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Development of Stem-Based Science Modules Integrated With Local Wisdom of Bali (*Catur Pramana*) and Character Content To Improve Scientific Process

Ni Wayan Sri Darmayanti[1*], Luh Kompiang Sari[2], Ni Putu Ayu Hervina Sanjayanti[3]

[1]Universitas Markandeya Bali, Indonesia

[2]Akademi Pariwisata Denpasar Bali, Indonesia

[3]Universitas Pendidikan Ganesha Bali, Indonesia

wyndarmayanti@gmail.com*

Abstract

Modern science education in the 21st century highly prioritizes the integration of science literacy, 4C skills, and digital competence. To address this need, this study focuses on designing and evaluating a STEM-based science teaching module that incorporates Balinese *Catur Pramana* values and character education. Following the Research and Development (R&D) framework, the project applied the five stages of the ADDIE model. The evaluation process involved content and media specialists, alongside a trial group of 31 fifth-graders at SDN 2 Manukaya, Gianyar. Data were gathered through expert appraisal forms analyzed via Aiken's V formula, student feedback surveys, and pre-test-post-test assignments. The evaluation from experts placed the module in the "High" validity range, yielding Aiken's V scores of 0.75 for the cover design, 0.72 for substance, and 0.71 for layout structure. In practice, embedding *Catur Pramana* principles helped students grasp complex topics more easily and boosted their engagement during hands-on project sessions. Moreover, the academic impact was evident from a mean N-Gain score of 0.70, indicating a high effectiveness in improving students' science process skills across the classroom. These outcomes prove that local cultural philosophy acts as a powerful cognitive bridge rather than just a decorative theme. Consequently, elementary school educators are encouraged to utilize this module to deliver meaningful, culturally relevant science lessons. For future studies, expanding the research to a larger and more varied group of schools would help confirm these benefits on a broader scale. Future investigators are encouraged to examine the long-term impact of this module across wider and more diverse educational contexts.

Keywords: Science module, STEM, *Catur Pramana*, Science Process Skills, Local Wisdom

INTRODUCTION

Education in the 21st century plays a crucial role in ensuring that learning is not merely a transfer of knowledge, but education is now required to produce individuals who possess learning and innovation skills, are proficient in using technology and information, and are prepared to work and survive with various life skills (Pratiwi et al., 2019). Education now emphasizes the need for educators to implement and develop 4C skills (Communication, Collaboration, Critical Thinking and Problem Solving, and Creativity and Innovation) in learning so that students are ready to face the realities of the 21st century (Kasse & Atmojo, 2022). The challenges of 21st century education require students to have competencies in science, technology, engineering, and mathematics (Rahma & Arafah, 2025). To prepare students for the 21st century, they will need other skills such as communication skills, problem-solving, critical thinking, creative thinking, and the ability to collaborate (Ashyar & Huda, 2022). According to Sihombing and Rochintaniawati (2025), an innovative approach that combines technology and sustainability education is key to addressing current science literacy challenges, as evidenced by the success of STEM-based teaching materials that have been shown to enhance students' understanding and awareness. STEM education serves as an alternative approach to prepare students for the challenges of the 21st century, aiming to promote and support the development of critical thinking, problem-solving, creativity, and scientific literacy in students from an early age (Septiadevana & Abdullah, 2024).

In the context of primary education, the subject of Natural Sciences (IPA) plays a central role as the main vehicle for integrating these STEM components. Science learning is no longer just about memorizing theories; it has become an active inquiry process. Science learning emphasizes the skills of the scientific process, which not only transfers knowledge but also produces outcomes. The skills of the scientific process include activities such as observing, classifying, questioning, formulating hypotheses, predicting, using tools and materials, planning experiments, conducting experiments, interpreting, applying concepts, and communicating (Fajriah & Dwiastuti, 2017). Thus, the abilities within the skills of the scientific process can train students to think logically, analytically, and systematically. Furthermore, the scientific process skills empower students to discover and solve problems as well as increase ability to imagine and generate ideas and also its creativity nature, collaboration when the student mutual aid each other or discuss some problem or experiment. Such abilities can reinforce and enrich current 4C education competencies. The STEM approach is reported to have a positive influence on science learning, including students' creativity, critical thinking ability, and problem-solving skill (Barokah et al., 2024). In line with this, Mu'minah and Aripin (2019) explain that learning that integrates STEM is capable of combining mastery of academic concepts with real-world learning that can be applied in daily life, so that students are expected to be able to solve problems, become logical thinkers, master technology, and relate culture to learning. Real-world learning can utilize an approach that is also integrated with the surrounding culture so that students can learn directly with real concepts in their environment, one of which is integrating local wisdom as a characteristic of a region.

Catur Pramana is one of the educational concepts in Hinduism that consists of four main concepts in the Pursuit of Knowledge, namely Pratyaksa Pramana, Anumana Pramana, Upamana Pramana, and Sabda Pramana. First, Pratyaksa Pramana is the process of acquiring knowledge through direct observation of objects, either with or without aids. Kerti (2018) emphasizes that the concept of pratyaksa pramana has four factors that influence the truth of the data, namely the condition of the observing subject, the characteristics of the object, the expected results, and the observation instruments used. Second, Anumana Pramana emphasizes logical analysis of the observed phenomena.In the context of learning, this stage is implemented through scientific activities such as classifying, predicting, formulating hypotheses, and analyzing variables operationally (Wijaya, 2020). Third, Upamana Pramana, is learning-by-comparing: students gain new knowledge by comparing a subject to be studied with other concepts that are known (Darmayanti et al., 2025). The last of these, Sabda Pramana, is communication by or in the form of sound or spoken words.

