Developing STEM-Based Interactive Learning Modules Integrating Samawa Local Culture to Enhance Students' Conceptual Understanding and Science Process Skills

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Abstract - *This study developed and tested the effectiveness of an interactive learning module based on Science, Technology, Engineering, and Mathematics (STEM) integrated with the local culture of Samawa. The main objective was to improve students' conceptual understanding and science process skills of SMA Negeri 4 Sumbawa Besar on kinematics material. Using the ADDIE model research and development (R&D) method, the module was validated by material and media experts before being tested on 30 students through a One-Group Pretest-Posttest design. The validation results showed that the module was very feasible to use, while the implementation test results showed a significant increase in conceptual understanding (N-Gain = 0.65) and science process skills (N-Gain = 0.75). Thus, this module is proven to be effective as an alternative teaching material that is contextual and relevant to the demands of 21st-century learning.*

Keywords*: Interactive Module; STEM Approach; Samawa Local Culture; Conceptual Understanding; Science Process Skills.*

INTRODUCTION

The development of twenty-first century education demands continuous innovation to prepare students who not only master academic concepts but are also skilled in scientific, technological, engineering, and mathematical processes (STEM). The STEM approach has been widely recognized as an effective learning framework for developing twenty-first century skills such as critical thinking, creativity, collaboration, and problem-solving (Bybee, 2013; Ardianti et al., 2020). However, the implementation of STEM in Indonesia still faces several challenges, one of which is the limited integration of local culture that can support more meaningful concept understanding for students (Hadinugrahaningsih et al., 2017). In fact, incorporating local culture into STEM not only deepens conceptual understanding but also enhances students' scientific process skills, motivation, and curiosity (Nurhaliza et al., 2024; Firdaus et al., 2023).

Conceptual understanding and process skills are two essential and complementary aspects of science learning. Strong conceptual understanding enables students to construct knowledge meaningfully, while process skills such as observing, predicting, experimenting, and analyzing data equip them with the ability to apply this knowledge in real contexts (Harlen, 2014). Without mastery of both, students often rely on memorization and struggle to connect scientific concepts with real-life problems. The low ability of Indonesian students to apply their knowledge of science and mathematics, as reflected in the TIMSS 2019 results which were 27 percent below the international average (Mullis, 2020), indicates an urgent need for more integrative learning approaches. This issue, combined with Indonesia's low ranking in scientific and mathematical literacy in PISA 2022,

shows that traditional, memorization-based learning methods are no longer sufficient.

One of the culturally rich yet underutilized resources for STEM learning is the Samawa culture of Sumbawa, West Nusa Tenggara. Samawa traditions contain ecological principles, traditional technologies, and elements of ethnomathematics that can serve as a foundation for contextual learning materials (Rahman et al., 2020). Unfortunately, the lack of STEM-based learning materials that incorporate Samawa cultural wisdom makes it difficult for students to connect abstract scientific knowledge with their own cultural experiences. Integrating local wisdom in education is essential not only for strengthening students' cultural awareness within their community but also for preserving local identity amid the growing influence of globalization (Shufa et al., 2018). Studies also show that culture-based learning improves student engagement and enhances conceptual retention (Aikenhead, 2017).

The main problem in science and mathematics education in Indonesia lies in students' low conceptual understanding and process skills. PISA 2022 results place Indonesia near the bottom, ranking seventy-fourth out of eighty-one participating countries in scientific and mathematical literacy (OECD, 2023). One major contributing factor is the dominance of memorization-based teaching that provides limited opportunities for inquiry-based activities (Abbas et al., 2023). Teachers also often lack interactive and contextually relevant teaching materials. The disconnect between the national curriculum and local culture further widens students' conceptual gaps. When science instruction is not connected to local cultural practices, students tend to feel that the content is distant and less applicable to their lives (Agil et al., 2023). This issue is exacerbated by the limited availability of learning resources that combine STEM with ethnoscience approaches, despite evidence that such integration significantly increases motivation and learning outcomes (Zidny et al., 2020).

The selection of kinematics as the focus of this study is based on its strong relevance to observable cultural phenomena within the Samawa community. Kinematics introduces concepts such as speed, acceleration, and displacement, which can be directly observed in traditional Samawa activities, for example Berapan Kerbau (buffalo racing) and Main Jaran (horse racing). These cultural events provide rich opportunities for analyzing linear and projectile motion. By linking kinematics concepts to familiar and culturally meaningful activities, abstract content becomes more concrete, engaging, and easier for students to understand. This connection bridges the gap between formal scientific knowledge and the lived experiences of the learners.

