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DEVELOPMENT OF PHYSICS TEACHING MATERIALS WITH CULTURAL ETHNOSCIENCE IN INDONESIA AND THAILAND TO IMPROVE STUDENTS' LITERACY, NUMERATION AND LOVE OF THE HOMELAND

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Abstract. The main aim of this research is to develop teaching materials that contain cultural ethnoscience based on understanding by design to improve literacy, numeracy and the character of love for one's country. The specific objectives of the research: (1) describe the characteristics of the developed teaching materials, (2) test the validity of the developed teaching materials, (3) test the readability level of the developed teaching materials.
This research and development (R&D) uses the 4-D model (Define, Design, Develop and Disseminate). The stage begins with needs analysis and problem identification; designing prototypes of teaching materials that contain cultural ethnoscience based on understanding by design; developing, validating, testing and assembling products; ends with disseminating the product. The pilot product for teaching materials that contains cultural ethnoscience based on understanding by design developed in this research is Sound Waves. The data collection instrument is a validation sheet for teaching materials; gap test to test readability; literacy & numeracy test, love of homeland culture scale to test the effectiveness of teaching materials; and a Likert scale to determine the practicality of using teaching materials. The data analysis technique uses the Aiken's V formula for validation tests, percentages for assessing gap tests. The characteristics of teaching materials that contain cultural ethnoscience based on understanding by design have the features "Our Culture!", "Let's Try!", and "Why is this?". "Our Culture!" contains articles and readings related to ethnoscience, to support the character of love for the country. The “Let's Try It!” contains experiments related to the material. The “Why is This?” contains questions about conceptual understanding, literacy and numeracy. With this question, it is hoped that students will better understand the concept and stimulate critical thinking. The teaching materials developed are valid, easy to understand, the hope is that they can improve literacy, numeracy and the character of patriotism higher than those using other teaching materials, and are practical/easy to use.

INTRODUCTION

Indonesia and Thailand have similar education systems, from early childhood education to tertiary education [1]. The significant difference lies in vocational education. Vocational education in Thailand applies a length of study of 5 (five) years, while in Indonesia it is only 3 (three) years. Thailand implements 9 years of compulsory education, like in Indonesia. Quality assurance at the primary and secondary education levels is carried out through national examinations, to show the academic achievements of students from all provinces, which are used as a reference for policies to improve the quality of education. This is the same as Indonesia which applies a minimum competency assessment which is not used to determine graduation. Thailand's student ability in terms of literacy and numeracy ranks higher than Indonesia, but is still low compared to other countries. A comparison of the PISA 2022 results is presented in Table 1.

Table 1 Comparison of Mathematical Literacy Scores. Reading and Science Indonesia – Thailand

	Obtaining PISA Scores		
Ability	**Indonesia**	**Thailand**	**Mean OECD**
Mathematic Literacy	366	384	472
Reading Literacy	369	379	476
Science Literacy	383	409	485

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Indonesia and Thailand both implement a flexible curriculum, focusing on increasing literacy and numeracy, achieving attitudes/values after completing education, and a student centered learning approach, as well as adapting to the skills demands of the 21st century.

Learning in the 21st century refers to learning that can equip students with knowledge and skills in literacy, higher level thinking, mastery of technology, and leadership [2,3,4]. This research focuses on literacy, numeracy and the character of love for culture/homeland. This is in accordance with the curriculum targets in Indonesia, namely the Pancasila Student Profile (P3) and Thailand with its 5 curriculum targets.

P3 is the embodiment of Indonesian students as lifelong learners who have global competence and behave in accordance with Pancasila values, with six main characteristics: faith, devotion to God Almighty, and noble character, global diversity, mutual cooperation, independence, critical reasoning, and creative [5]. The power of Pancasila values is believed to be able to build personality [6]. P3 was promoted as an effort to realize the character of society [7] and nation [8]. The development of the implementation of Pancasila from time to time shows setbacks [9]. The spirit of mutual cooperation is increasingly fading, critical and creative reasoning is also unable to compete with other countries. Students' knowledge of the culture and character of patriotism is lacking. This can be seen from the many violations of school regulations, reduced social feelings in society, using impolite language, and also a lack of interest in the local culture of one's own nation. Students think that showing love for Indonesian culture is enough just to attend the ceremony [10]. Other P3 conditions such as critical reasoning, global diversity of students also have not shown encouraging results. Critical thinking skills involve logical reasoning and systematic thinking in problem solving [11,12], and support the skills of analyzing, applying and evaluating [13].

