanding but also fosters students' mathematical mindset. Initial data indicated that mathematics learning at SMP Negeri 2 Prambanan required instructional materials that were more independent, interactive, and exploratory. The previously developed module had employed a GeoGebra-assisted Didactical Situation approach to support the improvement of Grade VIII students' mathematical mindset.

This need became the basis for module development in the present study. Geometry often requires students to imagine shapes, recognize patterns, formulate conjectures, and validate spatial relationships. Such activities cannot be sufficiently facilitated through procedural explanations. Students need learning experiences that allow them to face challenges, try strategies, revise mistakes, and reflect on their thinking processes. In this context, the mathematical mindset is not positioned as a motivational message, but as a learning experience constructed through mathematical activities.

The module was then developed by integrating three main elements: the context of Prambanan Temple, the use of GeoGebra, and the ethno-didactical situation sequence. Prambanan Temple provides a cultural context rich in shapes, patterns, symmetry, proportions, and spatial structures. GeoGebra functions as a tool for visual exploration and validation, while the ethno-didactical situation provides a learning structure that encourages students to move from concrete observation to concept formulation and validation. This framework is relevant to the view that mindset interventions in mathematics are more meaningful when they are directly connected to learning activities, rather than standing alone as general messages about effort or motivation (Bui et al., 2023; Saefudin, et al., 2023). Table 1 shows that the need for module development is not only technical but also pedagogical. The module needs to help students experience mathematics as a process that can be learned through effort, strategy use, correction, and reflection.

Table 1. Needs Analysis for Mathematical Mindset Development

Analysis Aspect	Main Findings	Implications for Module Development
Students' needs	Students need more visual, interactive, and exploratory mathematics activities.	The module includes exploration-based GeoGebra activities.
Learning needs	Learning should not merely emphasize final answers.	The module provides opportunities for students to try, revise, and validate their ideas.
Mathematical mindset	Students need to be trained to deal with challenges, obstacles, effort, criticism, and the success of others.	The module includes mathematical mindset reflection activities.
Cultural context	Prambanan Temple has potential geometric elements, such as shapes, patterns, symmetry, and spatial structures.	The Prambanan Temple context is used as a source of geometric situations.
Technology	GeoGebra supports geometric visualization and exploration.	The module includes GeoGebra-assisted construction and validation activities.

Design of the GeoGebra-Assisted Ethno-Didactical Module

The module developed in this study was based on an ethno-didactical situation through GeoGebra within the context of Prambanan Temple. Prambanan Temple was not merely used as a cultural illustration, but as a source of geometric situations that encouraged students to observe, make conjectures, construct objects, validate results, and reflect on their learning process.

Figure 1. Cover and content of the developed GeoGebra-assisted ethno-didactical module based on Prambanan Temple for Grade VIII geometry learning.

GeoGebra was used as an exploratory tool because it allows students to dynamically manipulate geometric objects. Students can change points, lines, measurements, or shapes, and immediately observe the effects on their constructions. This characteristic is important for developing a mathematical mindset because mistakes can be observed, revised, and discussed as part of the learning process. This finding is in line with studies on GeoGebra showing that this tool supports visualization, exploration, and dynamic representation in mathematics learning (Gökçe & Güner, 2022; Yohannes & Chen, 2023).

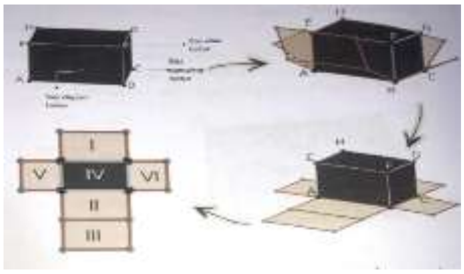
Figure 1 shows the identity of the developed product, namely a Grade VIII geometry module that integrates the context of Prambanan Temple, the Didactical Situation approach, and GeoGebra-assisted activities. This display is important to demonstrate that the module was designed from the outset as a contextual teaching material, not merely as a digital worksheet.