The development of an interactive STEM-based learning module enriched with Samawa cultural elements is expected to serve as a solution to these challenges. Such a module does not only support conceptual understanding through a multidisciplinary approach but also strengthens students' cultural identity. Previous studies have shown that digital culture-based learning modules are effective in improving literacy skills and introducing cultural values to students (Ananda et al., 2024; Muslimin and Fatimah, 2024). The use of digital media can also improve accessibility and personalization in learning, which is particularly beneficial in remote regions such as Sumbawa (Fu, 2013). This module is aligned with the Merdeka Belajar policy that emphasizes contextual learning to support

the development of the Pancasila Student Profile (Kemendikbud, 2021).

Through this module, students are expected to experience improvement not only in conceptual understanding but also in process skills such as observation, experimentation, data analysis, and logical reasoning. The module also encourages students to actively engage in solving real cultural problems, making learning more meaningful. For these reasons, this study represents a strategic effort to deliver learning that is academically relevant, socially and culturally contextualized, and aligned with the competencies required in the twenty-first century.

RESEARCH METHODS

This study employed a Research and Development (R&D) method aimed at producing a specific learning media product and examining its effectiveness. The product developed in this research is an interactive learning module that integrates a STEM approach with Samawa local culture to improve students' conceptual understanding and process skills.

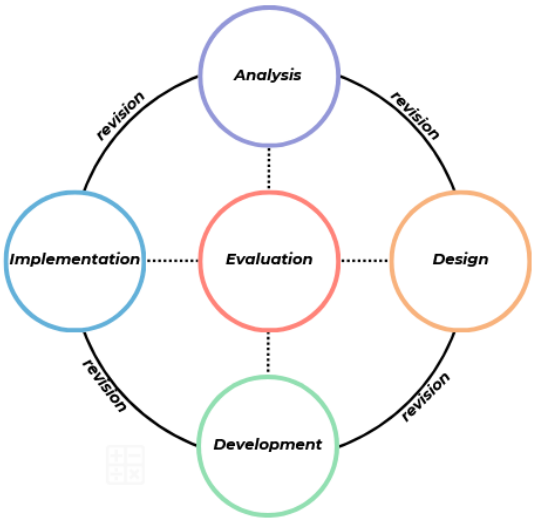


Figure 1. ADDIE Research and Development Design

The development model used was ADDIE, a systematic framework designed to address learning problems through well-structured stages. The ADDIE model was applied to produce a learning module that aligns with students' needs and characteristics through a sequential and programmed development procedure. The model consists of five main stages: Analysis, Design, Development, Implementation, and Evaluation, as presented in Figure 1.

The first stage, analysis, was conducted to identify learning needs, subject matter, and learner characteristics. The second stage, design, involved preparing the product specifications based on the analysis results, developing a storyboard, and preparing research instruments. The third stage, development, focused on producing the initial module according to the design, validating it through experts, revising it, and conducting a limited trial. The fourth stage, implementation, involved applying the product more broadly to examine its effectiveness and identify potential weaknesses. The final stage, evaluation, was conducted to review the product comprehensively and refine it based on user feedback. Each stage was carried out in sequence to ensure that the final product met learning needs and matched student characteristics.

The objects of this study were the characteristics and validity of the product, along with its effectiveness in improving students' conceptual understanding and process skills. The research subjects consisted of expert validators in media and content, practitioners in the field, and students from SMA Negeri 4 Sumbawa. Data sources included expert validation results, teacher responses, and student responses. Data were collected through expert validation questionnaires, practitioner and student response questionnaires, and tests of conceptual understanding and process skills.

The questionnaire data were analyzed using descriptive statistics and presented in

percentage form. The overall percentage scores were then interpreted using the revision decision guidelines in Table 1.

Table 1. Decision-Making for Revision

Achievement Level	Qualification	Description
81-100	Excellent	No revision needed
61-80	Good	No revision needed
41-60	Fair	Revision required
21-40	Poor	Revision required
0-20	Very Poor	Revision required

Table 1 shows the criteria for revision decisions based on validators' assessments. A score of 81 to 100 is categorized as Excellent and requires no revision. A score of 61 to 80 is categorized as good and also requires no revision. A score of 41 to 60 is categorized as fair and requires revision. A score of 21 to 40 is categorized as poor and requires revision, and a score of 0 to 20 is categorized as very poor and requires revision.

