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Development of Geometry Transformation E-Module Using Contextual Teaching and Learning on Ruang GTK with GeoGebra

Aliyah Aziz [1], Elsa Komala [2], Sarah Inayah [3,*]
[1, 2, 3] Universitas Suryakancana, Cianjur
*Corresponding Authors: inayahsarah@unsur.ac.id

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ABSTRACT

Mathematics is a basic science that is essential for mastering other sciences and continues to develop to meet the demands of the 21st century. Meaningful mathematics learning requires a contextual and technology-based approach. Kurikulum Merdeka is a government effort to address this challenge. However, obstacles remain in its implementation, such as teachers' lack of understanding of the learning modules and students' understanding of the material. Therefore, this study aims to develop a Geometry Transformation e-module using the Contextual Teaching and Learning (CTL) model in the Ruang GTK with the assistance of GeoGebra, which has been tested for its feasibility and practicality. This study uses a Research and Development (R&D) approach with the ADDIE model, through five stages: analysis, design, development, implementation, and evaluation. The research subjects consisted of three experts in material, media, language, and mathematics learning for the feasibility test and three mathematics teachers for the practicality test. The instruments used included an observation sheet, a validation sheet, and a practicality sheet. The developed e-module consists of four sub-chapters: Translation, Reflection, Rotation, and Dilation. This e-module also includes flowcharts, prerequisite materials, learning activities, teaching materials, learning media, GeoGebra, Student Worksheets (LKPD), and assessments. The study results showed that this e-module was highly feasible with a score of 85.14% and very practical with a score of 89.33%. This module is easily accessible and supports contextual and technology-based learning.

Keywords: contextual teaching and learning (CTL); e-modules; geogebra; geometric transformation; ruang gtk.

INTRODUCTION

Education is a crucial foundation for human development and national survival (Mardiana & Hajron, 2024). One form of education is the learning of subjects, such as mathematics, which is taught from an early age through university. Ratnasari (2020) notes that mathematics is a branch of science that plays a crucial role in education and serves as a foundation for other sciences. In addition to being a foundation for other sciences, mathematical skills are essential skills that must be continuously developed to face the challenges of the 21st century. Mathematical skills and knowledge are crucial for daily life, career development, and the foundation for the development of science and technology. Therefore, mathematics can be used as a medium for developing 21st-century skills (Putri et al., 2022).

Kurikulum Merdeka focuses on student-centered, technology-based, and differentiated learning. PLP observations indicate that high school students' mathematical abilities vary within a single class, in line with Jahrir (2024) who emphasized differences in student backgrounds and learning needs. Rapor Pendidikan Nasional (2024) shows that

students' average numeracy ability is in the moderate category (66.3%), an increase from the previous year (47.62%). However, the implementation of the Kurikulum Merdeka still faces obstacles, particularly teacher skills in developing technology-based interactive learning modules (Yunus et al., 2024). Teachers also experience difficulties in developing assessments (Gusmawan & Herman, 2023), and only 30% of teachers understand the components of learning modules (Nur, 2023), even though learning modules are crucial for learning implementation (Rismawanda & Mustika, 2024).

To support curriculum implementation, the government introduced the Platform Merdeka Mengajar (now Ruang GTK), which provides technology-based learning resources and inspiration (Putra et al., 2023). Observations indicate that teachers have utilized this platform. Ruang GTK is considered suitable for developing interactive, multimedia-based e-modules, thus encouraging student learning independence (Laraphaty et al., 2021; Muljo et al., 2024).

In the Kurikulum Merdeka, Learning Outcomes (CP) for grade 11 include Number, Algebra and Functions, Geometry, Data Analysis and Probability, and Calculus (Ichiana et al., 2023). However, the Geometry teaching module in the Ruang GTK is still limited, especially the Geometric Transformation material in Advanced Mathematics Phase F. This material discusses changes in the position and shape of geometric figures (Pertiwi & Siswono, 2021). Students still struggle to understand Geometric Transformations, both in formulas, problem solving, and concept visualization. The dominant errors are misconceptions due to disjointed learning methods (Maulani & Zanthy, 2020), as well as haste and a lack of conceptual understanding (Anastasia & Mardhiyana, 2021). Primrose et al. (2024) also found that students have difficulty identifying information, organizing steps, and applying formulas correctly. Therefore, a module that is contextual and easy to understand is needed.

