

Development of a STEM E-Module Based on the Local Wisdom of the Maluku Islands to Improve the Scientific Literacy of PGSD Students

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Abstract

Science learning for prospective teachers requires instructional materials that can connect scientific concepts with real-life problems and local cultural contexts; however, learning materials that integrate STEM with the local wisdom of the Maluku Islands to strengthen the scientific literacy of elementary teacher education students remain limited. This study aimed to develop a STEM-based e-module integrating the local wisdom of the Maluku Islands and to determine its validity, practicality, and preliminary effectiveness in improving the scientific literacy of Elementary Teacher Education (PGSD) students. This study employed a Research and Development (R&D) approach using the ADDIE model, which consists of Analysis, Design, Development, Implementation, and Evaluation, with a one-group pretest-posttest design for the preliminary effectiveness trial. The product trial involved 41 fifth-semester students from Class E of the PGSD Study Program enrolled in the STEM Education course, while product validation involved six validators consisting of two subject-matter experts, two media experts, and two language experts. Data were collected through observation, needs analysis questionnaires, expert validation sheets, a 25-item student response questionnaire, and a 24-item scientific literacy test administered as pretests and posttests. The data were analyzed quantitatively using the Gregory Index, practicality percentages, the Wilcoxon signed-rank test, and N-Gain analysis based on the ideal maximum score. The results showed Gregory Index values of 0.86 for content, 0.92 for media, and 0.95 for language, all of which were categorized as very high. The e-module achieved a practicality score of 85.97%, indicating a very practical category. The mean scientific literacy score increased from 24.80 on the pretest to 69.21 on the posttest, representing an improvement of 44.41 points (Wilcoxon $Z = -5.58$, $p < 0.001$, $r = 0.87$), with a mean N-Gain of 0.59 in the medium category. These findings indicate that the STEM-based e-module integrating the local wisdom of the Maluku Islands is valid, practical, and demonstrates preliminary effectiveness in supporting the improvement of scientific literacy among the PGSD students in the trial class. The e-module can be used as contextual instructional material in STEM Education, while further research is recommended to involve comparison groups, broader samples, and parallel test forms to strengthen evidence of its effectiveness.

Keywords: E-Module, STEM, Local Wisdom of the Maluku Islands, Scientific Literacy, Elementary Teacher Education Students

Abstrak

Pembelajaran sains bagi mahasiswa calon guru memerlukan bahan ajar yang mampu menghubungkan konsep ilmiah dengan persoalan nyata dan budaya lokal, sementara bahan ajar yang mengintegrasikan STEM dan kearifan lokal Kepulauan Maluku untuk penguatan literasi sains mahasiswa PGSD masih terbatas. Penelitian ini bertujuan mengembangkan e-modul STEM berbasis kearifan lokal Kepulauan Maluku serta mengetahui validitas, kepraktisan, dan efektivitas awalnya dalam meningkatkan literasi sains mahasiswa PGSD. Penelitian menggunakan metode Research and Development (R&D) dengan model ADDIE yang meliputi Analysis, Design, Development, Implementation, dan Evaluation, dengan desain satu kelompok pretest–posttest pada uji efektivitas awal. Uji coba melibatkan 41 mahasiswa Semester V Kelas E Program Studi PGSD yang mengikuti mata kuliah Pendidikan STEM dan enam validator yang terdiri atas dua ahli materi, dua ahli media, dan dua ahli bahasa. Data dikumpulkan melalui observasi, angket analisis kebutuhan, lembar validasi ahli, angket respons mahasiswa (25 butir), serta tes literasi sains (24 butir) berupa pretest dan posttest. Data dianalisis secara deskriptif kuantitatif dan inferensial menggunakan Indeks Gregory, persentase kepraktisan, uji Wilcoxon signed-rank, dan N-Gain berbasis skor maksimum ideal. Hasil penelitian menunjukkan Indeks Gregory sebesar 0,86 pada aspek materi, 0,92 pada aspek media, dan 0,95 pada aspek bahasa, seluruhnya berkategori sangat tinggi. Kepraktisan e-modul mencapai 85,97% dengan kategori sangat praktis. Rata-rata literasi sains meningkat dari 24,80 pada pretest menjadi 69,21 pada posttest, dengan peningkatan 44,41 poin (uji Wilcoxon $Z = -5,58$; $p < 0,001$; $r = 0,87$) dan rata-rata N-Gain sebesar 0,59 pada kategori sedang. Temuan ini menunjukkan bahwa e-modul STEM berbasis kearifan lokal Kepulauan Maluku layak, praktis, dan menunjukkan efektivitas awal dalam mendukung peningkatan literasi sains mahasiswa PGSD pada kelas uji coba. Produk ini dapat digunakan sebagai bahan ajar kontekstual dalam Pendidikan STEM, sedangkan penelitian selanjutnya disarankan melibatkan kelompok pembandingan, cakupan subjek yang lebih luas, dan tes paralel untuk memperkuat bukti efektivitasnya.

Kata Kunci: E-Modul, STEM, Kearifan Lokal Kepulauan Maluku, Literasi Sains, Mahasiswa PGSD

Introduction

Higher education can no longer emphasize conceptual mastery alone; it must also equip students with the ability to understand phenomena, evaluate information critically, and use scientific knowledge in decision-making. In science education, these abilities are reflected in scientific literacy, namely the capacity to explain phenomena scientifically, evaluate scientific information or inquiry, and use evidence to draw conclusions.

Scientific literacy is one of the essential competencies that prospective teachers need to possess in the 21st century (Ridho, 2025; Verawati & Wahyudi, 2024). Scientific literacy concerns not only the ability to understand concepts, but also the ability to explain phenomena scientifically, interpret data, and use evidence in decision-making (Choudhary, 2024; OECD, 2023). For students of the Elementary School Teacher Education (Pendidikan Guru Sekolah Dasar, PGSD) Study Program, this ability is particularly important because they are being prepared to become teachers who will build the foundations of scientific thinking in learners from the elementary school level.

