Journal of Applied Science, Engineering, Technology, and Education *ISSN: 2685-0591 (online)*
Vol. 8 No. 2 (2026)
https://doi.org/10.35877/454RI.asci4704

Development of an E-module for Mathematics Learning within the Ammatoa Cultural Context to Support Students' Creative Thinking Skills

Sri Satriani[a,b], Cholis Sa'dijah[a*], Sukoriyanto[a], Hery Susanto[a], & Abdul Halim Abdullah[c]

[a]*Department of Mathematics, Universitas Negeri Malang, Malang 65145, Indonesia*
[b]*Department of Mathematics Education, Universitas Muhammadiyah Makassar, Makassar 90222, Indonesia*
[c]*Faculty of Educational Science and Technology, Universiti Teknologi Malaysia, Johor 81310, Malaysia*

Abstract

This study aimed to develop a mathematics e-module integrated with Ammatoa culture to foster seventh-grade students' creative thinking skills in learning cubes and rectangular prisms. The study employed a Research and Development (R&D) design using the Plomp model, which consists of preliminary investigation, prototyping, and evaluation phases. The participants were mathematics teachers and seventh-grade students at SMPN 20 Bulukumba, located in the Ammatoa customary area. Data were collected through interviews, expert validation sheets, practicality questionnaires, and pretest-posttest instruments in the small group. The validity of the product was analyzed using Aiken's V, while students' improvement in creative thinking skills was measured using N-gain analysis. The findings showed that the developed e-module was valid, with an average Aiken's V score of 0.728. In terms of practicality, the small-group trial yielded an average score of 4.19, while teacher and student responses reached 4.19 and 4.22, respectively, all of which were categorized as practical. The implementation results also revealed improvement in students' creative thinking skills. The fluency aspect achieved an N-gain score of 0.767, categorized as high, while flexibility reached 0.700, and originality obtained an N-gain score of 0.492, categorized as moderate. These results indicate that the e-module was effective in improving students' ability to generate multiple ideas and diverse solutions, although improvement in originality was relatively lower. Overall, the Ammatoa culture-integrated mathematics e-module can serve as a culturally relevant and practical digital learning resource for fostering students' creative thinking skills.

Keywords: E-module; Mathematics learning; Ammatoa cultural context; Culture-based learning; Creative thinking skills

Received: 5 March 2026 Revised: 6 June 2026 Published: 31 August 2026

1. Introduction

In this age of technology and globalization, education is being challenged more than ever before. Because the learning environment is in schools, these institutions should adjust to give helpful and fun learning for the students, which will guide them to success in life (Delıta et al., 2022). Technology will become a revolutionary means to obtain various ways of learning so that it can be more effective and flexible without limits on time or place (Sitthiworachart et al., 2022); (Supuwiningsih et al., 2023); (Faizah et al., 2024). The noun technology name for another term would be the electronic me (e-modules) (Hidayah & Jailani, 2025), (Kumar et al., 2024). The e-module teaches in digital forms of technology; text, pictures, video, animations and interactive exercises (Mahendri et al., 2023); (Alyusfitri et al., 2024). Those diłos were additional work on (Delıta et al., 2022).

We will require creative thinking from students ahead. Creative thinking skills refer to the ability to produce novel, innovative thoughts for generating solutions or discovering new tactics used to develop something. Creative thinking skills are important for generating new insights and for finding new ways to approach problems in varying environments ((Dilekçi & Karatay, 2023), (Ibrayeva et al., 2022). More than rote learning of formulas, even though good skills of the creative mathematical thinking aspect in mathematics education attached to relation with understanding concept, logical reasoning and problem solving was needed by students (Apriandi et al., 2023); (de Vink et al., 2022); (Kurniawan et al., 2022) . In practice, math lessons still all too frequently focus on tedious problems and drills not connected to

* Corresponding author.
E-mail address: cholis.sadijah.fmipa@um.ac.id

students' lives (Boaler, 2022). It discourages students from thinking outside the box.

Making learning more engaging is one way to increase its relevance, and we can achieve this by connecting what students learn with their own communities and cultures. It is the premise of a culturally responsive pedagogy that students find greater ease in learning when the subject material relates to their culture (Howard, 2021); (Kumi-Yeboah & Amponsah, 2023); (Gulya & Fehervari, 2024) . The explanation can be that learning often occurs when we have problems related to real world situations, which is why bringing the local culture into math lessons for students can be helpful (Cesaria et al., 2025). In this manner, they not only learn what the concept is about but also how math can be applied in real life in their daily activities (Sa'dijah et al., 2024). This integration allows for students to foster creativity by examining various concepts and cultural differences (Apriandi et al., 2023); (Anwar et al., 2024).

