BASA (BAROMETER SAINS)
Jurnal Inovasi Pembelajaran IPA
https://e-journal.unimudasorong.ac.id/index.php/basa/
e-ISSN: 2723-6242

Validity and Practicality of a Papuan Local Wisdom-Based Chemistry E-Module on Colloid Materials

Ardian Hangga Kelana

Universitas Internasional Papua, Jayapura, Indonesia
* Corresponding author: ardianhkelana@iup.ac.id

Article information

Article history:
Received 08/06/2026
Accepted 25/06/2026
Published 30/06/2026

Keywords:
Chemistry e-module;
Papuan local wisdom;
Colloidal systems;
Instructional material Development;
Contextual learning.

ABSTRACT

The integration of local wisdom into digital instructional materials has become an important strategy for promoting contextual and meaningful science learning. However, chemistry learning in many Indonesian secondary schools still relies on conventional teaching materials that rarely incorporate local cultural contexts, resulting in students experiencing difficulties in relating abstract scientific concepts to their daily lives. This study aimed to develop a chemistry e-module based on Papuan local wisdom on the topic of colloidal systems and to evaluate its validity and practicality. The study employed a Research and Development (R&D) approach using the ADDIE (Analysis, Design, Development, Implementation, and Evaluation) model. The developed e-module was validated by subject matter experts and media experts and subsequently implemented through limited-scale and large-scale trials involving students and chemistry teachers at SMA YPK Diaspora Kotaraja Jayapura. The results indicated that the e-module achieved an average validity score of 88% from subject matter experts and 89% from media experts, both categorized as Highly Valid. The practicality evaluation also showed highly positive results, with average scores of 90% in the limited-scale trial, 87% in the large-scale trial, and 83% from teacher responses, indicating that the developed e-module was Highly Practical. The integration of Papuan local wisdom throughout the learning objectives, concept explanations, learning activities, and evaluations enabled students to connect scientific concepts with authentic cultural experiences, thereby supporting more contextual and meaningful chemistry learning. Therefore, the developed chemistry e-module is considered suitable for classroom implementation and has the potential to support culturally responsive chemistry education in Indonesian secondary schools.

DOI: 10.36232/basa.v7i1.6249

How to Cite: Kelana, A. H. (2026). Validity and Practicality of a Papuan Local Wisdom-Based Chemistry E-Module on Colloid Materials. *Basa (Barometer Sains): Jurnal Inovasi Pembelajaran IPA*, *7*(1), 19–34. https://doi.org/10.36232/basa.v7i1.6249

INTRODUCTION

Chemistry education in the 21st century is expected not only to focus on conceptual mastery but also to develop students' critical thinking, problem-solving, creativity, and digital literacy skills. Advances in information technology have transformed the way students acquire, process, and utilize information in the learning process. Therefore, the use of digital technology in learning has become a key strategy for creating a more interactive, flexible, and student-centered learning experience. The OECD (2023), through the framework of the 2022 Programme for International Student Assessment (PISA), emphasizes that students need to be equipped with the ability to access, evaluate, and use information critically as part of 21st-century competencies. In line with this, UNESCO (2023) identifies digital transformation in education as one of the key strategies for improving the quality of learning while preparing students to face the challenges of a digital society.

One way technology is utilized in learning is through the use of digital instructional materials, particularly e-modules. E-modules are electronic teaching materials that integrate various media such as text, images, animations, videos, audio, and interactive exercises into a single learning unit. Compared to printed modules, e-modules offer advantages because they allow students to learn independently, provide immediate feedback, and present abstract concepts through more engaging visualizations. Various studies have shown that the use of e-modules can improve students' learning motivation, independent learning, science literacy, and learning outcomes because they provide a more active and interactive learning experience (Halim et al., 2023; Siregar et al., 2022). Therefore, the development of e-modules is a promising alternative for improving the quality of chemistry education in schools.

Nevertheless, chemistry remains one of the subjects that most students find difficult. The nature of chemistry—which involves many microscopic, symbolic, and abstract concepts—makes it difficult for students to develop a comprehensive conceptual understanding. One topic that exhibits these characteristics is colloidal systems. This topic requires students to understand the relationship between particle properties, formation processes, types of colloids, and their applications in everyday life. If instruction is delivered solely through lectures and textbooks, students tend to memorize concepts without understanding how they relate to real-world phenomena. This results in poor conceptual understanding and underdeveloped ability among students to connect chemistry to their surrounding environment.

