Development and Validation of an Ethnoscience-Based Physics Teaching Module Through Flipped Learning to Support Students' Self-Regulation and Creativity

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Abstract - *This study aims to develop and validate an ethnoscience-based physics teaching module integrated with flipped learning for teaching temperature and heat. The module is designed to support students' self-regulation and creativity through contextual learning activities grounded in local wisdom. This study employed a research and development (R&D) approach using the ADDIE model, limited to the Development stage. The module was evaluated by two subject matter experts, one media expert, and one learning practitioner using Likert-scale instruments. The content expert validation yielded an average score of 91.45%, while the media expert and learning practitioner evaluations resulted in scores of 90.38% and 92.31%, respectively. All scores fell within the very valid category. The ethnoscience context incorporated into the module is the traditional salt-making process, which is relevant to the concepts of temperature and heat. These validation results indicate that the developed module is highly valid and suitable for use as an innovative instructional material. Based on expert evaluations, the module has the potential to support learning activities aimed at fostering students' self-regulation and creativity. Further research is needed to examine its effectiveness through classroom implementation.*

Keywords*: Teaching Module; Ethnosains; Flipped Learning; self-regulation; Creativity*

INTRODUCTION

Physics learning at the high school level plays a strategic role in building students' understanding of natural phenomena. However, the reality on the ground shows that physics learning is still often abstract, teacher-centered, and lacks the relevance of scientific concepts to real-life contexts. This condition has an impact on students' low involvement, motivation, and high-level thinking skills (Wang et al., 2023).

One of the solutions offered is the ethnoscience approach, which is a learning approach that integrates local knowledge, culture, and community wisdom into modern science learning. Through this approach, students can understand scientific concepts through phenomena that are close to their lives so that learning becomes more meaningful and contextual (Basu et al., 2019). In Indonesia, the abundant local cultural richness makes this approach very relevant, one of which is through the use of the traditional salt making process as a source of learning physics on temperature and heat materials.

On the other hand, technological developments and the demands of 21st century education encourage the need for a learning model that is able to develop students' learning independence. Flipped learning comes as an innovative model that flips conventional learning patterns: learners learn the material independently before learning in class, while face-to-face time is used for discussion, exploration, and problem-solving (Siddiqui & D'Mello, 2020). This model has been shown to be effective in improving students' self-regulation and creativity (Öztürk & Çakıroğlu, 2021).

The combination of ethnoscience approaches and flipped learning models offers significant potential in the development of physics teaching materials. However, research that specifically integrates these two approaches on temperature and heat matter with the context of traditional salt making is still very limited. On that basis, this study addresses this gap by developing and validating an ethnoscience-based teaching module through flipped learning, with the specific aim and scope of the study elaborated further below.

Some previous research supports the relevance of this approach. Iriani et al. (2024) show that ethnoscience-based learning encourages creativity through exploratory activities rooted in cultural phenomena. Meanwhile, Erfan et al. (2025) reported that ethnopedagogy-based learning increases creativity because it provides space for students to develop ideas independently. Meanwhile, Bunga et al. (2025) and Alifa et al. (2024) show that ethnoscience-based teaching materials have high validity and are suitable for use in physics learning.

Various studies have also shown that the development of ethnoscience-based modules and teaching materials has a positive impact on the development of competencies in the 21st century. Project-Based Learning-based modules integrated with ethnoscience have been proven to be able to improve students' science literacy and collaboration skills (Rayis et al., 2025). In addition, the development of ethnoscience-based physics teaching materials on motion dynamics has proven to be effective in improving students' critical thinking skills (Rodiah et al., 2025). Other research also shows that ethnoscience-based teaching materials are able to increase students' creativity through the presentation of contextual material and relate physics concepts with local wisdom in the surrounding environment. All of these findings show that the ethnoscience approach has great potential in supporting physics learning that is oriented towards 21st century skill development.

On the other hand, the use of technology in learning is growing in line with the demands of the implementation of the Independent Curriculum which emphasizes student-centered learning. One of the learning models that is considered to be able to support independent learning is *Flipped Learning*. This model provides students with the opportunity to learn material before learning takes place so that face-to-face time in class can be used for discussion, problem-solving, experimentation, and collaborative activities. These characteristics make *Flipped Learning* highly dependent on the ability of students to manage their learning process independently or *self-regulated learning*.

Although various studies have succeeded in developing ethnoscience-based teaching materials to improve science literacy, critical thinking, creativity, and collaboration (Rayis et al., 2025; Rodiah et al., 2025), research that integrates ethnoscience approaches with *the Flipped Learning* model in the form of teaching modules designed to support students' self-regulation and creativity is still relatively limited. In fact, self-regulation is one of the important competencies that determines the success of students in participating in *Flipped Learning*-based learning, because students are required to be able to plan, monitor, and evaluate their learning process independently before participating in classroom learning.