The Ammatoa are an ethnic group that lives in Kajang District, Bulukumba Regency, South Sulawesi, Indonesia. They are traditionalists, as evidenced by their tight-knit society. This allows educators to design math challenges that represent crucial values intrinsic to their simplicity, resistance, symbiosis with nature, and other products, manifestations, and living ways (D'Ambrosio, 2020), (Baharullah & Satriani, 2023), (Cesaria et al., 2025). Teacher also can use of patterns, measurements, comparisons or geometric shapes that you see in day-today life and the cultural products to teach math concept (Chaudhary et al., 2023); (D'Ambrosio, 2024). The other reason for employing Ammatoa culture in math subjects is also a good way based on the introduction and strengthening local culture because it gives students learn by placing the learning context about real-life situations easier for students to understand.

Despite the promising prospects of local culture in education, research on mathematics e-modules development integrating local culture and aiming to develop creative thinking abilities remains limited. Several researchers also focus their studies on the development of e-modules (Apriandi et al., 2023), including cultural context integrated into mathematics (Supriyadi et al., 2024); (Hidayah & Jailani, 2025). Nevertheless, research applying regression analysis to construct Ammatoa culture-oriented mathematics e-modules as a means of enhancing students' creative thinking is inadequate. The disparity manifests itself in practice as well. Based on initial observation in several schools located in the Ammatoa customary area, mathematics teachers have not been able to create integrated teaching material that reflects local culture. Teachers still use printed books that are often unrecognizable in their students' lives, and there aren't many opportunities for them to be trained or mentored toward culture-based teaching materials.

As more and more people use digital learning, the need for new teaching materials is becoming more and more important. Teachers have learned that traditional methods don't always keep students interested, especially when the material is presented in a boring way (Alyusfitri et al., 2024). Interactive e-modules are adapted to students' current culture, so that learning becomes more flexible and fun as well as useful (Supriyadi et al., 2024). Therefore, culturally sensitive e-modules in mathematics are necessary to incorporate educational technology in a contextually relevant way while providing a platform for students to engage creatively in solving problems. Before that, the preparation of a digital mathematics module integrated with Ammatoa culture as teaching material to develop students' creative thinking skills, which this research aims to create and analyze. This module is expected to serve as a reference for educators in implementing mathematics learning grounded in real student experience, especially in the Ammatoa indigenous community.

2. Literature Review

2.1. E-Modules in Mathematics Learning.

One of the new ideas widely applied in education is e-modules. An electronic module (E-module) is a series of teaching materials that are packaged digitally, where generally there are many multimedia elements like text, images, animations, and videos to aid in learning experiences (Faizah et al., 2024); (Hidayah & Jailani, 2025) . Based on a systematic review of available literature, the use of e-modules is appropriate in learning mathematics and teaching difficult topics for higher levels, including their delivery using more varied techniques (Supriyadi et al., 2024). E-modules enable students to study mathematics material independently and more freely (Hidayah & Jailani, 2025). E-modules minimize the requirement for discipline that is usually applied to students; e-modules can automatically identify the performance and achievements of students, and can be accessed anytime by anyone who has an internet connection (Delıta et al., 2022). Amini et al., (2025) found that the function of e-modules in the math class is also proven to be helpful for students based on an experiential theory course, as well as high-level creative and critical thinking ability.

2.2. Mathematical-Cultural Fusion

Ethnomathematics is an approach that the education world believes may be on the rise in terms of maths conversations. Ethnomathematics is a pedagogical approach that connects the teaching of mathematics to the culture of an area (D'Ambrosio, 2020). Ethnomathematics claims that the math concepts students work with are not only similar across cultures but also embedded into local practices and traditions that have evolved over generations in society (Rosa & Orey, 2024). Ethnomathematics will not only give the students creative methods of solving problems, but it also brings practical scenarios that are relevant to the student (D'Ambrosio, 2024) (Rosa & Orey, 2022). This has made mathematics more useful and approachable. (D'Ambrosio, 2024) also mentions that when local culture is integrated into maths lessons, it makes the learning experience more relevant for students as it emphasizes the relationship between what students already know and the knowledge they are now to develop. Another method is to create e-modules that incorporate local culture into each learning experience related to math, making the material easier for students to understand and more enjoyable (Supriyadi et al., 2024).

