



Development of a Deep Mathematics DEMA Model of Sequences and Series Based on North Kalimantan Batik for Class X DKV SMK Negeri 4 Tarakan

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ABSTRACT

The low relevance of mathematics teaching materials to the vocational context and local culture hampers learning in Vocational High Schools majoring in Visual Communication Design. This study aims to develop a Deep of Math learning module based on ethnomathematics of North Kalimantan batik motifs using the Analyze, Design, Develop, Implement, and Evaluate development model. The research and development method applies expert validation sheets and user response questionnaires on a Likert scale of 1–4, with quantitative and qualitative descriptive analysis. Expert validation resulted in a score of 75% for materials and 66% for media, with an average of 71% (feasible category). Implementation was limited to 15 students and 2 teachers, obtaining a response of 79.83% from students and 71.25% from teachers, with an average practicality of 75.54% (practical category). The module increases the relevance of arithmetic and geometric sequences through Dayak batik motifs. The Deep of Math module is feasible and practical as an independent teaching material, although it requires strengthening of high-level analysis.

Keywords: *Learning Module; Ethnomathematics; North Kalimantan Batik; ADDIE Model; Vocational High School Mathematics; Visual Communication Design.*



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INTRODUCTION

Education is a fundamental right and a key pillar of national development, guaranteed by the Indonesian constitution. Providing quality education requires the implementation of a curriculum that is responsive and relevant to changing times. In Indonesia, during the 2022–2024 period, this was reinforced through the implementation of the Independent Curriculum, a new approach aimed at improving the quality and relevance of learning by enhancing students' freedom to learn, creativity, and ability to adapt to future needs (Gumilar *et al.*, 2023). The Independent Curriculum is viewed positively by many teachers because it provides greater space for learning innovation and student competency development (Jannah & Rasyid, 2023).

However, in practice, the implementation of the Independent Curriculum faces several obstacles, both in terms of planning, resource availability, and teacher readiness. The final evaluation of 2024 showed that to increase its effectiveness, the Independent Curriculum needs to be strengthened with a deep learning approach *in* learning design.

In the 21st century -, quality education emphasizes not only mastery of knowledge but also the development of relevant soft skills, such as the 6Cs (critical thinking, creativity, collaboration, communication, citizenship, and character). The development of these six competencies can be optimized through in-depth learning, an approach that emphasizes conceptual understanding, active participation, and the application of knowledge in real-world contexts. In the context of mathematics learning, this model has the potential to be a long-term solution to the decline in student understanding, especially when many students experience difficulties in understanding and solving -math problems.

Mathematics still faces various obstacles in the learning process. Poor mathematical understanding directly impacts students' ability to solve problems in their environment. Mathematics is often viewed as a daunting subject, from kindergarten -to high school, and even at the university level (Mulhamah, 2018). Several studies have found that mathematical anxiety plays a significant role and is significantly related to students' mathematical abilities (Julya & Nur, 2022) . This situation highlights the urgency of developing mathematics learning designs that not only reduce anxiety but also strengthen understanding and critical thinking skills.

The concept of ethnomathematic the relationship between mathematics and mathematical practices within a local cultural context offers a relevant theoretical framework for strengthening meaningful and contextual mathematics learning. Ethnomathematics is derived from three elements: *ethno* (culture, language, jargon, codes of conduct, myths, and symbols), *mathema* (knowing, understanding, and performing activities such as coding, measuring, clarifying, inferring, and modeling), and *tics* (techniques or skills). Thus, ethnomathematics is within a theoretical framework that emphasizes that mathematics learning should begin from the cultural context and real practices familiar to students.

On the other hand, deep learning in a pedagogical context refers to a learning approach that emphasizes conceptual understanding, active participation, and the application of knowledge in authentic situations. Recent research on educational innovations using *deep learning models* in Indonesia (Suwandi *et al* ., 2024) shows positive contributions to critical thinking skills, student participation, and engagement, but still faces challenges related to infrastructure, teacher readiness, and adherence to traditional curricula. A review of the *deep learning curriculum discourse* (Muvid, 2024) views the urgency of changing to a *deep learning curriculum* as no more crucial than improving the equity of educational development. Meanwhile, the implementation of the *deep learning approach* at SDN 1 Wulung, Blora (Wijaya *et al* ., 2022) successfully integrated *meaningful* , *mindful* , and *joyful learning* through a local context, thereby improving -students' critical thinking skills, character, social-emotional skills, and learning motivation. Although several studies have developed teaching materials based on local wisdom and ethnomathematics in mathematics, research gaps are still visible in several aspects: (1) Most teaching materials based on ethnomathematics and local wisdom are still being developed on trigonometry, plane figures, and series -, and especially at the elementary/junior high school level. For example, the development of local wisdom-based trigonometry teaching materials (Nurafni *et al* ., 2020) showed high feasibility from validators and good responses from teachers and students. The development of ethnomathematics textbooks through *the nuwo sesat object* on the material of flat shapes (Ardiansyah *et al* ., 2022)