PGSD students are required not only to master science content, but also to design learning that is relevant to learners' needs. In reality, science learning in higher education still often focuses on theoretical conceptual mastery, so students are not yet optimally able to connect science concepts with real problems in everyday life. This condition results in students' limited ability to explain phenomena scientifically, use evidence, and relate science to life contexts that are close to learners.

Preliminary observations of PGSD students enrolled in the STEM course showed that some students still had difficulty connecting science concepts with contextual situations, explaining scientific phenomena coherently, and using scientific knowledge to solve simple problems close to their lives. In addition, the instructional materials used in the course did not specifically integrate the STEM approach with local culture as a learning context. These findings indicate a need for instructional materials that are more contextual, systematic, and relevant to the characteristics of students as prospective elementary school teachers.

This need becomes even more important given the current direction of learning, which emphasizes flexibility, deep conceptual understanding, and learner-centered learning. The implementation of the Merdeka Curriculum gives educators room to deliver learning that is more contextual and meaningful (Ariani et al., 2025). For PGSD students as prospective teachers, this situation demands readiness to design learning that not only delivers content, but also builds learning experiences that are reflective, close to learners' lives, and foster deeper understanding.

One approach relevant to addressing this need is the STEM (*Science, Technology, Engineering, and Mathematics*) approach. The STEM approach provides opportunities for students to learn through the integration of concepts, problem solving, and the application of knowledge to real situations. Recent studies show that STEM learning can increase learning engagement, strengthen interdisciplinary understanding, and support the development of 21st-century competencies (Portillo-Blanco et al., 2024). For PGSD students, STEM-based learning experiences are also important because they illustrate how science can be taught in a more holistic, less fragmented way that is closer to real-life problems (Siregar et al., 2025).

STEM learning becomes more meaningful when it is connected to the social and cultural context in which students live (Ifah et al., 2025). Culture and local wisdom can serve as learning resources that connect scientific concepts with learners' experiences, practices, and social environment, making science learning more contextual and meaningful (Hasyim & Sujiono, 2023; Rosyidah et al., 2025). Studies on STEM education emphasize the importance of local context so that learning is not abstract but relevant to learners' learning experiences (DeCoito et al., 2024). In this context, local wisdom can function as a bridge connecting science concepts with the realities of everyday life (Rosyidah et al., 2025).

The Maluku Islands possess a wealth of local culture with great potential to serve as a context for STEM learning. The life of island communities, the relationship between people and their environment, and the traditional knowledge that has developed within local culture can be drawn upon as meaningful learning resources (Buton et al., 2026; Septianti & Afiani, 2020). Using local culture in learning requires media that suit current learning needs (Nuraini et al., 2026). One medium that can be developed is the e-module. E-modules allow content to be presented flexibly and systematically through a combination of text, images, videos, exercises, and learning reflections (Nurhayati et al., 2025; Winangun et al., 2024). Recent studies show that digital instructional materials based on STEM and local wisdom have the potential to help improve scientific literacy and build more contextual learning experiences (Menon et al., 2025; Sihombing & Rochintaniawati, 2025). For PGSD students, experience in using such e-modules is also important as professional preparation, because they will later be expected to select, adapt, and develop instructional materials that suit learners' needs.

A review of the literature shows that a considerable number of studies on STEM, e-

modules, and local wisdom have been conducted, but most still focus on school students and have rarely targeted PGSD students as prospective teachers. Studies that specifically develop a STEM e-module based on the local wisdom of the Maluku Islands to improve the scientific literacy of PGSD students also remain very limited. This indicates an important research gap to be filled, especially because PGSD students need learning experiences that not only improve conceptual understanding but also prepare them to become teachers capable of designing contextual and meaningful science learning.

Based on the above, the novelty of this study lies in the development of a STEM E-Module Based on the Local Wisdom of the Maluku Islands to Improve the Scientific Literacy of PGSD Students. This novelty is evident in the integration of the STEM approach, Maluku local wisdom, and the strengthening of prospective teachers' scientific literacy within a single digital instructional product. This study addresses several key problems: how the STEM e-module based on the local wisdom of the Maluku Islands was developed to improve the scientific literacy of PGSD students, how valid and practical the developed e-module is, and how effective the e-module is in improving the scientific literacy of PGSD students. The developed product is expected not only to support the current learning of PGSD students, but also to serve as pedagogical preparation for them as future teachers capable of delivering science learning that is contextual, innovative, and aligned with the needs of elementary school learners.

Research Method

This study employed the *Research and Development* (R&D) method using the ADDIE model, namely *Analysis, Design, Development, Implementation, and Evaluation* (Arofah & Cahyadi, 2019; Branch, 2009; Dawis et al., 2023; Plomp & Nieveen, 2013). The preliminary effectiveness trial used a one-group *pretest-posttest* design (Shadish et al., 2002).

The trial involved 41 fifth-semester students from Class E of the PGSD Study Program enrolled in the STEM Education course. The fifth semester consists of six classes, and Class E was selected based on accessibility because the researcher is the lecturer of the course. Therefore, the trial results are intended as evidence of practicality and preliminary effectiveness in that class and are not intended to be generalized to all fifth-semester students of the PGSD Study Program. Product validation involved six validators, namely two subject-matter experts (Biology Education, doctoral degree; Physics Education, master's degree), two media experts (Educational Technology, master's degree), and two language experts (Language Education, doctoral and master's degrees). To maintain data objectivity, the test was scored using a standard answer key, and the questionnaire was completed using anonymous respondent codes. Scoring was carried out by a team member who did not teach the trial class.

The *Analysis* stage identified learning needs, student characteristics, and the potential of the local wisdom of the Maluku Islands through observation and a needs analysis questionnaire. The *Design* stage produced the e-module design, including the content structure, objectives, materials, activities, and layout, as well as the research instruments.