In the implementation stage, the product was tested on students using a one-group pretest posttest design as shown in Table 2. In this design, pretests and posttests were administered to measure students' abilities before and after the treatment, which consisted of learning using the interactive STEM-based module rooted in Samawa local culture that had been developed.

Table 2. Desain Uji Coba Produk

O_1	X	O_2

Description:
O_1 = pre-test
X = treatment
O_2 = pos-test

To determine the effectiveness of the product in improving students' conceptual understanding and process skills, the normalized gain score (N-gain) was calculated. Furthermore, a paired sample t-test was conducted to examine the product's effectiveness.

RESULTS AND DISCUSSION

1. Analysis

The Analysis stage is the initial phase of the ADDIE model, aimed at identifying development needs and formulating instructional goals based on actual conditions in the field. In this study, three types of analysis were conducted through a preliminary investigation, which included material analysis, learner analysis, and learning needs analysis. The purpose of the material analysis was to ensure that the content presented in the interactive learning module based on Science, Technology, Engineering, and Mathematics (STEM) integrated with Samawa local culture is relevant, accurate, and aligned with learning objectives and the current curriculum. The learner analysis was conducted to understand students' characteristics, abilities, interests, and motivation both individually and in groups. The needs analysis aimed to identify the fundamental problems faced by students that require the development of an interactive STEM-based learning module integrated with Samawa culture.

Based on observations at the school and interviews with teachers and students at SMA Negeri 4 Sumbawa, it was found that the physics learning process still relies heavily on government-issued textbooks. In addition, teachers have not previously developed modules that integrate local culture. As a result, teachers play a dominant role in delivering material while students tend to be passive. The lecture method remains the primary approach in the classroom, which limits active participation and leads to a decline in student learning outcomes. These findings indicate a mismatch between the learning approach

used and the characteristics of physics content, particularly kinematics, which ideally requires active engagement, problem-solving ability, critical thinking, conceptual understanding, and scientific process skills.

For this reason, an innovative learning medium is needed to encourage students to take a more active role in learning. One alternative is the development of an interactive learning module using a STEM approach rooted in Samawa local culture. This module is highly needed as it presents theoretical concepts in a contextual manner, emphasizing cultural elements familiar to students in Sumbawa combined with a STEM perspective. This approach allows students to apply their knowledge directly, enabling deeper and more meaningful conceptual understanding. Relating physics content to local culture also increases student interest and improves comprehension because the context is familiar to their daily environment. In addition, the STEM approach trains students to think critically, solve problems, and collaborate through experimental and modeling activities (Putri et al., 2020). This not only improves their understanding of kinematics but also helps develop creativity and cultural awareness. Therefore, the Analysis stage provides a strong foundation for developing an interactive module based on Samawa culture that responds to pedagogical needs and is relevant to the contextual challenges faced by students and teachers in physics learning.

2. Design

The Design stage is an important phase that bridges the identified learning needs from the field with the process of developing the actual product. The aim of this stage is to design an initial prototype of a kinematics module that incorporates a STEM approach and Samawa local culture to improve students' conceptual understanding and scientific process skills in a contextual manner. Several key activities were carried out during this stage. These included determining the format of material presentation, designing appropriate learning strategies, preparing assessment instruments and evaluation methods, and organizing the content structure and overall system of the module. The e-module was designed to be interactive, with a structured and engaging layout that enables students to use it independently. Each section of the module includes clear instructions and a sequential learning flow that allows students to understand the material without relying heavily on teacher support.

The development of the e-module utilized several applications such as Canva, Google Forms, and PhET simulations. Canva was used to design the module by taking advantage of its user-friendly features. Google Forms was used to facilitate access to evaluation questions embedded in the module so that students can complete them easily via a browser such as Google Chrome. The module can be accessed at any time via a smartphone without location constraints. PhET simulations were integrated to support virtual experimentation using interactive science laboratories. The combination of these tools ensures accessibility, interactivity, and efficiency. The material on straight-line motion, velocity, and acceleration was contextualized through local Samawa phenomena such as Berapan Kerbau and Main Jaran. The module was designed as an interactive digital resource that guides students through observing events, analyzing motion data, and solving problems using a STEM approach. Assessment instruments were prepared in the form of expert validation questionnaires for media

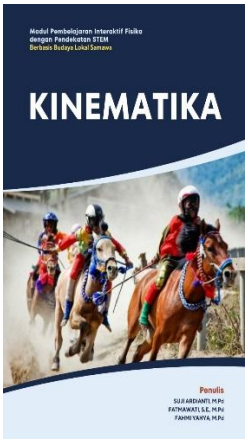
and content, student and teacher response questionnaires, and field testing instruments.