To address the challenges in learning Geometric Transformation, researchers designed an e-module based on the Contextual Learning and Teaching (CTL) model. CTL is an approach that connects learning materials to students' real-world contexts and encourages them to relate knowledge to everyday life. This model involves seven main components: constructivism, inquiry, questioning, learning communities, modeling, reflection, and authentic assessment (Fitrah et al., 2024). CTL has been shown to improve learning outcomes, as evidenced by Hasan (2021) and Ruwaidah (2022), who found that this model improves learning achievement through increased classroom activity and interaction. In addition to the appropriate model, the researchers also incorporated GeoGebra software as a complement to support students' understanding of the visualizations in the Geometric Transformation material to facilitate student comprehension. One of GeoGebra's features, namely the ability to display coordinates, is used to determine coordinate points, create line segments, draw plane figures, and so on (Miranda & Nurmitasari, 2022).

In several previous studies, the development of e-modules on Geometric Transformation material has been carried out using various approaches and technologies. Febdhizawati et al. (2023) used GeoGebra and flipbooks based on Culturally Responsive Teaching (CRT), while Kurniawan et al. (2023) utilized Flip PDF and Canva. Arisa et al. (2023) developed CTL-based student worksheets on the specified material. However, there has not been a published e-module on Geometric Transformation that can be accessed

directly through the Ruang GTK. In addition, there has not been any research that combines the CTL model with GeoGebra media in an e-module. This is a research gap as well as a novelty in this study. Therefore, the focus of this research is the Development of Geometry Transformation E-Module Using Contextual Teaching and Learning on Ruang GTK with GeoGebra.

RESEARCH METHODS

This study used the Research and Development (R&D) method with the ADDIE development model. This model was chosen because it supports development based on real-world needs, such as student characteristics, learning objectives, and available media. ADDIE consists of five stages: analysis, design, development, implementation, and evaluation. A summary of the development procedure is presented in Figure 1.

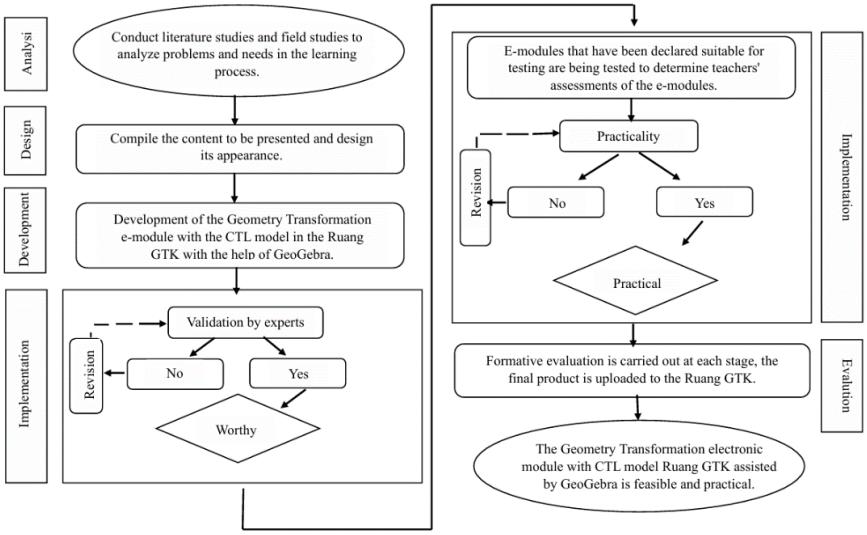


Figure 1. Research Flow Using the ADDIE Development Model

This research was conducted from the analysis stage on February 3, 2025, to the formative evaluation on May 2, 2025. The research subjects included three experts in material, media, language, and mathematics learning for the feasibility test, and three mathematics teachers for the practicality test. The instruments used included an observation sheet (for the preliminary study), a validation sheet (to assess feasibility), and a practicality sheet (to assess ease of use by teachers). Observation indicators for each aspect are presented in Table 1.

Table 1. Observation Sheet Indicators

Aspect	Indicators
Teaching Modules	Availability of teaching modules in the mathematics learning process.
	Condition of mathematics learning modules.
Media in Mathematics Learning	Availability of mathematics learning modules in the Ruang GTK.
	Condition of learning media.
Learning Process	Use of modules in the learning process.
	Student learning engagement and understanding.

The observation sheets were analyzed descriptively through systematic observation and recording of student activities during the learning process, as well as the teaching materials, modules, and learning media used. Validation sheet indicators for each aspect are presented in Table 2.

Table 2. Validation Sheet Indicators

Aspect	Indicators
Materials Expert	Suitability and completeness of the presentation of components in the introduction.
	Suitability of the quality of the content components in the Geometric Transformation e-module with the Contextual Teaching and Learning (CTL) model in the GeoGebra-assisted Ruang GTK.
	Completeness of the construction in the content.
	Effectiveness and practicality of the user.
Media Expert	Clarity and appropriateness of the presentation display.
	Suitability of the cover, text, font, layout, colors, and images.
	Ease of user access and interactive media can encourage students to learn independently.
	Effectiveness and practicality of the user.
Linguist	Suitability of the use of clear and communicative language.
	The language in the media meets didactic requirements and is appropriate for students.
	Language use is in accordance with EYD guidelines.
	General assessment: conclusion: appropriate/inappropriate.
Mathematics Learning Expert	Suitability of the e-module with the syntax of the Contextual Teaching and Learning (CTL) model.
	Completeness of the Contextual Teaching and Learning (CTL) model components in the e-module.