One approach considered capable of addressing this issue is integrating local wisdom into chemistry education. Local wisdom refers to the knowledge, values, traditions, and cultural practices that have developed within a community as a result of human interaction with the environment. From an ethoscience perspective, local wisdom can serve as a contextual learning resource that connects scientific concepts with students' real-life experiences. Learning that integrates local wisdom not only enhances conceptual understanding but also strengthens cultural identity, fosters environmental awareness, and makes learning more meaningful because it is closely tied to students' daily lives.

Papua possesses a wealth of culture and natural resources that hold great potential for integration into chemistry education. Various traditional food products, the utilization of local plants, the processing of marine products, and the activities of indigenous communities contain scientific concepts closely related to the topic of colloidal systems. For example, the process of making papeda, processing sago, and preparing various traditional Papuan foods can be explained through the concepts of dispersion, coagulation, and colloidal properties. Thus, integrating Papuan local wisdom into the e-module not only helps students understand chemical concepts more concretely but also enhances their appreciation for local culture as part of the nation's identity.

A number of previous studies have shown that the development of teaching materials based on local wisdom has a positive impact on science learning. Subiyanto and Siregar (2018) reported that a chemistry module based on Papuan local wisdom was able to improve students'

learning outcomes on the periodic table of elements. Research by Siregar et al. (2022) showed that e-modules for chemistry based on Papuan local wisdom covering oxidation-reduction reactions demonstrated very high levels of validity and practicality. Other studies have also reported that integrating ethnoscience into learning can improve students' science literacy, learning motivation, and critical thinking skills (Karubaba et al., 2026; Kelana & Irawan, 2024). These findings indicate that learning that utilizes local cultural contexts holds great potential for improving the quality of science education.

Nevertheless, a review of previous research indicates that most studies still focus on product development or testing the effectiveness of teaching materials based on local wisdom. Research that specifically evaluates the feasibility of products in terms of validity and practicality before widespread implementation remains relatively limited. Furthermore, research on the development of interactive e-modules based on Papuan local wisdom for colloidal systems is still very scarce, even though this subject matter is closely linked to the cultural and environmental phenomena of Papuan society. Consequently, a research gap remains: there are currently no interactive e-modules available that integrate Papuan local wisdom into colloidal systems material and have been tested for validity and practicality as teaching materials for chemistry.

Preliminary observations and interviews with chemistry teachers at YPK Diaspora Kotaraja High School in Jayapura indicate that instruction is still dominated by the use of textbooks and conventional teaching materials. The use of digital teaching materials remains limited, while teaching materials that integrate chemistry concepts with Papuan local wisdom are not yet available. This situation causes students to have difficulty understanding the material on colloidal systems because the concepts they are learning have not been linked to their own experiences or the environment they are familiar with. Therefore, there is a need to develop digital teaching materials capable of integrating chemistry concepts with Papuan local wisdom so that learning becomes more contextual, engaging, and meaningful.

Based on this description, this study aims to analyze the validity and practicality of a chemistry e-module based on Papuan local wisdom regarding colloidal systems. This study is expected to contribute to the development of contextual digital teaching materials, enrich the study of ethnoscience in chemistry education, and serve as an alternative for teachers in implementing instruction that is relevant to students' characteristics and the local environment.

METHOD

This study is a research and development (R&D) project aimed at producing a chemistry e-module based on Papuan local wisdom on the topic of colloidal systems, as well as testing its validity and practicality before implementing it in the classroom. The Research and Development approach was chosen because it not only produces learning materials but also systematically evaluates the quality of those materials through validation and limited pilot testing, thereby ensuring the resulting instructional materials are suitable for use in the learning process (Sugiyono, 2022).

The development model used is ADDIE (Analysis, Design, Development, Implementation, and Evaluation), developed by Branch (2009). The ADDIE model was chosen because it features systematic and flexible development stages and is widely used in research on the development of digital instructional materials. Through these five stages, the developed product can be tailored to user needs while being continuously evaluated before its implementation in the learning process. The stages of the ADDIE development model are shown in Figure 1.

