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NEED ANALYSIS FOR DEVELOPING STEAM-BASED DIFFERENTIATED LEARNING MODULES TO IMPROVE STUDENT LEARNING OUTCOMES IN MADRASAH ALIYAH, ENREKANG REGENCY

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ABSTRACT

Monotonous learning routines, the lack of learning resources that cater to students' learning styles, and the abstract nature of mathematical concepts contribute to low mathematics learning outcomes. This study aims to identify the need for developing learning modules that accommodate students' diverse learning styles and incorporate contextual examples of mathematical concepts and STEAM cross-disciplinary sciences in real-life situations. The study involved 11 teachers and 120 students from *Madrasah Aliyah* in Enrekang Regency. The data were collected through questionnaires, observations, and interviews. The needs analysis revealed that existing learning resources provided by teachers did not accommodate students' varied learning styles. Teachers primarily used student worksheets, which lacked contextual examples of mathematical applications and interdisciplinary STEAM integration. Additionally, technology was underutilized as a differentiation tool, despite the availability of adequate learning environments and resources to support its integration. These findings highlight the urgent need for learning modules that are tailored to students' learning styles and integrated with STEAM to enhance mathematics learning outcomes.

Keywords: Need analysis; STEAM; fifferentiated instruction; learning module; learning outcome

1. INTRODUCTION

Mathematics, as one of the fundamental subjects in the education system, plays a crucial role in developing students' cognitive abilities. Mathematics learning is expected to enhance students' logical, critical, precise, and efficient thinking skills (Fadilah & Hakim, 2022; Yusdiana & Hidayat, 2018). Additionally, it contributes to building mathematical connections, problem-solving abilities, reasoning, communication, and mathematical representation skills (Manullang, 2017). However, in practice, mathematics is often perceived as a difficult subject by many students (Jalal, 2020). Its abstract nature, heavy reliance on formulas, and tendency to induce anxiety contribute to mathematics learning outcomes that often fall below expectations (Jalal, 2020; Supriatna & Zulkarnaen, 2019).

Mathematics anxiety is one of the key factors contributing to low student learning outcomes (Artama et al., 2020), as evidenced by interviews with several mathematics teachers at *Madrasah Aliyah* in Enrekang Regency. The results of the Final Semester Exam (*UAS*) revealed that more than 50% of students failed to meet the Minimum Completion Criteria (*KKM*). To fulfil graduation requirements, teachers had to supplement students' scores with additional assessments, highlighting a fundamental issue in the mathematics learning process. Furthermore, classroom observations indicated low student engagement, particularly among those with weaker mathematical abilities. These students tended to be passive, struggled with completing assignments, and had difficulty understanding the real-world relevance of mathematics.

This problem does not only come from students, but also from teachers and the learning methods used. Preliminary studies on several research results show various challenges, such as the lack of variation in learning methods (Nurulaeni & Rahma, 2022; A. I. Sanjaya & Pratama, 2021; Sukendra & Sumandya, 2020), low utilization of technology as an innovative learning medium (Nurulaeni & Rahma, 2022; Sari, 2019), and learning models that are not in accordance with student characteristics (Oktavia et al., 2023; Rosmitha Sari et al., 2023; Sari, 2019). Teachers tend to use traditional learning approaches, such as lectures and assignments, without providing meaningful learning experiences. The modules or learning devices used are also limited to standard materials that do not support the development of critical and creative abilities of students (Agusta & Sa’dijah, 2021).

In this context, a differentiated learning approach becomes relevant as a solution. Differentiated learning allows teachers to accommodate the diverse needs, interests, and learning styles of students(C.A. Tomlinson & McTighe, 2012; Carol Ann Tomlinson, 1999). By understanding the learning profile, interests, and readiness of students through diagnostic assessments, teachers can design more personalized learning (Carol Ann Tomlinson & Moon, 2014). However, the implementation of this approach still faces many obstacles. Teachers often have difficulty in determining the appropriate differentiation strategy, both in content, process, and learning products. As a result, differentiated learning has not been optimal in improving mathematics learning outcomes.