The scientific literacy test consisted of 24 multiple-choice items covering three scientific literacy competencies (OECD, 2023), with eight items each, using Maluku local wisdom stimuli (Table 1). The same test was used as the *pretest* and *posttest*. The test was first piloted with 40 fifth-semester students from Class D on 31 August 2026. The pilot results showed that all items were valid ($r\text{-count } 0.49\text{--}0.87 > r\text{-table } 0.312$); the difficulty

levels comprised 2 easy, 18 moderate, and 4 difficult items; item discrimination was in the good to very good category (mean $D = 0.82$); and the KR-20 reliability was 0.95 (KR-21 = 0.94), which is categorized as very high. The practicality questionnaire consisted of 25 statements on a 1–5 Likert scale covering ease of use, readability and presentation, ease of learning STEM, local wisdom, and benefits for scientific literacy. The questionnaire was piloted with the same Class D students after they had read the e-module. The results showed that all items were valid ($r\text{-count } 0.77\text{--}0.92 > r\text{-table } 0.312$), with a Cronbach's Alpha reliability of 0.99, which is categorized as very high.

Table 1 Blueprint of the Scientific Literacy Test

Competency	Indicator	Items
Explaining phenomena scientifically	Applying science and STEM concepts to explain local phenomena	1–8
Evaluating and designing scientific inquiry	Formulating questions, controlling variables, and assessing procedures	9–16
Interpreting data and evidence scientifically	Reading data, recognizing patterns, and drawing evidence-based conclusions	17–24

The *Development* stage realized the design as an e-module, which was then validated by experts using a 1–4 scale and revised based on the validators' suggestions (Dahal et al., 2023). The *Implementation* stage was carried out on 2–5 September 2026 through a *pretest*, learning using the e-module, a *posttest*, and completion of the practicality questionnaire. The *Evaluation* stage assessed the validity, practicality, and effectiveness of the e-module.

The data were analyzed using descriptive quantitative and inferential analyses (Wibowo et al., 2023). Validity was analyzed using the Gregory Index with the categories very high (0.80–1.00), high (0.60–0.79), moderate (0.40–0.59), low (0.20–0.39), and very low (0.00–0.19) (Sugiyono, 2013). Practicality was analyzed from the percentage of questionnaire scores relative to the ideal maximum score, with the categories very practical (81–100%), practical (61–80%), fairly practical (41–60%), less practical (21–40%), and impractical (0–20%).

Effectiveness was analyzed using a *pretest–posttest* difference test; data normality was tested with the Shapiro–Wilk test as the basis for choosing between the paired *t*-test and the Wilcoxon *signed-rank* test ($\alpha = 0.05$). Improvement was calculated using N-Gain with an ideal maximum score of 100 and categorized as high ($g \geq 0.70$), moderate ($0.30 \leq g < 0.70$), or low ($g < 0.30$) (Hake, 1998).

All participants received an explanation of the objectives and procedures of the study and gave their consent to participate. The data obtained were used for research purposes and for reporting the results of the product development.

Results

This study produced a STEM e-module based on the local wisdom of the Maluku Islands, developed to support the improvement of PGSD students' scientific literacy. The development process was carried out systematically using the ADDIE model, which consists of five stages, namely *Analysis*, *Design*, *Development*, *Implementation*, and *Evaluation*. Each stage produced findings that served as the basis for the next stage, from needs identification and product design, through e-module development and validation, to implementation and evaluation of the product's validity, practicality, and effectiveness. The results of each development stage are described below.

Analysis Stage

The *analysis* stage was the initial stage in developing the STEM e-module based on the local wisdom of the Maluku Islands. This stage was carried out to obtain an overview of learning needs, the characteristics of students as e-module users, the initial state of scientific literacy, gaps in the instructional materials used, and the potential of the local wisdom of the Maluku Islands that could be integrated into STEM learning. This analysis served as the basis for determining the characteristics of the product to be developed.

Overall, the analysis results showed that PGSD students need instructional materials that can connect STEM concepts with real situations and environments close to their lives. Based on the preliminary identification, some students still had difficulty connecting science concepts with contextual situations, explaining scientific phenomena coherently, and using scientific knowledge to solve simple problems. Meanwhile, the instructional materials used in the course did not specifically integrate the STEM approach with local culture as a learning context. This condition indicates a gap between the competencies students need as prospective teachers and the available instructional materials.

The analysis of user characteristics showed that PGSD students have needs that differ from those of elementary school learners. Students not only need to understand STEM concepts but also need to be prepared to develop STEM learning experiences for elementary school pupils. Therefore, the instructional materials need to guide students toward the ability to analyze phenomena, formulate scientific problems, conduct simple investigations, use data and evidence, evaluate alternative solutions, and design learning appropriate to pupils' developmental characteristics. Thus, the e-module functions not only as a source of content but also as a means of strengthening the academic and pedagogical competencies of prospective teachers.

The analysis results also highlighted the importance of strengthening students' scientific literacy. In this study, scientific literacy is understood not merely as conceptual mastery, but as encompassing the ability to explain phenomena scientifically, evaluate information or inquiry, and use evidence to draw conclusions. This need is consistent with the aim of the study, which places the improvement of PGSD students' scientific literacy as one of the main targets of e-module development. Therefore, the product needs to provide activities that encourage students to observe phenomena, ask questions, process information, analyze data, use evidence, and provide scientific reasoning for the decisions they make.

Another important finding of the analysis stage was the need to integrate the local wisdom of the Maluku Islands into instructional materials. The island environment, community practices, traditional technologies, natural resource management, and various forms of local knowledge have the potential to be used as sources of phenomena and problems in STEM learning. However, local wisdom should not be used merely as an illustration or supplementary material. Its integration needs to be contextual and ethical, taking into account the values, rules, and characteristics of the community, sources of information, and the limits of knowledge that may be used. The developed product therefore needs to position local wisdom as a learning resource that enables students to connect scientific knowledge with the realities of life in Maluku communities. This principle is also reflected in the developed product, which treats local knowledge as a living practice with values, history, rules, and a social context that must be respected.