Based on these conditions, it is necessary to develop ethnoscience-based

teaching modules through *Flipped Learning* that not only meet the validity aspect as a teaching material, but also be able to facilitate students to develop self-regulation and creativity. Therefore, this study aims to develop and validate an ethnoscience-based physics teaching module integrated with flipped learning. The module is designed to support students' self-regulation and creativity through contextual learning activities based on the traditional salt-making process, as one of the innovative teaching materials that integrate local wisdom with 21st-century learning, so that it can support the implementation of the Independent Curriculum in a contextual and meaningful manner.

RESEARCH METHODS

This research uses a Research and Development (R&D) approach with the ADDIE (Analysis, Design, Development, Implementation, Evaluation) model which is limited to the Development stage. The selection of the ADDIE model is based on its systematic and iterative characteristics, making it suitable for the development of teaching materials that require a continuous evaluation process (Branch, 2009).

Analysis Stage

The analysis stage is carried out to identify learning needs, analyze the characteristics of students, and map the content of the material. The results of the analysis show that physics learning in high school is still dominated by conventional approaches that are less contextual. Material analysis identified that the traditional salt-making process contains concepts of temperature and heat, such as solar heat radiation, heat transfer, seawater evaporation, and changes in the shape of substances.

Design Stage

The design stage includes the preparation of the module structure as a whole, including the determination of learning outcomes, learning objectives, concept maps, ethnoscience activities, integration of flipped learning syntax, as well as the preparation of Student Worksheets (LKPD) and assessment instruments. At this stage, validation instruments are also designed for use by experts.

Development Stage

The development stage is the core of this research, namely the realization of the design into a teaching module product. The module is structured by integrating the content of physics, temperature and heat materials with the ethnoscience context of traditional salt making and flipped learning syntax. After the module is completed, it is validated by three groups of validators: two subject matter experts, one media expert, and one learning practitioner.

The validation instrument used a five-level Likert scale questionnaire (1 = Very Poor to 5 = Very Good). Quantitative data were analyzed using the eligibility percentage formula:

$$P = (\Sigma x / \Sigma xi) \times 100\% \qquad (1)$$

Description:
P = Percentage of eligibility; Σx = Total score obtained; Σxi = Maximum number of scores.

Qualitative data in the form of comments and validator suggestions were analyzed descriptively as the basis for product revision.

The validation instrument was developed based on indicators of content, presentation, language, graphics, ethnoscience integration, flipped learning implementation, self-regulation support, and creativity support. The instrument was reviewed by expert validators before being

used in the validation process. Since this study focused on product development and expert validation, the quality of the instrument was established through expert judgment. Statistical analyses such as Aiken's V, Content Validity Ratio (CVR), and inter-rater reliability were not conducted and are acknowledged as limitations of the present study.

Table 1. Product Validity Criteria

Percentage (%)	Category
81–100	Highly Valid
61–80	Valid
41–60	Quite Valid
21–40	Less Valid
0–20	Invalid

RESULTS AND DISCUSSION

Results

A. Characteristics of Developed Modules

The resulting teaching modules have several characteristics that distinguish them from conventional physics teaching materials. First, the module is designed by integrating the local cultural context in the form of the traditional salt making process as a medium for introducing the concept of temperature and heat. Each topic begins with a narrative and illustration that relates physics concepts to the stages of salt making, such as solar heat radiation to explain the transfer of heat by radiation, and evaporation of seawater to discuss changes in the shape of substances.

Second, the modules are structured following a flipped learning syntax which consists of two main phases: the pre-class phase and the classroom phase. In the pre-class phase, students read materials, watch learning videos (via QR code), and work on pre-learning activity sheets. In the class phase, activities are focused on group discussions, exploration of ethnoscience phenomena, and the completion of student worksheet. Third, the module contains components explicitly designed to support self-regulation, such as self-study planning sheets, progress monitoring sheets, and self-reflection rubrics.

B. Results of Validation of Content Experts

Validation of content experts was carried out by two validators to assess the feasibility of the module from the aspects of material, presentation, language, graphics, creativity, ethnoscience, and student worksheet. Full results are presented in Table 2.