The five goals of the Thai curriculum include (1) Morality, ethics, desired values, self-esteem, self-discipline, obedience to God. (2) Knowledge and skills to communicate, think, solve problems, technological know-how skills, and life skills. (3) Good physical and mental health, cleanliness, (4) Patriotism, awareness of responsibility and commitment as a citizen and member of the world community, and (5) awareness of the need to preserve Thai culture and local wisdom.

Understanding by design is used to design learning that refers to the goals to be achieved in learning, including science [14]. Teaching materials are needed that can increase students' motivation in studying science. Teaching materials that involve culture in students' environments really help students understand science material because the examples used are contextual and close to students.

Science teaching materials that include cultural ethnoscience based on understanding by design need to be developed because there is not much availability of teaching materials that involve the surrounding culture. The results of the analysis of existing science teaching materials, it was concluded that their development was partial, not yet containing a comprehensive culture to improve literacy, numeracy and the character of patriotism [15,16].

Literacy and numeracy are important for students to be able to apply their knowledge and skills in solving problems [17]. Literacy facilitates students' learning experiences in innovative, collaborative, creative learning practices [18], and understanding of science and technology [19]. The importance of critical thinking and literacy skills for students encourages stakeholders to improve them to be on par with other countries. Currently, Indonesian students' literacy is still low. The results of PISA 2000 – 2022 show that Indonesia's position is consistently in the top 10 from the bottom [20-22]. Students' critical thinking skills are also still low [23-26]. Science literacy [27,28], mathematics literacy [29,30], ICT literacy [31] and STEM literacy [32,33] are also still low. The low level of critical thinking and literacy skills is influenced by the learning model applied [11,34], learning methods, and the lack of opportunities to answer HOTS questions [23]. This condition is the basis for developing teaching materials that can increase literacy, numeracy and love of culture/homeland.

Formulation of the problem:

1. What are the characteristics of teaching materials that contain cultural ethnoscience based on understanding by design?
2. What is the validity of the teaching materials that contain cultural ethnoscience based on understanding by design that have been developed?
3. What is the readability level of teaching materials that contain cultural ethnoscience based on understanding by design?
4. What is the effectiveness of teaching materials that contain cultural ethnoscience based on understanding by design in increasing literacy, numeracy and love of culture/homeland?
5. How is the practicality of using teaching materials that contain cultural ethnoscience based on understanding by design developed?

METHOD

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This research and development (R&D) uses the 4-D model (Define, Design, Develop and Disseminate) [35]. The development research steps are shown in Figure 1.