2.3. Culture-Based E-Modules and Creative Thinking Skills

Students need to generate new solutions for the challenges facing the world today. The creative thinking abilities of students may be demonstrated in their ability to generate many solutions for each problem, think creatively, and develop innovative ways to complete their work. According to Amini et al (2025), showing students how to solve context problems gives them. The local culture was incorporated into the mathematics-based e-modules to enhance students' creative thinking skills (Purwoko et al., 2023). By using culturally relevant problems, teachers can encourage students to think through math problems theoretically as well as unconstrained, because their solutions will ultimately work within their own culture (Supriyadi et al., 2024). In Indonesia, one example of a learning activity in geometry is examining geometric symmetry in patterned traditional handicrafts or calculating the volume of a conventional product (Prahmana & D'Ambrosio, 2020). It cultivates an environment where students can learn math with autonomy and freedom to solve problems.

3. Methods

This research and development (R&D) study was conducted to develop an Ammatoa culture-integrated math e-module to improve students' creative thinking skills. The development model used in this research is the Plomp model, which consists of three stages: initial investigation, Prototype Developer, and Evaluation. The research subjects of this study were mathematics teachers and seventh-grade students at SMPN 20 Bulukumba situated in the Ammatoa indigenous community.

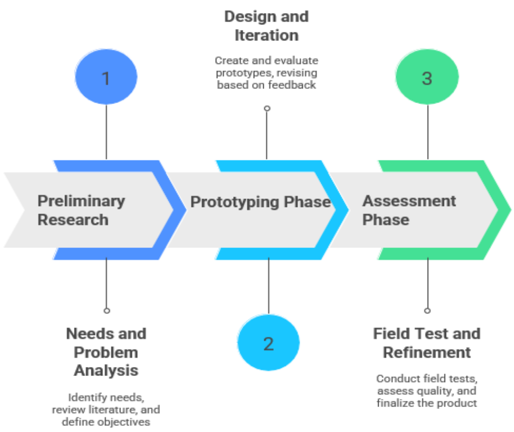

Figure 1. Plomp Development Model Phases

At this stage of the initial investigation, the researcher has become aware of the need to develop an e-module by analyzing students' characteristics, learning objectives, instructional material design, study environment, and teacher teaching. The findings from this stage were used to formulate the framework of the e-module prototype. The design focused on the content modules, material presentation, and a flipbook-based visual interface of an e-module in its prototype development phase. Also in this phase, formative evaluation (self-evaluation, expert review, individual/face-to-face evaluation, and small-group evaluation) was conducted. Subject matter experts, media experts, and design experts validate the developed product and revise it based on validators' suggestions and feedback to improve the e-module's content, language, appearance, and interactivity. Then, practically, after the e-module was revised based on teacher and student feedback, a limited pilot test was conducted with seventh-grade students, and it is expected to have the potential to improve creative thinking skills.

Data Research obtained by means of interviews, a validation expert sheet, a practicality questionnaire, and a creative thinking skills test with pretest and post-test forms. Using both qualitative and quantitative descriptive methods to perform data analysis. Qualitative descriptive analysis was applied to review the validators' input, criticisms, and suggestions, which served as the foundation for any changes to the product. Data on validity, practicality, and the improvement of students' creative thinking ability were analyzed using quantitative descriptive methods. Validity data were collected using validation sheets with a 1–5 Likert scale and were respectively analyzed using Aiken's V formula to assess the validity level of the e-module. Practicality data were obtained from teacher and student response questionnaires, while analysis of creative thinking skills was performed using pretest and posttest scores from the N-gain test. The examined aspects of creative thinking were, namely, fluency, flexibility, and originality. Aiken's V formula and its validity categories are as follows:

$$V = \frac{\sum s}{n(c-1)} \ with \ s = r - lo$$

Descriptions:
r = score given by validator
lo= lowest score on the scale
c = highest score on the scale

To interpret the validity values obtained from the above calculations, the validity criteria classification shown in Table 1 below is used.

Table 1. Aiken's V Validity Criteria for E-Modules

Score Inverval	Criteria
$0.81 < X \leq 1.00$	Very Valid
$0.61 < X \leq 0.80$	Valid
$0.41 < X \leq 0.60$	Sufficiently Valid
$0.21 < X \leq 0.40$	Less Valid
$0.00 < V \leq 0.20$	Not Valid

Then the formulas for calculating practically is:

$$\boldsymbol{X} = \frac{\textbf{Total score obtained for aspect}}{\textbf{Number of respondents}}$$

Table 2. Practicality Criteria

Score Inverval	Criteria
$X > 4{,}2$	Very Practical
$3.4 < X \leq 4.2$	Practical
$2.6 < X \leq 3.4$	Practical Enough
$X \leq 2.6$	Less Practical

To assess students' creative thinking ability, the researcher employed quantitative and qualitative analysis methods to compare pretest scores before the implementation phase to determine the initial level of students' ability and posttest scores after the implementation phase was completed. The categories of improvements in students' creative thinking skills are shown in Table 3.