as well as interactive teaching materials based on local Banten culture on sequences and series (Trisnawati, 2022), also showed very good qualifications. However, there has not been much research that constructs local ethnomathematics-based modules integrated with the *deep learning approach* in the context of secondary schools outside Java, especially vocational schools. (2) Although the Heyzine-based mathematical logic e-module for vocational schools has been proven valid, practical, and effective (Erawati *et al.*, 2022), there has not been any research that combines the interactive e-module format with the local ethnomathematics context and the principles of *deep learning* simultaneously. The development of ethnomathematics-based modules on sequences and series (Hardiyanti *et al.*, 2022) has also shown very valid and effective categories, but still does not integrate depth of thinking and technological elements explicitly. (3) Studies on the application of *deep learning* in Indonesia still focus largely on the conceptual level and examples in elementary schools. Research (Suwandi *et al.*, 2024) and (Wijaya *et al.*, 2022) demonstrate the effectiveness of *deep learning* in elementary schools, but research integrating *deep learning*, local ethnomathematics, and technology-based teaching materials at the secondary level (SMP/SMK) is still relatively limited. This opens up opportunities to develop mathematics learning designs in vocational schools that systematically combine the Independent Curriculum, local wisdom, and a *deep learning approach*.

Based on gap said, research This develop DEMA (*Deep of Math*), namely module learning mathematics on the material pattern numbers, sequences arithmetic, sequence geometry, as well as the application integrates North Kalimantan batik motifs as context ethnomathematics. The integration designed through visual presentation, examples contextual, practice, activity learning, summary, test formative, and challenges *Higher Order Thinking Skills* (HOTS). With design mentioned, the batik motif is not placed solely as element decorative, but as context for help participant educate recognize pattern, building connection interrepresentation, understanding concepts, and implementing line as well as series in relevant situations. Position This strengthen aspect novelty study Because combine three components that have been This relatively separate, namely ethnomathematics of local batik of North Kalimantan, pedagogy *deep learning*, and the need learning mathematics at DKV Vocational School.

Based on the background and research gaps above, the novelty of this research lies in: (1) Integration of the Independent Curriculum, *deep learning*, and local ethnomathematics in the design of mathematics learning in vocational schools majoring in Visual Communication Design (DKV); and (2) development and implementation of technology-based teaching materials (interactive e-modules) that combine local ethnomathematics and *deep learning* principles to reduce mathematical anxiety and improve students' critical thinking skills. Based on description said, research This aim to : (1) Develop a mathematics learning design based on the Independent Curriculum, *deep learning*, and local ethnomathematics for vocational high school students majoring in Visual Communication Design; and (2) Analyze the influence of this learning design on students' mathematical anxiety and critical thinking skills.

RESEARCH METHODS

Research Design

Study This is research and development (R&D) which aims produce learning models mathematics DEMA (*Deep of Math*) based ethnomathematics of North Kalimantan batik motifs. For participant educate Class X and XI Visual Communication Design (DKV)

Expertise Program at State Vocational School 4 Tarakan. Research development chosen Because study oriented towards producing and testing eligibility product learning before used in a way more wide. The development model used is ADDIE, which consists of over five stages systematic, namely *Analysis, Design, Development, Implementation, and Evaluation*. The use of ADDIE in development teaching materials allow need participant education and curriculum analyzed moreover first, then translated to in design product, validated, implemented in a way limited, and evaluated based on empirical data. Approach similar has used in development module mathematics in education vocational and development based teaching materials ethnomathematics (Putri & Junaedi , 2022; Mandur et al., 2026).

Study This focused on development and testing limited product. Therefore that, the evaluation was carried out is evaluation formative, not testing effectiveness through experiment or quasi- experiment. Consequently, the results study used for determine level feasibility and practicality beginning module, whereas claim about effectiveness to results learning has not been done in study This.

