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Need Analysis to Develop Fluid Digital Teaching Material Integrated STEM and Ethnoscience to Promote Conceptual Understanding and Creative Thinking Skills of Students

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ABSTRACT

Twenty first century learning requires students to master concepts and have the ability to think creatively in solving contextual problems. However, based on observations at SMA Pertiwi 1 Padang, several problems were found in physics learning, namely the limitations of digital teaching materials, problems with fluid materials, low mastery of students' concepts, creative thinking skills that have not yet developed, and teaching materials that have not been integrated with STEM and ethnoscience. To respond to this, a needs analysis stage was carried out with a Research and Development (R&D) approach using the Hannafin and Peck models. Data was collected through questionnaires to 33 students and 3 physics teachers, a discourse test to reveal problems with fluid materials and creative thinking skills, and mid-semester exam results to see the mastery of concepts. The results of the analysis show that teaching materials are not optimally supporting ICT-based learning and the integration of STEM and ethnoscience. Students' scores are still below the minimum completeness criteria. These findings show the need to develop innovative, interactive, and contextual digital teaching materials to facilitate more meaningful physics learning.

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INTRODUCTION

Twenty first century is known as the age of science and technology. Science and technology are the main pillars of every aspect of life today. As we all know, this century has brought many changes, such as the rapid development of science and technology, which has led to changes in the education system, which in turn has led to changes in curriculum, media, and technology (Rahayu et al., 2022). Educational transformation in this century is crucial to ensure that students not only acquire knowledge but also relevant skills for life and the ever-evolving world of work. This aligns with Mardhiyah's (2021) opinion that in the 21st

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century, not only knowledge but also skills play a role in 21st century learning

The 21st century skills have become one of the main focuses in modern learning. Life in the 21st century requires a variety of skills (Mufit et al., 2020). In this era, there has been a significant shift from traditional learning methods to more interactive and technology-based methods. The basic principles of 21st century learning emphasize real-world activities and contexts (Asrizal et al., 2018). Essentially, to achieve educational goals, students are expected to possess 21st century skills known as the 4C's, which include: Critical Thinking and Problem Solving, Creativity, Communication Skills, and the Ability to Work Collaboratively (Fitrah et al., 2022). These skills are crucial in equipping students to navigate an increasingly complex world (Fitria et al., 2025).

One of the key factors in mastering 21st century skills is a deep understanding of concepts. Conceptual mastery involves not only understanding definitions or formulas, but also the ability to logically connect various principles and apply them in diverse situations. Students with strong conceptual understanding are generally more capable of identifying cause-and-effect relationships, recognizing patterns in problems, and evaluating and selecting the most effective problem-solving strategies. This is especially important in learning physics, a discipline filled with abstract concepts such as force, energy, and momentum, which are not always visible or easily understood through everyday experiences. Without a solid grasp of these concepts, students may struggle to build meaningful new knowledge and tend to rely on rote memorization. However, this often becomes a challenge, especially in physics, which involves abstract and complex concepts. Strengthening students' concept mastery is essential, as it supports the development of creative thinking skills (Sailil Hana & Subali, 2023).

Creative thinking has become one of the main skills that students must possess in the 21st century. This skill is necessary for developing new ideas, increasing efficiency, and finding solutions to difficult problems related to learning and students' real-life situations (Daulay & Asrizal, 2024). Every individual needs to continuously adapt to their environment to avoid falling behind in the progress of the times (Maryanti et al., 2023). Many students still experience difficulties in developing this ability. One of the main causes is the conventional learning approach that tends to provide less space for exploring new ideas. This results in students becoming passive and less trained in generating innovative solutions, which ultimately impacts their low ability to think creatively both in the classroom and in everyday life. To ensure that 21st century skills can be mastered by students, learning can utilize Information and Communication Technology (ICT) (Husniyah & Asrizal, 2023).