For an ideal implementation of the integration of *Catur Pramana* concept in basic education, structured and contextual teaching materials have to be available. In this support, printed modules provide an effective alternative in which students can be able to do self-directed learning without needing very much guidance from the teacher (Maryono & Budiono, 2020). Modules are the most widely used teaching material to learn such independence and learning becomes more effective and efficient in terms of time, money, facilities, and energy to achieve optimal learning objectives using a structural approach (Maymunah et al., 2023). More than just a source of material, comprehensively designed teaching modules also have great potential in internalizing positive character values in students. This is highly relevant to the demands of an education system that is not only oriented towards technology adaptation but also focuses on strengthening character in line with the values of Pancasila. The explanation above aligns with the research of Fauziah et al. (2025), which developed STEM-based teaching materials for the fourth-grade science curriculum, specifically on energy. The validation test results show that these teaching materials are very suitable for use, with content feasibility scores of 87% (Very Suitable), graphics 82% (Suitable), presentation 79% (Suitable), language 94% (Very Suitable), and STEM integration 100% and 97% (Very Suitable). Student responses to these teaching materials were also very positive, reaching 95% with the criteria of "Very Good" in limited and wide-scale trials. These teaching materials are considered effective in enhancing learning motivation, conceptual understanding, and 21st century skills such as critical thinking, creativity, and problem-solving. Research by Wicaksono (2020) on the implementation of STEM-based science learning in anticipation of the Industrial Revolution 4.0 analyzes the supporting aspects of science learning and its implementation in facing the Industrial Revolution 4.0, showing that the supporting aspects of science learning relevant to the Industrial Revolution 4.0 include the use of innovative problem/project-based learning models, approaches that integrate science, technology, and society, as well as the development of 21st century skills such as critical thinking, problem-solving, and creativity.This research concludes the importance of creating a globally competitive generation through the development of cognitive abilities, as well as the creative and innovative skills of students, in line with the demands of the Industrial Revolution 4.0 and preparing for the golden generation of 2045.

The two studies above indicate that the development of STEM-based modules can be effectively applied in the classroom. These studies focus on the general development of STEM teaching materials or the implementation of STEM, while this research will specifically weave STEM concepts with the cultural richness of Bali. This means that the module will not only teach science, technology, engineering, and mathematics but will also utilize the concept of local wisdom, namely *Catur Pramana*, in the process of acquiring knowledge. The integration of *Catur Pramana* into STEM education serves as a cognitive framework that aligns indigenous Balinese epistemology with the empirical nature of scientific inquiry. Specifically, Pratyaksa Pramana (Direct Observation) directly anchors the 'Science' component by encouraging students to utilize their senses and instruments to gather empirical data. Anumana Pramana (Logical Inference) corresponds to the formulation of hypotheses, variable analysis, and logical deduction. Meanwhile, Upamana Pramana (Analogy and Comparison) enhances the 'Engineering' and 'Mathematics' designs through analogical modeling and comparative problem-solving, and Sabda Pramana (Authoritative Testimony) strengthens scientific literacy as students validate their findings against reliable literature or expert explanations. This structured alignment ensures that local wisdom functions as the core cognitive driver in developing students' science process skills."This approach will make learning more relevant, meaningful, and contribute to preserving and fostering pride in culture. The benefits of developing this module are not only to encourage students to master scientific concepts but also to actively and meaningfully train students in the skills of the scientific process and instill positive character traits in students. Thus, this module functions not only as a learning aid but also as a means of forming students' comprehensive competencies in knowledge, skills, and attitudes, in accordance with the Pancasila student profile and the demands of the 21st century. Previous research focused on the general development of STEM teaching materials, while this research specifically weaves STEM concepts with the cultural richness of Bali. In response to this research gap, this study aims to systematically integrate local culture into formal STEM education at the elementary school level.This research provides scientific contributions in three aspects: (1) presenting instructional design principles (Transferable Design Principles) in integrating local epistemology into STEM; (2) providing evidence of how local wisdom functions as a cognitive mediator; and (3) offering a conceptual framework for using *Catur Pramana* as a scientific thinking methodology. Specifically, this research seeks to answer several fundamental questions, namely: 1. How is the validity of the STEM-based science module integrated with Balinese local wisdom (*Catur Pramana*) and character content designed to enhance students' science process skills?, 2. How is the practicality of the STEM-based science module integrated with Balinese local wisdom (*Catur Pramana*) and character content evaluated in elementary school science learning?, 3. How effectively does the implementation of the STEM-based science module integrated with Balinese local wisdom (*Catur Pramana*) and character content enhance students' science process skills?

METHOD

This research is a type of development research (Research and Development), which is a research method aimed at producing a specific product and testing its effectiveness, in the form of a STEM-based science module integrated with the local wisdom of Bali (*Catur Pramana*) and character education. This module is designed to enhance the science process skills of elementary school students. The research location is at SD N 2 Manukaya, located at Br. Malet, Desa/Kelurahan Manukaya, Kecamatan Tampaksiring, Kabupaten Gianyar, Provinsi Bali, Postal Code 80552. The research period is from June to August 2025. The subjects of this research are all teachers at SD N 2 Manukaya and 31 fifth-grade students from SD N 2 Manukaya. The object of the research conducted by the researcher is the development of a STEM-based science module integrated with the local wisdom of Bali (*Catur Pramana*) and character education. The development model applied in this study is the Five Stage development model, often called ADDIE (Analysis, Design, Development, Implementation, Evaluation). The below is an example of the stages involved in this analysis (Syahid et al., 2024).