Research Setting and Participants

Study was held at SMK Negeri 4 Tarakan, North Kalimantan, in the Visual Communication Design Expertise Program. The selection location based on characteristics DKV learning which has relatedness strong with visual representation, patterns, composition, and design, so that relevant with utilization of batik motifs as context ethnomathematics. Subject study consists of on three group. First, two expert validators, namely One expert material and one media expert, whose job is evaluate eligibility content and design module. Second, two subject teachers lesson Mathematics plays a role as users and product evaluators at stage implementation limited. Third, 15 participants educate, consisting of over 10 participants educate class XI and 5 participants educate Class X of the DKV Expertise Program, who participated in the trial limited and provide response to module. Composition subject the in accordance with character study development stage the beginning that places validation experts and trials users as base evaluation formative product.

Amount participant limited education cause results study No intended for generalized to all over participant vocational school education. Trial used for get information beginning about understandability, ease usage, power attraction and acceptance module before done study advanced with more samples big.

Development Procedure

Development module done through the five stages of ADDIE as following.

1. Analysis

Stage analysis aim identify need development module, characteristics participant educate, demands curriculum, characteristics field DKV expertise, as well as potential culture local that can used as context learning mathematics.

Analysis need done through observation during activity Introduction Field Schooling (PLP) and identification condition learning mathematics. Analysis results show that participant educate face difficulty when material served in a way dominant through text and verbal instructions. Participants education also needs more visual representations and examples applicable. In addition the available teaching materials do not optimally connect material rows and rows with context field skill and environment culture participant educate.

Analysis curriculum done with identify Achievements Learning (CP), Learning Objectives (TP), material principal, and characteristics learning mathematics at the vocational school level. The material developed covering pattern numbers, sequences arithmetic, sequence geometry, as well as implementation line arithmetic and geometry.

Analysis context culture furthermore done with identify North Kalimantan batik motifs that have element patterns, repetition, regularity, and relationships between elements that can

represented through draft mathematics. Analysis results the used as base for select and develop context ethnomathematics in module.

2. Design

Stage design done with compile design conceptual and structural module based on results analysis needs, curriculum, characteristics participant education and context ethnomathematics.

The module was named **DEMA (Deep of Mathematics)** and designed as teaching materials that combine draft mathematics with context culture local. Structure module consists of on three part main, namely:

- 1) The **introductory section** includes cover, foreword, table of contents, achievements Learning, Learning Objectives and instruction use module;
- 2) The **content section** includes Module 1 Number Patterns, Module 2 Arithmetic Sequences, Module 3 Geometric Sequences, and Module 4 Applications of Arithmetic and Geometric Sequences;
- 3) The **cover section** includes summary, evaluation, glossary, bibliography, and information writer.

Each unit is designed load introduction contextual, description concepts, examples, activities learning practice, summary test formative, as well as HOTS activities. The context of North Kalimantan batik motifs used for help participant educate identify patterns and regularities before connect it with representation mathematical.

From a visual perspective, the module designed using A4 format, supporting colors readability, consistent typography, batik motif illustrations, and appropriate layout with characteristics participant DKV education. Development design use **Adobe InDesign** Because device the support grid arrangement, typography, visual composition, and integration element graphics.

3. Development

Stage development done with realize design become prototype DEMA module. Mathematics material, context ethnomathematics, illustrations, activities learning, practice, and instruments evaluation arranged in accordance the design that has been made.

Product furthermore validated by two experts, namely **expert material and media experts**. Validation expert material covers aspect suitability material with CP and TP, accuracy concept, presentation materials, use language communication, interactivity, development participant educate, sequence channel think, and accuracy terms and symbols mathematics.

Validation media experts include aspect systematics, logic presentation, sequence, suitability illustration, completeness components, size module, typography, usage color, readability, design cover and design content.

Each validator provides evaluation use Likert scale 1–4 and give comments and recommendations improvement. Validation results quantitative used for determine level eligibility product, whereas input qualitative used as base revision before module implemented. Procedure validation expert and practical test like This common used in study development teaching materials and modules learning.

4. Implementation

After done revision based on results validation, module implemented in a way limited to users target. Trial involving **15 participants educate**, consisting of over 10 participants educate class XI and 5 participants educate class X, and **2 Math teachers**.

At the stage This participant educate use DEMA modules in the learning process and provide response to product. Response participant educate directed at aspects convenience usage,

clarity instructions, power pull appearance, readability, relevance materials and support module to Study independent.

Teacher responses are directed at aspects relevance material, clarity presentation, appropriateness of media, convenience use, flexibility implementation and suitability module with need learning. Approach the in line with study development module vocational school mathematics that assesses practicality through teacher and participant perspectives educate.