The validation sheet was assessed using a 5-point Likert scale, ranging from strongly disagree to strongly agree. Data were analyzed qualitatively and quantitatively. Qualitative analysis was used to process validator comments and suggestions as a basis for revisions, while quantitative analysis was used to calculate the e-module's feasibility score. Practicality indicators for each aspect are presented in Table 3.

Table 3. Practicality Sheet Indicators

Aspect	Indicators
Benefits	Teachers' interest in using e-modules.
	The presentation of the material helps teachers deliver interactive learning.
	The presentation of questions/problems is interesting and not overwhelming for students.
	The use of e-modules adds variety to the learning materials for students.
Convenience	The ease and suitability of using e-modules in learning.
	The ease of understanding the instructions.
	The ease of operating the e-modules.
	The ease of understanding the sentences and language in the e-modules.

Practicality was assessed using a 5-point Likert scale, ranging from disagree to strongly agree. The data obtained were quantitative and analyzed to present a practicality score for the developed e-module.

RESULTS AND DISCUSSION

The result of this research is a Geometry Transformation e-module with Contextual Teaching and Learning (CTL) model in Ruang GTK assisted by GeoGebra which has been tested for its feasibility and practicality, and is equipped with a flow, prerequisite materials, learning activities, teaching materials, learning media, GeoGebra, Student Worksheets (LKPD), and assessments. This e-module was developed in accordance with the ADDIE

development procedure with the results of e-module development from each stage as follows.

Analysis Phase

The analysis phase began with a literature review to strengthen the theoretical foundation, followed by fieldwork through observations at SMA Negeri 1 Cianjur using observation sheets. The observations showed that: 1) the school implements Kurikulum Merdeka; 2) the commonly used learning models are Discovery Learning, Problem-Based Learning, and Project-Based Learning; 3) the duration of each lesson is 45 minutes; 4) teaching module references are obtained from the internet or Ruang GTK; 5) teachers and students are familiar with technology-based learning media, but GeoGebra is rarely used; 6) the use of mobile phones is permitted to support learning; 7) students are active in learning, but have diverse learning styles and abilities; 8) Mathematics is compulsory in grade 10, while grade 11 begins to be divided based on interest, including Matematika Tingkat Lanjut, although not all students choose to pursue their own interests.

Design Phase

In Matematika Tingkat Lanjut, students must achieve a CP related to Geometric Transformations. However, because not all students choose this subject based on personal interest, learning outcomes are often less than optimal. Observations indicate that students still have errors in illustrating the concept of Geometric Transformations and related matrix operations in this material. Based on these findings, the researcher adjusted the e-module development through the following stages: 1) defining the material; 2) establishing the CTL model with the syntax of invitation, exploration, explanation & solution, and action; 3) establishing GeoGebra media and a publication platform through Ruang GTK; 4) creating a media storyboard; and 5) designing the research instrument. The storyboard is presented in Figure 2.

Figure 2. E-Module Storyboard

Development Phase

The development phase involved realizing the design of the CTL-based Geometry Transformation e-module in the Ruang GTK with the assistance of GeoGebra. The e-module was saved in PDF format and ready for implementation. The storyboard in Figure 2 displays the cover, introduction, table of contents, Translation, Reflection, Rotation, and Dilation modules, and the conclusion. Each sub-chapter was developed in a structured manner,

containing the flow, prerequisite material, learning activities, material descriptions, media, worksheets, and assessments.

Implementation Phase

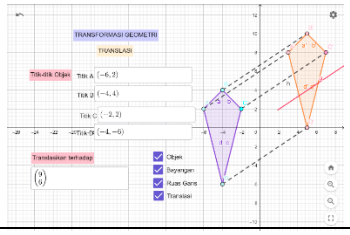
After the e-module was developed, a feasibility test was conducted by experts in material, media, language, and mathematics learning, as well as a practicality test by mathematics teachers at SMA Negeri 1 Cianjur. Revisions were made based on suggestions and comments from both tests to improve the quality of the e-module. The feasibility scores from the validators are presented in Table 4.