Table 2. Structure of the module for mathematical mindset development

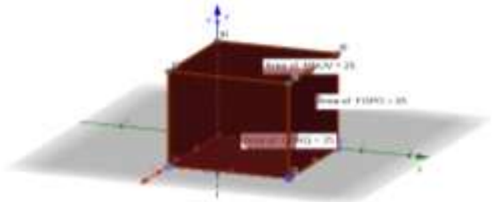
Module Component	**Description**	**Mathematical Mindset Orientation**
Introduction to Prambanan Temple	Presents visual representations and the cultural context of Prambanan Temple.	Fosters curiosity and cultural connectedness.
Geometric situation	Students observe shapes, patterns, or symmetry in the Prambanan Temple.	Develops students' courage to face challenges.
GeoGebra activity	Students construct and validate geometric objects.	Train effort, strategy use, and perseverance.
Group discussion	Students compare conjectures and strategies.	Strengthens students' acceptance of feedback.
Mindset reflection	Students reflect on mistakes, strategies, and effort.	Develops awareness that mathematical ability can grow.
Teacher guide	The teacher facilitates action, formulation, validation, and institutionalization.	Supports a productive learning environment.

The structure presented in Table 2 shows that a mathematical mindset is integrated into the core activities of the module. Students are not only asked to answer problems, but are also guided to experience mathematical thinking processes: observing, trying, formulating conjectures, validating, revising, and reflecting. From the perspective of the Theory of Didactical Situations, mathematics learning occurs when students interact with the milieu and develop strategies to solve problems (Artigue et al., 2014; Brousseau, 2002b). In this module, Prambanan Temple and GeoGebra function as the milieu that enables students to experience geometric challenges productively.

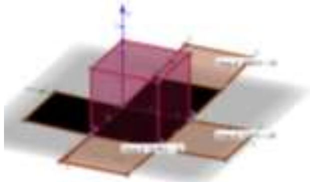
(a) Batur's shape resembles a cuboid



(b) Batur abstraction is an object shaped like a cuboid, which will be opened in the form of a cuboid net



(c) The cuboid resembles a rectangular shape formed using the GeoGebra application



(d) The net of a cuboid formed using the GeoGebra application

Figure 2. GeoGebra-based visualization of a Batur as a rectangular prism to support students' exploration of surface area through side identification, net representation, and area calculation.

Figure 2 shows an example of a GeoGebra activity used by students to visualize the surface area of the *Batur*. In this visualization, the *Batur* is represented as a quadrilateral prism that can be unfolded into a net. Each face in the net is labeled with its area, allowing students to see that surface area does not come from a single face, but from the sum of all faces composing the solid figure. Through this representation, students can connect the three-dimensional form of the *Batur* with its two-dimensional net.

This activity helps students understand that the surface area of a quadrilateral prism is obtained by adding the areas of all its faces. In the context of a rectangular prism, students are guided to recognize two faces with dimensions $p \times l$, two faces with dimensions $p \times t$, and two faces with dimensions $l \times t$, so that the surface area of the rectangular prism is $2(p \times l) + 2(l \times t) + 2(l \times t) = 2(pl + pt + lt)$. Thus, the surface area formula is not introduced as an initial formula to be memorized, but is constructed through the process of observation, unfolding the solid, and adding the areas of its constituent faces.

This GeoGebra activity also supports the development of a mathematical mindset. When students try to create a rectangular prism model, unfold its net, or recheck the results of their surface area calculation, they are given space to try, revise, and validate their work. If the construction is not yet accurate, students can modify the points, dimensions, or arrangement of faces in GeoGebra. This process helps students view mistakes as part of learning, rather than as failure.

Thus, the exploration of the *Batur* of Prambanan Temple through GeoGebra not only clarifies the concept of surface area but also builds a learning experience that emphasizes challenge, effort, perseverance, and strategy (Saefudin et al., 2025). This is in line with the orientation of a mathematical mindset, in which mathematical ability can develop through effort, reflection, and strategy improvement (Boaler & Aler, 2016; Bui et al., 2023; Saefudin, Wijaya, Dwiningrum, et al., 2023). In addition, the use of GeoGebra as a dynamic visual medium enables students to test and validate geometric ideas more concretely, as emphasized in studies on the role of GeoGebra in supporting exploration and dynamic representation in mathematics learning (Gökçe & Güner, 2022; Yohannes & Chen, 2023).