Education based on Information and Communication Technology (ICT) is an essential aspect of 21st-century learning. Learning in this era should enable students to leverage information technology to enhance their skills (Asrizal et al., 2022). This aligns with Fuadah's (2023) stated that education is one of the aspects of human life influenced by the advancement of Information and Communication Technology (ICT). ICT not only enhances students' access to learning but also improves the learning process by offering interactive and collaborative learning method (Asrizal et al., 2024). Technologies like computers, the internet, and educational applications enable students to learn more flexibly and personalize their learning according to their styles and needs.

Digital teaching materials support 21st century learning through the use of ICT in education. According to Asrizal's (2018), Digital teaching materials designed and developed using Information and Communication Technology (ICT) tools can help students grasp concepts more effectively. The advantage of digital teaching materials lies in their ability to visualize abstract physics concepts, such as fluids, through animations and simulations that ease comprehension. Additionally, digital teaching materials provide flexible access, allowing students to learn anytime, and offer interactive features for virtual experiment simulations that enrich the learning experience. Digital teaching materials are utilized as interaction tools between teachers and students in both online and offline learning processes (Riyasni et al., 2023). Digital teaching materials not only facilitate the mastery of physics concepts but also develop students' creative thinking skills through exploration and technology-based problem-solving.

Digital teaching materials can be developed using STEM and Ethnoscience approaches to enhance student engagement in learning. In recent years, more people have recognized the need to reform current education to integrate STEM to meet the needs of the modern world (Babalola & Keku, 2024). The STEM approach combines Science, Technology, Engineering, and Mathematics in learning. Mathematics is used for data processing, while technology and engineering apply scientific knowledge (Ariyatun, 2021).

Ethnoscience, on the other hand, is an educational approach that aligns culture with the science studied in schools, thereby enhancing students' learning experiences. In brief, the Ethnoscience approach focuses on translating indigenous knowledge into scientific knowledge (Zakiyah & Sudarmin, 2022). By combining STEM and Ethnoscience approaches, students not only learn about culture through theory but also participate in real-life examples that strengthen their understanding of the importance of preserving cultural heritage (Daulay & Asrizal, 2024). The integration of these two approaches in digital teaching materials can help students facilitate concept mastery, creative thinking skills, and relate science to everyday life.

Based on the observations conducted at SMA Pertiwi 1 Padang, several issues were identified that students and teachers face in physics learning. These issues include problems with the use of teaching materials, the utilization of ICT, students' difficulties with fluid mechanics, students' creative thinking skills, and students' concept mastery. The instruments used included a questionnaire on problems in physics learning, issues with the teaching materials used by students, discourse test questions on fluid mechanics, discourse test questions on creative thinking skills adjusted to creative thinking indicators according to experts, and midterm exam results to determine students' initial concept mastery.

The actual conditions in the school highlight issues with the teaching materials used by students. A needs analysis questionnaire was administered to students regarding the development of teaching materials. The analysis results indicate that the current materials have not fully utilized digital resources. Students expressed the need for interactive and engaging teaching materials in physics learning. Another issue concerns the challenges in physics learning. A questionnaire was given to three teachers, revealing that the teaching materials used have not optimally supported the learning process. Teachers still struggle with using software to create teaching materials, resulting in materials that are not yet digital-based. Additionally, teachers have not integrated STEM and Ethnoscience into the use of teaching materials. The third real condition relates to fluid mechanics. Based on the test results conducted on XI F 1 students at SMA Pertiwi 1 Padang through questions related to fluid mechanics, the overall results showed that 33 students scored below the minimum competency criteria with an average score of 26. This proves the need for more engaging teaching materials related to fluid mechanics so that students better understand the material and can improve their learning outcomes. The fourth real condition relates to the creative thinking skills of students at SMA Pertiwi 1 Padang. These results were obtained from the creative thinking skills test given to students, consisting of 8 questions. Based on the answers provided by students, their creative thinking skills are still low. This is evidenced by students' answers that are still fixated on the answers in the book, so students only memorize the answers and do not understand their meaning. The last real condition relates to students' concept mastery. Initial concept mastery was obtained from the average midterm exam scores of XI F 1, XI F 2, XI F 3, and XI F 4 students at SMA Pertiwi 1 Padang. The average midterm exam scores were XI F 1 with an average of 52, XI F 2 with an average of 51, XI F 3 with an average of 45, and XI F 4 with an average of 53. All average midterm exam scores have not met the minimum competency criteria for physics subjects, indicating that students' initial concept mastery in physics is still low.