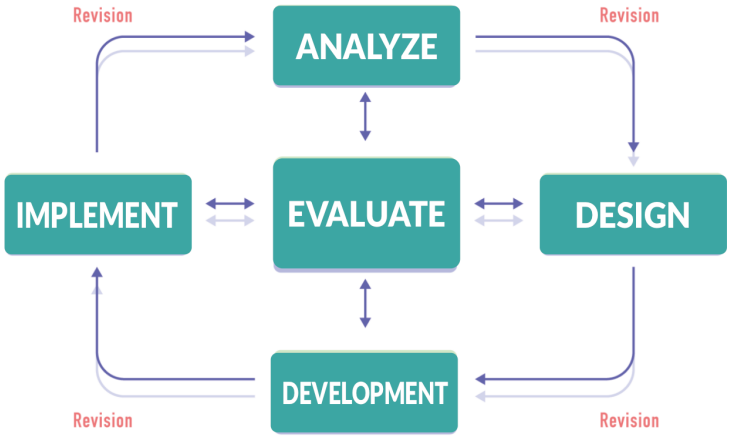

Figure 1. The ADDIE development model

The analysis phase was conducted through an analysis of learning needs, learner characteristics, the curriculum, and the subject matter of colloidal systems. The needs analysis was carried out through observations and interviews with chemistry teachers at YPK Diaspora Kotaraja High School in Jayapura to identify learning challenges and the need for digital instructional materials capable of integrating chemistry concepts with Papuan local wisdom. In addition, an analysis of learning outcomes and the characteristics of colloidal system material was conducted as the basis for developing the e-module content.

The design phase included developing the e-module framework, formulating learning objectives, mapping the material, developing research instruments, and designing the e-module user interface. At this stage, concepts of colloidal systems were integrated with various phenomena drawn from Papua's local wisdom, such as the process of processing sago into papeda, the utilization of local food ingredients, and various community activities related to the concepts of dispersion, emulsion, coagulation, and colloidal properties. This integration aims to provide a more contextual learning experience so that students can more easily connect chemical concepts to their daily lives.

The development phase involved designing and creating e-modules using digital media development software in accordance with the established design. The resulting product includes learning materials, illustrations, contextual images, instructional videos, practice questions, assessments, and learning activities that integrate the concept of colloidal systems with Papuan local wisdom. Next, the product was validated by a team of subject matter experts and media specialists to gather feedback on content, presentation, language, design, and the e-module's usability. The validation results served as the basis for revising the product prior to the implementation phase.

The implementation phase involved a limited pilot test with chemistry teachers and students at YPK Diaspora Kotaraja High School in Jayapura to assess the e-module's practicality. Teachers evaluated the material's relevance, ease of use, feasibility of implementation, and the e-module's effectiveness in the learning process. Meanwhile, students provided feedback on ease of use, clarity of content, visual presentation, and the e-module's effectiveness in helping them understand the concept of colloidal systems.

The evaluation phase was conducted formatively at each stage of development through revisions based on feedback from validators, teachers, and students. The evaluation aimed to ensure that the e-modules met quality criteria before being recommended as supplementary teaching materials for chemistry instruction. The research subjects consisted of two expert validators, one chemistry teacher, and students from the 11th grade at YPK Diaspora Kotaraja High School in Jayapura who participated in the limited pilot test. Subjects were selected

through purposive sampling, taking into account their direct involvement in the product development and pilot testing processes.

The research instruments consisted of a content expert validation sheet, a media expert validation sheet, a teacher response questionnaire, and a student response questionnaire. All instruments were designed using a five-point Likert scale to assess the quality of the e-modules based on content, presentation, language, appearance, and ease of use. The data were analyzed using quantitative descriptive methods, specifically percentages. The validation scores were calculated using the following equation.

$$V = \frac{\sum X}{\sum X_i} \times 100\%$$

V = validity percentage,
$\sum X$ = sum of the scores obtained,
$\sum X_i$ = maximum total score.

Next, the product's validity level was interpreted based on the criteria proposed by Akbar (2013), namely highly valid (85.01–100%), valid (70.01–85.00%), moderately valid (50.01–70.00%), less valid (35.01–50.00%), and invalid (≤35.00%). The practicality analysis was conducted using the same percentage formula and then interpreted based on the practicality categories used in this study. A product was deemed suitable if it met the minimum validity category based on expert validation results and was practical based on the results of trials conducted by teachers and students.

RESULTS AND DISCUSSION

The primary objective of this study was to develop a chemistry e-module based on Papuan local wisdom for the topic of colloidal systems and to evaluate its quality in terms of validity and practicality. The product was developed through the ADDIE model, beginning with needs analysis, instructional design, product development, implementation, and evaluation. The developed e-module integrates scientific concepts with various examples of Papuan local wisdom, enabling students to learn chemistry through contextual phenomena that are closely related to their daily lives. The evaluation of the product involved expert validators, chemistry teachers, and students to determine whether the developed e-module met the criteria of a high-quality digital teaching material. The results of the study are presented in three main sections, namely: (1) the characteristics of the developed e-module, (2) the validity of the e-module, and (3) the practicality of the e-module.