Validity of the Developed Module

The expert validation results showed that the module met the validity criteria. The content expert validation obtained Aiken's V values ranging from 0.875 to 1.00 for the aspects of content feasibility, language feasibility, and the module based on Didactical Situation. The presentation feasibility aspect obtained a value of 1.00, while the media expert validation for the graphics aspect obtained Aiken's V values ranging from 0.875 to 1.00, as presented in Table 3. Therefore, the module was considered feasible for use in learning.

Table 3. Expert validation results of the developed module

Validation Aspect	Number of Items	Aiken's V Range	Category	Relevance to Module Development
Content feasibility	12	0.875–1.00	Valid	The geometry content is appropriate for use.
Presentation feasibility	6	1.00	Valid	The module structure supports step-by-step learning.
Language feasibility	7	0.875–1.00	Valid	The instructions are understandable for students.
Didactical Situation	8	0.875–1.00	Valid	The didactical sequence supports exploration and validation.
Graphics/media feasibility	17	0.875–1.00	Valid	The module layout and media support the use of GeoGebra.

The validation results indicate that the module has adequate feasibility in terms of content, presentation, language, didactical design, and media display. In the context of developing mathematical mindset, module validity is important because the designed activities must be mathematically accurate, easy to understand, and able to provide space for students to engage actively. A valid module is not only one that aligns with the learning content, but also one that offers learning experiences that enable students to develop effort, strategy use, perseverance, and reflection.

Practicality of the Module in Limited Implementation

The module trial was conducted in two stages: a small-scale trial involving 5 students from Grade VIII B and a large-scale trial involving 32 students from Grade VIII A of SMP Negeri 2 Prambanan. After using the module, students completed a response questionnaire to assess its practicality and a mathematical mindset questionnaire to examine the development of their mathematical mindset.

The student response results showed that the module obtained a mean score of 39.5, which was categorized as highly practical. This finding indicates that the module could be used effectively by students in the learning process. Practicality is an important aspect because the development of mathematical mindset requires students' active engagement. If the module instructions are difficult to understand or the digital activities are too complex, students will face more technical obstacles rather than focusing on mathematical exploration.

Table 4. Practicality results related to mathematical mindset development

Data Source	Main Result	Category	Implications for Mindset Development
Small-scale trial	5 students	Initial trial	The module could be reviewed before broader implementation.
Large-scale trial	32 students	Main implementation	Mindset data could be analyzed descriptively and inferentially.
Student responses	M = 39.5	Highly practical	The module was easy to use and supported students' learning engagement.
Implementation notes	Some students still needed assistance in using GeoGebra.	Technical guidance needed	Digital activities should be designed in a gradual and scaffolded manner.

Table 4 shows that the module was sufficiently practical for use in learning. However, the note that some students still needed assistance in using GeoGebra should be considered. This does not weaken the function of the module, but indicates the need for more gradual technical guidance. With simpler instructions, students can focus more on the main goals of learning, namely exploring, revising, validating, and reflecting on the geometry learning process.

Students' Mathematical Mindset Development

The main analysis in this study focused on the development of students' mathematical mindset. The data were analyzed based on six dimensions: mathematical ability and intelligence, challenge, obstacles, effort, criticism, and the success of others. These six dimensions refer to the mathematical mindset framework used by Saefudin, et al. (2023). The descriptive results of students' mathematical mindset development by dimension are presented in Table 5.

Table 5. Descriptive results of students' mathematical mindset by dimension

Mathematical Mindset Dimension	Number of Items	Pretest M	Pretest SD	Posttest M	Posttest SD	Difference
Mathematical ability and intelligence	2	2.05	0.57	2.22	0.57	+0.17
Challenge	4	1.56	0.24	1.87	0.30	+0.31
Obstacles	4	1.91	0.46	2.13	0.41	+0.21
Effort	3	1.67	0.37	1.98	0.36	+0.31
Criticism	3	1.85	0.52	1.85	0.54	0.00
Success of others	4	1.73	0.48	1.84	0.26	+0.12
Total mathematical mindset	20	1.77	0.21	1.96	0.19	+0.19

Table 5 shows that the total mean score of students' mathematical mindset increased from M = 1.77, SD = 0.21 in the pretest to M = 1.96, SD = 0.19 in the posttest. This increase indicates a positive tendency after students learned to use the module. The largest increases occurred in the dimensions of challenge and effort, each by +0.31, followed by the obstacles dimension by +0.21. The increase in the challenge dimension indicates that students became more prepared to engage with geometry tasks that required exploration. This can be explained by the characteristics of the module activities, which did not directly provide final procedures, but asked students to observe patterns of the Prambanan Temple, formulate conjectures, and test constructions using GeoGebra. The increase in the effort dimension indicates that students were more encouraged to use strategies and effort in completing tasks. This finding is in line with Bui et al. (2023), who stated that mindset interventions in mathematics are stronger when connected to concrete learning activities.