Based on the description of the issues mentioned, a solution is needed to develop digital teaching materials integrated with STEM and Ethnoscience to facilitate students' mastery of concepts and creative thinking skills. The initial stage in the development of digital instructional materials involves conducting a comprehensive needs analysis. This study specifically focuses on identifying the needs of both teachers and students with respect to digital learning resources in the context of physics education. The contribution of this study serves as a reference for the development of Digital Fluid Teaching Materials Integrated with STEM and Ethnoscience to Facilitate Mastery of Concepts and Creative Thinking Skills of Students.

METHODS

This research employs the Research and Development (R&D) method with the objective of systematically designing, developing, and evaluating a specific product. The primary focus of this study is to create digital teaching materials that are not only valid in terms of content and methodology but also practical and user-friendly for educators and students during the learning process. The development process involves several stages, including needs analysis, product design, prototype creation, limited testing, and evaluation followed by revisions based on the feedback received. Through this approach, it is expected that the resulting digital teaching materials will enhance the effectiveness and efficiency of learning, thereby supporting the achievement of educational goals optimally in the current digital era.

The study utilizes the Hannafin and Peck development model, which consists of three systematic and iterative phases: needs analysis, design, and development with implementation. In the needs analysis phase, researchers identify the specific challenges and requirements faced by both teachers and students in learning fluid-related physics concepts, serving as the foundation for the subsequent phases. The design phase involves the creation of a framework for digital teaching materials, incorporating appropriate content, media, and learning strategies aligned with the principles of STEM (Science, Technology, Engineering, and Mathematics) and ethnoscience, ensuring cultural relevance and contextual learning. During the development and implementation phase, the digital teaching materials are produced and introduced in the classroom setting, followed by continuous evaluation and revision based on feedback from experts and users. Each phase includes rigorous assessment to ensure the product's validity, practicality, and effectiveness.

This research focuses on the first phase of the Hannafin and Peck development model, which is needs analysis. This phase is conducted by identifying the needs in developing digital teaching materials. The needs analysis includes analyzing issues in physics learning, issues with the use of teaching materials, issues with fluid mechanics content, issues with creative thinking skills, and issues with students' concept mastery. The needs analysis for teaching materials was given to 33 students in the form of a questionnaire containing 20 statements. For the analysis of physics learning issues, a questionnaire containing 24 statements with 4 indicators was given to 3 teachers. The indicators include issues with the use of teaching materials, difficulties in utilizing and using software, issues with integrating STEM in physics learning, and issues with integrating Ethnoscience in physics learning. For the analysis of issues with fluid mechanics content, 4 discourse test questions were given to 33 students. Additionally, the analysis of creative thinking skills was conducted with an initial test in the form of a discourse test containing 8 questions adjusted to the indicators of creative thinking skills. Finally, the analysis of concept mastery was obtained from the average midterm exam scores of XI F 1, XI F 2, XI F 3, and XI F 4 students.

The data analysis technique used in this research is descriptive statistical analysis. Descriptive statistics is a data analysis technique that describes or illustrates the collected data as it is without intending to make general conclusions. Descriptive statistical data can be presented in the form of standard tables or frequency distributions, line or bar graphs, pie charts, pictograms, group descriptions using mode, median, and mean, as well as group variations through range and standard deviation (Sugiyono, 2017).