The module is structured systematically, beginning with the cover, preface, table of contents, concept map, introduction containing user guidelines and learning outcomes, problem starters based on local phenomena, learning activities including content, practical tasks, and evaluations, followed by a glossary, references, and author profile. Cultural integration is embedded throughout the module through illustrations, local terminology, and narratives that reflect Samawa community practices relevant to scientific thinking.

3. Development

In this stage, the module was developed based on the design previously prepared, followed by a validation process to ensure product quality. The initial visual design of the module is shown in Figure 2.

Validation involved two material experts and two media experts who have experience in developing instructional media and are lecturers in Physics Education at the University of Samawa. In addition to the module, the research instruments in the form of tests on conceptual understanding and scientific process skills were also validated. The validation process was carried out using a Likert-scale questionnaire equipped with comment and suggestion columns to obtain qualitative input from the experts. Validation was conducted by material and media experts to assess the feasibility of the module's content, while the practicality test was carried out by teachers and students to evaluate its applicability in learning.



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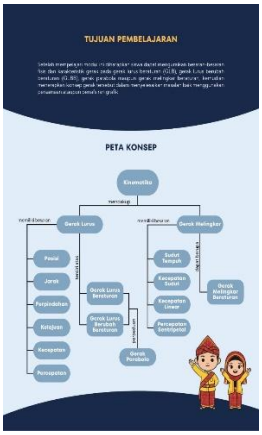

Display of Learning Objectives and Concept Map

Introduction

Content

Figure 2. visual design of the module

1) Media Expert Validation Results

The media expert validation aimed to assess the visual aspects, functionality, and interactivity of the developed module, particularly in terms of presenting digital elements that students can access independently. Five main aspects were evaluated.

Table 3. Media Expert Assessment

No	Aspect	Expert Assessment	Category
1	Physical Appearance	89%	Excellent
2	Introduction	92%	Excellent
3	Usability	85%	Excellent
4	Tasks/Evaluation	87%	Excellent
5	Summary	96%	Excellent
Average		89.7%	Excellent

Based on Table 3, the results of the media expert validation show that the developed e-module falls into the Excellent category, with an average percentage score of 89.7 percent.

This indicates that the module is considered highly feasible from the perspective of digital media. The visual appearance was rated attractive and consistent, the navigation within the e-module was easy to understand, and the interactive components such as buttons, simulations (PhET), and digital assessments (Google Forms) functioned optimally. However, one expert provided a suggestion for improvement, noting the need to enhance readability by using color combinations with higher contrast, particularly for text placed on colored backgrounds, so that information is easier to read for all users.

2) *Material Expert Validation Results*

Material expert validation focused on scientific content, the integration of the STEM approach, and alignment with the curriculum and the cultural values of Samawa. The five main aspects evaluated are shown in Table 4.

Table 4. Results of the Material Expert Validation

No	Aspect	Expert Assessment	Category
1	Physical/Appearance	85%	Excellent
2	Learning Aspect	92%	Excellent
3	Content Aspect	90%	Excellent
4	Task/Evaluation	88%	Excellent
5	Summary Aspect	92%	Excellent
	Average	89,5%	Excellent

Table 4 shows an average score of 89.5 percent, indicating that the module is very strong in terms of substance and pedagogy. The kinematics material is presented in a logical sequence and is integrated with local cultural elements such as Berapan Kerbau and Main Jaran, which strengthens students' connection between theory and everyday life. However, both experts recommended maintaining and further reinforcing the integration of the STEM approach in the e-module, particularly in project activities, experiments, and data analysis, so that students can develop process skills and improve their conceptual understanding of kinematics.

3) *One-to-One Trial Results*

The One-to-One Trial evaluation was conducted with three students representing high, medium, and low ability levels. These three students had prior experience learning kinematics, enabling them to provide relevant feedback on the developed e-module. The goal of this evaluation was to examine readability, clarity of instructions, and ease of use for students with different characteristics. A comprehensive analysis was conducted across several key aspects, which included the efficiency of module use, the quality of the material, the learning design, and implementation aspects.