The obstacles dimension also increased. This indicates that students began to be more able to persist when facing difficulties. GeoGebra played an important role because construction errors could be immediately seen and revised. Thus, students gained the experience that mistakes are not the end of the learning process, but part of the process of understanding concepts. This characteristic is consistent with studies showing that GeoGebra supports exploration, manipulation, and dynamic representation in mathematics learning (Gökçe & Güner, 2022; Yohannes & Chen, 2023).

However, the criticism dimension did not increase. The pretest and posttest means remained at M = 1.85. This finding indicates that the module was not yet sufficiently strong in facilitating students' acceptance of criticism, correction, or feedback. The validation activities appeared to occur more through students' interaction with GeoGebra than through peer feedback. Therefore, the module revision needs to add peer feedback activities, discussions of mistakes, and reflections on how input from the teacher or peers is used to improve strategies.

Category of Students' Mathematical Mindset

In addition to being analyzed through mean scores, the mathematical mindset results were also categorized into four levels: Fixed-Fixed (FF), Fixed-Growth (FG), Growth-Fixed (GF), and Growth-Growth (GG). These categories were adapted from Saefudin, et al. (2023) , who distinguished the characteristics of fixed and growth mathematical mindsets among junior high school students. The categorization results of students' mathematical mindset profiles by dimension are presented in Table 6.

Table 6. Category of students' mathematical mindset by dimension

Mathematical Mindset Dimension	Pretest M	Pretest Category	Posttest M	Posttest Category	Change
Mathematical ability and intelligence	2.05	Growth-Fixed	2.22	Growth-Fixed	Remained GF
Challenge	1.56	Growth-Fixed	1.87	Growth-Fixed	Remained GF
Obstacles	1.91	Growth-Fixed	2.13	Growth-Fixed	Remained GF
Effort	1.67	Growth-Fixed	1.98	Growth-Fixed	Remained GF
Criticism	1.85	Growth-Fixed	1.85	Growth-Fixed	Remained GF
Success of others	1.73	Growth-Fixed	1.84	Growth-Fixed	Remained GF
Total mathematical mindset	1.77	Growth-Fixed	1.96	Growth-Fixed	Remained GF

Note: 0.00-0.75 = Fixed-Fixed (FF); 0.76-1.50 = Fixed-Growth (FG); 1.51-2.25 = Growth-Fixed (GF); 2.26-3.00 = Growth-Growth (GG).

The categorization results show that all dimensions were in the Growth-Fixed (GF) category in both the pretest and posttest. This means that students had shown a tendency toward a growth mathematical mindset, although some fixed mindset characteristics were still present. This finding is consistent with Saefudin, et al. (2023), who found that many junior high school students tend to show a growth mathematical mindset, but it is not yet fully strong when they face mathematical challenges and difficulties.

Although the category did not increase to Growth-Growth (GG), the mean scores showed positive development. The posttest mean for the mathematical ability and intelligence dimension reached 2.22, approaching the GG category threshold. This indicates that students began to view mathematical ability more strongly as something that can develop through practice, effort, and strategy. However, because the total score remained in the GF category, the module still needs to be strengthened so that students' learning experiences can more consistently foster a stronger growth mindset.

Statistical Evidence of Mathematical Mindset Improvement

To strengthen the descriptive results, the total mathematical mindset scores were analyzed statistically. The Shapiro–Wilk normality test showed that both the pretest and posttest data were normally distributed, with $W = 0.959$, $p = 0.264$ for the pretest and $W = 0.964$, $p = 0.343$ for the posttest. Therefore, the analysis was continued using a paired-sample t-test.