In addition, the STEAM (Science, Technology, Engineering, Arts, Mathematics)-based learning approach offers opportunities to integrate various disciplines in innovative learning (Katz-Buonincontro, 2018). STEAM encourages students to be actively involved in project-based learning processes, develop creativity, and solve real problems(Perignat & Katz-Buonincontro, 2018). For example, STEAM-based projects allow students to design products, create simulations, or explore mathematical concepts that are relevant to other fields. This approach also provides flexibility in differentiation strategies, so that teachers can create learning experiences that are inclusive and relevant to students' interests (Ramey & Stevens, 2023).

However, the implementation of STEAM in *Madrasah Aliyah* Enrekang Regency has not been optimal. Teachers do not yet have sufficient competence in integrating technology, art, and other multidisciplinary concepts into mathematics learning.

Based on the existing challenges and opportunities, this study aims to analyze the need for developing a STEAM-based differentiated learning module. This module is designed to enhance students' mathematics learning outcomes. Through this approach, mathematics learning is expected to become more relevant, meaningful, and effective in fostering students' critical thinking and creativity. This research not only contributes to the development of learning materials but also provides practical recommendations for teachers to improve the quality of instruction in *Madrasah Aliyah*.

2. METHODS

This study employs a descriptive research design. Descriptive analysis aims to accurately describe, interpret, and explain a variable or situation under investigation (Mustami, 2015). The research was conducted in January 2024 at seven *Madrasah Aliyah* in Enrekang Regency. It involved 120 eleventh-grade students and 11 mathematics teachers from the same grade level. Data collection was carried out using five methods:

a. Questionnaire. This questionnaire was used to explore information regarding the need for developing STEAM-based differentiated learning modules filled by teachers and students. The questionnaire is a combination of closed answer questions and open answer questions.

b. Interview. Interview was conducted with the economics teachers and students of class XI at *Madrasah Aliyah* in Enrekang regency. The interview was conducted to obtain the data regarding the implementation of the mathematics learning at school and the curriculum at school, review the use of the learning media and learning model, and explore the students' opinions regarding the daily learning as well as the students' participation in the learning process. Interviews were also carried out to confirm the answers of teachers and students on the questionnaire.

c. Test. Tests were given to measure initial abilities and identify material that students have and have not mastered. The test is in descriptive form so that researchers can see the flow of students' problem solving so that researchers can identify the strengths and weaknesses of students' conceptual understanding of 143 in the trial class.

d. Observation. Observation was conducted at class XI of *Madrasah Aliyah* to obtain the data regarding the students' learning activities, teachers' performances in the classroom, and student learning environment.

e. Documentation. The data collected through the documentation consisted of the data regarding the curriculum, the syllabus, teaching materials, and the students' mathematics learning outcomes.

According to Kurnia, et al. (2019), in the context of the module development, the need analysis is conducted with: a) Analysis of situation, b) Analysis of teacher's performance, c) Students analysis, d) Analysis of learning objectives, and e) Analysis of subject material.

a. Analysis of situation. Analysis of situation was carried out to determine the learning environment experienced by participants, including: general profile of teachers, educational service facilities, and learning media.
b. Analysis of teacher's performance. Activities at this stage include collecting information on basic problems faced in learning. The information collected as a basis for conducting Analysis of teachers' performance are: teacher perceptions and implementation of differentiated learning and STEAM, and the availability of learning resources for students.
c. Analysis of student's characteristics. Study of student characteristics based on knowledge, skills, and learning styles. The information analyzed is the readiness of students to learn the material and the form of learning module development needed by students in order to improve their competencies.
d. Analysis of learning objectives. Analysis of learning objectives is a necessary step to determine the abilities or competencies that students need to have. There are several points that need to be obtained are the learning objectives and the achievement of learning objectives.
e. Analysis of subject material. Analysis of subject material concerns the identification of the presentation of material in learning resources used by teachers.

The data were analyzed interpretatively and descriptively by arranging the data systematically, organizing the data into categories, synthesizing, and drawing conclusions.

3. RESULTS AND DISCUSSION

a. Analysis of Situation

The situational analysis in the development of STEAM-based differentiated learning modules is conducted to assess the available resources and students' learning environment. This ensures that the developed modules and their features can be utilized optimally-practical for both teachers and students while effectively achieving learning objectives (Sanusi et al., 2015). The analysis examines various aspects of the learning environment, including general teacher profiles, educational service facilities, and learning media.