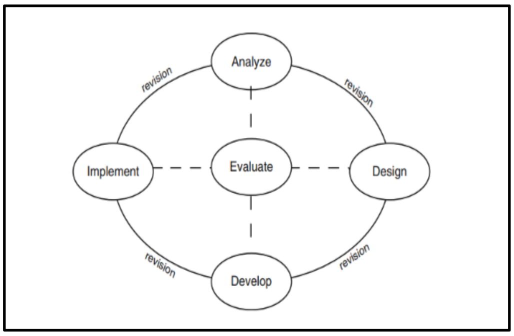

Figure 1. ADDIE Model

The first, the analysis phase, investigates the needs for elementary school science learning because observations, teacher interviews and curriculum analysis are carried out. At this step, some things are carried out such as; observing science learning in all teachers in SD N 2 Manukaya, observing students' understanding of concepts and science process skills, analyzing the frequency of meetings, and analyzing the teaching materials of science using the stage of *Catur Pramana*. Through the analysis stage, it is expected to identify problems and the need for interactive learning materials, so that a needs analysis can be compiled. Second, the design stage is the step taken to draft the initial design of the STEM-based science module, where the activity steps are integrated with the local wisdom of Bali, namely *Catur Pramana*, and character education to produce a prototype or initial design of the teaching module. At this stage, a storyboard and design of the teaching module will be produced. Third, in the development stage, the STEM-based teaching module is developed by integrating elements of local wisdom as learning steps in the teaching module and also incorporating character education. This is followed by product testing, which includes validity testing, using an instrument in the form of a product validity questionnaire for media experts and content experts. Three experts evaluate the product to assess its quality and assign quality scores. Each expert evaluates the quality indicators on a scale of 1 to 5 and also offers suggestions for revisions if necessary. The validated aspects include the module cover, module content, and module anatomy. The discussion of the validation results. The quality of the product is evaluated using Aiken's V formula (Ilyana et al., 2025). in the equation below.

$$V=\frac{\sum s}{n(c-1)}$$

In the formula above, it can be explained that V = validation score, s = *r -l0*, r = score from experts, *l0* = minimum score, n = number of experts, c = maximum score. Furthermore, the validation criteria are shown in Table 1 below.

Table 1. Validation Criteria by Experts/Practitioners

No	*Vscore*	Criteria
1	> 0.80	Very High
2	0.60< V < 0.80	High
3	0.40< V < 0.60	Sufficient
4	0< V < 0.40	Buruk

Fourth, the implementation stage involves conducting limited trials in elementary schools to measure the practicality and effectiveness of the STEM-based science module integrated with the local wisdom of Bali (*Catur Pramana*) and character education. The product that has undergone validation is then tested for practicality using an instrument in the form of a practicality questionnaire. The practicality test takes place during science lessons specifically involving elementary school students at SD N 2 Manukaya. Meanwhile, the effectiveness test is conducted by administering pre-tests and post-tests to students to measure the effectiveness of the product through the improvement of students' Science Process Skills (KPS), by comparing students' learning outcomes before and after using the teaching module. The test data is analyzed using the N-Gain Score test to assess the level of effectiveness in improving students' abilities. To find the level of practicality, the formula as in Equation 2 is used, and the criteria for the practicality of the STEM-based science module integrated with the local wisdom of Bali (*Catur Pramana*) and character education are presented in the following Table 2.

$$\textit{Practicality Level}=\frac{\text{Jumlah skor yang siperoleh}}{\text{Jumlah skor total}}\text{ X100 (\%)}$$

Table 2. Criteria for the Practicality of the Science Module (Octavia et al., 2024)

No	Criteria	Formula
1	Very Practical	81% - 100%
2	Practical	61% - 80%
3	Sufficient	41% - 60%
4	Less Practical	21% - 40%

In addition, the effectiveness of the teaching module is known from students' increase in Science Process Skills (KPS). The instrument to know the effectiveness of module in terms of Science Process Skills

(KPS) is compiled based on six main indicators, because these are related with nature of seeking truth through natural phenomena. The instrument in the study is an observation sheet of performance test that has an analytical rubric scale 1-5. For each of these indicators, a range of behaviour are specified (Performance Items). The 1-5 scale was used in an effort to help reveal the degree of nuance and complexity-to students' proficiency, with the interpretation that a score of "1" represents an ability that is described by a descriptor (s) as not yet evident, while a score of "5" indicates full (Expert Level) mastery. Data from this scale is then analyzed using N-gain analysis to measure how much modules are effective in increasing students' KPS.

Table 3. Classification of gain normality values (Oktavia & Prasasty, 2019)

Construct	**Elements of *Catur Pramana***	**KPS Indicators**	**Observation Items (Aspects Assessed)**	**Score Scale**
Science Process Skills	Pratyaksa (Observation)	Observing	Precision using the five senses in identifying phenomena/objects.	1 - 5
	Pratyaksa (Observation)	Using Tools	Skill and safety in operating tools and practical materials.	1 - 5
	Anumana (Logic)	Collecting Data	Discipline, honesty, and neatness in recording the facts of observations.	1 – 5
	Anumana (Logic)	Data Interpretation	The ability to connect facts to answer research questions.	1 – 5
	Anumana (Logic)	Concluding	The ability to synthesize findings into final statements based on empirical evidence.	1 – 5
	Word (Authority)	Communication	Clarity and fluency in presenting findings verbally/presentation.	1 – 5

The effectiveness analysis is obtained from the pre-test and post-test data using the gain test (N-gain score). The effectiveness of the teaching module can be seen from the improvement in the pre-test and post-test results of the students, which is then analyzed using the N-gain test with the following equation 3.

$$\text{N gain}=\frac{S_{post}-S_{pre}}{S_{max}-S_{pre}}$$

The explanation of the formula above is: N gain indicates the value of the gain normality test, S-post indicates the pre-test score, S-pre indicates the post-test score, and S-max indicates the maximum score. The calculation results are then categorized according to the N-Gain criteria. The categories consist of three levels: high, medium, and low, as shown in Table 4 below.

Table 4. Classification of gain normality values (Oktavia & Prasasty, 2019)

Gain normality values	**Criteria**

$0.70 \leq g \leq 1.00$	High
$0.30 \leq g < 0.70$	Sedang
$0.00 \leq g < 0.30$	Rendah

Meanwhile, the categorization of N-Gain results in percentage (%) can be seen in Table 5 below.