5. Evaluation

Stage evaluation done in a way formative and integrated in every stage development. Evaluation at the stage analysis used for ensure need product identified in a way right. Evaluation at the stage design done for ensure structure and components module in accordance with characteristics users. Evaluation at the stage development done through validation experts and revisions product. Next, evaluate at the stage implementation done based on teacher and participant responses educate. Because research only up to the trial limited, the evaluation does not include testing effectiveness through design experiment. Therefore that's the conclusion study limited to **feasibility and practicality beginning DEMA module**.

Research Instruments

Instrument study consists of on three type.

First, the sheet validation expert material. Instrument This used for evaluate quality content and aspects pedagogical module. Indicator evaluation covering suitability with CP and TP, accuracy concept, depth material, presentation, language, sequence material, and suitability with characteristics participant educate.

Second, the sheet validation media expert. Instrument used for evaluate quality technical and visual modules, including systematics, layout, size, typography, illustrations, color, readability, completeness components, as well as quality design.

Third, questionnaire response user. Questionnaire given to teachers and participants educate after implementation limited. Instrument measure convenience usage, clarity instructions, power attraction, readability, relevance material, flexibility usage and support to learning independent.

All over instrument use Likert scale 1–4, with score 1 indicates evaluation lowest and a score of 4 indicates evaluation highest.

Data Analysis

Quantitative data from sheet validation and questionnaire response analyzed use statistics descriptive in the form of total score, score maximum, and percentage achievement. Percentage eligibility counted use formula:

$$P = (\Sigma x / \Sigma xi) \times 100\%$$

Information:

P = percentage feasibility / practicality;

Σx = sum scores obtained ;

Σxi = sum score maximum .

Percentage results Then categorized based on criteria used in research, namely:

Percentage	Category
81–100%	Very Good / Very Good
61–80%	Decent / Good
41–60%	Enough Worthy
21–40%	Less than worthy
0–20%	Not feasible

(Source : Pratama, MP, Ruruk, S., & Karuru, P. (2023)

Qualitative data in the form of validator comments and suggestions as well as users analyzed in a way descriptive to determine parts necessary for products to be revised. Revision done with consideration of suitability, substance, readability, systematics, visual design, and user needs.

Analysis produces three main outputs, namely **(1) level eligibility module based on validation expert**, **(2) level practicality based on teacher and participant responses**, and **(3) recommendations for revision of product based on qualitative data**.

Research Quality and Scope

Quality of product determined based on two main indicators, namely validity / feasibility and practicality. Product stated worthy if results of evaluation expert fulfil minimum category "Eligible", whereas practicality determined based on response of users in the minimum category of "Good". Approach evaluation of validity and practicality through validation expert as well as response of users. Lots used in study development ADDIE-based teaching materials.

Study limitations on the number of test subjects small and implementation limited to one school. Thus, the results of research have not been able to be used to conclude effectiveness of module to results of study in a certain area. Testing effectiveness through design experiment with more samples big recommended for study next.

RESULTS AND DISCUSSION

Results

This study employed a research and development (R&D) method based on the ADDIE model, which consists of five stages: Analysis, Design, Development, Implementation, and Evaluation. This model was chosen because it provides a systematic framework for designing, developing, and testing the feasibility of learning products in a step-by-step and measurable manner. The research was conducted up to the implementation stage, but the evaluation stage, in the sense of a broad-scale summative evaluation, was not conducted within the scope of this study.

1. Analysis Stage (*Analyze*)

The analysis stage is the foundation of the ADDIE model, which aims to identify conceptual and empirical foundations for product design. The study focuses on three main aspects: needs analysis, curriculum analysis, and analysis of student characteristics and the school environment.

a. Needs Analysis

The analysis results indicate that students in the class tend to prefer visual and kinesthetic learning. This finding is based on observations during the School Field Introduction Program (PLP), where students experienced difficulties when work steps were presented solely through verbal instructions or text with a high level of information density. This condition indicates the need for a more representational and applicable material presentation strategy.

In the context of vocational education, practicum teachers in vocational high schools face diverse levels of student competency mastery within a single learning session. This heterogeneity demands adaptive, differentiation-based classroom management strategies. However, limited time to prepare diverse teaching materials often presents an operational obstacle. This situation indicates the need for systematically designed learning modules that include essential materials, worksheets, and standardized and objective evaluation instruments.