Mathematics teachers at *Madrasah Aliyah* in Enrekang Regency have met the minimum qualification requirements. The majority (8 teachers or 47.05%) have at least five years of teaching experience, a level of experience that should equip them with sufficient expertise to deliver quality instruction. All participating teachers had attended training on instructional methods. Their professional development was facilitated through the *MGMP* (Mathematics Subject Teachers Forum) across all *madrasahs* in Enrekang Regency, as well as programs organized by the central government, the education office, and internal school initiatives. These included seminars, one-day meetings, coaching sessions, workshops, and technical guidance lasting one to three days.

In addition to teachers, the operationalization of educational services at the seven *madrasahs* is supported by various facilities and learning media that enhance the learning process. However, observations indicate that, in general, *madrasahs* in Enrekang Regency lack adequate educational facilities, which may hinder the optimal implementation of educational services. Regarding the use of learning media, all mathematics teachers utilize technology-based learning tools. However, these tools are rarely used due to limited availability and insufficient preparation, despite the presence of an adequate internet network.

Based on the situational analysis, it can be concluded that in terms of *madrasahs'* operational experience, as well as teachers' minimum qualifications and educational relevance, *madrasahs* in Enrekang Regency have the potential to deliver quality education. However, some *madrasahs* still face limitations in classroom facilities and learning media. Furthermore, the available learning media have not been utilized optimally due to teachers' lack of preparation in integrating them effectively into the learning process.

b. Analysis of Teacher's Performance

The analysis of teacher's performance stage is the basis for product development needs as a solution to solving learning problems (Ortega et al., 2022). At the analysis of teacher's performance, researchers explore information regarding teacher perceptions and the implementation of STEAM-based differentiated learning and the availability of learning resources for students by questionnaire, observation, and interview. This is in line with the Analysis of teacher's performance in the research by Miskiyyah, et al., who conducted Analysis of teacher's performance through learning observations and interviews with teachers to find deficiencies in the learning process (Miskiyyah et al., 2023). In line with Suryadi, et al., who conducted Analysis of teacher's performance to determine basic problems in the development of learning media through interviews with teachers (Suryadi et al., 2020). Information at the Analysis of teacher's performance stage provides conclusions regarding the description of the basic problem, namely the low motivation of teachers in providing learning resources that accommodate students' learning styles.

Differentiated learning, which is identical to the implementation of the Independent Curriculum that has been running for 2 academic years, has made all teachers (11 people/100%) familiar with the term differentiated learning. However, there are still teachers (5 people/45.45%) who are unable to explain the application of differentiated learning and (11 people/100%) still have difficulty implementing differentiated learning. The difficulties felt by teachers in implementing differentiated learning include: a) teachers need to prepare learning devices that can accommodate the diversity of students; b) teachers need a longer time allocation so that learning planning does not run optimally; c) limited learning facilities; d) less than optimal implementation of learning strategies; and e) difficulty in preparing learning plans based on the results of diagnostic assessments.

Regarding STEAM knowledge, all teacher respondents (11 teachers or 100%) lack familiarity with the STEAM approach. For them, STEAM is a new concept, and they have no prior knowledge of its fundamental principles, significance, or integration into mathematics learning. None of the teachers have received training on STEAM in any professional development programs they have attended. Consequently, none of them have implemented STEAM in their teaching practices. Similarly, a study on elementary school teachers in Indonesia found that many lacked a clear understanding of the STEAM approach, with only 37.6% of respondents claiming to have a good comprehension of it (Roshayanti et al., 2022). These findings highlight the urgent need for enhanced STEAM education and training for both teachers and students to improve their understanding and effective implementation of the approach.