The need for learning based on local context is also relevant to the direction of the

Merdeka Curriculum in elementary schools. Learning under the Merdeka Curriculum gives teachers room to design learning experiences that are pupil-centered and connected to real-life contexts. Learning design begins with the Learning Outcomes (Capaian Pembelajaran), which are then broken down into learning objectives, evidence of learning, activities, assessments, and supporting materials. In this context, the potential and local wisdom of Maluku can become meaningful learning resources because they help prospective teachers design learning that is close to pupils' experiences and the characteristics of their environment. The developed product also positions problems arising from the environment, practices, or real needs as an important part of meaningful learning.

The analysis of technology needs showed that instructional materials also need to be presented in a flexible form that suits the characteristics of today's student learning. Technology should be used to support the learning process, such as assisting observation, data collection, analysis, presentation of information, and communication of results. However, conditions in an island region require realistic use of technology, taking into account the availability of devices, the stability of networks and electricity, the cost of data access, and the possibility of offline use. Therefore, an e-module was considered appropriate to develop because it can combine content, visuals, activities, exercises, and learning resources in a single instructional material that can be used more flexibly.

Based on the overall analysis results, it can be concluded that there is a need for a STEM e-module based on the local wisdom of the Maluku Islands that is contextual, systematic, flexible, oriented toward improving scientific literacy, and supportive of PGSD students' readiness as prospective teachers to design learning in line with the characteristics of the Merdeka Curriculum in elementary schools. The results of the *analysis* stage then served as the basis for determining the structure, content, learning activities, form of presentation, and assessment instruments in the *design* stage.

Design Stage

The *design* stage was carried out as a follow-up to the results of the *analysis* stage. The identified needs were then translated into an initial design of the STEM e-module based on the local wisdom of the Maluku Islands. The design took into account the interrelationships among learning objectives, content, learning activities, local wisdom, scientific literacy, and the competencies of PGSD students as prospective elementary school teachers. This stage included developing the module's content structure, learning objectives, STEM- and local wisdom-based content, learning activities, and research instruments in the form of expert validation sheets, a student response questionnaire, and a scientific literacy test.

The design began with arranging the structure and flow of the e-module content in stages. The content was designed to progress from understanding the basic concepts of STEM and scientific literacy, exploring local wisdom as a source of scientific problems, integrating STEM in problem solving, scientific inquiry, the use of digital technology, learning design, assessment, and the development of media from local materials, to the implementation of STEM learning in elementary schools. This flow was arranged so that students move gradually from the ability to understand and analyze toward the ability to develop and implement STEM learning.

At this stage, scientific literacy became one of the foundations for designing learning activities. Learning activities were directed so that students not only acquire content, but also identify phenomena, formulate investigable problems, use and interpret data, evaluate

evidence, compare alternative solutions, and construct evidence-based explanations. This design is aligned with the aim of the study to develop an e-module that supports the improvement of PGSD students' scientific literacy.

The local wisdom of the Maluku Islands was designed as a context for STEM learning. Contexts such as Sasi, sago processing, Timba Laor, Baileo, and Orembai or Arumbae were used as sources of phenomena and problems that can be examined through science, technology, engineering, and mathematics. Their integration took into account the accuracy of sources, safety, cultural values, and ethics in using community knowledge. Thus, local wisdom does not merely serve as an example but becomes a context that connects STEM concepts with the life of communities in the Maluku Islands.

The e-module design also considered the needs of PGSD students as prospective elementary school teachers. The content and activities were directed toward students' ability to analyze Learning Outcomes, pupils' characteristics and developmental phases, formulate learning objectives, determine evidence of learning, design activities, develop assessments, and prepare Student Worksheets (Lembar Kerja Murid). This direction is consistent with the learning principles of the Merdeka Curriculum, which place pupils' needs and characteristics as one of the foundations for designing learning.

Technological aspects were also considered in the e-module design. Technology was used to support observation, data collection and processing, presentation of information, development of learning resources, and communication of results. Its use was adapted to the characteristics of the island region, particularly regarding the availability of devices, network and electricity access, and the possibility of using the materials offline.

Learning activities were designed in varied forms, including case analysis, problem solving, simple investigations, project-based activities, development of digital learning resources, learning design, assessment development, creation of STEM media from local materials, and teaching simulations. With this design, students not only learn STEM concepts but also produce various learning tools and experiences that can be used in elementary schools. Media development, for example, follows a process of needs analysis, design, production, testing, and product improvement.

At this stage, the layout of the e-module was also designed, covering the arrangement of titles, learning objectives, content, illustrations, tables, contextual examples, learning activities, summaries, and exercises. The presentation was designed systematically so that students can easily follow the learning flow and understand the relationship between the content and the activities carried out.

In addition to the product design, research instruments were also developed in the form of expert validation sheets, a student response questionnaire, and a scientific literacy test. These instruments were used in the subsequent stages to obtain data on the validity, practicality, and effectiveness of the developed e-module.

Based on this process, the outputs of the *design* stage consisted of the initial design of the STEM e-module based on the local wisdom of the Maluku Islands, the structure and sequence of content, learning objectives and activities, the design for integrating local wisdom and scientific literacy, the e-module layout design, and the design of the research instruments. These design outputs then served as the reference in the *development* stage for realizing a complete e-module product.

Development Stage

The *development* stage was carried out by realizing the design prepared in the *design* stage as a STEM e-module based on the local wisdom of the Maluku Islands. The initial product was developed based on the design and then validated by subject-matter experts, media experts, and language experts before being used in the trial stage.