Table 5. Categorization of N gain score, Volunteers (Septrianda et al., 2025)

Percentage	Criteria
>40	Not Effective
40 – 50	Less Effective
56 – 74	Quite Effective
>76	Effective

The fifth stage is the evaluation phase conducted to analyze products that still have deficiencies in order to obtain recommendations for improving the developed product. After the evaluation process, the final product is ready for publication and wider implementation.

RESULTS AND DISCUSION

Result

The development of this science module follows a systematic procedure from the ADDIE development model aimed at producing teaching modules that are not only content-valid but also practical in their implementation in the classroom. In the Analysis stage, it was found that science learning at SD N 2 Manukaya requires innovations that can connect abstract concepts with the students' environmental realities and also the need for the integration of science process skills aligned with local values. The development of the STEM (Science, Technology, Engineering and Mathematics) based science module with Bali's local wisdom *Catur Pramana* is expected to provide novelty material for effective contextualized and integrated learning as well as nurture the whole student's nature. As Aris et al. (2024), applying structured learning modules may be a solution to improving learning quality, students are encouraged to work independently, more interested in learning and become active. Furthermore, STEM integration framed by local wisdom is recommended as a potential solution to promote science literacy and scientific attitude among elementary school students in addition facilitating the implementation of a more contextualized-STEM (Wahyu et al., 2025).

Furthermore, the product design stage involves the activity of structuring the STEM (Science, Technology, Engineering, and Mathematics) based IPA module framework that is integrated with the local wisdom of Bali, namely the concept of *Catur Pramana* (Pratyaksa, Anumana, Upamana, and Sabda Pramana) as the foundation for students' scientific knowledge acquisition. This module structure is designed interactively through learning activities with real projects. Application of the tradition-oriented approach to education has been directed toward increasing students' science literacy by incorporating local customs and values into studies. This approach helps more relevant and contextual material, making it easier for students to internalize a variety of scientific concepts in the daily life (Indriyanti et al., 2025). Every stage of project is organized to the level of *Catur Pramana*, so that the students do not only collect projects, but also make observations in detail, formulating logic hypotheses and testing it with reference literatures. This technique actively encourages students in their science process skills from observing, classifying to communicate experiment results scientifically. Character building is also integrated into every step of the activities or assignments in the module, such as the values of mutual cooperation, honesty in reporting data, curiosity, and responsibility towards the environment being internalized naturally. Thus, this IPA module not only serves as a learning resource that enhances students' intellectual intelligence and technical skills but also as an instrument for identity formation rooted in strong moral values. After the draft module is completed, the next step is the development of the teaching module.

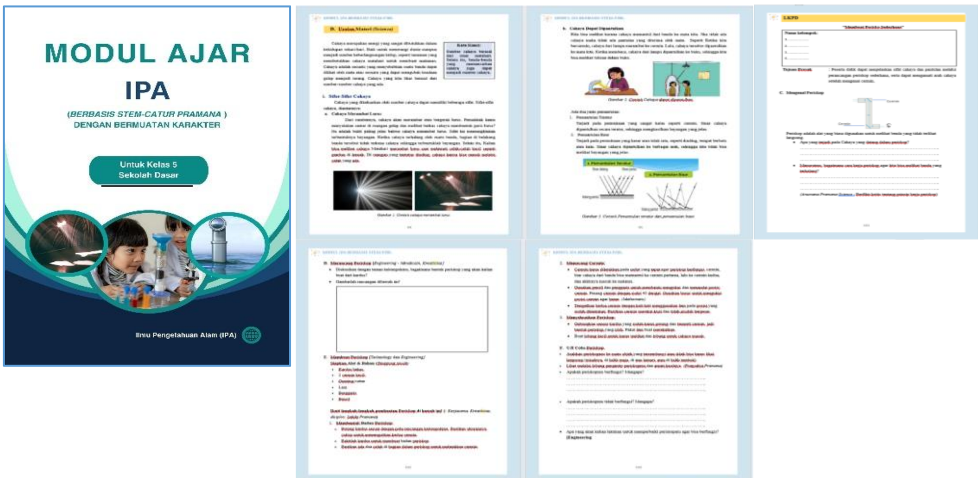

Figure 2. STEM-*Catur Pramana* Based Teaching Module Section

The development stage is carried out to transform the product design into a teaching module. The produced teaching module is validated for experts (Content, Media Design and Language Experts) to check the feasibility of the product prior to it try out. The module is tested with students on a small scale to determine its effect size on science process skills and student reaction to the modules as well as its validity and feasibility. This is part of the nature in the development process to make sure that the integration of *Catur Pramana* steps, is not only strong at theoretical level, but also applicable and practical for students to perform. Based on the assessment results obtained from the feasibility validation of the IPA module validated by 3 experts and analyzed using Aiken's V formula, it can be detailed in Table 6 below.