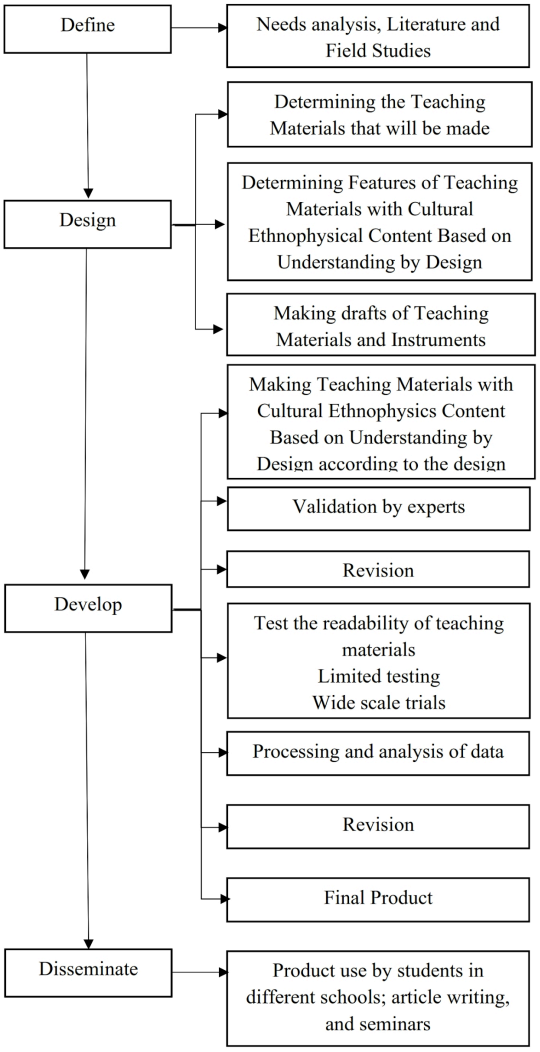

Figure 1. Research Procedure

The define stage aims to identify problems and collect information regarding needs for learning activities. Steps taken at the define stage: (1) Literature study and (2) Field study. At the literature study stage, researchers examine theories and examine research that is relevant to the product to be developed, namely Teaching Materials with Cultural Ethnoscience Content Based on Understanding by Design. The material developed is Waves. The field study stages were carried out with preliminary observations and analysis of problems related to literacy, numeracy and love of culture/homeland.

The design stage begins with preparing a prototype of Teaching Materials with Cultural Ethnoscience Content Based on Understanding by Design. which was developed. An example of the teaching material developed is the Wave material. The steps at the design stage include (1) preparing teaching material features, (2) preparing wave and cultural material that can be integrated, (3) preparing validation instruments, measuring literacy, numeracy and love of culture/homeland, (4) preparing questionnaires practicality.

The develop stage aims to develop the teaching materials produced at the design stage. At the development stage, the initial draft design of teaching materials is validated by experts, then product trials are carried out. Testing was carried out in three stages, namely: (1) small scale trials, (2) large scale trials, (3) product practicality tests by students. There are 5 expert validators, 3 lecturers and 2 Physics teachers. The product test subjects were high school students. The trial subjects were limited to 30 students, wide scale to 100 students. The trial design was pretest post-test control group design.

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Data collection instruments include an assessment sheet for product validation, scoring guidelines, and a Likert scale to determine the practicality of using the product. The data analysis technique uses the Aiken's V formula [36] for validation tests, Cronbach Alpha to determine reliability, the probability of answering correctly to determine the difficulty level of question items, discrimination for distinguishing power, and percentages to measure the level of readability of teaching materials, literacy, numeracy), love culture/homeland, and practicality tests. Increasing literacy and numeracy with N-gain.

The dissemination stage aims to inform the public about teaching material products through seminars and writing articles in journals, so that they can be used as references for further research, especially on issues of literacy, numeracy and love of culture/homeland.

RESULT AND DISCUSSION

Result

The results indicated that: characteristic of teaching materials, validity of product, and readability of product.

Characteristic of Teaching Materials.

There are three features that are characteristic of the teaching materials developed, shown in Table 2.

Table 2. Characteristic of Teaching Materials

Fitur	Icon	Description
Budaya Kita Nih! *Our Culture!*		Contains articles and readings related to ethnoscience, to support the character of love for the country
Ayo Mencoba! *Let's Try!*		Contains experiments related to the material and is made simple so that students are able to do it independently
Mengapa Begini? *Why like this?*		Contains questions about conceptual understanding, literacy and numeracy

Our Culture. In the Our Culture feature musical instruments from the region are displayed. The names of musical instruments can be different even though they are the same in Indonesia. An example of the "Our Culture" feature is shown in Figure 2.

Product Validity

The results of the validation of teaching material products by 5 validators obtained an Aiken score of 0.93. This value is greater when compared to the V Aiken table, with 5 raters and 5 scale score ranges and a 5% significance level of 0.80. Thus it can be concluded that the teaching materials developed are valid.

Readability Teaching Materials.