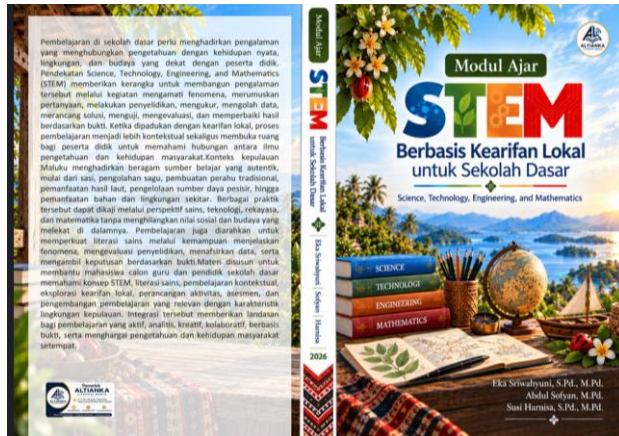
At this stage, the content and learning activities were fully developed by integrating STEM, scientific literacy, the local wisdom of the Maluku Islands, and the elementary school learning context. The product contains not only explanations of concepts, but also contextual phenomena, problem- and project-based activities, simple investigations, the use of digital technology, assessment development, media made from local materials, and STEM teaching simulations. This development was intended to enable students not only to understand concepts but also to use data, evidence, and problem solving in contexts close to the life of Maluku communities.

After the initial e-module product was developed, expert validation was conducted to assess the feasibility of the product. Validation involved six validators, consisting of 2 subject-matter experts, 2 media experts, and 2 language experts. The assessments were analyzed using the Gregory Index. The validation results showed coefficients of 0.86 for content, 0.92 for media, and 0.95 for language. All three values fall into the very high validity category (Table 2).

Table 2 Expert Validation Results for the Local Wisdom-Based Stem E-Module

Validation Aspect	Number of Validators	Gregory Index	Category
Content	2	0.86	Very high
Media	2	0.92	Very high
Language	2	0.95	Very high

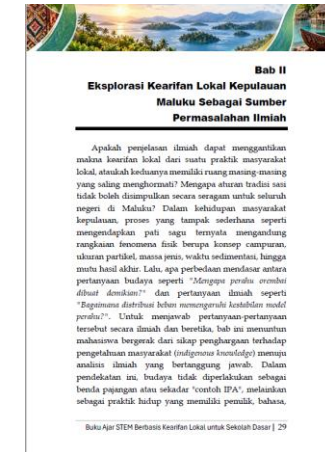
The validation results and expert feedback were then used as the basis for revising and refining the e-module in terms of content, presentation, layout, and language use. Thus, the output of the *development* stage was a STEM e-module based on the local wisdom of the Maluku Islands that had been developed, validated, and revised, making it feasible for use in the *implementation* stage, i.e., the trial with PGSD students.



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E. Contoh Integrasi STEM dalam Kearifan Lokal Maluku

Dua contoh berikut dipilih untuk menunjukkan dua bentuk sistem pengetahuan yang berbeda. Sasi Laut mewakili pengelolaan sumber daya berbasis aturan dan keputusan kolektif. Perahu Orembi atau Arumbae mewakili teknologi maritim yang menggabungkan pengetahuan bahan, bentuk, gerak, keseimbangan, dan fungsi sosial. Pembahasan berfokus pada kemungkinan analisis STEM dan pemecahan masalah, bukan pada penyamaan seluruh praktik budaya di Maluku.

a. Sasi Laut sebagai Sistem Pengelolaan Sumber Daya Berkelanjutan

1) Konsep dan Kedudukan Sasi Laut

Sasi pada dasarnya mengatur pembatasan pemanfaatan sumber daya tertentu dalam ruang dan waktu yang ditetapkan. Dalam Sasi Laut, aturan dapat mencakup kawasan, jenis sumber daya, alat yang boleh atau tidak boleh digunakan, masa penutupan, pembungkam, pemanenan, serta pengawasan. Bentuk pelaksanaannya berbeda antarwilayah sehingga penjelasan tentang Sasi Laut harus selalu menyebut konteks lokasi dan sumber informasi. Kajian di Maluku Tengah menjelaskan Sasi Laut sebagai sistem

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e. Chapter content integrating STEM with Maluku local wisdom



f. Learning activities section

Rangkuman

Kearifan lokal merupakan pengetahuan, nilai, keterampilan, aturan, dan cara masyarakat mengambil keputusan berdasarkan pengalaman panjang dalam berinteraksi dengan lingkungan dan kehidupan sosial. Pengetahuan lokal atau *indigenous knowledge* tidak hanya berisi pengamatan empiris, tetapi juga berkaitan dengan bahasa, identitas, sejarah, nilai, spiritualitas, hubungan sosial, dan hak masyarakat atas wilayahnya. Oleh karena itu, kearifan lokal tidak tepat diperlakukan hanya sebagai kumpulan fakta tradisional yang kemudian digantikan oleh penjelasan sains. Pengetahuan lokal dan pengetahuan ilmiah dapat dipertemukan secara dialogis dengan tetap menghargai ruang dan karakter masing-masing.

1. Hubungan Kearifan Lokal, STEM, dan IPAS di Sekolah Dasar

Konteks budaya Maluku dapat menjadi titik awal pembelajaran STEM dan IPAS karena menyedakan fenomena nyata yang dekat dengan kehidupan murid. Sains digunakan untuk menjelaskan fenomena dan mekanisme alam; teknologi berkaitan dengan alat, proses, dan cara kerja yang digunakan masyarakat; rekayasa digunakan untuk merancang atau memperbaiki solusi berdasarkan kriteria dan kendala; sedangkan matematika digunakan untuk mengukur, membandingkan, mengolah data, serta mendukung pengambilan keputusan. Dalam IPAS, integrasi tersebut

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g. Summary section

Latihan

Tulis jawaban dengan bahasa yang jelas dan sistematis. Setiap jawaban harus menunjukkan kemampuan menganalisis hubungan antara kearifan lokal, konsep ilmiah, dan integrasi STEM.