Table 6. Results of the Validation Test of the Teaching Module by Experts

No	Assessment Aspects	Indicators	Expert 1	Expert 2	Expert 3	Total Score	Aiken's V	Average
1	Cover of the Science Module	The title of the Science Module represents the entire content of the module	4	4	4	12	0.75	0.75
		The title of the Science Module attracts students' interest to engage in science learning	4	4	4	12	0.75	
		The illustration on the cover depicts the content of the Science Module so that	4	4	4	12	0.75	

		students can guess its contents						
		The title of the Science Module represents the entire content of the module	4	4	4	12	0.75	
2	Content of the Science Module	The content of the Science Module is easy for fifth-grade students to understand	4	4	4	12	0.75	0.72
		The content of the Science Module uses simple language, making it easy for fifth-grade students to read and understand	4	4	4	12	0.75	
		The content of the Science Module book contains images and texts that are interconnected.	3	4	4	11	0.67	
		The style and accuracy of the language in the Science Module are suitable for fifth-grade students.	4	4	4	12	0.75	
		The content of the Science Module can attract students' interest in engaging with science learning.	3	4	4	11	0.67	
		The text in the Science Module is well-written, with appropriate punctuation for the students' age level and good sentence coherence.	4	4	4	12	0.75	
3	Anatomy of the Science Module.	The design of the Science Module is clearly presented.	3	4	3	10	0.58	0.71
		The choice of font captures students' attention.	4	4	4	12	0.75	
		The font type in the IPA Module is easy to read for students.	4	4	4	12	0.75	
		The layout/systematics of writing is not too rigid and facilitates students in reading.	4	4	4	12	0.75	

In general, this science module received very positive responses on various assessment aspects. The data shows that the quality of the module falls into the High category, proving that the integration of local values and the STEM approach has been systematically packaged. The aspect of the science module cover, with 3 indicators, received an average Aiken's score of 0.75, categorized as High. This indicates that the external appearance of the module has successfully represented modern science material while remaining rooted in local identity. The content aspect of the science module, consisting of 6 indicators, achieved an Aiken's score of 0.72, also categorized as high, although there were notes on the connection between images and text as well as interest appeal, which scored 0.67. However, overall, the content of the module is deemed appropriate. The anatomy aspect of the science module received an average score of 0.71, categorized as high. Although the layout design indicator received a Fair category (0.58) from one expert, improvements in font selection made this module a comfortable medium that facilitates students in conducting STEM exploration activities. Referring to the categorization range of $0.60 < V < 0.80$ with a high category, the assessment results from the three experts on the STEM-based science module integrated with the local wisdom of Bali *Catur Pramana* and character content can be said that all items are valid or suitable for use. After passing the expert validation phase, the implementation level of this module was tested directly through a user response questionnaire involving 31 fifth-grade students from SDN 2 Manukaya. Based on the collected data, an average practicality percentage of 90.08% was obtained. This achievement confirms that the STEM-*Catur Pramana*-based science module falls into the "Very Practical" category and is highly suitable for use as a learning support medium in elementary schools.

Table 7. Results of the Practicality Questionnaire for the Science Teaching Module

No	Statement	Total Score	Percentage	Category
1	I feel happy and understand science better because the teacher explains using the STEM-based teaching module integrated with the Local Wisdom of Bali (*Catur Pramana*) and Character Content.	142	91.61%	Very Practical
2	I am motivated to learn science because the teacher teaches science using the STEM-based teaching module integrated with the Local Wisdom of Bali (*Catur Pramana*) and Character Content, making it easier to understand the material discussed.	137	88.39%	Very Practical
3	I enjoy participating in science learning because the STEM-based teaching module integrated with Balinese Local Wisdom (*Catur Pramana*) and Character Content contains many interesting images, making it more engaging and not boring.	139	89.68%	Very Practical
4	I do not enjoy participating in science learning because it is not interesting when using the STEM-based teaching module integrated with Balinese Local Wisdom (*Catur Pramana*) and Character Content.	135	87.10%	Very Practical
5	I can use the tools and materials provided in the STEM-based teaching module integrated with Balinese Local Wisdom (*Catur Pramana*) Character Content and according to the learning guidelines, making science learning more enjoyable.	144	92.90%	Very Practical

6	I feel bored learning science using the STEM-based teaching module integrated with Balinese Local Wisdom (*Catur Pramana*) and Character Content because the media is less engaging.	140	90.32%	Very Practical
7	I feel I do not understand the science lesson material when taught using the STEM-based teaching module integrated with Balinese Local Wisdom (*Catur Pramana*) and Character Content because there are too many images.	140	90.32%	Very Practical
8	I am having difficulty using the STEM-based teaching module integrated with Balinese Local Wisdom (*Catur Pramana*) and Character Content, which makes the material discussed less understandable.	140	90.32%	Very Practical
		TOTAL	**90.08%**	**Very Practical**

From the analysis of each indicator, the result of practicality test indicates that students have provided a very good response toward the utilization of STEM-based science module as an integration learning with Balinese local wisdom (*Catur Pramana*) and character content. Among the concept understanding indicator, 91.61% of student felt that it was easier to understand difficult material by working on real project and supported by the visual presentation while work instruction led to be ease for has been very helpful (90.32% rating). The effectiveness of the module in enhancing technical and procedural aspects is evident from the indicator of tool and material usage, which received the highest score of 92.90%. This proves that the operational guidelines in this module are very adaptive and easy for students to apply in the learning process. In addition to being technically excellent, the presence of the cultural value of *Catur Pramana* creates a strong connection between the teaching material and the local life reality of the students, thereby increasing learning enthusiasm to 88.39%. Character development and skills captured a 90.32% for the module in attitudes fostered relative to that of diligence, cooperation, and responsibility. Students also felt that their science process skills in a range from 0-100% as forming hypotheses and making conclusions significantly increased with an average score of 87.10%. Systematic critical learning in each period of the module also received a good reply (90.32%) which turned out to reduce student's boredom with project appeal level at 89.68%. In general, the average percentage of all that have fallen in the category "Very Practical" was 90.08% Those results showed that a Heuristic-based STEM science module integrated *Catur Pramana* and character developed is very feasible and ably practical. This approach not only assists the students to comprehend abstract concepts through project visualization, but also accomplishes an interest-based, enjoyable and organized learning process. Next, after practicality test, the effectiveness of the module to improve students' learning achievement was tested. This test effectiveness is implemented by giving the pre-test and post-test to 31 fifth-grade students in SD Negeri 2 Manukaya with a total of six discovery indicators which are used to assess science process skills. The N-gain analysis is then calculated based on the difference in scores obtained on the scale. The details of the pre-test and post-test scores for each indicator can be seen in the following Figure 3.