The results of the needs analysis are analyzed using a formula where the obtained score is divided by the maximum score and then multiplied by 100.

$$Score = \frac{Total\ scores\ obtained}{Maximum\ score} \times 100$$

The criteria for determining needs analysis can be seen in the following table:

Table 1. Criteria for Teacher and Student Needs Analysis

Interval	Category
80-100	Very Agree
66-79	Agree
56-65	Neutral
40-55	Disagree
30-39	Very Disagree

Source: (Arikunto, 2018)

Table 2. Criteria for Analysis of Students' Creative Thinking Skills Needs

Interval	Kategori
80-100	Very Good
66-79	Good
56-65	Fair
40-55	Poor
30-39	Very Poor

Source: (Arikunto, 2018)

RESULTS AND DISCUSSION

Results

The first analysis result of this study is the analysis of teacher needs related to problems in physics learning. The instrument used is a questionnaire sheet for teachers consisting of 4 indicators. This questionnaire was given to 3 teachers at SMA Pertiwi 1 Padang. The data obtained serve as a basis for identifying the main challenges teachers face in delivering effective physics learning. The results of the analysis are presented in table 3.

Table 3. Results of Problem Analysis in Physics Learning

Indicator	Score
Problems with the use of teaching materials	80
Difficulty in utilizing and using software	77
The problem of STEM integration in physics learning	80
The problem of integrating ethnoscience in physics learning	77
Average	**78,5**

Based on the table, it can be explained that the first indicator related to the problem of using teaching materials obtained an average answer of 80 with the agree category. For the second indicator related to the difficulty of utilizing and using software, an average answer was obtained of 77 with the agree category. Furthermore, for the third indicator related to the problem of STEM integration in physics learning, an average answer was obtained of 80 with the agree category. For the last indicator related to the problem of ethnoscience integration in physics learning, an average answer was obtained of 77 with the agree category. Based on the table, the results indicate that participants generally agree that there are problems in the use of teaching materials, software utilization, as well as the integration of STEM and ethnoscience in physics learning.

The second analysis result of this study is the analysis of students' needs related to the problems of teaching materials used in physics learning. The instrument related to the problems of teaching materials used in physics learning uses a questionnaire sheet for students consisting of 20 statement items. This questionnaire was given to 31 students of class XI F 1 at SMA Pertiwi 1 Padang. The results of the analysis are presented in table 4.

Table 4. Results of Problem Analysis of Teaching Materials Used in Physics Learning

Indicator	Score
The teaching materials used by teachers are less varied	79
The teaching materials used are not interactive and interesting enough so that physics material feels difficult.	80
The teaching materials used by teachers are not equipped with images, videos or other supporting media.	83
Students have difficulty understanding physics concepts because the teaching materials available are only in the form of text without clear visualizations.	85
Students have difficulty understanding the relationship between physics and other sciences such as STEM.	84
Teaching materials used by teachers rarely link physics to the surrounding culture (ethnoscience)	76
The teaching materials used by teachers do not support independent learning because they are not available in digital format.	81
Students find it difficult to remember learning materials because the teaching materials do not have interactive features.	84
The teaching materials used do not provide clear practical guidance, so students have difficulty carrying out physics experiments.	79
The teaching materials used do not arouse students' curiosity enough to explore physics concepts further.	84
The teaching materials used do not yet show the relationship	80

between physics theory and modern technology.	
Students have difficulty practicing questions because the teaching materials used do not provide exercises for each sub-material and are collected online.	84
Students cannot evaluate their own mastery of concepts because the teaching materials used do not provide competency tests with automatic scores.	80
The teaching materials used do not provide video-based experimental guides that can help students before carrying out the practical work directly.	83
Students have difficulty understanding the teacher's explanation because the teaching materials do not provide recordings or digital materials that can be studied again.	82
The teaching materials used are less flexible because they can only be accessed in printed form.	85
The teaching materials used do not facilitate students' creative thinking skills.	84
Students are less motivated to learn because the teaching materials do not present the material in the form of videos and images.	81
Students have difficulty completing physics assignments because the teaching materials do not provide interactive and easily accessible digital guides.	83
Students want to use digital teaching materials that can be used online via smartphone or computer.	87
Average	**82**

Based on the table, it can be explained that in point 20 the highest average was obtained, namely 87 with the category of strongly agreeing that students want to use digital teaching materials. In addition, all answers given by students related to the statements contained in the questionnaire were in the category of agreeing to strongly agreeing. If analyzed, the average of all student answers of 82 was included in the category of strongly agreeing regarding the existence of problems with teaching materials used in physics learning.