This improvement in creative thinking ability is carried out using written tests before and after using the developed media. The Assessment Rubric for the Student Creative Thinking Test can be seen in Table 4

Table 3. Category of Improving Students Creative Thinking

Average	Criteria
$g > 0,7$	Tall
$0.3 < g \leq 0,7$	Keep
$0 < g \leq 0,3$	Low
$g \leq 0$	Fail

Tabel 4. Assessment Rubric for the Student Creative Thinking Test

Aspects	Student Response to the Question or Problem
Fluency	The student provides more than one relevant idea and the answer is correct
Flexibility	Student provides varied answers from different perspectives, and the results are correct
Originality	The student provides an answer using their own method, with correct calculation process and result

4. Results and Discussion

4.1. Result

This This development research has yielded a product in the form of a mathematics learning module contextualized within the Ammatoa culture, aimed at enhancing students' creative thinking skills through flipbooks, following the stages of the Plomp development model.

4.1.1. The first stage of the investigation

The initial phase of the investigation sought to provide a comprehensive view of the research context by examining teachers' and students' expectations towards materials used in mathematics-based learning. Conversations with six mathematics teachers across three schools suggested that classroom instruction was still primarily dependent on printed textbooks and PowerPoint presentations; however, both tools are held to fall short in fostering meaningfully productive efforts towards the development of students' creative thinking. The paper textbooks still dominate; however, the majority of the activities and exercises in these texts tend toward convergent or single-solution problems that offer little opportunity for students to engage in creative mathematical thinking. This is certainly a new opportunity for teachers participating in this e-math module by incorporating the Ammatoa culture. The connection seems to go hand in hand with the restricted accessibility of culture-based mathematics learning materials, where teachers may not have undergone sufficient professional development and have been unsupported at an institutional level in designing their own digital instructional resources. These findings not only implicate semiprofessional students in an Ammatoa culture-integrated mathematics e-module but also indicate serious challenges to its implementation. Therefore, the e-module cannot be treated as an ordinary product of educational technology; it is an innovative breakthrough in education that requires a specific context in which its feasibility and effectiveness would only be tangible when matched with local school realities, i.e., teachers' digital literacy, supporting structures, and a professional development ecosystem. To this end, the e-module developed in the underpinning study is a suitable learning resource that requires gradual implementation, with professional teacher support, and an adaptable, flexible approach for meaningful e-module adoption in the Ammatoa context..

4.1.2. Prototyping stage

The development of an Ammatoa culture-integrated mathematics e-module involves several components. Figure 2 shows a display of the e-module that has been created.

In this module, you will learn about flat-sided shapes, like cubes and blocks. The material talks about the parts of blocks and cubes, how to make different kinds of cube and block nets, how to find the surface area of cubes and blocks, and how to find and figure out the volume of cubes and blocks. The e-module display is meant to get students interested in learning about cubes and blocks by showing pictures and problems based on the Ammatoa culture after they have finished the material components. A flipbook will be used to show off the design of the e-module.

The development of an Ammatoa culture-integrated mathematics e-module includes formative evaluation stages consisting of self-evaluation results, expert review results, face-to-face evaluations, small-group feasibility test results, and feasibility test results based on teacher and student feedback. The first result, namely self-evaluation, is that this evaluation was conducted prior to consulting and discussing with experts; self-evaluation was first conducted on the e-module that had been designed. The results obtained can be seen in Table 5.

Figure 2. Display E-module

Table 5. Self Evaluation Result

Aspect	Before Revision	After Revision
Cover Page	The cover features only the institution's logo	In addition to the institutional logo, we have added the Diktisaintek Berdampak logo and SDG 4
Table of Contents.	No table of contents is displayed in the e-module	A table of contents has been added to the e-module

The next result is the expert review. Two experts in content and media validation checked this e-module product to make sure it was correct The validation sheet was completed by three faculty members (expert validators). The validation results for the e-module indicate that the developed e-module falls into the valid category. The validity results for the e-module are presented in Table 6.