Furthermore, during the PLP period, it was apparent that students often experienced difficulties preparing for the numeracy assessment. This was because the material in textbooks tended to be theoretical and inadequate in providing case studies relevant to the students' chosen areas of expertise in vocational schools. Developing thematic modules integrated with the vocational context is a strategic solution that can ensure that each stage of the mathematical logic learning process is truly measurable and relevant to the competency achievement indicators in the curriculum.

b. Curriculum Analysis

The Independent Curriculum for 10th-grade vocational school students prioritizes the development of a Pancasila student profile, focusing on core topics such as geometry, symmetry, and sequences, which can be integrated into Dayak batik motifs. Learning Outcomes (CP) require students to master mathematical concepts relevant to everyday life.

c. Analysis of Student and School Characteristics

Tenth and eleventh grade students in the Visual Communication Design (DKV) expertise program exhibit characteristics consistent with the Generation Z typology, particularly in terms of their familiarity with digital technology and their predominance of visual content consumption. Observations during the PLP (Planning for Learning) revealed a relatively high level of creativity and imaginative capacity, particularly in project-based assignments that require visual exploration of ideas. In terms of learning preferences, students' dominant tendencies are toward a visual-kinesthetic style, so learning design needs to consider the integration of demonstrative elements and applied practice.

As a relatively new educational institution, the school is still in the development phase of its facilities and infrastructure. Practical support facilities, such as computer labs with graphic design specifications, are still being procured. This situation demands adaptive learning strategies, including the development of flexible and contextual teaching materials and the optimization of the *Bring Your Own Device (BYOD)* approach with lightweight and functional open-source software.

2. Design Stage (*Design*)

The design phase begins with the development of a conceptual design that includes learning objectives, material structure, and presentation strategies. The researcher then systematically developed a module framework, including the sequence of chapters, subchapters, evaluation components, and supporting visual elements. Module development was carried out using Adobe InDesign software, chosen for its capabilities in typography arrangement, grid management, and precise integration of graphic elements.

a. Physical Specifications and Module Structure

The DEMA (Deep of Math) module is designed in A4 format (a revision of the initial A5 design), using Times New Roman font size 12 pt, printed in color, with Indonesian language according to the latest KBBI rules. Structurally, the module consists of three main parts: (1) Introduction, which contains a cover based on North Kalimantan batik motifs, a foreword, a table of contents, as well as Learning Outcomes (CP) and Learning Objectives (TP); (2) Contents, which is divided into four submodules — Module 1 Number Patterns, Module 2 Arithmetic Sequences, Module 3 Geometric Sequences, and Module 4 Applications of Arithmetic and Geometric Sequences; and (3) Conclusion, which includes a glossary, bibliography, and the author's biography.

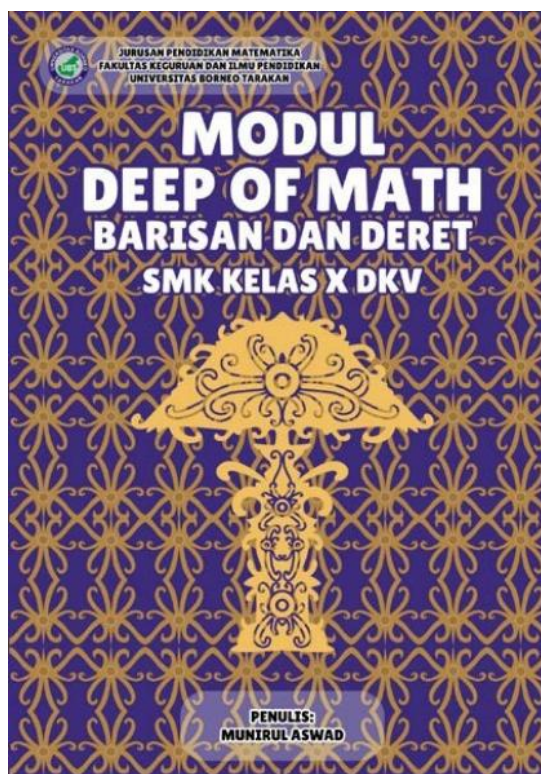


Figure 1 Front Cover First Version

Each submodule contains pedagogically integrated components, including Learning Outcomes, learning activities (introduction, material description, and exercises), a summary, a formative test, and a *Higher Order Thinking Skills* (HOTS)-based challenge section. The division of material into submodules is adapted from the Open University's teaching materials development model, which emphasizes independent learning through segmented units.



Figure 2 Back Cover First Version

b. Visual Design and Local Identity

The module cover design features batik elements and visual representations of North Kalimantan as a cultural context that serves more than just a decorative function, but also serves as a visual strategy to build contextual connections with students in the Visual Communication Design (DKV) program. This approach also aims to bridge abstract mathematical concepts with cultural experiences relevant to students. The principles of balance, contrast, and simplicity are applied throughout the design, resulting in an elegant and professional appearance.