The third analysis result in this study examines students' needs related to challenges in fluid topics. The instrument used is a question sheet consisting of four questions, administered to 33 students in class XI F1 at SMA Pertiwi 1 Padang. The analysis results are presented in Figure 1.

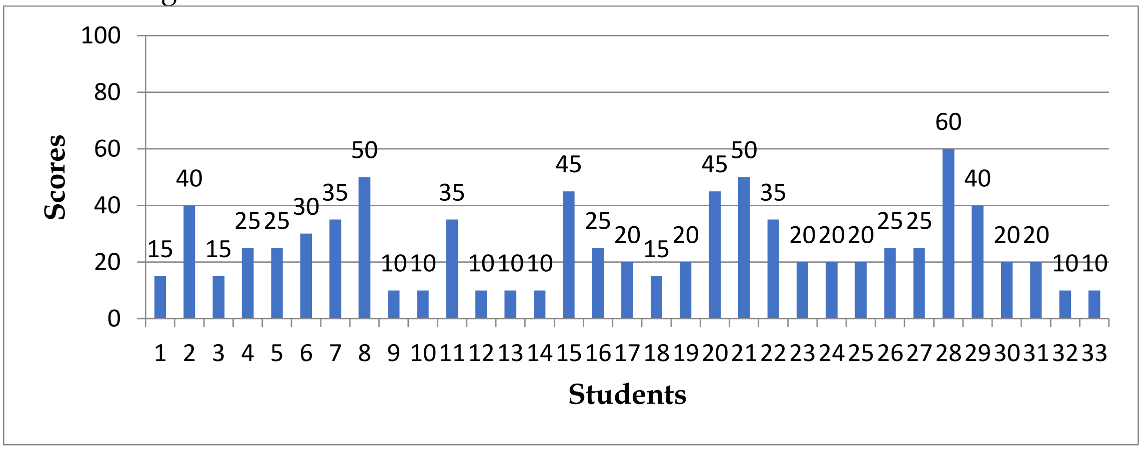

Figure 1. Results of Problem Analysis in Fluid Matter

The picture presents the results of a study that investigates students' needs related to the challenges they face in understanding the topic of fluids. The data were obtained through a diagnostic instrument in the form of a question sheet consisting of four open-ended questions. This instrument was administered to 33 students of class XI F1 at SMA Pertiwi 1 Padang. The bar chart in the figure illustrates the individual scores of each student, revealing a wide range of performance levels. Most students scored between 10 and 35, indicating significant difficulties in mastering fluid concepts. Only a few students achieved higher scores, with the highest being 60, suggesting that only a small portion of the class has a strong understanding of the material. These findings highlight the need for targeted instructional support and the development of digital teaching materials that address specific learning gaps in the topic of fluids.

The fourth analysis result of this study is the analysis of student needs related to the problem of concept mastery. The instrument used is the Mid-Semester Test score. Initial concept mastery is obtained from the scores of students in class XI F 1, XI F 2, XI F 3 and XI F 4 at SMA Pertiwi 1 Padang. The results of the analysis are presented in table 5.

Table 5. Results of Analysis of Students' Concept Mastery Problems

Class	Average
XI F 1	52
XI F 2	51
XI F 3	45
XI F 4	53
Overall Average	**50**

Based on Table 4, it can be explained that the average midterm exam scores of students in class XI F 1 is 52. For class XI F 2, the average score is 51. Class XI F 3 has an average score of 45. Furthermore, the average score for class XI F 4 is 53.

The final analysis of this research is the needs analysis of students related to creative thinking skills. The instrument used was a set of questions. The questions given to 33 students of class XI F 1 at SMA Pertiwi 1 Padang consisted of 8 items. The results of this analysis are presented in Figure 2.