Table 6. Results of Content Material Validation

Aspects	**Validation Items**	**Validator Score**		
		Val 1	**Val 2**	**Score**
Format	a. The writing system of the teaching module is clear and detailed	4	4	0.750
	b. The identity of the teaching module is presented completely.	4	4	0.750
	c. The description of the teaching module is presented completely.	4	4	0.750
	d. The assessment plan is clearly structured.	3	4	0.625
	e. The learning objectives are presented completely.	4	4	0.750
	Score			0.725
Material Suntance	a. The learning materials are compiled comprehensively with a systematic sequence and layout	4	4	0.750
	b. The learning materials are compiled comprehensively with a systematic sequence and layout	3	4	0.625
	c. Ammatoa cultural elements can be used to support students' understanding of the learning materials	4	4	0.750
	d. Learning steps with models developed in accordance with learning objectives.	3	4	0.750
	Score			0.719
Language	a. The language rules used are in accordance with the General Guidelines for Indonesian Spelling.	4	4	0.750

Aspects	Validation Items	Validator Score		
		Val 1	Val 2	Score
	b. The language used is communicative and does not cause double interpretations.	4	4	0.750
	Score			0.750
	Average Total Score			0.731

Meanwhile, the results of validation by media and design experts on the e-module can be seen in the following table 7:

Table 7. Results of media and design validation

Aspect	Validation Items	Validator Score		
		Val 1	Val 2	Score
Interactive	a. Ease of use of interactive features	4	4	0.750
	b. Student engagement in interactive activities	4	4	0.750
	Score			0.750
Display quality	a. The module display is attractive	4	4	0.750
	b. The colors used are not contrasting	4	4	0.750
	c. The e-module design is in accordance with graphic elements	4	4	0.750
	d. The sentence structure is appropriate	3	4	0.625
	e. The module's systematics are in accordance with standards	4	3	0.625
	Score			0.700
Language	a. The language used is not ambiguous	4	4	0.750
	b. The language rules used are in accordance with the General Guidelines for Indonesian Spelling	4	4	0.750
	c. The language used is easy for students to understand	4	4	0.750
	Score			0.750
	Average Total Score			0.733

In general, the validity results of the material, media, and design of this E-module based on Aiken's V category can be seen in the following table 8.

Table 8. Result of E- module Validity

Validity Aspect	Aiken's V Score	Category
Format	0.725	Valid
Material Substance	0.719	Valid
Language	0.750	Valid
Interactive	0.750	Valid
Display quality	0.700	Valid
Average	0.728	Valid

After confirming that the module is possible, the next step is to change the electronic module that has been made based on feedback and suggestions from experts in the field and in media and design. Table 9 shows suggestions and input from experts in the field, as well as experts in media and design.

Table 9. Improvement Suggestions from Content Experts and Media and Design Experts

Validator	Suggestions	Revision Results
Expert Contents 1	1. The steps in the learning plan for the module should be changed to fit the model being used. 2. Make the sentences that explain the parts of cubes and blocks easier for junior high school students to understand.	1. The steps of the activities have been changed to fit the model used. 2. The sentence structure has been improved to make it easier for junior high school students to understand.

Validator	Suggestions	Revision Results
	3. Make sure the pictures you use are clear and consistent.	3. The appearance of images has been changed to ensure consistency
Expert Contents 1	1. The instructions for the e-module need to be better so that students can understand them better. 2. Add table of contents and references.	1. The instructions for use have been put together following the suggestions. 2. A table of contents and references have been added.
Expert Media and Design 1	1. The pictures that are shown must be clear and match the text.	1. The pictures have been changed to make them clearer.
	2. Ensure consistency in the colors of the images presented.	2. The colors in the pictures shown have been changed to make sure they all match.
Expert Media and Design 2	1. The font size in the material needs to be changed so that it isn't too boring or too thick.	1. The font size has been changed to make it easier to read, and the layout of the information isn't too dense.
	2. There can be no more than three pictures on each page.	2. The display of the images has been changed so that each page can only load three images at a time.

4.1.3. Assessment Phase

These assessment phases are based on the small-group practical assessment. The small-group evaluation was conducted after the face-to-face evaluation was completed. The small-group evaluation involved having students practice the mathematics learning module on cubes and rectangular prisms that had been approved. The practical results of the module, based on student feedback in the small groups, are shown in Table 10.