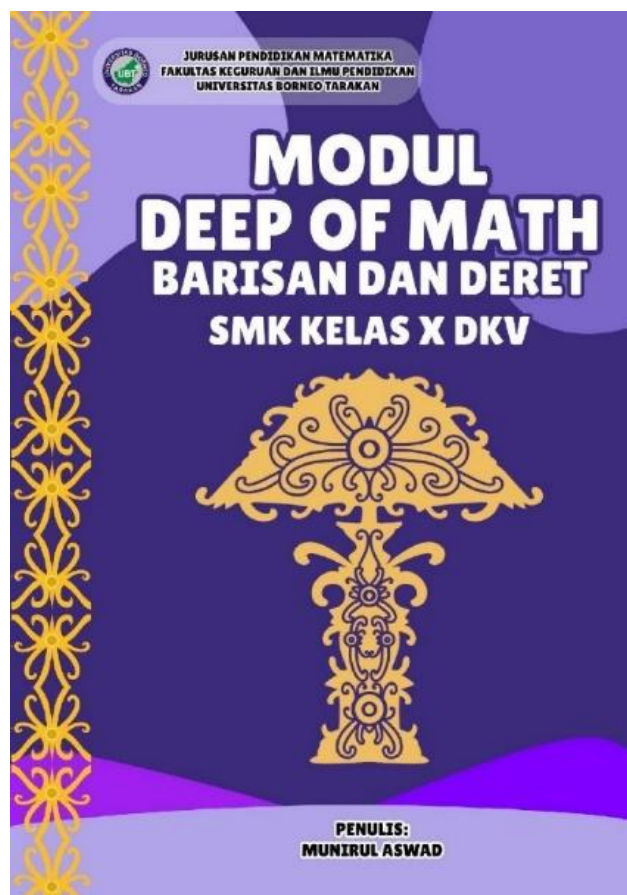


Figure 3 Front Cover Pre-Validation Version

During the design iteration process, the initial version of the module was found to have several structural and visual weaknesses: the lack of a table of contents and a foreword, inconsistent layout, and overly dense cover graphics. These findings formed the basis for a gradual revision, including structural refinements, layout reorganization, visual element simplification, and typographic adjustments to make it more proportional and informative.



Figure 4 Back Cover Pre-Validation Version

3. Development Stage

During the development phase, the module prototype is realized in the form of a concrete product according to the designed specifications. Development includes the development of interactive materials and the integration of supporting visual media. Prior to implementation, the module undergoes a validity test by two expert validators to ensure content suitability, media suitability, and consistency with instructional objectives.

a. Validation by Material Experts

The material validation was carried out by Dr. Arief Ertha Kusuma, M.Pd. on December 9, 2025. The assessment included 13 indicators which included aspects of suitability with CP and TP, material accuracy, presentation techniques, language clarity, communicative, dialogic and interactive, suitability with student development, sequential flow of thought, and use of terms and symbols.

Based on Table 1, all 13 indicators received a score of 3, categorized as Good. The total score was 39 out of a maximum of 52, equivalent to 75%. Referring to the eligibility criteria used, a score range of 60% to 80% is categorized as 'Feasible'. Therefore, the DEMA module is deemed suitable for use from a material perspective, although there are two qualitative improvement notes that require further action.

Qualitatively, the subject matter expert validator provided two recommendations for improvement. First, improve the writing style and consistency of typing according to the General Guidelines for Indonesian Spelling (PUEBI), including typo correction, spacing, and consistent title hierarchy and typography. Second, improve the completeness of the reference list used in the module. The validator recommended that all sources be listed in full according to APA format, including the author's name, year of publication, title of the work, publisher, and DOI (DoI) if available. Both recommendations were revised before the module entered the implementation phase.

b. Media Expert Validation

Media validation was conducted by Dr. Shinta Wulandari, M.Pd. on December 9, 2025. The assessment included 11 indicators including systematic writing, logic, presentation sequence, suitability of images, completeness of components, module size, use of fonts, use of color, readability, and cover design and module content.

Based on Table 2, the module received a total score of 29 out of a maximum of 44, equivalent to 66%. The indicator with the highest achievement was the coherence of presentation with a score of 4 (Very Good), while several aspects such as writing systematics, completeness of presentation, module size, font usage, and content design received a score of 2 (Fairly Good). This percentage is in the range of 61%–80%, so the module is categorized as 'Appropriate' from a media aspect.