The cross-sectional test of the developed teaching materials consists of 20% of the total number of teaching material pages. The gap test is made with the provisions, the first paragraph is left intact, then the sentence will be separated for every 7th word, except for conjunctions and prepositions. Students are asked to fill in the gaps with the correct words, the same as those in the teaching material or their synonyms. Intermediate tests are carried out for Indonesian students. The results of giving the cloze test to 100 students obtained an average score of 76%. This value, when compared with the Bormuth criteria, is in the easy to understand category.

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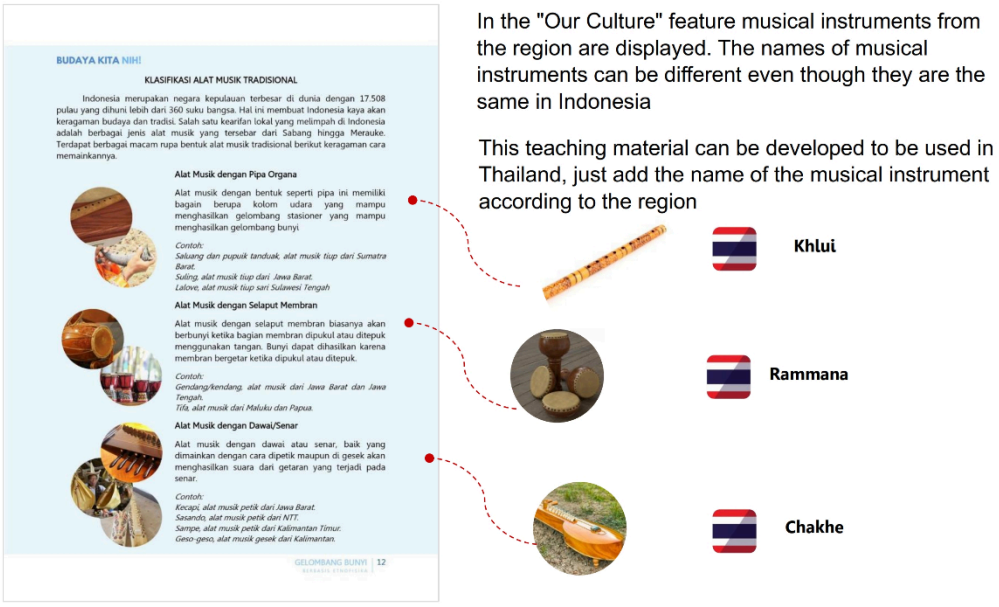

Figure 2. Example of "Our Culture!" Feature

Effectiveness of Teaching Materials in Increasing Literacy, Numeracy and Love for Culture/Homeland

The effectiveness of teaching materials in increasing literacy and numeracy, using quasi-experimental methods, pretest posttest control group design with the Problem Based Learning model. The test results obtained the average score and increase (N-gain) of the experimental and control groups as in Table 3.

Table 3. Mean Scores Pre, Post, and N-gain Experimental and Control Groups

Group	Literacy			Numeracy		
	Pretest	Posttest	N-gain	Pretest	Posttest	N-gain
Exsperiment	46.00	95.00	0.91	17.00	64.00	0.57
Control	41.00	53.85	0.21	12.80	42.00	0.36

Increased love for culture/homeland can be seen from his understanding of traditional musical instruments in Indonesia, his attitude towards cultural preservation. Apart from that, knowledge of the culture of other countries, especially Thailand, was also measured. The average love of country score is seen from the mode (score 3), in the developing category.

Practicality of Teaching Materials

The average value for the practicality of using teaching materials is 84%, in the practical category. Teaching materials are easy to use, contain ethnoscience that exists around students, in accordance with the wave material being taught.

Discussion

Science teaching materials containing cultural ethnoscience based on understanding by design, especially Sound Waves material, are intended to achieve the learning objectives required in the curriculum for high school students. The learning objectives that will be achieved by applying this teaching material are (1) students know the reasons behind a tradition that develops in society from a science/physics perspective, more precisely traditions or local wisdom related to sound wave material. (2) Students understand that sound wave material in physics is simpler and closer to social life. (3) Teaches that science (physics) exists in all walks of life. The final achievement as an accompanying impact is that students can promote cultural exchange and collaboration in an interconnected world and demonstrate this in behavior.