1. Jelaskan perbedaan antara pengetahuan lokal (*indigenous knowledge*) dan pengetahuan ilmiah. Mengapa penjelasan ilmiah tidak boleh digunakan untuk menggantikan seluruh makna budaya suatu praktik masyarakat Maluku?
2. Analisis keterpaduan unsur *Science*, *Technology*, *Engineering*, dan *Mathematics* dalam tradisi Sasi Laut. Berikan masing-masing satu contoh konsep atau keterampilan yang dapat dikembangkan dalam pembelajaran IPAS di SD.
3. Jelaskan proses pengolahan sagu mulai dari penghancuran empulur hingga pengeringan. Identifikasi sedikitnya empat konsep sains yang terdapat dalam proses tersebut dan jelaskan keterkaitannya dengan STEM.
4. Tradisi Timba Laor berkaitan dengan fenomena biologis dan kondisi lingkungan laut. Analisis bagaimana tradisi tersebut dapat dikembangkan menjadi pembelajaran STEM yang aman dan sesuai untuk murid SD tanpa melakukan pengamatan langsung di laut pada malam hari.
5. Pilih salah satu kearifan lokal Maluku yang dibahas dalam bab ini, kemudian rumuskan satu masalah ilmiah yang dapat diselidiki oleh murid SD.

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h. Exercises section



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i. References section

Figure 1 Final Product of the Stem E-Module Based on the Local Wisdom of the Maluku Islands for Pgsd Students (Prospective Elementary School Teachers)

Implementation Stage

The *implementation* stage was carried out after the e-module had gone through validation and revision. At this stage, the STEM e-module based on the local wisdom of the Maluku Islands was applied in actual learning with PGSD students enrolled in the STEM Education course. The implementation stage was aimed at obtaining pretest and posttest data as well as students' responses to the developed product.

The implementation was carried out on 2–5 September 2026 with 41 fifth-semester PGSD students in Class E. Students used the e-module as instructional material during STEM Education learning activities. The use of the e-module was intended to engage students in learning that integrates STEM concepts, scientific literacy, and the local wisdom of the Maluku Islands through contextual activities, problem analysis, investigation, and problem solving.

The implementation activities included administering a pretest to obtain an overview of students' initial scientific literacy, using the e-module in the learning process, administering a posttest, and completing the student response questionnaire. The data obtained at this stage were then used to determine the practicality of the e-module and changes in students' scientific literacy after the learning.

Thus, the outputs of the *implementation* stage consisted of student response data and the scientific literacy pretest and posttest results of 41 fifth-semester PGSD students in Class E. These data were then analyzed in the *evaluation* stage to determine the practicality and effectiveness of the e-module.

Evaluation Stage

The *evaluation* stage was carried out to assess the final quality of the STEM e-module based on the local wisdom of the Maluku Islands after the development and implementation stages. The evaluation focused on three main aspects, namely the validity, practicality, and effectiveness of the e-module.

In terms of validity, the expert assessments showed that the e-module obtained Gregory Index values of 0.86 for content, 0.92 for media, and 0.95 for language. All three values fall into the very high validity category, so the e-module was judged feasible for use in learning.

In terms of practicality, the questionnaire administered to 41 students yielded a total score of 4,406 out of an ideal maximum score of 5,125 (41 respondents, 25 items, highest score of 5), giving a practicality percentage of 85.97%. This percentage falls into the very practical category. Thus, the e-module was judged easy to use and supportive of students' learning process.

The effectiveness of the e-module was analyzed through students' scientific literacy *pretest* and *posttest* results. The analysis showed that the mean *pretest* score was 24.80 (SD = 7.39), while the mean *posttest* score was 69.21 (SD = 5.09). Thus, there was a mean increase of 44.41 points (SD = 8.62) after students participated in learning using the STEM e-module based on the local wisdom of the Maluku Islands. The Shapiro–Wilk normality test on the difference scores yielded $W = 0.933$ with $p = 0.019$, indicating that the data were not normally distributed; therefore, the Wilcoxon *signed-rank* test was used. All 41 students obtained higher *posttest* scores than *pretest* scores. The test results showed a statistically significant difference between *pretest* and *posttest* scores ($Z = -5.58$; $p < 0.001$), with a large effect size of $r = 0.87$.

