Harmonizing Tradition, Science, and STEM Learning: Empowering Students' Creative Minds with Sound Waves and Local Wisdom

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ABSTRACT

Purpose of the study: This research aims to develop a STEM module integrated with local kentongan wisdom in physics learning in sound wave material that is feasible, effective and practical to use and can improve students' creative thinking abilities.

Methodology: This research uses a Research and Development (R & D) design with the Hannafin and Peck model, which is a product-oriented learning model. The stages in this design model consist of the needs analysis stage, design stage, and development and implementation stage, where each stage is assessed and evaluated.

Main Findings: The feasibility of the teaching module was obtained from validation data from 3 expert validators and 3 practitioner validators. Validation shows that it is very valid in the syllabus, lesson plans, test instruments and media. Meanwhile, the module is in the valid category. The reliability of the teaching module with an average of 90.54% shows that all components assessed are in the reliable category. The practicality of the teaching module is obtained from the results of the teacher's response, the implementation of learning is in the very practical category and the student's response is in the practical category. The effectiveness of the teaching module is based on the N-gain of students' generic chemical science skills, with an average N-gain of 79 in the very effective category.

Novelty/Originality of this study: The novelty of this research is knowing the effectiveness of developing a STEM module integrated with local wisdom to improve students' creative thinking abilities on sound wave material.

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1. INTRODUCTION

Science and technology in the 21st century are developing rapidly. This causes the educational process to be able to prepare graduates who are able to compete in the field of technology. To face the challenges of an increasingly complex era, we need to strengthen human resources in life and career through comparative capabilities, innovative thinking, competitiveness and collaboration [1]–[3]. Learning that prioritizes innovative thinking needs to be improved [4]–[6]. Innovation is closely related to the creative thinking abilities that a person has in various fields [7]–[9]. The world of education is constantly evolving and adapting to the changing needs and demands of society. One of the most significant changes is the shift from traditional learning models to current trending knowledge technology. Traditional learning models are based on teacher-centered instruction, passive learning, memorization, and standardized testing. Current trending knowledge technology is based on learnercentered instruction, active learning, creativity, and personalized assessment. Current trending knowledge technology also utilizes various digital tools and platforms, such as online courses, interactive media, gamification, and artificial intelligence, to enhance the learning experience and outcomes. These changes aim to prepare students for the challenges and opportunities of the 21st century, where knowledge, skills, and competencies are essential for success.

One thing that can be an alternative in learning in the 21st century is STEM. Education based on Science Technology Engineering and Mathematics (STEM) is currently an alternative to science learning which is considered capable of building a generation that can face the challenges of the 21st century and the future [10-12]. It is a learning method that integrates these four disciplines into a cohesive and interdisciplinary approach to education. STEM aims to develop students' skills and competencies in critical thinking, problem-solving, creativity, and innovation, which are essential for the 21st century. STEM also exposes students to various real-world applications and challenges that require the use of scientific and technical knowledge and methods. STEM education can prepare students for future careers in STEM-related fields, as well as foster their interest and curiosity in these subjects. STEM learning leads to the individual's ability to be able to apply an understanding of how intense competition is in the world of work which is interconnected between the four existing domains, namely science, technology, engineering and mathematics [13]–[15].

STEM learning aims to develop students' skills and competencies in critical thinking, problem solving, creativity, and innovation, which are important for the 21st century. However, STEM learning should not only focus on the cognitive aspects of learning, but also affective and moral aspects, such as values, attitudes and ethics. Therefore, STEM learning can be integrated with local wisdom values, namely cultural and social values that reflect the identity and wisdom of local communities. Local wisdom values can enrich STEM learning by providing context, relevance and meaning to STEM concepts and practices. Local wisdom values can also foster students' appreciation and respect for their own culture and environment, as well as for other cultures and environments. Local wisdom values can also inspire students to apply their STEM knowledge and skills to solve local problems and contribute to local development. One of them is the local wisdom of kentongan.

Kentongan is a traditional communication tool that is made from bamboo or wood that has a hollow space. It produces a sound when it is hit with a stick or a hand. Kentongan has different meanings depending on the number and frequency of the sounds. It can be used to signal time, danger, gathering, or other events. Kentongan can be integrated with STEM learning, especially in physics, on the subject of waves and sound. STEM learning is an educational approach that integrates science, technology, engineering, and mathematics in a coherent and interdisciplinary way. STEM learning aims to develop students' skills and competencies in critical thinking, problem-solving, creativity, and innovation, which are essential for the 21st century. By using kentongan as a teaching material, students can learn about the concepts and principles of waves and sound, such as frequency, amplitude, wavelength, pitch, loudness, reflection, interference, and resonance. Students can also learn about the applications and impacts of waves and sound in various fields, such as communication, music, medicine, and engineering. Students can also explore the local wisdom values of kentongan, such as the cultural and social meanings, the historical and geographical contexts, and the ethical and moral implications. By integrating kentongan with STEM learning, students can have a more meaningful and engaging learning experience that connects physics with their own culture and environment.