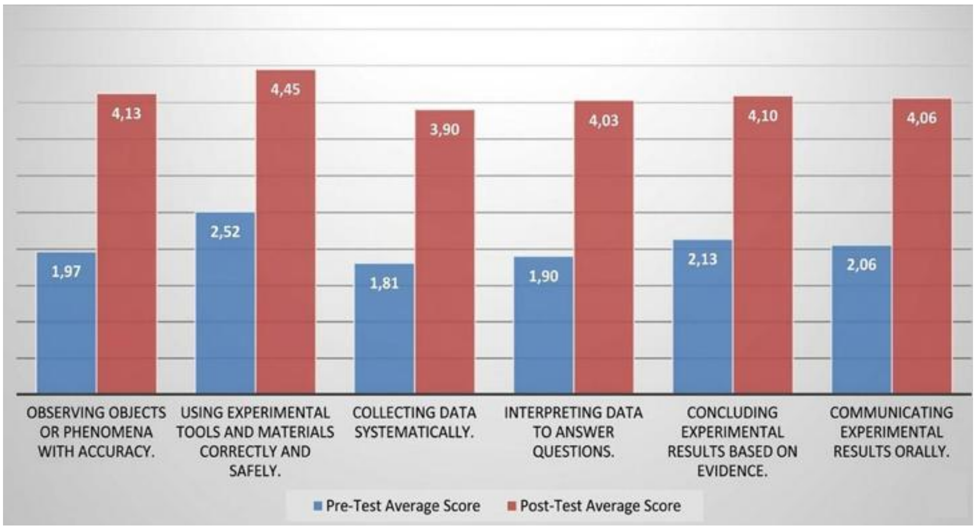

Figure 3. Results of Pre-test and Post-test of Science Process Skills per Indicator

The data collected is then evaluated using N-Gain analysis to measure the significance of the improvement in students' science process skills, with the results detailed as follows.

Table 8. Description of N-Gain Test Data Results per KPS Indicator

No	Science Process Skills Indicators	Average Pre-test Score	Average Post-test Score	*N-Gain*	Category
1	Observing objects or phenomena carefully	1.97	4.13	0.71	High
2	Using tools and materials accurately & safely	2.52	4.45	0.78	High
3	Collecting data systematically	1.81	3.90	0.66	Medium
4	Interpreting data to answer questions	1.90	4.03	0.69	Medium
5	Summarizing experimental results based on evidence	2.13	4.10	0.69	Medium
6	Communicating experimental results orally	2.06	4.06	0.68	Medium
	Overall Average	**2,10**	**4,10**	**0,70**	**High**

Based on Table 8 above, the average improvement in each indicator of students' science process skills shows an N-Gain of 0.70, categorized as high. The most progress is made in terms of students' ability to operate experimental tools and material, which shows an N-Gain of 0.78. These findings empirically show that Pratyaksa step (Direct Observation) integrated in STEM framework, guiding the student to the concrete process. It is also confirmed by the increase in the data interpretation and conclusion drawing indicators (N-Gain 0.69), showing that there are cognitive processes, which are provoked by Anumana stage. Through Anumana, local wisdom is no longer merely a context but becomes a logical thinking tool that helps students connect experimental results with abstract scientific concepts. This reinforces that *Catur Pramana* functions as an effective cognitive mediator in STEM learning in elementary schools.

Table 9. Distribution of Students' Science Process Skills (SPS) Achievement based on N-gain 31 Students

N-gain Category	Score Range	Number of Students (f)	Percentage (%)
High	$0.70 \leq g \leq 1.00$	13	41.94%
Medium	$0.30 \leq g < 0.70$	18	58.06%
Low	$0.00 \leq g < 0.30$	0	0.00%
Total		31	100%
Average N-gain		**0.70**	**Category: High**

Based on the effectiveness test results, it shows that the STEM-based IPA module of *Catur Pramana* has a significant positive impact on students' Science Process Skills (KPS). The N-gain distribution results in Table 9 indicate that 100% of students achieved a medium to high category, with a class average of 0.70 in the "High" category, and it is evident that not a single student (0%) falls into the low category. Although the N-gain value is at 0.70 (The threshold for the high category), the stability of the data among these 31 students proves that the module has very reliable effectiveness. This demonstrates that this module has a stable and reliable level of effectiveness in enhancing students' abilities. This finding contributes design principles that can be transferred, indicating that the integration of local epistemology (Such as ways of acquiring knowledge in certain cultures) into the STEM framework can strengthen students' inquiry and reasoning. The significant enhancement in students' science process skills (SPS) is deeply rooted in the operationalization of the *Catur Pramana* stages during STEM projects. During the hands-on sessions (Such as constructing simple environmental filtration systems), the integration of Anumana Pramana forced students to transition from passive observers to active logical thinkers. Instead of merely copying a predefined procedure, students were required to predict outcomes and classify variables systematically. Furthermore, the culturally familiar context of Balinese values lowered cognitive barriers, allowing fifth-graders to rapidly bridge their everyday experiential knowledge with abstract scientific concepts, thereby resulting in a high and well-distributed N-Gain score across the trial group.