The media expert validator provided four recommendations for qualitative improvements. First, add explicit module usage requirements at the beginning, covering prerequisite knowledge, ideal learning duration, and success criteria. Second, add operational scoring guidelines, including a per-activity assessment rubric, a scoring scale, an answer key, and a self-assessment checklist to support independent learning. Third, change the module size from A5 to A4 to improve readability and compatibility with existing printing machines. Fourth, improve the design of the content section so that each sub-chapter has clear, hierarchical headings and coherent transitions between paragraphs. All of these recommendations were followed up before implementation.

c. Recapitulation of Validation Results

A summary of the assessment results from the two validators is presented in Table 1 below.

Table 1. Summary of Expert Validation Results

Assessment Aspects	Acquisition Score	Maximum Score	Percentage
Material	39	52	75%
Media	29	44	66%
Final Average			71% (Eligible)

Overall, the average validation percentage for the material (75%) and media (66%) aspects resulted in a final score of 71%, placing the DEMA module in the Feasible category. This result indicates that the module has met the minimum requirements for implementation, although improvements are still being made based on all validator recommendations before the module is submitted to users.

4. Implementation Stage

After validation-based revisions were completed, the module was implemented to students in the Visual Communication Design (DKV) expertise program as end users. The researcher acted as both a facilitator and observer to identify the module's utilization patterns by grades 10 and 11. To test the module's effectiveness and acceptability, data were collected through a response questionnaire distributed to 15 students (10 grade 11 students and 5 grade 10 students) and 2 Mathematics subject teachers.

a. Student Responses

The student response questionnaire consisted of 10 indicators measuring ease of use, appropriateness of instructions, attractiveness of the display, and the effectiveness of the module in supporting independent learning. Based on the results of the questionnaire, the 15 students involved obtained a total average score of 31.93 out of a maximum score of 40, equivalent to an achievement percentage of 79.83%. This achievement is in the Good category and approaching Very Good. The indicators with the highest scores were clear instructions and attractive display (3.40 each), while the lowest indicator was the ability to use in various conditions (2.80). Although the average shows positive results, the distribution of scores shows quite significant variation. One student achieved a maximum score of 40, while several others

scored below 20. This variation reflects the heterogeneity of student abilities, especially in applying the concept of sequences in local cultural contexts and difficulties in analyzing more complex geometric patterns.

b. Teacher's Response

Teacher assessment focused on the relevance of the material, clarity of presentation, appropriateness of the media, and ease of implementation in the classroom. Data were obtained from two Mathematics teachers who acted as field evaluators. Based on the questionnaire results, the total score of the two teachers reached 57 out of a maximum score of 80, with an achievement percentage of 71.25%, which is categorized as Good (range 60%–79%). Aspects with the highest scores include clear instructions, attractive displays, easy- to-understand language, material accessibility, speed of learning preparation, material relevance, and interactive and innovative aspects. Aspects that need to be improved relatively are compatibility with all situations, effectiveness of learning management, and learning differentiation. In addition, there are recommendations regarding adjustments to the flexibility of implementation time allocation to be more adaptive to class dynamics.

c. User Response Recapitulation

A summary of the responses from teachers and students is presented in Table 6 below.

Table 2 Summary of User Response Results

Response Subject	Acquisition Score	Maximum Score	Percentage
Teacher	57	80	71.25%
Student	31.93	40	79.83%
Final Average	-	-	75.54% (Practical)

Cumulatively, the average percentage of user responses from teachers (71.25%) and students (79.83%) resulted in a final score of 75.54%, placing the DEMA module in the Practical category. These results indicate that the module can be used effectively in the learning process, from both the perspective of teachers and students.

5. Evaluation Stage

The evaluation in this study was formative and implemented in an integrated manner at every stage of implementation. The evaluation process was conducted through a synthesis of data obtained from expert validation and user responses during the limited trial phase. Assessments by the material and media validators resulted in several recommendations for improvement that were followed up to ensure the accuracy of mathematical concepts, the accuracy of arithmetic and geometric sequence representations, and the suitability of the visual design to the characteristics of DKV students.

The formative evaluation results indicate that the module meets the validity criteria based on the validator's assessment (average 71%) and received a positive response from teachers and students (average 75.54%). The module also provides a more flexible learning alternative through the presentation of materials and interactive activities, thus potentially supporting the learning process under conditions of limited resources. However, these findings need to be understood in the context of a limited trial with a relatively small number of respondents, so they cannot yet be generalized as the results of a large-scale summative evaluation.