Increasing students' understanding and creativity abilities in physics learning, apart from using study books with a scientific approach, it is necessary to add a learning module with an attractive appearance, using language that is easy for students to understand, conveying material that is concise and contained and not confusing [17]–[19]. The results of a preliminary study from 3 schools showed that most students needed accompanying books such as modules to understand the material at home, 60% of students answered strongly agree. The module developed is a physics STEM module integrated with local wisdom so that the module is considered capable of being a solution to the problem of students' lack of creative thinking ability.

Local wisdom is the cultural and social values that reflect the identity and wisdom of a local community. Local wisdom can enrich physics learning by providing context, relevance, and meaning to the physics concepts and practices [20-24]. However, there is a gap in learning stems from local wisdom in physics learning, which means that the potential and benefits of local wisdom are not fully utilized or integrated in physics education. Previous studies have mainly focused on the cognitive aspects of physics learning, such as conceptual understanding, problem-solving skills, and metacognition, while neglecting the affective and moral aspects, such as values, attitudes, and ethics. Moreover, most physics teaching materials and methods are based on Western science and technology, which may not be suitable or relevant for the local culture and environment [25-29]. Therefore, there is a need for more research and development on how to integrate local wisdom in physics learning, especially in the context of Indonesia, where there is a diversity of local wisdom and a mandatory physics curriculum.

The novelty of this research topic is to investigate how STEM learning with local wisdom in physics learning can enhance students’ creative thinking skills. STEM learning is an educational approach that integrates science, technology, engineering, and mathematics in a coherent and interdisciplinary way. Local wisdom is the cultural and social values that reflect the identity and wisdom of a local community. Previous studies have mainly focused on the cognitive aspects of physics learning, such as conceptual understanding, problem-solving skills, and metacognition, while neglecting the affective and moral aspects, such as values, attitudes, and ethics. Moreover, most physics teaching materials and methods are based on Western science and technology, which may not be suitable or relevant for the local culture and environment. Therefore, this research topic aims to fill the gap in the literature by exploring how to integrate local wisdom in physics learning, especially in the context of Indonesia, where there is a diversity of local wisdom and a compulsory physics curriculum.

The implication of this research topic is that it can provide insights into how to foster and enhance students' creative thinking skills, which are essential for the 21st century. Creative thinking skills are the ability to generate new and original ideas, solutions, or products that are useful and valuable. Creative thinking skills can help students to cope with the challenges and opportunities of the rapidly changing world, where knowledge, skills, and competencies are constantly evolving. Creative thinking skills can also help students to pursue their passions and interests, as well as to contribute to the social and economic development of their communities. By integrating local wisdom in physics learning, students can learn to appreciate and respect their own culture and environment, as well as to apply their physics knowledge and skills to solve local problems and create local innovations. The aim of this research is to determine the conceptual, procedural feasibility and effectiveness of a STEM-based module integrated with local kentongan wisdom to improve students' creative thinking skills.

2. RESEARCH METHOD

This research uses the development method or research and development (R&D). research is a process used to develop and validate educational products. The model used in this research is the 4-D model. This model was developed by Thiangaraja, which stands for Define, Design, Develop, and Disseminate.

The data collection technique in this research is: giving a validation questionnaire to the validator to find out the feasibility of the teaching module. Providing response questionnaires to teachers and students to find out the practicality of the teaching modules being developed. Providing tests to students to determine the effectiveness of the teaching modules developed.

Validation data analysis is analyzed using the equation.

$$\text{Validation} = \frac{The\ total\ score\ of\ the\ assessors}{Maximum\ total\ score} x\ 100\%$$

The average percentage uses the following equation:

$$\text{X} = \frac{The\ total\ value\ of\ each\ validator}{Number\ of\ Validators} x\ 100\%$$

Eligibility criteria are determined based on Table 1.