The assessment focused on indicators within each aspect and was also evaluated as a whole. The data from the one-to-one evaluation were summarized in the form of scores and analyzed to identify strengths and areas requiring improvement in the e-module. The complete results of the evaluation are presented in Table 5.

Table 5. Results of the Assessment for Each Aspect in the One-to-One Evaluation

No	Aspect	Average Score	Percentage	Category
1	Efficiency	3,58	72%	Good
2	Material	4	80%	Excellent
3	Instructional Design	4.25	85%	Excellent
4	Implementation	3.41	68%	Good
Average		**3,81**	**76,25%**	**Good**

Based on the results of the one-to-one trial presented in Table 5, the overall average score of the e-module is 3.81 or 76.25 percent, which falls into the Good

category. The highest percentages were found in the Learning Design aspect at 85 percent and the Material aspect at 80 percent, both of which are categorized as Excellent. This indicates that the structure, layout, and content of the e-module effectively support the learning process. On the other hand, the Efficiency aspect received 72 percent and the Implementation aspect received 68 percent, both categorized as Good, which suggests that improvements are needed in accessibility, compatibility across different devices, and time efficiency. Respondents also recommended enhancing the font size and contrast, as well as providing additional examples for topics considered difficult so that the content becomes easier to understand.

4) Small Group Trial Results

The small group evaluation phase was conducted to assess the practicality and readability of the module in a limited instructional setting. This trial involved fifteen students consisting of five high-achieving students, five average-achieving students, and five low-achieving students. All participating students had prior learning experience related to the material presented in the e-module, particularly kinematics, enabling them to provide objective assessments of the module's content and appearance. The complete results of the evaluation are presented in Table 6.

Table 6. Results of Each Aspect Assessment in the Small Group Trial

No	Aspect	Average Score	Percentage	Category
1	Efficiency	3,73	75%	Good
2	Material	3,85	77%	Good
3	Instructional Design	4.05	81%	Excellent
4	Implementation	3.96	79%	Good
Average		**3.89**	**78%**	**Good**

Based on the results of the small group trial presented in Table 6, the overall mean score was 3.89 or 78 percent, which falls into the Good category. The aspect with the highest percentage was the Learning Design aspect, which obtained a score of 81 percent and was categorized as Excellent. This indicates that the arrangement of the material, the coherence of the components, and the visual presentation of the e-module were effective in supporting STEM-based learning. This effectiveness is reflected in the systematic integration of science, technology, engineering, and mathematics concepts within project activities, experiments, and data analysis.

The Implementation aspect obtained a score of 79 percent and the Material aspect obtained a score of 77 percent, both categorized as Good. These results indicate that the content presented is relevant and successfully connects physics concepts with real phenomena grounded in Samawa local culture, such as the application of kinematics principles in the daily activities of the local community. Meanwhile, the Efficiency aspect obtained the lowest score, which was 75 percent, and was also categorized as Good.

Respondents suggested improving the accessibility of interactive elements, clarifying the instructions for activities based on Samawa local culture, and adding more varied examples that integrate STEM with local wisdom. These improvements are expected to better facilitate students in constructing conceptual understanding while also strengthening science process skills, including observing, classifying, measuring, interpreting data, and drawing conclusions.

4. Implementation

The interactive STEM-based learning module integrated with Samawa local

culture, which had been validated and revised during the formative evaluation stage, was then implemented to examine its effectiveness and practicality through summative evaluation. This stage involved thirty students and one physics teacher at the senior high school level. The implementation was conducted to obtain a comprehensive picture of the effect of the module on the learning process and learning outcomes, as well as users' responses toward the module. The research findings at this stage include assessments of the module's effectiveness in improving conceptual understanding and science process skills, as well as its practicality as measured through student response questionnaires related to ease of use, readability, attractiveness, and content relevance to classroom learning.

1) Product Effectiveness in Improving Conceptual Understanding

Students' conceptual understanding of physics was measured using multiple-choice questions developed based on seven key indicators: interpreting, exemplifying, classifying, generalizing, inferring, comparing, and explaining (Rohman et al., 2021). These indicators were selected to provide a comprehensive overview of students' conceptual understanding, ranging from basic information processing to higher-order analytical and synthetic thinking skills.