Discussion

Validity of the STEM-based science module integrated with Balinese local wisdom (Catur Pramana) and character content designed to enhance students' science process skills

The development of the STEM-based Science module integrated with the local wisdom of *Catur Pramana* and character content has proven effective in improving the quality of learning in elementary schools. This module is an innovative effort to bridge the gap between the understanding of abstract science concepts and the learning approach related to the cultural realities of elementary school students. Validation by the expert after obtaining of validation value is showing it that, this developed module comes in "High" category with average Aiken's V value 0.71 to 0.75, means developing of such a module is good and feasible. The strength of this validity is based on the harmony between STEM elements and *Catur Pramana* steps. Theoretically, the integration of the stages of Pratyaksa (Observation), Anumana (Inference), Upamana (Comparison), and Sabda (Source of Authority) provides a foundation for students to acquire scientific knowledge. The use of Aiken's V formula proves that each item in the aspects of cover, content, and anatomy of the module has met the standards of learning media feasibility. It is important to note that the main scientific contribution of this research goes beyond merely producing a physical module; it lies in the design principles that integrate local epistemology into modern STEM education. This integration pattern can be replicated or transferred by other researchers in different cultural contexts. First, the developed conceptual framework shows how the stages of *Catur Pramana* function as cognitive mediators in the inquiry process. The stages of Pratyaksa (Direct Observation) and Anumana (Logical Inference) systematically reinforce the steps of Science and Engineering in STEM, where local wisdom is not just a contextual complement but a trigger for students' scientific reasoning. Second, this study provides empirical evidence that a cultural context familiar to students' daily lives can reduce cognitive barriers when they encounter complex science concepts. Thus, this research offers a model of knowledge transition: how traditional values can be transformed into measurable and applicable science process skills for 21st century education.

This validation finding simultaneously reinforces the instructional design principles (Transferable Design Principles) proposed in the introduction, that the systematic integration of local epistemology into the STEM structure can create instruments that are theoretically robust and pedagogically relevant. In line with the opinion of Tahya et al. (2022) which explains that the developed teaching module is recommended to provide variations in learning to better motivate students in receiving subjects that are considered boring by them, in addition, the importance of presenting the module in developing students' science process skills also helps teachers facilitate and develop students' science process skills, which are essential elements in science learning. Thus, this STEM-based science module, *Catur Pramana*, has been developed into a functional learning instrument ready to support the creation of meaningful, contextual, and character-building learning experiences.

The Effectiveness and Practicality of a STEM-Based Science Module Integrated with Balinese Local Wisdom (Catur Pramana) and Character Values for Improving Students' Science Process Skills

This research also demonstrates the effectiveness of the *Catur Pramana* steps (Pratyaksa, Anumana, Upamana, and Sabda Pramana) as a foundation for knowledge acquisition. Through this syntax, students not only technically assemble STEM projects but also conduct in-depth observations and build logical hypotheses. Data shows that the effectiveness of increasing KPS in the "High" category with an N-Gain of 0.70. Although the N-gain score of 0.70 is at the threshold of the high category, the stability of the data showing 0% of students in the low category proves that this design principle has a very reliable (Robust) effectiveness for students with diverse ability levels. This increase is triggered by the transition from the Pratyaksa stage to Anumana. In the Anumana stage, learners are encouraged to engage in logical reasoning to predict the outcomes of their STEM projects. This process proves that local wisdom in this research is not merely a contextual ornament but a key variable that drives the inquiry process and skill development in learners.

This approach directly stimulates students' science process skills, as reflected in the practicality questionnaire results of 87.10% on the indicators of observing skills and formulating hypotheses. This is supported by the opinion of Wahyu et al. (2025) that local wisdom-based STEM integration is an innovative solution to bridge science literacy with students' social realities, making learning more meaningful. Consistently, Imron et al. (2025) note that the Ethno-STEM application has successfully encouraged student learners to become more interested and motivated to learn, develop lessons that are relevant in their lives and at school, critical thinking skills as well as creative thinking in the completion of innovative problem solving projects. The involvement of *Catur Pramana* as a learning syntax on this module allow the cultural values become guideline for students to take part in science practices on their science learning. Such comparison also demonstrates that the implementation of STEM approach through *Catur Pramana* as the contextual learning device, can encourage students to learn as is being evidenced by a very good score in learning motivation aspect, which was equal to 89.68 %. As explained by Wati et al. (2024), project-based STEM learning effectively enhances student motivation and active participation through projects and collaboration among students, deepening conceptual understanding through the exchange of ideas and communication compared to conventional teacher-centered learning, which triggers low student engagement. The high practicality value, indicating an average score of 90.08% and an indicator of tool and material usage at 92.90% with the category "Very Practical," proves that the developed module is capable of presenting systematic scientific work instructions while remaining adaptive to the cognitive characteristics of elementary school students. This is in keeping with what the STEM approach seeks to achieve an emphasis on doable tasks and real problem solving. Moreover, the obtention of 91.61% in concept understanding coming from real projects demonstrates that students feel more supported when teaching abstract science content through structured activities. This is also supported by the report of Cahyanti et al. (2024) that argues STEM provides a learning-focus which is interdisciplinary in nature and helps to “bridge the gap between theory and practice in education”.

By using STEM-based modules incorporated the stage of *Catur Pramana*; Pratyaksa (Observation), Anumana (Logic), Upamana (Comparison) and Sabda (Validation of Sources), students' understanding of abstract science concepts and view it through real project visualization purposes. STEM education and guidance of the real situation in learning are opportunities to promote critical thinking and problem-solving that are highly useful for students' achievement at identifying problems and solving them in practice situations (Nam et al., 2023). his is in line with the research of Maryanti and Suminar (2023) which explains that ethno-STEM learning combined with learning models can give meaningful experience to students through creative and creative thinking processes in students that were inspired by learning activities where students are given the opportunity to actively try, explore knowledge independently and interpret ideas from problem topics in learning activities Astawan et al. 2023) and Septajati and Widowati (2024) also explain that the implementation of STEM-based scientific learning has a positive impact on students' critical and creative thinking skills.