Analysis of teacher's performance indicates that mathematics teachers face challenges in developing effective learning materials and utilizing technology in the classroom. Many teachers rely heavily on textbooks and companion books from publishers, limiting students' access to diverse learning resources (Choirudin et al., 2021). The lack of exploration of alternative teaching methods and materials is often due to time constraints, limited facilities, and low creativity (Choirudin et al., 2021; Dini Yatul Ulva & Amalia Fitri, 2022). Teachers struggle with creating comprehensive learning devices, including syllabi, lesson plans, and assessment instruments (W. Sanjaya et al., 2022; Wahyuningsih et al., 2021). To address these issues, several studies suggest innovative teaching modules that align with curriculum requirements and incorporate project-based learning to enhance students' problem-solving abilities (W. Sanjaya et al., 2022). These approaches could help overcome the limitations of current teaching practices and resources in mathematics education.

c. Analysis of student characteristics

The results of documentation of student learning outcomes on the material of Function Composition and Inverse and teacher interviews show that every year less than 50% of students do not achieve learning outcomes. The learning objectives that are difficult for students to achieve are solving problems using the concept of function composition and inverse function. This shows that students' ability to apply the concepts learned in the real world is still low. Low understanding of the concept can be seen from students' inability to use the concept in the real world. In addition, the measurement of students' initial abilities was carried out to map what students already knew and did not know by giving a pretest. The pretest results showed that more than 50% of students were not able to solve the Function Composition and Inverse problems with the following achievements:

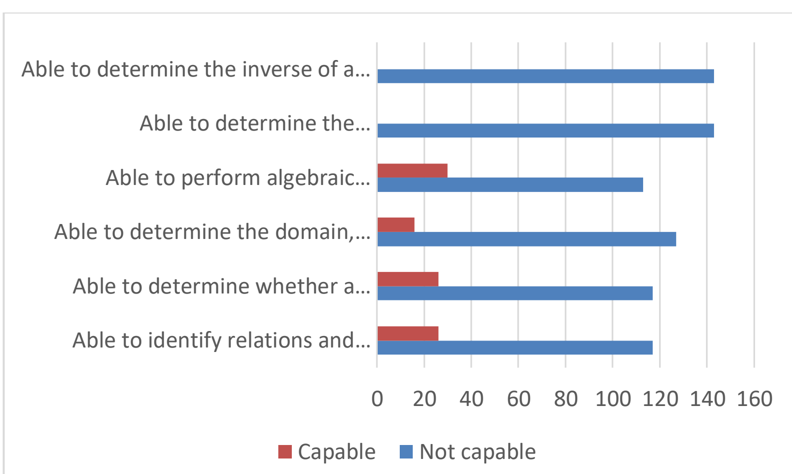

Figure 1. Pretest Results for Function Composition and Inverse Material

Understanding students' prior knowledge is essential in developing learning modules that align with their abilities and ensure an appropriate level of difficulty. If a module is too challenging or too easy, students may become frustrated or bored, which can hinder the learning process. By assessing what students already know, modules can be designed to provide gradual and appropriate challenges. Additionally, information on students' prior knowledge helps identify gaps or misconceptions that may exist. This allows the developed learning modules to address misconceptions and build accurate understanding. This approach aligns with research conducted by Nadiyah and Faaizah, who implemented formative assessments at the analysis stage before proceeding to the design stage. Their study focused on evaluating employee competencies in accordance with the objectives of the Polytechnic Malaysia curriculum (Nadiyah & Faaizah, 2015). Similarly, Camillan emphasized that modules designed based on student abilities are more efficient, as they address real and relevant student needs. This approach saves time for both teachers and students, making the learning process more effective and focused (Huang, 2005).

The students of class XI are in the age of 16 years included in the adolescent phase, in which the process of the brain growth reaches the perfection functionally and cognitively (Kazi & Galanaki, 2020). Adolescence is a phase of life in which the capacity to acquire and use knowledge efficiently reaches its peak. According to Piaget, in terms of the cognitive development, teenagers enter the formal operational stage that already have the ability to think abstractly, reason logically, and draw conclusions from the available information (Sugianto & Darmayanti, 2022). However, Piaget's theory of the cognitive development also received criticism that the cognitive abilities could emerge more slowly than Piaget's estimates. Sometimes teenagers still think concretely operationally or just master the formal operations (Santrock, 2009). Thus, at this stage, the students of class XI still think based on the concrete things in the daily life. Therefore, the appropriate learning to make the students connect the learning materials with the daily life is STEAM learning. STEAM can be applied across various subjects and educational levels, actively involving students in the learning process and helping them connect concepts to real-life situations (Bin Amiruddin et al., 2022).