To determine the level of product effectiveness in improving conceptual understanding, the normalized gain score (N-Gain) was calculated. The N-Gain was obtained by comparing pretest and posttest scores for each indicator to determine the extent of improvement in students' understanding after using the e-module. The N-Gain values served as the basis for evaluating the product's effectiveness in enhancing students' cognitive learning outcomes, particularly in the domain of conceptual understanding in physics. The percentage results for each aspect of conceptual understanding are presented in Table 8.

Table 8. Sajian Data Pemahaman Konsep

Observed Process Skill	Average Score Percentage (%)		N-Gain	Gain Category
	Pretest	Posttest		
Giving Examples	29	87	0.82	High
Classifying	52	86	0.71	High
Interpreting	44	87	0.77	High
Comparing	30	69	0.56	Medium
Inferring	57	78	0.49	Medium
Explaining	38	78	0.65	Medium
Generalizing	43	76	0.58	Medium
Average	41.86	80.14	0.652	**Medium**

Based on Table 8, the conceptual understanding test results show a significant improvement from pretest to posttest after the use of the module. The average pretest score of 41.86 percent increased to 80.14 percent on the posttest, with an N-Gain value of 0.652, which falls into the medium category. This indicates that the developed module was effective in improving students' conceptual understanding, although the level of improvement varied across indicators.

A more detailed analysis shows that the Exemplifying indicator experienced the highest improvement with an N-Gain of 0.82, which falls into the high category. This indicates that the module effectively helped students connect abstract physics concepts with real phenomena that are culturally relevant to them (Manggul and Pratiwi,

2025), such as Berapan Kerbau and Main Jaran. This finding aligns with Setiawan et al. (2025) and Mukaromah et al. (2022), who found that culture-based learning enhances scientific literacy and strengthens students' ability to relate learned concepts to real examples in their environment. Culturally integrated STEM learning has been shown to be effective in developing scientific process skills, fostering creativity, and improving critical thinking.

Furthermore, the Classifying indicator (N-Gain 0.71) and the Interpreting indicator (N-Gain 0.77) also showed improvements in the high category. These findings are consistent with Davidi et al. (2021), who demonstrated that the STEM approach can train basic scientific process skills such as classification and data interpretation through experimental and analytical activities that cultivate critical thinking.

However, several indicators remained in the medium category, including Comparing (0.56), Inferring (0.49), Explaining (0.65), and Generalizing (0.58). These results indicate that students still experience difficulties in developing higher-order thinking skills such as drawing inferences, comparing concepts, and making generalizations. This condition aligns with the PISA 2022 report (OECD, 2023), which states that Indonesian students generally struggle with analytical and synthetic scientific reasoning.

In addition, the paired-sample t-test using SPSS reinforces these findings. The significance value obtained was 0.00, which is lower than 0.05, indicating a significant difference between the pretest and posttest results. Thus, the interactive STEM-based learning module integrated with Samawa local culture had a significant impact on improving students' conceptual understanding of physics. This is consistent with the findings of Nurwahidah (2023), who reported that activity-based and contextual science learning can improve conceptual understanding while strengthening scientific thinking skills.

STEM-based learning integrated with local culture has been proven effective in improving students' conceptual understanding, particularly in indicators involving concrete skills such as providing examples, classifying, and interpreting. These results show that the integration of local culture can help bridge abstract physics concepts and make them easier to understand. However, indicators requiring higher-order thinking skills have not yet reached optimal achievement. Therefore, further strategies are needed, including the use of open-ended problems, collaborative projects, or investigative activities to better support students in developing abstract and critical thinking. With continuous improvement, the interactive STEM-based module based on Samawa local culture has strong potential to become an advanced learning resource that promotes comprehensive conceptual understanding while strengthening higher-order thinking skills.

2) Product Effectiveness in Improving Students' Science Process Skills

Science process skills are fundamental abilities that need to be developed in physics learning to foster scientific thinking among students. In this study, students' science process skills were assessed using essay-based test instruments developed according to indicators of basic and integrated process skills (Juwita, 2022). Unlike observational assessments, the use of essay questions in this study allowed students to articulate their scientific reasoning in written form and demonstrate the extent to which they understood and applied scientific methods within STEM-based learning integrated with

Samawa local culture. The test consisted of five essay questions, each representing one of the five indicators used. The complete results of the science process skills test are presented in Table 9.