What is interesting about this study is that it employs *Catur Pramana* as a cognitive mediator. The infusion of *Catur Pramana* in this module is not only culturally based, it also fundamentally serves as a cognitive tool that mediates between students' common sense and their formal scientific structures. This mediating role is clearly evident in the transition from the stage of Pratyaksa (Sensory Observation) to Anumana (Logical Reasoning). Compared to previous research, there is a significant difference that makes this study unique. Previous studies tended to use local wisdom merely as a context for the material, whereas this research employs the values of local wisdom from *Catur Pramana* as a method of thinking in solving STEM problems. This mediating role is clearly evident in the transition from the stage of Pratyaksa (Sensory Observation) to Anumana (Logical Reasoning). The interaction of tasks in the module and teacher guidance has proven to facilitate students' transition from the stage of Pratyaksa (Empirical Observation) to Anumana (Logical Conclusion). The findings of the research indicate a significant increase in the indicator of "use of tools and materials" with the highest N-gain of 0.78 (High Category).

This proves that the Pratyaksa stage provides concrete procedural guidance for students in exploring phenomena empirically. But the cognitive mediation is only effectuated through task interactions which take place in the module where teacher guidance helps students to bring about their passage at stage of Anumana. Here local wisdom serves as a logical means to assist students in relating their sensory experiences with logic-constructions, or even mobilizing more abstract scientific conclusions. Data interpretation and conclusion drawing indices improved with this mediation, yield an N-gain of 0.69. This is in line with the findings of Putri (2025) and Syalsa et al. (2025), which explain that Ethno-STEM-based learning is an effective strategy for enhancing students' critical thinking skills as it allows them to integrate scientific knowledge with local culture in a broader context. Furthermore, Wahyu et al. (2025) emphasize that local wisdom-based approaches like this are innovative solutions to improve science literacy and creative thinking skills through the framework of Culturally Responsive Teaching (CRT). Moreover, the role of this mediation is reinforced by the stage of Upamana (Comparison). As emphasized by Darmayanti et al. (2025) the comparative method in Upamana

Pramana helps students build a deep understanding by critically analyzing the similarities and differences of concepts. Finally, the stage of Sabda Pramana (Validation of Sources/Authority) serves as a mediator to train students' information literacy. With the explosion of digital information, students learn to be able to confirm information through reliable sources, either teachers or scientific books. It can be concluded that in this module, *Catur Pramana* functions as the "Cognitive Compass" in guiding students' inquiry experience to ensure that their process of inquiry is still systematic, valid, and culturally relevant.

This module also effectively assimilates character values, which can be confirmed by a favorable receiving rate of 90.32% to the character value from students on cooperation, accuracy and responsibility while exploring STEM projects together with local value can assist in students' identity formation. The high score (89.68%) of influence on learning motivation indicates that students, involvement in culture-based projects to replace low participation in teacher-centered learning 3. This further supports that of Mustoip et al. (2024) STEM learning approach has a great potential in the development of collaborative character and creative thinking, students not only can work well in groups but also are able to think creatively in solving any problem they confront. However, this study has an extended attention to embed students' affective and cognitive aspects; in contrast to others that usually treat affective and cognitive separately, the STEM *Catur Pramana*-based module connects them both in the unit. Our students learn to think critically in all STEM projects and they become persons of character as we reflect character values in every learning experience within this module. Beyond cognitive and procedural gains, the module effectively integrated character cultivation aligned with the Pancasila student profile. Qualitative observations revealed that embedding Balinese local wisdom naturally nurtured ethical scientific behaviors. For instance, during the data-gathering phase, students demonstrated high integrity and honesty in recording actual observation numbers rather than fabricating results. The collaborative nature of the engineering design challenges also fostered mutual aid (Gotong Royong) and shared responsibility for group tasks. This proves that the module fulfills a holistic educational goal by simultaneously enriching students' intellectual capabilities and emotional-ethical characters.

In general, the findings in this study validate that STEM-based science module integrated with *Catur Pramana* and character is not merely a mere book but as media innovation that can improve intellectual intelligence and science skills while character building on elementary students holistically. This study shows very encouraging results but it has its limitations: the trial is limited to one school, SD N 2 Manukaya. To enhance the generalizability, research on a multi-site scale and more time frames such as long-term retention of knowledge are required. Suggested research includes: the incorporation of digital technology into the module i.e., using interactive e-modules to strengthen the "Technology" component of STEM, which will ensure that learning contexts were more relevant for 21st century challenges.

CONCLUSION

This research successfully developed a science module based on the STEM approach integrated with the philosophy of local wisdom from Bali, namely *Catur Pramana*, to strengthen the character and scientific process skills of elementary school students. Through a systematic ADDIE model development procedure, this module has proven to meet very high feasibility criteria based on expert validation with Aiken's V index ranging from 0.71 to 0.75. The benefits of this module are not only the content but also its practicability scales up to 90.08 for a "Very Practical" category. The data shows that integration of local values can develop the abstract science material into more concrete, applicable and meaningful science learning at students of SD N 2 Manukaya. Furthermore, the main findings of this study provide concrete evidence that the implementation of the module significantly improves students' KPS, as indicated by an N-Gain score of

0.70 (High Category) supported by a uniform distribution of improvement across all students without any low category. This affirms that the syntax of STEM-*Catur Pramana* learning has a stable cognitive driving force, thus facilitating students with various initial ability levels not only to complete technical projects but also to be guided in honing their observation skills, building logical hypotheses, and validating findings based on credible literature. Overall, the character content internalized in every project activity has proven to foster collaborative attitudes, honesty in data reporting, and environmental responsibility naturally.

Theoretically, this research contributes an innovative framework that positions local wisdom not merely as a context but as a method of thinking (Epistemological Tool) in STEM education. Although this study focuses on the cultural concept of Bali, the design principle of this module, which uses traditional ways of thinking as the basis for STEM inquiry, can be applied to other cultural contexts. We acknowledge that the scope of this research is still limited to one region with a small number of students. Therefore, future research needs to involve more schools and teachers to test whether the same results remain consistent. Additionally, it is also important to investigate how the impact of this module affects students' technological literacy skills over a longer period of time.

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