Table 10. Small Group Practicality Test Result

Aspect	**Practically Score**	**Category**
Usabilitiy	4.08	Practical
Ease to use	4.17	Practical
Attractiveness	4.33	Very Practical
Clarity	4.00	Practical
Helpful	4.08	Practical
Efficient	4.33	Very Practical
Adventages of e module	4.33	Very Practical
Average	4.19	Practical

Small-group evaluation: Electronic math module pilot-testing with a small group of six seventh-grade students This assessment was conducted with a view of determining the product's utility. The electronic math module in the small group had "practical" score was 4.19. This statement scored the lowest, stating that it did not take so long to understand the electronic module. The small group students still took a long time to understand the electronic module. The electronic module was redesigned and its design simplified in order for students to understand. The statement "The appearance of the e-module caught my attention." got the highest score. The color selection, images, and layout of the e-module attract attention, with e-modules being more practical than teaching materials in print. In addition, Teachers' Responses Result Related to Practicality are revealed in Table 11.

Results of the practicality evaluation of electronic modules based on teachers' responses showed that the average practical score given by teachers was 4.19. This shows that the e-modules that were developed are valid and feasible to be used in mathematics learning in schools. The results of the next set of evaluations focus on students' practicality assessment, as shown in Table 12.

Based on student responses, the practicality score of the Ammatoa culture-integrated mathematics e-module was 4.22 which falls into the practical category. This finding indicates that the e-module is feasible and user-friendly for classroom use; however, its effectiveness in improving students' creative thinking requires further empirical testing through comparative implementation.

Table 11. Teacher Practicality Test

Aspect	Practically Score	Category
Usabilitiy	4.33	Very Practical
Ease to use	4.00	Practical
Attractiveness	4.33	Very Practical
Clarity	4.00	Practical
Helpful	4.00	Practical
Efficient	4.33	Very Practical
Adventages of e module	4.33	Very Practical
Average	4.19	Practical

Table 12. Students Practicality Test

Aspect	Practically Score	Category
Usabilitiy	4.33	Very Practical
Ease to use	4.17	Practical
Attractiveness	4.33	Very Practical
Clarity	4.00	Practical
Helpful	4.08	Practical
Efficient	4.33	Very Practical
Adventages of e module	4.33	Very Practical
Average	4.22	Practical

After the Ammatoa culture-integrated mathematics e-module, designed to support students' creative thinking skills, was deemed suitable by experts, it was implemented in the classroom and used as a pilot study for field development. The pilot study was conducted with 20 seventh-grade students at SMPN 20 Bulukumba. During this implementation, an assessment of the students' creative thinking abilities will also be conducted. The assessment of students' creative thinking skills will be conducted through a pretest and a posttest. The pretest is administered before the e-module is used, while the post-test is conducted after the e-module has been used. The improvement in students' creative thinking skills, as measured by fluency, flexibility, and originality, is shown in Table 12.

Table 13. N gain value on the creative thinking indicator

Creative Thinking Aspect	Pretest Mean	Post-test Mean	Std. Deviation	Std.Error Mean	N. gain
Fluency	2.20	3.55	0.293	0,066	0.767
Flexibility	2.30	3.50	0.377	0.084	0.700
Originality	1.95	3.00	0.239	0.053	0.492

The results of the analysis in Table 13 indicate that students' creative thinking ability improved across all indicators after the learning intervention. This improvement is evident in the increase in mean scores from pretest to posttest: fluency increased from 2.20 to 3.55, flexibility from 2.30 to 3.50, and originality from 1.95 to 3.00. Based on the N-gain classification, the fluency aspect obtained a score of 0.767, which falls into the high category, while flexibility, with a score of 0.700, and originality, with a score of 0.492, are classified as moderate. These findings suggest that the learning intervention was more effective in enhancing students' fluency in thinking than in improving their flexibility and originality. Nevertheless, all indicators showed improvement, suggesting that the implemented learning process had a positive effect on students' creative thinking ability. The results of the students' pre- and post-tests for each aspect are also presented as histograms in Figure 3.

Figure 3 shows the distribution of pre-test and post-test scores for three indicators of creative thinking ability: fluency, flexibility, and originality. In general, there appears to be a shift in the distribution of scores from pre-test to post-test toward higher scores across all indicators. For the fluency indicator, students' scores, which were predominantly at 2 and 3 in the pre-test, shifted to a predominance of 4 in the post-test. For the flexibility indicator, the distribution of scores also increased, as indicated by a higher frequency of score 4 in the post-test. Meanwhile, for the originality indicator, pre-test scores, which tended to be concentrated at 1 and 2, shifted to a predominance of 3 in the post-test. These findings indicate that applied learning can to support students' creative thinking abilities across all indicators.