Table 2. Content Expert Validation Results

Assessment Aspects	Max Score.	Validator I	Validator II
Material Eligibility	28	27	28
Presentation	24	20	22
Language	16	16	15
Graphics	16	13	14
Creativity Development	16	12	14
Etnosains & Flipped Learning	16	16	16
Student Worksheet	20	18	18
Quantity	152	136	142
Percentage (%)	100	89,47	93,42
Category		Highly Valid	Highly Valid

The average validity percentage of the two validators is 91.45% with the category of very valid. The high validity value indicates that the content of the module is in accordance with the Learning Outcomes (CP) and Learning Objectives (TP) of temperature and heat materials. The validator positively assessed the context of traditional salt making used, because it was able to connect the concept of physics with real phenomena logically and authentically (Basu et al., 2019). However, the validator

provided notes so that the indicators of self-regulation and creativity were explicit so that they could be distinguished from concept comprehension. The revision was carried out by adding self-regulation indicators to the student worksheet and reflection sheets, as well as adding open tasks based on problem-solving.

C. Validation Results of Media Experts

Media expert validation assesses aspects of the module's display, layout, typography, image quality, and readability. The results are presented in Table 3.

Table 3. Media Expert Validation Results

Assessment Aspects	Max Score.	Scores Obtained
Module Display	20	18
Layout	20	18
Typographers	20	19
Image Quality	20	18
Readability	24	21
Quantity	104	94
Percentage (%)	100	90,38%
Category		Highly Valid

The percentage of validity of media experts is 90.38% (very valid). A systematic display and visualization relevant to the context of traditional salt making are considered to be able to support the readability and attractiveness of the module. The validator suggested an improvement in the resolution of some images and the consistency of the writing format, which has been acted upon in the revised version of the module.

D. Validation Results of Learning Practitioners

Practitioner validation assesses aspects of curriculum suitability, ease of use, flipped learning activities, potential to support self-regulation, and creativity. The results are presented in Table 4.

Table 4. Learning Practitioner Validation Results

Assessment Aspects	Max Score.	Scores Obtained
Curriculum Fit	20	18
Ease of Use	20	19
Flipped Learning Activities	20	18
Self-Regulation	20	19
Creativity	24	22
Quantity	104	96
Percentage (%)	100	92,31%
Category		Highly Valid

The validation of learning practitioners resulted in a percentage of 92.31% (very valid). Practitioners especially appreciated the clear structuring of flipped learning activities between the pre-class and class phases, which made it easier for teachers to manage learning. This is in line with Öztürk and Çakıroğlu (2021) who stated that flipped learning is able to increase students' learning independence.

E. Recapitulation of Validation Results

Overall, all validators gave highly valid ratings to the modules developed. These results are consistent with the research of Bunga et al. (2025) who reported that ethnoscience-based teaching materials obtained high validity, and Alifa et al. (2024) who found ethnoscience-based e-modules to be valid and effective as physics teaching materials.

Table 5. Recapitulation of the Results of All Validators

Validator	Percentage (%)	Category
Content expert I	89,47	Highly Valid
Content expert II	93,42	Highly Valid

Validator	Percentage (%)	Category
Average content Expert	91,45	Highly Valid
Media Member	90,38	Highly Valid
Learning Practitioner	92,31	Highly Valid

F. Product Revision

Table 6. Revisions Based on Validator Input

Yes	Validator's Advice	Revisions Made
1	Indicators of self-regulation are not yet clear	Adding self-regulation indicators to student worksheet and learning reflection
2	Creativity instruments need to be distinguished from concept questions	Add an open task based on troubleshooting
3	Less detailed module usage instructions	Clarify the steps of using the module
4	Image quality needs to be clarified	Replace images with higher resolution
5	Activities need to be adjusted time allocation	Adjust the duration of activities on modules

Discussion

The development of ethnoscience-based teaching modules through *flipped learning* on temperature and heat materials in this study succeeded in producing products that meet high feasibility criteria from all aspects assessed. Based on the results of the validator assessment, this module is in the "Very Valid" category with an average score of 91.45% from content experts, 90.38% from media experts, and 92.31% from learning practitioners. These figures indicate the theoretical and practical adequacy of the module for use as a formal instructional device in the classroom (Nieveen, 1999). The success of this development is inseparable from the harmonious structural integration between physics content, cultural context (ethnoscience), and independent learning syntax (*flipped learning*). The high validity value in the material aspect (91.45%) confirms that the presentation of the concepts of temperature and heat in the module has been scientifically accurate and relevant to the Learning Outcomes (CP).

The main advantage of this module lies in the reconstruction of indigenous *knowledge* in the process of making traditional salt into scientific knowledge. So far, physics learning is often felt alienated from the reality of students' lives because it is presented in the form of abstract mathematical formulas (Wang et al., 2023).