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This Ethnoscience-based Sound Wave Teaching Material was developed based on writing guidelines issued by the National Education Standards Agency. The teaching materials provide lots of supporting reading with good topics and readability levels. The criteria that a reading must fulfill in order to support student literacy and numeracy include: (1) the text or reading presented is sufficient to represent the material presented, (2) the text or reading is presented in an interesting, easy, clear, right on target, and does not cause multiple meanings and are common in oral or written communication, (3) through information texts students can obtain facts, data and information to develop insight and knowledge, and (4) accuracy in choosing language varieties that suit communication needs [37].

The teaching materials developed include original science and scientific materials that support ethnoscience learning. Apart from that, teaching materials also really support the development of literacy and numeracy skills in students with excellent availability of texts or readings used as stimulus. Apart from that, the text or reading presented has a readability level and uses good language. The content presented in the reading also has content that is relevant to ethnoscience learning, presented in 3 main features, namely "Our Culture!", "Let's Try!", and "Why is this?" with an easy to remember icon.

The “Our Culture!” invites students to explore the surrounding culture in accordance with the Sound Waves material. This feature contains articles and readings related to ethnoscience. Cultural involvement brings students closer to the local wisdom of their region, as well as their knowledge of cultures in other regions. The feature “Our culture!” presents information about musical instruments around students, which can be linked to the Sound Waves lesson material. The musical instruments around students become a means of remembering the subject matter they are studying for longer. In addition, culture can increase students' scientific literacy. This is in accordance with research results [38], that teaching materials based on Bundengan local wisdom can increase the scientific literacy of junior high school students in Wonosobo, Central Java, Indonesia. Ethnoscience can also improve students' scientific attitudes [39], thinking abilities [16], literacy and numeracy [40].

The “Let's Try It!” contains experiments related to Sound Wave material. The experiments presented are made simple so that students can do them independently. The experiment is presented with a simulation that can be scanned from a QR code, for example "Simulation of a loudspeaker diaphragm" to show the compression and stretching of longitudinal waves. Other experiments are "studying the differences in frequency and amplitude using the Frequency Sound Generator application", "The frequency of musical instrument notes around us", "Let's stack the waves", and many more. These experiments also support the understanding of the concept of Sound Waves.

The “Why This Is This” feature contains questions about qualitative understanding of concepts. With this question, it is hoped that students will better understand the concept of sound waves and stimulate critical thinking. Ethnoscience will make it easier for students to study the concept of sound waves presented. An example of a question in this feature is "Why does sound propagate faster in objects where the particles are close together?". "Why are sound dampeners installed in the cinema?", "Why is the sound of thunder louder at night than during the day?" and many more. These questions encourage students to think and read Sound Waves material so that student literacy becomes better.

The validity of the teaching materials developed is in the valid category. Validity is viewed in terms of material content and presentation of teaching materials. Aspects of content appropriateness include indicators: supporting literacy and numeracy, encouraging curiosity, up-to-date material, accuracy of Sound Waves and ethnoscience/ethnoscience material, suitability of material with learning outcomes. All indicators received an average score in the very valid category. Aspects of the appropriateness of presenting teaching materials include indicators: coherence and sequence, material presentation, presentation support, and presentation techniques. All indicators are considered very valid by the validator. This means that the teaching materials developed can increase students' curiosity, encourage students to be literate, foster a sense of pride in their own culture and respect for the culture of other countries, with a coherent, attractive presentation because it is supported by images and a QR code that can be scanned by students when want to know more details about the information in the teaching materials.