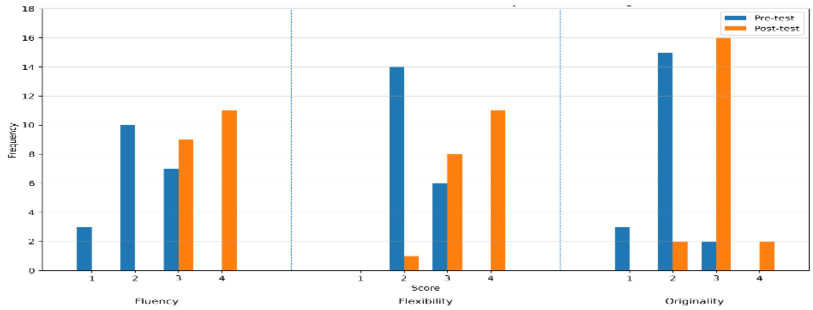

Figure 3. Combined Distribution of Pre-Test and Post Test Creative Thinking Skills

4.2. Discussions.

This research output is an integrated seventh-grade mathematics e-module that incorporates Ammatoa culture in grading cubes and rectangular prisms. The e-module was given in flipbook format and was developed using the Plomp model. The results of the data analysis indicate that the developed product is valid, practical, and feasible for use as a medium for developing students' creativity. The first is the validation results, where the e-module is declared valid in terms of format, material substance, language, interactivity, and display quality. Aiken's V statistic averaged 0.728, suggesting the product belonged to a legitimate category half the time. The results showed that the e-module developed met 3 important quality criteria: content and language, as well as media design feasibility. Validity is required to determine whether the instructional design follows appropriate learning objectives, organizes content, and presents content based on these objectives (Hidayah & Jailani, 2025). In relation to Learning development. From this perspective, learning tools need to be evaluated from multiple perspectives: content validity, construct validity, and process validity (Gashoot et al., 2025). Superimposition of the assessment results with experts' learning and material that refer to learning objectives and sub-material elements of Ammatoa culture in mathematical substance (very high) demonstrates that content and face validity have been achieved.

Revising made for a much better end product. Among the experts' recommendations was to finalize a model that roughly represents the learning path and to streamline some of the texts for junior high school students. Also, employing improved alignment and consistency in the presentation of images and GIFs – without sacrificing clarity (Suwandayani et al., 2023). Branding elements can be added to the Table of Contents, and references provided for help with finding answers as a PDF; font sizes must all be modified, along with having fewer images on each page. I would argue that the revisions themselves are imperative, as there is a difference in the quality of digital teaching materials that cannot be reduced to factual data but also hinges on the ideological and cognitive framing of information. This new layout follows established principles of multimedia learning (Mayer, 2024); (Twabu, 2025) like coherence/irrelevancy, signaling, and removing extraneous visual load context so that students can do germane processivig processes. The validation results indicated that the Ammatoa culture embedded the e-module into mathematics learning practices, both from a technical and a conceptual perspective.

Second, based on the feasibility reports, this e-module could be easily adopted in classroom learning. Small-group practicality, teacher-average practicality, and student-average practicality had values of 4.19 (practical), 4.19 (practical), and 4.22 (practical), respectively. These suggestions show that the e-module is beneficial in terms of usefulness, ease of use, appeal/interest (easy to implement), clarity (provides clarity of concepts and provides more insights/understanding), and helpfulness, especially as a learning medium. This factor is extremely attractive, and data indicate that the visual display of the e-module, including color selection, layout, and images, attracts students. This aligns with earlier studies suggesting that working with digital resources can once again enhance the situativity of the learning context for students and promote their work on mathematics content (Tang et al., 2022). However, the small-group study found that some students required more time to grasp the electronic module. Independence is very much a function of 1) the e-module's utility and substantive context, and 2) simple but clear directions in an intuitive interface. It is not only about the "easy to access," but also about students being able to read/use/browse the data at their level for learning. Similarly, the refinement and simplification of module structure are based on feedback from the small-group evaluation; if we believe this directly affects usability during implementation in real classroom environments, it is reasonable to do so.

The third finding in the implementation stage was that the e-module could improve students' creative thinking skills. The level of improvement was different for each indicator. N-gain rate of the fluency indicator reached 0.75 (high), indicating that students produced more relevant mathematical ideas. It had an N-gain of 0.700 (moderate), suggesting that students answered varied responses and differently approached the problem, the flexibility indicator. The originality indicator presented a result of moderate N-gain (0.492). Students did develop more original, personal thinking, but not to the extent of fluency. On the whole, the e-module was better at helping students generate a large number of responses than highly original solution strategies. Nevertheless, the increase in originality is significant: It reflects the most difficult and important aspect of creative thinking in mathematics.