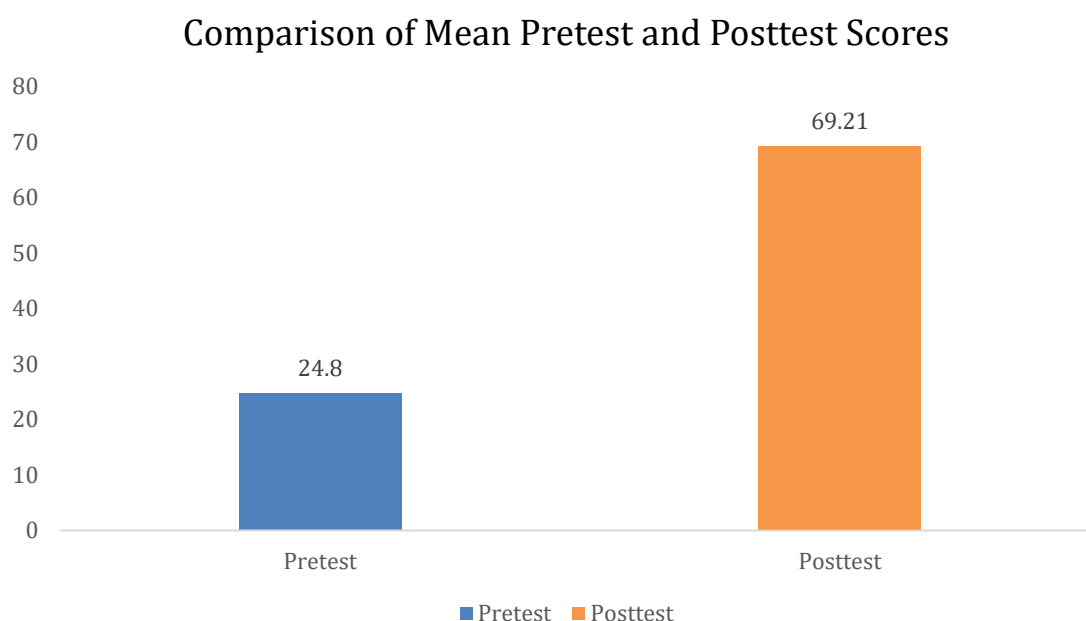


Figure 2 Comparison of Mean Scientific Literacy *Pretest* and *Posttest* Scores

The graph above shows a clear difference between scores before and after using the e-module. The higher mean *posttest* score compared with the *pretest* score indicates that students' scientific literacy scores increased after learning with the e-module. The test items were constructed with Maluku local wisdom stimuli and covered the competencies of explaining phenomena scientifically, evaluating and designing inquiry, and interpreting data and evidence. Thus, the score increase reflects students' improved ability to complete locally contextualized scientific literacy tasks.

The improvement in students' scientific literacy was analyzed using N-Gain, calculated individually for each student with an ideal maximum score of 100 and then averaged to obtain the group N-Gain. Based on the calculation for 41 students, the mean N-Gain was 0.59 (SD = 0.08), ranging from 0.40 to 0.78, which falls into the moderate category. Two students (4.9%) were in the high category, 39 students (95.1%) were in the moderate category, and no students were in the low category. This means that, on average, students achieved about 59% of the maximum possible improvement from their initial ability. A summary of the e-module evaluation results is presented in Table 3.

Table 3 Summary of E-Module Evaluation Results

Evaluation Aspect	Result	Category
Content validity	0.86	Very high
Media validity	0.92	Very high
Language validity	0.95	Very high
Practicality	85.97%	Very practical
Mean pretest	24.80 (SD 7.39)	—
Mean posttest	69.21 (SD 5.09)	Increased
Mean increase	44.41	Increased
Mean N-Gain (ideal maximum score 100)	0.59	Moderate
Wilcoxon test ($r = 0.87$)	$Z = -5.58; p < 0.001$	Significant

Based on the overall evaluation results, the developed STEM e-module based on the local wisdom of the Maluku Islands meets the criteria of validity, practicality, and preliminary effectiveness. The e-module has very high validity in terms of content, media, and language, received practicality responses in the very practical category, and showed a statistically significant improvement in students' scientific literacy ($Z = -5.58$; $p < 0.001$; $r = 0.87$), with a mean N-Gain of 0.59 in the moderate category.

Discussion

The results show that the developed STEM e-module based on the local wisdom of the Maluku Islands is of good quality in terms of validity, practicality, and preliminary effectiveness. Validation using the Gregory Index yielded values of 0.86 for content, 0.92 for media, and 0.95 for language, all of which are in the very high category. The practicality of the e-module reached 85.97%, in the very practical category. In addition, students' mean scientific literacy score increased from 24.80 on the *pretest* to 69.21 on the *posttest*, an increase of 44.41 points that was statistically significant according to the Wilcoxon test ($Z = -5.58$; $p < 0.001$) with a large effect size ($r = 0.87$). The mean N-Gain of 0.59 falls into the moderate category. These findings indicate that the developed product not only meets feasibility standards based on expert judgment, but can also be used in learning and is associated with improved scientific literacy among students after implementation.

The high validity of the e-module indicates that the experts judged the integration of STEM content, scientific literacy, local wisdom, media, and language to be appropriate to the characteristics of PGSD students. Meanwhile, the practicality level of 85.97% indicates that students were able to follow the structure of the content and activities in the e-module well. This result is important because a development product should not only be theoretically feasible but also usable in real learning situations. The systematic presentation of content, illustrations, contextual examples, learning activities, summaries, and exercises contributed to the product's ease of use.

The increase from mean *pretest* to *posttest* scores shows that, after learning with the e-module, students were better able to complete scientific literacy tasks. This improvement is related to the characteristics of the e-module activities, which guide students to identify phenomena, formulate problems, use and interpret data, evaluate evidence, and construct scientific explanations. These activities are consistent with scientific literacy, which emphasizes not only conceptual mastery but also the ability to explain phenomena scientifically, evaluate information or inquiry, and use evidence to draw conclusions.

The integration of local wisdom also provides a context closer to students' lives. In the e-module, Sasi, sago processing, Timba Laor, Baileo, and Orembai or Arumbae are used as sources of phenomena and problems that can be analyzed through the elements of *science, technology, engineering, and mathematics*. The use of these local contexts means that local wisdom is not merely a cultural illustration, but functions as a learning resource for connecting scientific concepts with the everyday practices of communities in the Maluku Islands.

These findings are consistent with previous studies, yet they also reveal differences that clarify the position of this study. [Winangun et al. \(2024\)](#) found a need to develop a case-based Basic Science Concepts e-module in the context of local wisdom for elementary teacher education students. However, that study was a preliminary study focusing on needs analysis and the characteristics of the e-module to be developed; it did not integrate STEM or test improvements in students' scientific literacy. [Rante et al. \(2025\)](#) also showed that

local wisdom-based science learning using *Conceptual Change Texts* can support conceptual change among prospective elementary school teachers. That study focused on conceptual change and the reduction of misconceptions, not on the development of a STEM e-module or scientific literacy.

In the Maluku context, [Buton et al. \(2026\)](#) developed a science e-module based on Maluku local wisdom featuring the contexts of cloves and nutmeg. The product was declared valid and practical and obtained an N-Gain of 0.77, but it was developed for fourth-grade elementary school students with a focus on mastery of science concepts. Meanwhile, [Asshagab & Ledang \(2026\)](#) found that students in Maluku need more contextual learning that supports the use of local phenomena, including boat activities and fishing life, as learning resources. However, that study was a needs analysis for mechanics learning and did not produce an e-module integrating STEM, local wisdom, and scientific literacy.