From the media aspect, the validity percentage of 90.38% indicates that the layout, typography, visualization, and readability of the modules have met the aesthetic and ergonomic standards of digital-print teaching materials. The use of infographics of the traditional salt-making process and consistent placement of instructions helps reduce *the extraneous cognitive load* of learners when interacting with the modules. Input from validators in the form of increasing image resolution is crucial, considering that clear visual stimuli on abstract materials such as the movement of particles during heating (heat) greatly affect students' mental representation of the concept (Herayanti & Prayogi, 2021). With sharp visualization and responsive QR code-based navigation , this module is ready to be implemented socioculturally and technically in high school physics learning.

The assessment from learning practitioners which reached 92.31% specifically appreciated the clarity of the structuring of *flipped learning activities* in the module. The integration of flipped learning syntax that divides learning into pre-class and class phases is designed to provide space that is theoretically expected to support the practice of *students'* self-regulation.

In the pre-class phase, this module is designed to encourage students to take an

active role in their own learning activities through the use of digital materials and learning videos accessed via *QR* codes. The self-study planning sheet and self-reflection rubric inserted at the beginning of the chapter serve as metacognitive instruments. These instruments are designed to support learners in setting learning targets, monitoring their own understanding, and evaluating the barriers faced before stepping into in-person classes. This mechanism is intended to encourage the transition of learners from passive to more active, self-regulated learners, consistent with the theoretical framework proposed by Lee & Kim (2022) and Öztürk & Çakıroğlu (2021); however, this transition was not measured empirically in the present study, which was limited to the development and validation stages. When learners enter the classroom phase with sufficient knowledge capital, face-to-face time is no longer spent on one-way lectures, but rather is optimized for in-depth discussions and the resolution of more complex conceptual problems (Siddiqui & D'Mello, 2020; Putri et al., 2023).

In terms of learning models, *the flipped learning* structure integrated in the module provides clear guidance for teachers and students. The pre-class phase is designed to support students in managing the learning process independently (self-regulation), while the class phase, through discussion and problem-solving, is intended to encourage the development of creativity. This design rationale is consistent with Lee and Kim (2022), who argued that flipped learning creates conditions conducive to the development of learning independence, although the present study did not empirically test this relationship.

From the perspective of creativity, the open-ended assignments designed in the module—which require students to relate the concept of physics with the phenomenon of salt making—encourage the emergence of indicators of creativity according to Torrance (1974), namely fluency, flexibility, originality, and elaboration. Dewi et al. (2024) confirmed that ethnoscience-based teaching materials have a positive influence on creativity because they provide a rich and authentic learning context. One of the important notes from the revision of the content expert is the need to distinguish the instrument of creativity from the question of understanding conventional concepts. Following up on these inputs, the module was revised by integrating *open-ended problems* based on ethnoscience phenomena in the student worksheet.

The provision of cultural exploration space in this module provides a rich stimulus for the cognitive structure of students. Ethnoscience-based learning does not limit students' thinking to one correct answer in a textbook, but rather opens up a wide discourse space so as to trigger their imagination and creativity (Iriani et al., 2024; Erfan et al., 2025). This is reinforced by Dewi et al. (2024) and Zulkarnaen and Ernita (2025) who affirm that contextual and culturally challenging materials have proven to be effective in triggering creative thinking skills because they present real problems that require multi-perspective solutions.

Although the teaching module developed has met the eligibility criteria with a very valid predicate from all aspects of assessment, this study still has some limitations that need to be considered. First, the scope of *Research and Development* (R&D) methods in this study is limited only to the development stage and has not yet stepped into the stage of *implementation* and *evaluation* thoroughly on a broad class scale. As a result, the empirical effectiveness of this module in improving students' self-regulation and creativity in the field cannot be measured quantitatively through test

instruments or action observations. Second, the ethnoscience context integrated in this module focuses specifically on the local wisdom of the traditional salt-making process, so generalizations of the use of this module may require further adaptation if applied to school environments that have different geographical characteristics or cultural backgrounds. These limitations open up opportunities for relevant research in the future to test these products in the implementation phase to obtain more comprehensive empirical data on their impact on learners' learning outcomes.

CONCLUSION

This study successfully developed an ethnoscience-based physics teaching module integrated with flipped learning for teaching temperature and heat, using the traditional salt-making process as its ethnoscience context. The module was developed following the ADDIE model, with the research limited to the Development stage. Expert validation results indicated that the module achieved a highly level of validity, with average scores of 91.45% from the subject matter experts, 90.38% from the media expert, and 92.31% from the learning practitioner. These results suggest that the module is suitable for supporting contextual learning activities designed to foster students' self-regulation and creativity. However, its effectiveness in improving these competencies has not yet been empirically established, as this study was limited to the development and validation stages. Future research should proceed to the Implementation and Evaluation stages to empirically examine the module's impact on students' self-regulation and creativity.

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