Discussion

Research Approach and ADDIE Model

This research is categorized as a research and development (R&D) that aims to produce a mathematics learning module based on North Kalimantan batik ethnomathematics for vocational high school students in the Visual Communication Design (DKV) expertise program. The ADDIE model proposed by Robert Maribe Branch was chosen because of its systematic, structured, flexible, and consistent nature in supporting the design process through to the evaluation of learning products, as proven in various educational studies.

Analysis Stage Findings

In the analysis stage, the identification of the characteristics of vocational high school students majoring in Visual Communication Design (DKV) revealed a dominant visual-kinesthetic learning style, in line with the findings of Yundaryati and Suyoto (2020) who emphasized the need for visual representation in vocational learning. The availability of text-based teaching materials with minimal illustrations was a major obstacle, so infographic-based modules and step-by-step procedural guides were designed as a relevant response. The curriculum analysis also emphasized the importance of integrating sequence and series material with the local cultural context (Safitri et al., 2022), where Dayak batik motifs were chosen to increase the relevance of DKV learning while supporting independent learning amidst limited school laboratory facilities.

Design and Development Phase Findings

The design phase adopted the Open University's four-submodule structure to facilitate gradual conceptual deepening, reduce cognitive load, and enhance conceptual understanding. Visual elements based on North Kalimantan's local identity on the module cover and content serve as a contextual bridge between abstract mathematical concepts and meaningful cultural representations. Validation of the development phase resulted in a score of 75% from subject matter experts, 66% from media experts, and an overall average of 71% (the "Fair" category), consistent with the criteria (Rizki et al., 2022) and (Wahidah, 2025). Iterative revisions based on validator recommendations—including improvements to the layout, addition of scoring guidelines, changes to A4 size, and design restructuring per sub-chapter—ensured systematic quality improvement prior to implementation.

Implementation Stage Findings

Implementation resulted in an average teacher assessment of 71.25% (Good category) and student responses of 79.83% (Good, approaching Very Good category), with teachers focusing on curriculum suitability, clarity of instruction, and student engagement—in line with Nurafni et al. (2020) on local wisdom-based teaching materials. The range of student responses (78%–84%) is consistent with studies of contextual mathematics modules, although the wide distribution of scores (maximum 40 to below 20) indicates heterogeneity in ability. Some students mastered basic formulas and Dayak batik applications, but another group struggled with complex geometric patterns, similar to findings (Harahap & Rakhmawati, 2022). This underscores the need for a structured remedial program and the addition of higher-level pattern analysis questions in the revised module.

Implications, Limitations, and Recommendations

The development of the ADDIE-based DEMA module resulted in a valid (71%) and practical (75.54%) product, with potential effectiveness in mathematics learning at Vocational High School Visual Communication Design (DKV), where the integration of North Kalimantan batik ethnomathematics increased relevance and engagement—supporting the argument of Mulyadi et al. (2021). However, the generalizability of the findings is limited by the small number of respondents (15 students, 2 teachers), making it a formative evaluation of a limited trial (Silitonga et al., 2022). Further research is recommended with large-scale

implementation via a quasi-experimental design for comprehensive effectiveness testing, as well as refining the duration for more optimal conceptual deepening.

CONCLUSION

This research successfully developed an ADDIE-based DEMA (Deep of Math) learning module that integrates ethnomathematics of North Kalimantan batik motifs, effectively addressing the needs of visual-kinesthetic style DKV vocational high school students amidst limited laboratory facilities. The module was declared feasible (average expert validation 71%) and practical (average user response 75.54%), with strengths in curriculum suitability, visual design, and support for independent learning, although the heterogeneity of student abilities requires strengthening complex geometric analysis exercises. These findings confirm the potential of local ethnomathematics to increase relevance and engagement in vocational high school mathematics learning, so that the DEMA module is ready to be adopted by teachers and schools to enrich contextual and inclusive teaching.

Conflict of Interest

The authors confirm that this manuscript was prepared without any conflicts of interest.

Generative AI Statement

The authors report that generative artificial intelligence (AI) was employed only in a limited capacity during manuscript preparation, primarily to refine the language, check grammatical accuracy, and improve the clarity and readability of the manuscript.

Author Contribution Statement

Munirul Aswad contributed to the conceptualization of the study, development of the Deep Mathematics DEMA model, research design and methodology, development of learning materials and research instruments, data collection, data analysis, interpretation of findings, and preparation of the original manuscript draft. Jero Budi Darmayasa contributed to the conceptualization and validation of the research framework and methodology, supervision of the research process, analysis and interpretation of the findings, and manuscript review and editing. Alfian Mucthi contributed to the development and validation of the learning materials and research instruments, data collection, data curation, validation of the research findings, and critical review of the manuscript.

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