Characteristics of the Developed Chemistry E-Module Based on Papuan Local Wisdom

The main product generated from this research is an interactive chemistry e-module based on Papuan local wisdom for teaching colloidal systems. The e-module was designed to facilitate independent learning by integrating textual explanations, illustrations, contextual images, videos, student worksheets, formative exercises, and evaluation activities into a single digital learning resource. In contrast to conventional instructional materials, the developed e-module systematically incorporates Papuan local wisdom throughout the learning process, allowing students to relate scientific concepts to authentic cultural and environmental phenomena.

The integration of local wisdom was not limited to the presentation of examples but was embedded throughout the instructional design. Several cultural elements, including papeda, barapen (traditional stone cooking), Papuan batik, the Youtefa Red Bridge, and musamus (ant houses), were selected because they represent everyday phenomena that can be scientifically explained through the concepts of colloidal systems. Such contextualization enables students to connect abstract chemistry concepts with familiar experiences while simultaneously fostering appreciation for local culture. This approach is consistent with the principles of

ethnoscience, which emphasize the integration of indigenous knowledge into science learning to make learning more contextual, meaningful, and culturally responsive (Aikenhead & Michell, 2011; Snively & Corsiglia, 2001).

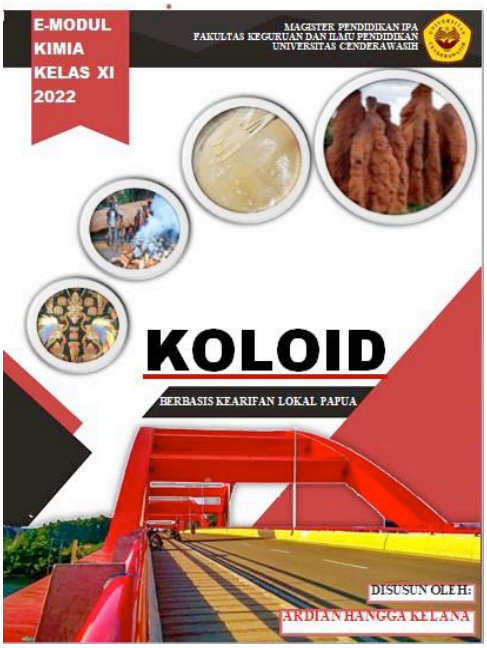

Figure 2. Front Cover of the Developed Chemistry E-Module Based on Papuan Local Wisdom

Figure 2 presents the front cover of the developed chemistry e-module. The cover was designed using Canva and incorporates various visual representations of Papuan local wisdom, including the Youtefa Red Bridge, papeda, Papuan batik motifs, barapen, and musamus. These visual elements were intentionally selected to introduce students to the cultural context embedded throughout the learning materials. Rather than functioning merely as decorative illustrations, the cover serves as an entry point that encourages students to recognize the relationship between chemistry concepts and their local environment from the beginning of the learning process.

The instructional structure of the e-module consists of learning objectives, concept maps, contextual learning materials, illustrations, videos, student worksheets, formative exercises, and evaluation activities. This systematic organization is intended to support students in constructing conceptual understanding independently while providing opportunities to actively engage with contextual scientific problems. According to Mayer (2021), well-designed multimedia learning materials facilitate meaningful learning because information is processed simultaneously through visual and verbal cognitive channels. Therefore, integrating multimedia elements into the e-module is expected to improve students' understanding of colloidal concepts while increasing their learning motivation.