The teaching materials developed also have a readability level that is easy to understand. The results of the gap test showed that students' correct answers were 76%. If the average test score is ≥ 61, then the readability level of the book is high [41]. This is in accordance with the opinion of [42] that a gap test score of > 57 means that the readability level is easy to understand. The test results of the developed teaching materials mean that they are easy to understand. The preparation of this teaching material has taken into account the following things: (1) designed in a simple and attractive way, (2) in accordance with the subject matter of learning, (3) in accordance with the student's level of thinking, (4) full of pictures, (5) full of color , (6) involves technology by providing links to other learning sources such as YouTube, websites, etc. Learning media provides unlimited space for students to gain information and experience directly [43]. The involvement of technology in teaching materials provides new learning experiences for students. This new experience also plays a role in fostering enthusiasm in participating in the learning process [44].

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The effectiveness of teaching materials containing cultural ethnoscience based on understanding by design, Sound Waves material, can be seen from the increase in students' literacy and numeracy regarding the material taught to them. The results of implementation in learning at school show that students are able to answer literacy and numeracy-based questions well. The results of testing the increase in literacy and numeracy in Table 3 show that students who use cultural ethnoscience-based teaching materials have a higher N-gain than those who use ordinary teaching materials. The increase in scientific literacy for the experimental group was 0.96, while for the control group it was 0.21. N-gain ≥ 0.7 is in the high category, < 0.3 in the low category [45]. Both groups have been tested for homogeneity, having homogeneous initial abilities. For the N-gain numeration for the experimental group it was 0.57 and the control was 0.36. Both are in the medium category. The increase in literacy is higher because the teaching materials present a variety of information, either explicitly presented in the teaching materials or which can be accessed by students themselves via the QR code provided. In addition, the existence of simple experiments that students can carry out themselves helps them become literate in scientific competencies that support their scientific literacy. Processing the results of simple observations/experiments can improve students' numeracy competence.

The results of this study support the findings of previous research. Developing science learning based on local wisdom not only improves positive character in students, but can also increase student learning achievement [46]. Scientific literacy in learning activities has a positive impact on scientific attitudes. The higher the level of scientific literacy, the better the scientific attitude that students will have [47]. Ethnoscience related to food can be integrated into chemistry teaching materials [48]. Ethnoscience can increase chemical literacy for prospective teachers [49].

Ethnoscience can also increase love of culture, both culture in your own country or from other countries. In this research, love of culture is associated with the Pancasian student profile (P3) for Indonesian students, aspects of global diversity. Indicators of global diversity include: (1) Recognizing and appreciating culture, (2) Communication and interaction between cultures, (3) Reflection and responsibility for experiences of diversity, and (4) Social justice. For students in Thailand, love of culture is part of the 5 curriculum targets, namely "Awareness of the need to preserve Thai culture and local Thai wisdom, environmental protection and preservation, and a community mindset with dedication to public service for peace and harmonious co-existence." . The results of this study support research findings [50], that the integration of cultural competence in various professions will be a key determinant in professional services, including in the field of education. Therefore, teachers must be able to utilize local culture to accommodate demands in the learning process. The importance of cultural integration in science is in line with Vygotsky's social constructivism [51]. This concept discusses the importance of cultural competence in education, which places greater emphasis on sociocultural concepts, namely the social and interactional context of students in learning [52].

The success of teaching materials containing cultural ethnoscience based on understanding by design in increasing literacy, numeracy and love of culture is also supported by the practicality of their use by teachers and students. Students think that teaching materials are easy to use, QR codes are easy to scan, interesting to read, provide information about culture that is linked to the lesson material, and the sequence of presentations is easy to follow. Students gave a practicality score of 84% in the practical category.

CONCLUSION

Based on the results of research and analysis of theory and previous research, several things can be concluded as follows.

1. The teaching materials developed have the characteristics of containing cultural ethnoscience, are based on understanding by design, are suitable for increasing literacy, numeracy and love of culture, have the feature: Our Culture! Come on, try it! and Why is This?

2. The teaching materials developed have been validated by experts, the validation results obtained a score of 93.25% in the very valid category

3. Teaching materials have a readability score of 76%, meaning that teaching materials are easy to understand

4. The teaching materials he developed have been proven to be able to increase literacy, numeracy and love of homeland culture to a greater extent than other teaching materials.

5. Teaching materials that contain cultural ethnoscience are practical to use

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