Table 4. Results of E-Module Feasibility Score Analysis

Expert				Amount
Material Expert	Media Expert	Language Expert	Mathematics Learning Expert	
88,89%	85%	86,67%	80%	340,56%
Average				85,14%

Based on Table 4, it is known that the e-module's feasibility across all aspects indicates that it is very feasible, with an average percentage of 85.14%. However, before implementation, the e-module was refined through revisions based on comments and suggestions from experts. Several forms of revisions made to the e-module based on the suggestions of material experts in this study are explained in Table 5.

Table 5. Revision of the Material Expert E-Module

Validator	Results of Material Expert Revision
D1	"The discussion shouldn't be too theoretical or lack visuals. Add illustrations of the Geometric Transformation process." Before: The Translation sub-chapter did not include GeoGebra. After: The GeoGebra Translation sub-chapter is included in the e-module. 
D2	"Add contextual questions to the practice questions." Before: There were no contextual questions on the practice questions sheet. After: There were contextual questions in each sub-chapter of the practice questions sheet.
D3	"It's better to put the composition subtopic on Geometric Transformations at the end." Before: Previously, the composition subtopic on transformations was included in each subchapter, with only a definition. After: 
	"Please adjust again, some questions don't quite match the material."

Validator	Results of Material Expert Revision
	Before: After:   "Focus the module on teachers/students." Before: Not yet focused on teachers. After: The module has been structured in such a way that it is focused on teachers as users.

Several forms of revisions made to the e-module according to the suggestions of media experts in this study will be explained in Table 6.

Table 6. Revision of the Media Expert E-Module

Validator	Media Expert Revision Results
D1	"The developed e-module would be more comprehensive if it included a link to an explanatory video or a video illustrating the transformation process." Before: There was no explanatory video introducing Geometric Transformations. After: 
D2	"There's more media interaction with the teacher." Before: Media interaction with the teacher was limited to Student Worksheets (LKPD), GeoGebra, and PowerPoint. After: Additional media was provided for answering quizzes. 
D3	"The module's purpose should be clearer." Before:  After: Additional editorial regarding the focus of the e-module discussion at the beginning of the introduction.

Revisions were not made by the language expert because the aspects of clarity, communication, appropriateness, content, and linguistic rules were good, so there were no suggestions/comments that needed to be improved. As for the final validation results, namely the mathematics learning expert, there were several forms of revisions made to the e-module according to the expert's suggestions in this study, which are explained in Table 7.

Table 7. Revision of the Mathematics Learning Expert E-Module

Validator	Results of the Mathematics Learning Expert Revision
D3	"Every syntax must be clear in the module, not just in the lesson plan." Previously: Syntax was only in the Learning Flow and Learning Activities..  After: Additional meeting instructions are provided in each sub-chapter to make it more practical.  

After the teaching module was revised, the e-module was uploaded and tested on three mathematics teacher validators at the school to determine its practicality by completing a practicality sheet. The results of the practicality assessment of the e-module are shown in Table 8.

Table 8. Results of the E-Module Practicality Sheet Analysis

Aspect	Validator			Total Score
	G1	G2	G3	
Benefits	45	57	55	157
Convenience	31	40	40	111
Amount				268
Percentage				89,33%

Based on Table 8, it is known that the overall practicality of the e-module shows a percentage result of 89.33%, this states that the e-module is very practical. The Geometry Transformation e-module with the Contextual Teaching and Learning (CTL) model in the Ruang GTK assisted by GeoGebra can be used without revision.

Evaluation Phase

The evaluation stage in this research was conducted only up to formative evaluation, namely, an evaluation to improve the developed e-module based on the results of the feasibility and practicality tests. The evaluation was conducted to assess the feasibility and practicality of the e-module in terms of material, media, language, and mathematics learning. The purpose of this evaluation was to identify deficiencies in the developed e-module so that

improvements could be made to address these weaknesses and errors. Thus, the resulting e-module can be optimized if widely implemented, especially by teachers as users. The e-module can be accessed in the Ruang GTK on the Bukti Karya page by searching for "Modul Transformasi Geometry_Aliyah Aziz.pdf" or using Google Drive by following link https://drive.google.com/drive/folders/14OSBTvptd5o5iaiaKVE4Dp1_yk5qJdol?usp=sharing.

CONCLUSION

The Geometry Transformation e-module with the Contextual Teaching and Learning (CTL) model in the GeoGebra-assisted Ruang GTK includes four main sub-chapters, namely Translation, Reflection, Rotation, and Dilation, which are arranged in one file. Each sub-chapter is equipped with a flow, prerequisite materials, learning activities, teaching materials, learning media, GeoGebra, Student Worksheets (LKPD), and assessments. The e-module can be accessed digitally through the Ruang GTK. This e-module is considered very feasible with an average percentage of 85.14% and very practical with a percentage of 89.33%.

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