The features of this e-module are designed to provide evidence to enhance students' creative thinking. Mathematical problems in Ammatoa cultural contexts have far greater meaning for students' reality and social life. The findings are consistent with the principles of sociocultural theory/learning and culturally responsive pedagogy, which suggests that learning will be more meaningful when it connects to students' culture (identity)/lived experiences (Howard, 2021), (Coppens & Kelley, 2025). This was useful for students to relate the abstract mathematical concepts in this study to contexts they are already familiar with. So, the students weren't merely encouraged to grasp concepts; along the way, they'd explored multiple ways of approaching problems that became dance-writ. It should be noted that contextualized mathematical experiences directly support the development of higher-order thinking (Purwoko et al., 2023), (Amini et al., 2025). Moreover, the digital flipbook format encouraged wilder creative ideas to flourish: you could present interactive and visual material in novel ways. Interactive worksheets, culturally relevant workstations, and open-ended problems allowed students to devise multiple solutions, justify their reasoning, and consider alternative routes. Indeed, previous studies have also reported similar results by analyzing discussions of culture and open-ended mathematical use as a module that has been shown to improve aspects of creative thinking, such as fluency, flexibility and originality (Purwoko et al., 2023). Similarly, interactive digital modules can enrich learning experiences that position students to think in different ways and engage productively with mathematical problems (Amini et al., 2025); (Faizah et al., 2024).

Hence, cultural infusion through an interactive digital exhibition seems to be an enabling factor. The second problem is that the Ammatoa cultural elements in the e-module are not only contextual illustrations but also cognitive bridges for mathematical understanding. This act of bridging local culture aligns with the proposition that one way to connect formal school mathematics and students' everyday knowledge is through local culture (Howard, 2021); (Purwoko et al., 2023); (Anwar et al., 2024). When realities in students' environments stimulate creative problem solving, and when they are connected to their own surroundings and draw on a variety of responses, they are more inclined to invest time thinking about the question posed (Alabbasi et al., 2022). This Ammatoa culture-integrated mathematics e-module influences the relevance of the content and pedagogical process, thereby enhancing students' mathematical creative reasoning. However, the results of this study should be interpreted cautiously. While evidence from the implementation suggested that students' creative thinking skills increased, empirical testing was limited to a single pilot study with a single class at a single school. Hence, this study also provides early, valid, practical, and promising evidence for the e-module's effectiveness in developing creative thinking; however, considerable scale-up is still required to yield more stringent empirical evidence. It is recommended to further study the efficacy of this Ammatoa Culture-based e-module using a larger population, comparative, and experimental design so that it can be implemented holistically in education.

5. Conclusion

This research aimed to produce a culture-integrated Ammatoa mathematics e-module for seventh-grade students in the material of cubes and rectangular prisms to develop creative thinking skills. Through the Plomp model characterized by the stages of preliminary investigation, prototyping and evaluation, an e-module was created as a culturally relevant digital learning resource linking mathematical concepts to their local context. This cultural integration is essential as it enables students to make connection between things they do, and makes learning more nuanced, relatable, and engaging. The results showed that the e-module developed was valid, practical, and potentially effective. As far as validity is concerned, the product gained an average of Aiken's V score (0.728), so it was considered valid in terms of content, language, presentation, interactivity and visual appearance. This finding shows that the e-module was appropriate enough to be used as a learning companion in mathematics. Within this range, the findings from small-group testing, teacher response, and student responses were all practical in nature. The results showed that the e-module is easy to use, and clear, attractive, and rich in content so it can help students conduct classroom learning activities. The implementation effects also indicated the augmentation of students' creative thinking ability. The fluency aspect had an N-gain score of 0.767, which functioned as high category, while the flexibility reached a value of 0.700 and originality achieved 0.492, both classified as moderate categories. These findings suggest the effective role of e-module in enhancing students' ability to generate various ideas and variation in solving strategies, but less improvement was noted in producing more original ideas. Thus, the Ammatoa culture-integrated mathematics e-module is classified valid, practical and culturally responsive digital learning resource that can be used to develop students' creative thinking skills in mathematics. Future studies should use larger samples and more rigorous research designs to further analyze its effectiveness.

Acknowledgements: The authors gratefully acknowledge the financial support provided by LPDP-EQUITY (Joint Supervision)

Conflicts of Interest: The authors declare that they have no conflicts of interest to report regarding the present study.

Contribution: Sri1: conceptualization, design, analysis, writing and revision of manuscript Cholis2: conceptualization, design, analysis, reviewing, supervision and revision of manuscript. Suko3: reviewing, supervision and data analysis and interpretation. Hery4: reviewing, data analysis and interpretation, Abdul5: reviewing and supervision.

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