Table 9. Presentation of Science Process Skills Data

Observed Process Skill	Average Score Percentage (%)		N-Gain	Gain Category
	Pretest	Posttest		
Asking Questions	33.33	95.00	0.92	High
Formulating Hypotheses	46.67	90.00	0.81	High
Planning Experiments	58.33	85.00	0.64	Medium
Interpreting	43.33	84.17	0.72	High
Communicating	48.33	81.67	0.64	Medium
Average	46.00	87.17	**0.75**	**High**

The measurement results indicate a significant improvement in science process skills after the use of the interactive STEM-based module integrated with Samawa local cultural elements. The average pretest score of 46.00 percent increased to 87.17 percent in the posttest, with an N-Gain value of 0.75 in the High category. This shows that the developed module was effective in training students' science process skills in both basic and integrated aspects.

When examined by indicator, the skill of Asking Questions showed the highest improvement with an N-Gain of 0.92, which falls into the high category. This finding indicates that the module enriched with Samawa cultural phenomena was able to stimulate students' curiosity, enabling them to become more skilled in formulating questions. Curiosity is the basis of scientific skills and can be cultivated through contextual learning activities (Muslimin and Rahim, 2023).

The Hypothesizing indicator also showed a high level of improvement with an N-Gain of 0.81, indicating that the module effectively facilitated students in developing tentative explanations based on theory and observed phenomena. This suggests that the STEM approach enhances students' critical thinking, particularly in constructing hypotheses (Ardianti, 2020; Widarta et al., 2024).

Meanwhile, the indicators of Planning Experiments (0.64) and Communicating (0.64) remained in the medium category. This suggests that students continue to face difficulties in designing systematic experiments and presenting results effectively. These challenges align with OECD (2023), which reports that Indonesian students generally have weaknesses in scientific abilities that require synthesis and communication. To address this, project-based learning or more intensive laboratory practice can serve as reinforcement strategies (Fitriyanti et al., 2021).

The Interpreting indicator obtained an N-Gain of 0.72, categorized as high, indicating that the module was effective in training students to analyze data and derive meaning from the information obtained. Additionally, the integration of ethnoscience with the STEM approach has been shown to improve students' interpretation skills because the learning becomes more contextual and closely related to their real-life experiences. STEM-based science learning combined with ethnoscience significantly enhances students' critical thinking and cultural literacy (Zidny et al., 2020; Atmojo et al., 2025).

The paired-sample t-test using SPSS yielded a significance value of 0.00, which is lower than 0.05. This indicates a significant difference between the pretest

and posttest results. Thus, the interactive STEM-based learning module integrated with Samawa local culture had a significant effect on improving students' science process skills. Overall, STEM-based learning combined with local cultural elements has been proven effective in improving science process skills, particularly in asking questions, hypothesizing, and interpreting data. However, improvements in planning experiments and communicating require further attention through learning strategies that emphasize independent investigation and group collaboration.

3) Teacher Responses

Teacher responses in this study aimed to obtain a comprehensive evaluation of the quality and feasibility of the interactive STEM-based learning module integrated with Samawa local culture, developed for kinematics material. The assessment was conducted by two experienced physics teachers and referred to five main aspects: content relevance, integration of the STEM approach, linguistic and presentation quality, practicality and implementability, and the module's impact on students.

The content relevance aspect assessed the alignment of the material with the curriculum, conceptual accuracy, support for science process skills, and connection to Samawa local culture, such as the application of motion concepts in traditional activities or local natural phenomena. The STEM integration aspect evaluated the incorporation of Science, Technology, Engineering, and Mathematics in learning. The linguistic and presentation aspect examined the use of communicative language, systematic material organization, and supporting illustrations. The practicality and implementability aspect analyzed the ease of classroom application without requiring complex additional facilities, as well as the usefulness of the module in the learning process. Finally, the student impact aspect focused on the module's contribution to improving conceptual understanding, learning engagement, and scientific thinking skills.

The results of the teacher response assessment are presented in Table 7.

Table 7. Teacher Responses

No	Aspect	Average Score	Percentage	Category
1	Content Appropriateness	4,62	92,50%	Excellent
2	Integration of the STEM Approach	4,66	93%	Excellent
3	Language and Presentation Feasibility	4,5	90%	Excellent
4	Implementability and Practicality	4,83	97%	Excellent
5	Impact on Students	4,66	93%	Excellent
Overall Average		**4,65**	**93,1%**	**Excellent**

Based on the evaluations provided by the two physics teachers, the interactive STEM-based learning module integrated with Samawa local culture received an overall average score of 4.65 or 93.1 percent, which falls into the "Excellent" category. This indicates that the developed module is considered to have very high quality and is suitable for classroom use.