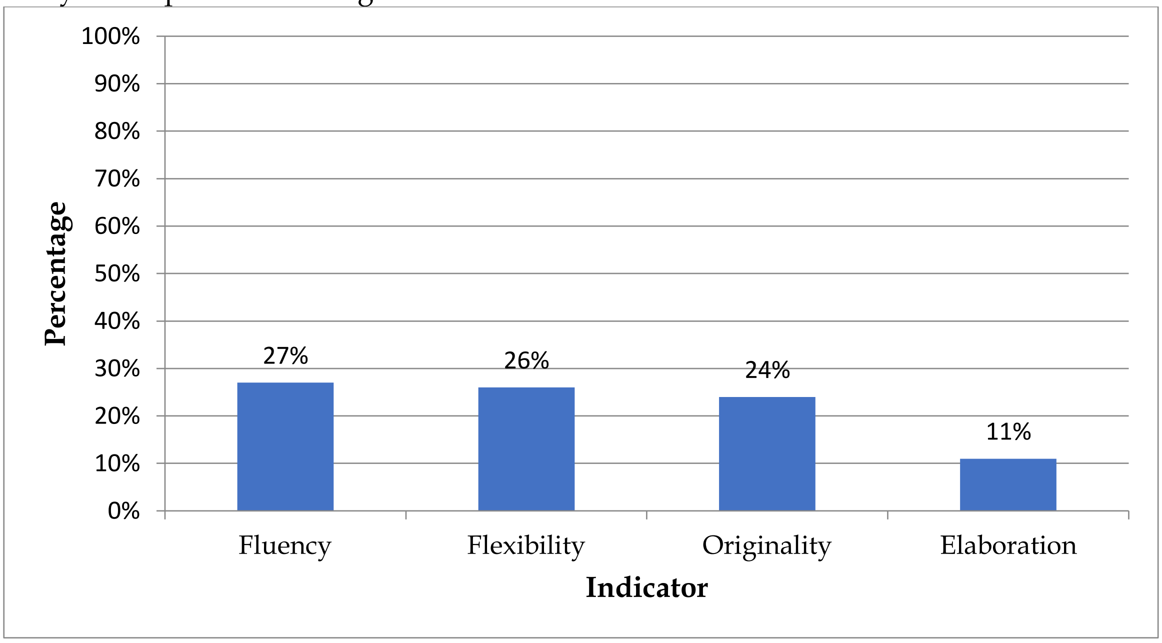

Figure 2. Results of Analysis of Students' Creative Thinking Skills Problems

Based on the image, it can be explained that students' creative thinking skills can be assessed using four key indicators: fluency, flexibility, originality, and elaboration. These indicators, as proposed by Munandar (2004), provide a comprehensive framework for evaluating various dimensions of creative thinking. The data reveals that students scored 27% for fluency, 26% for flexibility, and 24% for originality, all of which fall into the 'poor' category. Meanwhile, the elaboration indicator received the lowest score at 11%, placing it in the 'very poor' category. These findings suggest that students' creative thinking skills are still underdeveloped and require targeted instructional interventions to enhance their performance across all four areas.

Discussion

The analysis results show that the needs analysis can serve as a basis for developing digital fluid teaching materials integrated with STEM and Ethnoscience to facilitate students' mastery of concepts and creative thinking skills. The first analysis concerns issues in physics learning. The analysis indicates that the utilization of ICT in physics learning still faces challenges, particularly in the optimal use of teaching materials, difficulties in creating digital teaching materials, and the minimal integration of STEM and Ethnoscience. Uninteresting and unmotivating teaching materials impact students' low engagement, while difficulties in using software hinder innovation in learning. The lack of integration of STEM and Ethnoscience makes it difficult for students to connect physics concepts with real life. Therefore, it is necessary to develop digital teaching materials that are easy to use, engaging, and capable of enhancing students' mastery of concepts and creative thinking skills.