On the other hand, several studies show that successful integrated STEM learning is not always easy to achieve. The systematic review by [Margot & Kettler \(2019\)](#) identified various barriers faced by teachers in implementing STEM, including pedagogical challenges, curriculum structure and time constraints, concerns about assessment, and lack of support. [Portillo-Blanco et al. \(2024\)](#) also showed that the principles and characteristics of integrated STEM still vary, so its forms of implementation may differ across contexts. In island regions such as Maluku, limited devices, internet connectivity, and electricity, as identified in the analysis stage, may restrict the use of the e-module if it is not accompanied by an offline version. In addition, improvements in learning outcomes when using new media may be influenced by the *novelty effect* and by the accompanying instructional methods, rather than by the medium itself ([Clark, 1983](#)).

Based on this comparison, the novelty of this study can be seen in three aspects. First, contextual novelty, namely the use of various forms of local wisdom of the Maluku Islands as sources of STEM phenomena and problems, rather than merely as cultural information. Second, integrative novelty, namely the combination of STEM, the local wisdom of the Maluku Islands, and scientific literacy in a single e-module. Third, pedagogical novelty, namely that the product was developed specifically for PGSD students as prospective elementary school teachers. Thus, students are not only guided to understand STEM concepts and improve their scientific literacy, but also gain experience in how the potential of local culture and environment can be transformed into learning resources for elementary school pupils.

The study most closely related to this one is [Winangun et al. \(2024\)](#), as both target prospective elementary school teachers and use the context of local wisdom. Nevertheless, there are four fundamental differences. First, in terms of learning design, the e-module of Winangun et al. is case-based for the Basic Science Concepts course, whereas this e-module includes an engineering cycle that requires students to design, build, test, and improve solutions based on data, for example testing boat models to improve their design, so that the elements of technology, engineering, and mathematics are genuinely present in the learning activities. Second, in terms of research stage, Winangun et al. remained at the needs analysis stage, whereas this study has progressed to expert validation, practicality testing, and preliminary effectiveness testing. Third, in terms of measurement, scientific literacy was measured using a test mapped onto three scientific literacy competencies with Maluku local wisdom stimuli, so that the measured outcomes are aligned with the activities in the e-module. Fourth, the e-module contains pedagogical components that train students to analyze Learning Outcomes, formulate objectives, develop assessments, and develop STEM-

based Student Worksheets for elementary schools. This position distinguishes the present study from previous studies, which have mostly focused separately on local wisdom-based e-modules, conceptual change, students' conceptual mastery, or needs analysis.

Thus, the contribution of this study lies not solely in the development of digital instructional materials, but in the effort to transform the local wisdom of the Maluku Islands into a scientific and pedagogical context in elementary teacher education through the STEM approach. The results extend previous findings by showing that an e-module that uses local resources as context can support improvements in students' scientific literacy scores on locally contextualized tasks. Its potential to build students' readiness to develop contextual science learning in elementary schools was not directly measured in this study and requires further investigation, for example through analysis of students' work.

This study has several limitations. First, the effectiveness trial used a one-group *pretest-posttest* design without a comparison group, involving 41 students in a single class. Second, the *pretest* and *posttest* used the same test within a span of about four days. This condition allows for a *testing effect*. Future research is recommended to use a quasi-experimental design with a comparison group, parallel tests or randomized item order in the *pretest* and *posttest*, a longer interval between tests, instructors who are not the product developers, a larger number of validators, and analysis of students' work to strengthen the evidence of the e-module's effectiveness.

Conclusion

Based on the results of the research and development, it can be concluded that the STEM e-module based on the local wisdom of the Maluku Islands was developed through the five stages of the ADDIE model, namely *Analysis*, *Design*, *Development*, *Implementation*, and *Evaluation*. The product was developed by integrating STEM, scientific literacy, the local wisdom of the Maluku Islands, and the elementary school learning context. The practicality and effectiveness trials were conducted with 41 fifth-semester students from Class E of the PGSD Study Program enrolled in the STEM Education course.

The developed e-module has a very high level of validity. The validation results showed Gregory Index values of 0.86 for content, 0.92 for media, and 0.95 for language. In terms of practicality, the responses of 41 students yielded a percentage of 85.97%, in the very practical category. Thus, the e-module was judged feasible and practical for use in STEM Education learning in the trial class.

The e-module demonstrated preliminary effectiveness in supporting the improvement of students' scientific literacy. The mean *pretest* score of 24.80 increased to 69.21 on the *posttest*, an increase of 44.41 points that was statistically significant (Wilcoxon test, $Z = -5.58$; $p < 0.001$; $r = 0.87$). The mean N-Gain of 0.59 falls into the moderate category. These results indicate that the use of the STEM e-module based on the local wisdom of the Maluku Islands can support the improvement of PGSD students' scientific literacy in the trial class.

Statement on the Use of AI

The authors declare that they used ChatGPT, developed by OpenAI, to assist with language editing, improving sentence structure, summarizing, and organizing several parts of the manuscript to make them more systematic and easier to understand. The use of AI did not include scientific decision-making, data collection, data analysis, or drawing

research conclusions. All outputs obtained from the use of AI were reviewed, verified, and adjusted by the authors based on the research data and the scientific sources used. Despite the use of AI, the authors affirm that they are the sole authors of this article and take full responsibility for the accuracy, integrity, and entire content of the manuscript, as recommended by COPE.

Informed Consent

Participants received an explanation of the objectives, procedures, potential risks and benefits of the study, as well as their right to withdraw at any time without consequences. Written consent was obtained from all participants.

Conflict of Interest

The authors declare no conflict of interest.

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