The paired-sample t-test results showed a significant difference between the pretest and posttest mathematical mindset scores, $t(31) = -7.97$, $p < .001$. The mean total score increased from 35.47 to 39.28, with a mean difference of 3.81 points (see Table 8).

Table 8. Statistical results of students' mathematical mindset

Analysis	Result	Interpretation
Total pretest mean	35.47	Initial mathematical mindset score
Total posttest mean	39.28	Mathematical mindset score after module implementation
Mean difference	+3.81	An increase in the mindset score was observed
Shapiro–Wilk pretest	W = 0.959, p = 0.264	The pretest data were normally distributed
Shapiro–Wilk posttest	W = 0.964, p = 0.343	The posttest data were normally distributed
Paired-sample t-test	t(31) = -7.97, p < .001	The increase was statistically significant

These statistical results strengthen the descriptive findings that the GeoGebra-assisted module based on an ethno-didactical situation within the context of Prambanan Temple has the potential to improve students' mathematical mindset. This improvement was reflected not only in the total score but also in most dimensions, particularly challenge, effort, and obstacles. Pedagogically, these results indicate that the integration of cultural context and technology can create a more meaningful learning experience. Prambanan Temple brings geometry closer to students' cultural reality, while GeoGebra provides space for exploration, revision, and visual validation.

Integrated Interpretation of Findings

Overall, the developed module met three main criteria in development research: validity, practicality, and the potential to support the development of students' mathematical mindset. The quality criteria for instructional products generally include validity, practicality, and effectiveness or potential effectiveness (Plomp & Nieveen, 2013). The validity of the module indicates that its content, presentation, language, didactical design, and media display were feasible for use. The practicality of the module shows that students were able to use it effectively in learning. Meanwhile, the questionnaire results showed improvements in almost all dimensions of mathematical mindset, particularly challenge, effort, and obstacles.

The main contribution of this module lies in the design of the learning experience. Mathematical mindset was not developed through motivational advice, but through activities that required students to observe cultural patterns, try geometric constructions, revise mistakes, and reflect on strategies. This is in line with Bui et al. (2023), who emphasized that mindset interventions in mathematics are more meaningful when directly connected to learning activities. GeoGebra also played an important role because it enabled students to explore, manipulate, and validate geometric objects dynamically (Gökçe & Güner, 2022; Yohannes & Chen, 2023).

However, the critical dimension did not improve. This indicates that the module is not sufficiently facilitating student openness to correction and feedback. It is likely that the validation process occurs more through student interaction with GeoGebra, allowing students to visually correct construction errors, but not enough practice receiving and responding to feedback from peers or teachers. This finding is important because feedback helps students understand the gap between their work and the expected learning objectives (Hattie & Timperley, 2007). In the context of a mathematical mindset, criticism should be understood as a learning resource, not a negative assessment. Therefore, the module needs to be strengthened with peer feedback activities, discussion of errors, and reflection on how peer or teacher feedback is used to improve strategies. This way, students can be more open to correction as part of the mathematics learning process.

CONCLUSION

This study produced a GeoGebra-assisted teaching module based on an ethno-didactical situation within the context of Prambanan Temple to foster students' mathematical mindset in geometry learning. The developed module was considered feasible and practical for use because it was able to provide visual, interactive, and contextual learning. The main findings show that the module has the potential to support the development of students' mathematical mindset, particularly in terms of their willingness to face challenges, make efforts, and persist when encountering obstacles. The exploration of the Batur of Prambanan Temple through GeoGebra provided students with opportunities to observe geometric forms, try strategies, revise constructions, and validate their learning outcomes. Thus, students not only learned the concept of surface area visually but also experienced a mathematics learning process that emphasized effort, reflection, and improvement.

The implication is that mathematics teachers can use local cultural artifacts as meaningful contexts for geometry learning, while also utilizing GeoGebra to support conceptual exploration and validation. However, students' acceptance of criticism and feedback still needs to be strengthened through peer feedback activities, discussions of mistakes, and reflections on input from the teacher or peers. Future studies are recommended to test the module with a larger sample, use experimental or quasi-experimental designs, and examine more deeply how students' interactions with GeoGebra and cultural contexts contribute to the development of each dimension of mathematical mindset.

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