The second analysis concerns the teaching materials used in physics learning. The analysis indicates that the current teaching materials have not maximized the use of digital teaching materials. Most students desire more interactive and engaging teaching materials to make physics learning more effective. Additionally, the need for digital teaching materials is increasingly emphasized as a solution to enhance students' engagement and motivation in learning.

Digital teaching materials have several advantages. They can display a variety of graphic, audio, and video features comprehensively; engage students interactively, making learning less monotonous and allowing students to be more active during the learning process; accumulate information about students' activities in learning directly for assessment purposes; provide various additional information more practically and comprehensively that can be accessed via the internet (links) to various sources (websites); are practical and efficient in their use; and do not require large spaces or special places for use and storage (Kosasih, 2021).

Integrating STEM into learning offers many benefits. It can enhance comprehension of principles, concepts, and skills in a specific discipline; spark student interest and activate creative and critical thinking; support understanding and application of the scientific method; and improve students' ability to apply their knowledge (Sumaya et al., 2021). The integration of Ethnoscience has several benefits in the learning process. Ethnoscience can enable students to understand the indigenous science of their community, meaning that the cultural socialization process can take place in learning activities; after understanding the formation process of indigenous science and scientific science, students can differentiate between the two and directly prove the discovery activities of indigenous science and scientific science, thereby forming students' scientific attitudes; after knowing the indigenous science of their community, students can recognize the potential of indigenous science to be developed into scientific science; and students can master scientific science well along with examples from their surroundings that indicate forms of their community's indigenous science (Mukti et al., 2022). Digital teaching materials integrated with STEM and Ethnoscience will promote student-centered learning, connect learning with the real world, and link learning with students' experiences and local culture.

The third analysis concerns issues with fluid mechanics content. Based on the research conducted by Purnamasari et al. (2017) and Suherly et al. (2023) on the difficulties in static and dynamic fluid mechanics. The difficulty in fluid mechanics is because most students understand the material only in terms of the existing mathematical equations without deeply understanding the basic concepts. If this issue continues, students will fail to understand a concept, which will impact their understanding of subsequent materials. The test results also indicate that students' achievements remain well below the minimum competency criteria, highlighting the need for more engaging and interactive teaching materials to enhance their grasp of fluid concepts and improve learning outcomes.

The fourth analysis concerns students' concept mastery issues. The results show that students' initial concept mastery in physics is still low, as evidenced by the average midterm exam scores that have not reached the minimum competency criteria in all analyzed classes. This low concept mastery can hinder students' understanding of subsequent physics materials. Therefore, efforts are needed to improve students' concept mastery.

The final analysis concerns students' creative thinking skills. The results show that students' creative thinking skills in fluid mechanics are still low. Students tend to rely on answers from the book without truly understanding their meaning, so their creative thinking skills have not developed optimally. This is evident from the creative thinking skills test results, which show that the fluency and flexibility indicators are still in the 'poor' category, the originality indicator is also in the 'poor' category, while the elaboration indicator is in the 'very poor' category. This condition indicates the need to develop teaching materials that can encourage students to be more actively engaged in creative thinking in understanding and applying physics concepts.

CONCLUSION

Based on the research conducted, several results from the needs analysis can be concluded. The first analysis relates to issues in physics learning, with an average response of 78.5 in the 'agree' category. The second analysis concerns the teaching materials used in physics learning, with an average response of 82 in the 'strongly agree' category. The third analysis pertains to issues with fluid mechanics content, with all students' responses being far below the minimum competency criteria for physics. The fourth analysis relates to concept mastery issues, derived from students' midterm exam scores, showing an overall average score of 50The test results also indicate that students' achievements remain well below the minimum competency criteria for physics, which is set at 79. The final analysis concerns students' creative thinking skills in fluid mechanics, which are still low. This is evident from the creative thinking skills test results, with the fluency indicator at 27% in the 'poor' category, the flexibility indicator at 26% in the 'poor' category, the originality indicator at 24% in the 'poor' category, and the elaboration indicator at 11% in the 'very poor' category.

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