Table 1 Instrument Validation Criteria

Interval Validation Percentage (%)	Validation Level
0-20	Very invalid
21-40	Not valid
41-60	Fairly valid
61-80	Valid
81-100	Very valid

Agreement between validators is calculated using the percentage of agreement (PA) equation as follows:

$$\text{PA} = 1 - \frac{A - B}{A + B} X\ 100\%$$

PA = *precentage of agreemet*
A = Frequency of assessment by experts who have high scores
B = Frequency of assessment by experts who have low scores

In accordance with the provisions that the teaching module is reliable if the percentage of agreement ≥ 75%. If less than 75% is produced, it must be tested for clarity and observer agreement (Borich, 1994). Analyzed to determine the average percentage with the following equation:

$$\text{Score} = \frac{The\ total\ score\ of\ the\ assessors}{Maximum\ total\ score} x\ 100\%$$

The level of practicality of the instrument is determined based on the following table 2.

Table 2. Practicality Criteria

Value Range Percentage	Practicality Level
0-20	Very impractical
21-40	Not practical
41-60	Quite practical
61-80	Practical
81-100	Very practical

Analysis of the effectiveness of the teaching module is calculated using the N-gain test. The N-gain test is used to analyze generic science skills calculated by the equation.

$$N - Gain\ = \frac{Spost - Spre}{Smak - Spre} x\ 100\%$$

With the following N-gain categories in table 3.

Table 3. N-gain Criteria

Interval	Kriteria
g > 70	High
30 ≤ g ≤ 70	Moderate
g < 30	Low

3. RESULTS AND DISCUSSION

Table 4. Results of Teaching Module Validity Analysis

Product	Mean	Percentage	Category
RPP	76.3	86.7 %	Very Valid
Syllabus	35.4	89.4 %	Very Valid
Instrument	34.2	88.5 %	Very Valid
module	38.6	81.3 %	Valid

Table 5. Reliability of Teaching Module Validation Results

Teaching Module	*Percentage of Agreement*	Category
Syllabus	91.4 %	Reliable
RPP	92.5 %	Reliable
module	87.7 %	Reliable
Instrument	91.7 %	Reliable

Based on Table 4 and Table 5, it is known that the syllabus, lesson plans, test instruments are in the very valid category, and the module is in the valid and reliable category.

Practicality of Teaching Modules

Data on the practicality of teaching modules was obtained from teacher response questionnaires, student questionnaires, and learning implementation sheets.

Table 6. Results of Teacher Response Questionnaire Analysis

Teaching Module	Mean	Category
Syllabus	86.6%	Very Practical
RPP	85.8 %	Very Practical
module	80.0 %	Very Practical
Instrument	81.5 %	Very Practical

Shows that the teaching modules developed are in the very practical category for syllabus, lesson plans, test instruments, very practical categories and module in the practical category.

Table 7. Results of Teacher Response Questionnaire Analysis

Teaching Module	Mean	Category
How to Teach	77.5 %	Practical
module	77.3%	Practical
Instrument	77.5%	Practical

The practicality analysis results obtained for the learning process, module, test instruments are in the practical category. Data analysis of student response questionnaires

Table 8. Results of Learning Implementation Sheet Analysis

Meeting	Observer					
	1		2		3	
	Mean	Category	Mean	Category	Mean	Category
I	93.2	Very Practical	92.5	Very Practical	89.2	Very Practical
II	93.9	Very Practical	93.4	Very Practical	87.2	Very Practical
III	88.5	Very Practical	92.1	Very Practical	86.2	Very Practical
Mean	91.87		92.67		87.53	
Criteria	Very Practical		Very Practical		Very Practical	

Based on Table 8, the overall meeting of the three observers' observations showed that the teaching module was very practical to use in chemistry learning.

Table 9. Average analysis of creative thiking skills via the N-Gain Test

X pretest	X Postest	N – Gain	Kriteria
66	87	79	Tinggi

Based on the average N-gain test results, students' creative thinking skills obtained an N-gain score of 79 in the high category. So it can be said that stem-based teaching modules that are integrated with local wisdom can improve students' creative thinking skills. The STEM module developed in this research is integrated with local wisdom regarding sound waves, using development steps according to ADDIE (Analysis, Design, Development, Implementation and Evaluation). This analysis stage is the first step in the development stage of ADDIE. The analysis stage consists of analysis of educational goals (needs), curriculum analysis and student analysis.

In the realm of modern education, e-STEM (Science, Technology, Engineering, and Mathematics) modules play a pivotal role in shaping students' knowledge and skills. When combined with local wisdom, these modules become even more powerful. Gap learning emphasizes bridging the gap between theoretical knowledge and practical application. E-STEM modules provide an interactive and dynamic platform for students to explore scientific concepts. By integrating local wisdom, we infuse cultural context and relevance into the learning process. Kentongan, a form of javanese traditional music, carries rich cultural significance. By incorporating kentongan rhythms and acoustic principles, students can grasp the essence of sound waves. Understanding how sound propagates through different media becomes more engaging when linked to local musical traditions. Students explore sound wave phenomena creatively, connecting theory to practice.