In the perspective of constructivism, especially Situated Learning Theory, knowledge is built in meaningful actions, namely actions that have a meaningful relationship with each other in the cultural system. Learning occurs through student participation and experience by combining knowledge and doing. The participation and experience experienced by students are not just busy and doing, but are framed in a meaningful context(C.A. Tomlinson & McTighe, 2012).

Ausubel in Agra, et al., stated that learning becomes meaningful when it is related to the cognitive structure that exists in students, with strategies that have a high and complex level of thinking demands, ranging from meaningful reception learning to meaningful discovery learning(Agra et al., 2019). Mystakidis and Cortright, et al., explain that meaningful learning is learning that enables the development of critical thinking skills, problem solving, as well as the transfer of skills and use of knowledge in new situations(Cortright et al., 2005; Mystakidis, 2021).

Based on the characteristics of each student's learning style, teachers need to provide learning modules that can accommodate differences in student learning styles. When students were asked whether they knew their learning style, most students did not know their learning style. Meanwhile, from the aspect of student ability, students who measure themselves as having a faster learning speed than other students receive different treatment from teachers, including teachers asking students who understand faster to be asked by teachers to become peer tutors for their friends or asked to solve more difficult problems. Meanwhile, students with slower learning speeds usually receive special guidance from teachers or are given questions with an easier level of difficulty. However, from the assessment process, especially in formative and summative assessments, students with different characteristics and abilities get the same exam questions. This indicates that the madrasah and family did not conduct a diagnostic assessment to determine the learning style of students.

Understanding learning styles is crucial in developing learning modules that effectively accommodate each learner. By incorporating various learning styles into the material and activities, the modules ensure that all students regardless of their preferred learning style can achieve learning objectives more effectively. Moreover, students with different learning styles can collaborate by leveraging their individual strengths. Visual learners may contribute to visual design or illustrations, auditory learners can organize group discussions or presentations, and kinesthetic learners can lead hands-on experiments or simulations. This collaboration fosters peer learning and helps students develop essential interpersonal skills. Conducting a learning style analysis at the early stages of STEAM module development enables educators to tailor instructional delivery to best suit each student's learning preferences, ensuring both effectiveness and relevance. Learning styles such as visual, auditory, and kinesthetic represent the natural ways in which students perceive, process, and retain information (Glazunova et al., 2020; Larkin & Budny, 2005). Additionally, accommodating diverse learning styles enhances self-directed learning and student engagement. Modules designed with students' learning preferences in mind empower them to explore concepts independently (Mann & Willans, 2020). Thus, understanding each student's learning style allows the developed learning modules to be more responsive to their individual needs.

In fact, several research findings show that recognizing student diversity is critical to effective teaching (Khofshoh et al., 2023; Nur'azizzah et al., 2023; Yunita, 2022), reducing math anxiety(Suyanto, 2023), and students' independent learning abilities. Learning modules designed with students' learning styles in mind will help them explore concepts independently(Mann & Willans, 2020). However, many educators have difficulty implementing a differentiated approach. This begins with the difficulties of schools and teachers who often fail to conduct diagnostic assessments(Jatmiko & Putra, 2022; Yansa & Retnawati, 2021). As a result, teachers treat students uniformly, ignoring individual differences in learning styles and abilities(Turhusna & Solatun, 2020). Students are treated as the same entity. The teachers have not provided different learning services, which are adjusted to the diversity of student learning style characteristics, especially the provision of learning modules.

Regarding students' knowledge of STEAM and its application in learning, none of the students were familiar with the term STEAM. Interviews revealed that they were unable to connect the material they had learned with other STEAM-related fields or recognize learning approaches that integrate STEAM. In reality, integrating STEAM into learning offers new opportunities for students to engage in hands-on design-based learning and develop creativity and problem-solving skills (Katz-Buonincontro, 2018). STEAM-integrated learning not only considers students' learning styles but also fosters multidisciplinary competencies aligned with their talents and intelligences. For instance, in a STEAM-based project, students with kinaesthetic intelligence may build physical models, while those with visual-spatial intelligence may design visual representations of solutions (Malele & Ramaboka, 2020).

d. Analysis of Learning Objectives

Learning outcomes represent the competencies that students must achieve at each phase, beginning with the Foundation Phase in early childhood education (PAUD). In mathematics, learning outcomes are structured from Phase A to Phase F. At the *Madrasah Aliyah* level, mathematics learning is categorized into Phases E and F, where Phase E applies to Grade X and Phase F to Grade XI.