A more detailed review of each aspect shows that the content relevance aspect obtained an average score of 4.62 or 92.5 percent, categorized as Excellent. This indicates that the material in the module is relevant to the curriculum, conceptually accurate, and aligned with students' needs. The STEM integration aspect received an average score of 4.66 or 93 percent, also categorized as Excellent, showing that the module successfully integrates Science, Technology, Engineering, and Mathematics in a coherent manner.

The linguistic and presentation aspect obtained an average score of 4.5 or 90 percent, categorized as Excellent. This suggests that the module uses communicative and systematic language that is easy for students to understand. The highest score was found in the practicality and implementability aspect, with an average of 4.83 or 97 percent, also categorized as Excellent. This indicates that the module is highly practical to use in the classroom without requiring complicated additional facilities and can effectively support the learning process.

Finally, the student impact aspect received an average score of 4.66 or 93 percent, categorized as Excellent. This shows that teachers considered the module to have a positive influence on students' conceptual understanding, science process skills, and learning motivation. Overall, teacher responses demonstrate that the interactive STEM-based learning module integrated with Samawa local culture has very high quality in all assessed aspects. The module is considered relevant, practical, communicative, and effective in supporting physics learning in the classroom, making it a strong candidate for an innovative instructional material aligned with students' needs and characteristics.

4) Student Responses

The field test was conducted to evaluate the feasibility and acceptability of the module on a broader classroom scale. This stage involved 30 students consisting of ten high-achieving, ten average-achieving, and ten low-achieving students. This composition was selected to represent the diversity of academic abilities proportionally, ensuring that the resulting evaluations were more representative.

Based on the Student Response Table, the interactive STEM-based learning module integrated with Samawa local culture received an average score of 4.33 or 87 percent, which falls into the "Excellent" category. The module benefits aspect received the highest score (4.54 or 91 percent), indicating that students experienced a significant positive impact on their conceptual understanding and science process skills. Interactivity and engagement also received high ratings (4.38 or 88 percent), showing that the module effectively facilitated active and contextual learning aligned with the characteristics of STEM.

Table 10. Student Responses

No	Aspect	Average Score	Percentage	Category
1	Module Appearance and Design	4,23	85%	Excellent
2	Content and Material	4,17	84%	Excellent
3	Interactivity and Engagement	4,38	88%	Excellent
4	Module Benefits	4,54	91%	Excellent
Overall Average		4,33	87%	Excellent

The appearance and design aspect (4.23 or 85 percent) and content and material aspect (4.17 or 84 percent) were also rated Excellent, reflecting that the integration of Samawa local culture successfully enhanced the relevance and appeal of learning. These results indicate that the module effectively supports meaningful learning that is aligned with local cultural values.

CONCLUSION

Based on the research and development that have been carried out, it can be concluded that the interactive learning module using a STEM approach integrated with Samawa local culture is proven to be both feasible and effective in improving students' conceptual understanding and science process skills on

kinematics. The module was rated highly feasible based on expert validation of the material and media, with feasibility percentages of 89.5 percent and 89.7 percent, and received very positive responses from teachers (93.1 percent) and students (87 percent).

The module specifically improved conceptual understanding with an N-Gain score of 0.65, which falls into the medium category, and science process skills with an N-Gain of 0.75, which is categorized as high. The most significant improvement occurred in indicators of concrete conceptual understanding, such as providing examples (N-Gain 0.82), classifying (N-Gain 0.71), and interpreting (N-Gain 0.77). This shows that the integration of Samawa local culture through contextual examples such as *Berapan Kebo* (Buffalo Racing) and *Main Jaran* (Horse Racing) successfully helped students connect abstract concepts with meaningful and relatable contexts.

However, improvements in higher-order thinking skill indicators such as comparing, inferring, explaining, and generalizing were still within the medium category. This finding indicates that the module needs to be enriched with instructional strategies that better stimulate analytical, synthetic, and abstract thinking, for example through collaborative projects or more complex problem-solving activities.

In conclusion, the STEM-based interactive module grounded in Samawa local culture has strong potential as an innovative learning tool that not only enhances conceptual understanding and science process skills but also strengthens cultural literacy and twenty-first century competencies. For future development, refinements are needed to strengthen aspects related to higher-order thinking, along with wider implementation to ensure its effectiveness across diverse learning contexts.

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