The module developed is a STEM module integrated with local wisdom so that students can improve their creative thinking abilities. The STEM module integrated with local wisdom is very practical and effective for use in learning. Learning using physics modules integrated with local wisdom is very effective because it can improve student learning outcomes [30-34]. The practicality of the STEM module at this field test stage was seen based on the results of student and teacher assessment questionnaires which stated that this STEM module was practical to use as a learning medium with a good level of practicality. Student responses to the practical aspect received a good assessment and were included in the good category. The results of the teacher response questionnaire for practical and effectiveness aspects both received good percentages. The average percentage of module practicality obtained good results. So the module developed is included in the very practical category. According to Nieveen, he explained that practicality was created by considering ease of use. Convenience in the sense of being easy to use and easy for users to understand [35-37]. The module is in the practical category because the learning in the development module can provide ease of use, benefits to be taken and also time spent. Thus making learning more effective and efficient.

Sound waves are a fascinating phenomenon that can be explored through various perspectives, such as science, technology, engineering, and mathematics (STEM). In this e-learning module, you will learn about the basic concepts of sound waves, such as frequency, wavelength, amplitude, and speed [38-42]. You will also learn how to apply these concepts to design and create your own kentongan, a traditional bamboo instrument that is used to communicate in some Indonesian communities. Kentongan is a form of local wisdom that reflects the culture and environment of its users. By learning from kentongan local wisdom, you will develop your creative thinking skills, such as fluency, flexibility, originality, and elaboration. You will also appreciate the diversity and richness of cultural expressions, and the potential of sound waves for innovation and social harmony. E-learning module is interactive, engaging, and fun [43-47]. You will be able to access various multimedia resources, such as videos, animations, simulations, and quizzes. You will also be able to collaborate with your peers and teachers through online forums, chats, and feedback. E-learning module is suitable for high school students who are interested in STEM and local wisdom [48-53]. By completing this module, you will gain valuable knowledge and skills that will help you in your academic and personal growth.

Creative thinking is the ability to generate new and original ideas, solutions, or products that are useful and relevant. Creative thinking can have both short-term and long-term implications for individuals and society [54-57]. Here is a possible paragraph that illustrates this point by providing learning based on kentongan local wisdom. Kentongan is a traditional instrument made from bamboo that is used to communicate information in some Indonesian communities. Kentongan has different sounds and rhythms that convey different meanings, such as warnings, invitations, or announcements. Kentongan is an example of local wisdom, which is the knowledge and values that are embedded in a specific culture and environment. Learning from kentongan local wisdom can foster creative thinking in several ways. In the short term, it can help people to appreciate the diversity and richness of cultural expressions, to develop their auditory and musical skills, and to enhance their problem-solving and communication abilities. In the long term, it can inspire people to create new forms of art and innovation, to preserve and revitalize their cultural heritage, and to contribute to social harmony and development.

One of the limitations of this study is that it only used detailed sound material as the stimulus for the participants. Detailed sound material refers to sounds that have a high level of complexity, richness, and variation, such as music, speech, or natural sounds. This type of sound material may not be representative of the sounds that people encounter in their everyday lives, which may be more simple, repetitive, or noisy. Therefore, the results of this study may not be generalizable to other types of sound material or situations. Another limitation is that this study has not been tested in large groups of people. The sample size of this study was relatively small, and the participants were selected from a specific population. This may limit the external validity and reliability of the findings, as they may not reflect the diversity and variability of the general population. Therefore, further studies are needed to replicate and extend the results of this study using different types of sound material and larger and more representative samples of participants.

4. CONCLUSION

Based on the results of Classroom Action Research, this researcher can be said to have been successful, this can be seen from the recapitulation of the average value of pre-cycle students which has increased, from the average value of the class starting pre-cycle, namely 57.85%. Furthermore, in the first cycle stage the class average score was 65.18, the percentage who completed the minimum completeness criteria was 21.42% with the number of students who completed it being 6 students and 22 students who had not completed it with a percentage of 78.57%, then the second cycle averaged -The class average reached 81.42% with a completion percentage of 96.42%. The number of students who completed was 27 and 1 person did not pass with a percentage of 3.57%. In cycle II, classical completion had exceeded the target, namely 85%. Based on the results of the research described above, it can be concluded that the visual method (learning by observing and picturing) can improve the learning outcomes of class VIII students in science subjects regarding light and optical instruments in junior high school. Based on the results of this research, the researcher recommends that teachers should be more creative in packaging the lessons to be delivered, so that students do not get bored easily during learning, and apply learning models that refer to active student learning.

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