The material on Composition of Functions and Inverses is included in the learning outcomes of Phase F of Algebra and Function elements. The results of interviews with mathematics teachers of *Madrasah Aliyah*, the material on composition of functions and inverses is taught in Grade XI of the odd semester. The following are details of learning outcomes, and learning objectives that must be achieved by students and what materials will be studied in the material on composition of functions and inverses based on the results of curriculum documentation.

Table 1. Learning Achievements and Learning Objectives for the Material on Functions, Function Composition, and Inverses

Elements	Algebra and Functions
Learning Outcomes	At the end of Phase F, students can express data in matrix form. They can determine inverse functions, function compositions, and function transformations to model real-world situations using appropriate functions (linear, quadratic, exponential)
Learning Objectives	Students are able to 1. Understand the concept of function 2. Determine the domain, codomain, and range of a function. 3. Explain the requirements and rules for function composition. 4. Determine the composition of functions consisting of two or more functions. 5. Investigate the commutative and associative properties of function composition. 6. Use the concept of function composition to solve problems. 7. Explain the requirements and rules for creating inverse functions. 8. Determine the inverse of a function. 9. Use the concept of inverse functions to solve problems.
Learning Objective	Students are able to

Sequence	1. Understand the concept of function 2. Determine the domain, codomain, and range of a function. 3. Explain the requirements and rules for function composition. 4. Determine the composition of functions consisting of two or more functions. 5. Investigate the commutative and associative properties of function composition. 6. Use the concept of function composition to solve problems. 7. Explain the requirements and rules for creating inverse functions. 8. Determine the inverse of a function. 9. Use the concept of inverse functions to solve problems.
Content	1. Relations and Functions 2. Domain, Codomain, and Range 3. Composition of Functions 4. Inverse Functions

In the context of developing STEAM-based differentiated learning modules, learning objectives are linked to STEAM Crosscutting Concepts and Substructure and Engineering Practices (SEP) performance indicators. Crosscutting Concepts (CC) is a concept that links the use of terminology in different scientific disciplines to improve understanding and practical application in the fields of science and engineering. While Substructure and Engineering Practices (SEP) explains how scientists and engineers do their work. SEP practices train students to learn to solve problems. Both are dimensions of the STEAM approach issued by the Next Generation Science Standard (NGSS) ((NGSS), 2013; NGSS Lead States, 2013).

Determining STEAM performance indicators for each learning objective helps clarify the presentation of STEAM-based materials, learning activities within a differentiated STEAM framework, and assessment of learning outcomes. The analysis of learning objectives is related to the need to develop differentiated learning modules based on STEAM, including:

1) Learning objectives in the learning module adjust the learning objectives in all *Madrasah Aliyah* in Enrekang Regency.
2) Connecting concepts with real-world situations through the relationship between the mathematical concepts studied and the STEAM field.
3) Learning objectives are related to STEAM performance indicators which are used as a reference in compiling learning activities.
4) Increasing active participation and interaction of students in the learning process by accommodating students' learning styles through differentiated learning modules.
5) Technology-based module products that consider students' learning style preferences and preferences for the presentation of the material. Modules that integrate text, images, videos, animations, and games increase students' interest and motivation to learn.

Learning objectives play a crucial role in developing effective STEAM-based modules and improving students' skills. They provide clear direction for module components and help educators choose appropriate approaches. Well-designed learning objectives are essential for creating specific and measurable outcomes in instructional modules (Andhare et al., 2012). Therefore, the development of the module must be based on a comprehensive needs analysis, including student assessment, learning activities, and competency standards(Marta & Ramli, 2021). In the context of developing STEAM-based differentiated learning modules, the determination of learning objectives is carried out accompanied by an analysis of conformity with STEM performance indicators. This analysis needs to be carried out as a reference for learning activities and materials in STEAM-based differentiated modules.

e. Analysis of Subject Material

The analysis of subject material stage is carried out by identifying facts, concepts, principles, and procedures of the learning material. Based on observation, the use of learning resources used by *Madrasah Aliyah* teachers is mostly in the form of learning companion books that they call student worksheets. Based on the results of observations, the presentation of material in the companion books has not accommodated the characteristics of students' learning styles. The presentation of concepts is dominated by text, with few illustrations and examples of questions. If the Composition of Functions and Inverses material is classified, then 50% is procedural but in the form of routine procedures where questions are solved with routine solutions that do not involve high-level thinking skills.

In the need to develop differentiated learning modules based on STEAM, procedural materials in accordance with STEAM learning activities are presented in the form of projects, especially in learning with the aim of applying concepts to solve problems. The Composition of Functions and Inverses of Functions material is abstract so that the description of the material in the learning module is equipped with concrete examples that are relevant to the concepts being taught. In addition, the material needs to be linked to real situations or problems around them that are solved using concepts that have been learned by students. This learning activity helps students understand the concept more deeply and relevantly so that students can see how the material Function, Function Composition, and Inverse Function is applied in everyday life.

Research shows that the development of teaching materials using the STEAM framework offers several benefits for student learning. The results of the study indicate that STEAM-based teaching materials can improve learning outcomes (Mariyana & Usman, 2023) and facilitate the development of 21st century skills, including critical thinking, creativity, collaboration, and communication (Meiliasari et al., 2022). Learning modules with the STEAM framework also support differentiated learning to be easy to adopt and access by students (Yulianti et al., 2020).

Next is about the character of learning media as a medium for delivering teaching materials used in the *Madrasah Aliyah* of Enrekang Regency. Research on learning media and student learning styles reveals important insights for educational practices. Studies show that different media types accommodate various learning styles to varying degrees. Visual and auditory styles are most commonly addressed by media like slides, videos, and computers. Environmental and real-world objects can potentially accommodate all learning styles depending on their characteristics. Digital modules and computer-based media can cater to visual, auditory, and kinaesthetic styles simultaneously (Ragil Kurniawan, 2017). Research indicates that matching media to students' learning styles can improve learning outcomes. For instance, audio-visual media were found to be more effective than image-only media for students across different learning style preferences (Sit et al., 2021). Additionally, considering students' learning styles when selecting media can enhance engagement and learning effectiveness (Olive et al., 2010). These findings emphasize the importance of aligning media choices with students' diverse learning preferences to optimize educational outcomes.

4. CONCLUSION

The development of STEAM-based differentiated learning modules for *Madrasah Aliyah* mathematics in Enrekang Regency addresses critical needs and challenges identified through comprehensive analysis:

a. Analysis of situation: Teachers possess adequate qualifications and professional training; however, the limited availability and suboptimal use of learning facilities and media hinder effective teaching. These findings emphasize the need for accessible and practical modules that leverage existing resources and maximize their utility.

b. Analysis of teacher’s performance: Challenges in implementing differentiated learning and integrating STEAM approaches stem from limited teacher knowledge and preparation. Addressing these gaps through tailored training and innovative modules is crucial for enhancing teaching practices and learning outcomes.

c. Analysis of student’s characteristics: Students demonstrate low conceptual understanding and application skills, particularly in abstract topics like function composition and inverses. Additionally, their diverse learning styles are not adequately recognized or accommodated.

d. Analysis of learning objectives: Aligning learning objectives with STEAM crosscutting concepts and engineering practices ensures relevance and practical application of mathematical concepts.

e. Analysis of subject material: Existing learning resources lack depth, variety, and alignment with differentiated and STEAM methodologies.

The findings highlight the importance of developing STEAM-based differentiated learning modules that accommodate diverse learning styles, integrate real-world applications, and leverage innovative teaching practices. This module aims to overcome the limitations of current teaching approaches, enhance student engagement, and improve learning outcomes in mathematics education.

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Authors' contribution

Putriyani S.: Contribution: conceived and designed the analysis, collected the data, performed the analysis, and wrote the paper.

Muh. Khalifah Mustami: Contribution: Provided guidance on conducting research and performed the analysis.

Misykat Malik Ibrahim: Contribution: Provided guidance on conducting research and performed the analysis.

Syamsuddin : Contribution: Provided guidance on conducting research and performed the analysis.

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