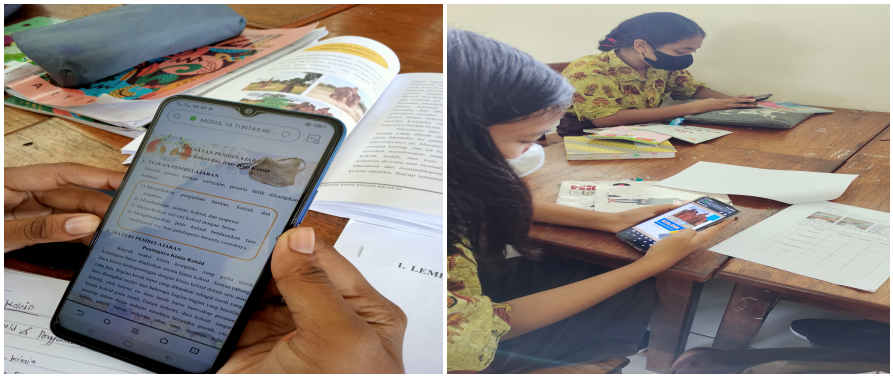

Figure 3. Implementation of the Chemistry E-Module During Classroom Learning

Figure 3 illustrates the implementation of the developed chemistry e-module during classroom learning. Students accessed the e-module individually using smartphones while participating in learning activities on colloidal systems. During the implementation, students explored contextual examples based on Papuan local wisdom, completed learning activities independently and collaboratively, and discussed scientific concepts guided by the learning materials provided in the e-module. This classroom implementation demonstrates that the developed instructional material can be integrated effectively into authentic learning situations.

The classroom implementation also indicates that digital instructional materials can facilitate more student-centered learning. By providing access to contextual information, multimedia resources, and structured learning activities, the e-module encourages students to actively construct knowledge rather than relying solely on teacher explanations. This finding aligns with the constructivist perspective proposed by Piaget (1972) and Vygotsky (1978), which emphasizes that knowledge is constructed through active interaction with learning resources and social environments. Furthermore, the use of contextual examples based on Papuan local wisdom supports meaningful learning because students are able to associate scientific concepts with cultural practices that are already familiar to them.

Another important characteristic of the developed e-module is the systematic integration of local wisdom throughout the instructional components. Unlike many contextual teaching materials that merely use local culture as introductory examples, the present e-module embeds Papuan local wisdom into learning objectives, concept explanations, illustrations, student activities, formative exercises, and evaluation tasks. Consequently, local wisdom functions not only as supporting information but also as the primary learning context through which students develop scientific understanding. This characteristic represents the principal novelty of the developed instructional product.

The development of culturally contextualized digital teaching materials has been widely recognized as an effective strategy for improving science learning because it connects scientific knowledge with students' sociocultural backgrounds. Previous studies have demonstrated that integrating local wisdom into science instruction improves conceptual understanding, learning motivation, and scientific literacy while simultaneously preserving local cultural values (Aikenhead & Michell, 2011; Siregar et al., 2022; Kelana & Irawan, 2024). Therefore, the developed chemistry e-module is expected not only to function as a digital learning resource but also to become a medium for integrating chemistry learning with Papuan cultural identity.

Validity of the Developed Chemistry E-Module Based on Papuan Local Wisdom

Following the development of the chemistry e-module, its theoretical feasibility was evaluated through expert validation involving subject matter experts and media experts. The validation process was conducted to determine whether the developed e-module fulfilled the criteria of quality instructional materials in terms of content accuracy, presentation, language, graphical design, and usability before being implemented in classroom learning. The results of the expert validation are presented in Figure 4 and Figure 5.

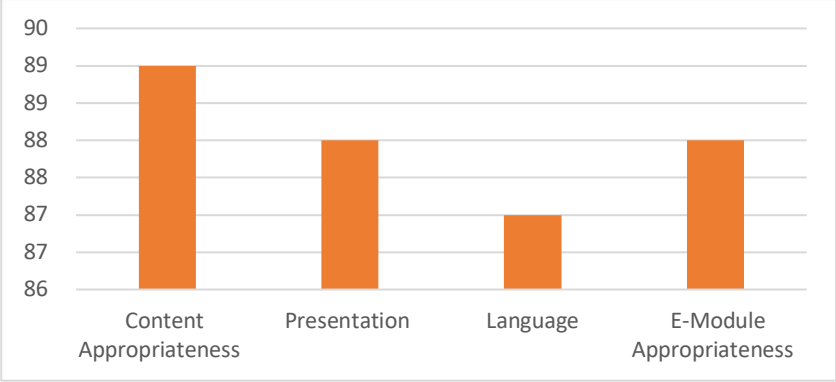

Figure 4. Percentage of Subject Matter Expert Validation Results

Based on Figure 4, the validation conducted by the subject matter experts showed that all assessment aspects achieved percentages ranging from 87% to 89%, with an overall average of 88%, which falls into the Highly Valid category. The content suitability aspect obtained the highest score (89%), followed by the presentation aspect (88%) and the language aspect (87%). These findings indicate that the developed chemistry e-module has fulfilled the essential requirements of instructional materials in terms of scientific accuracy, instructional organization, and language appropriateness.

The high score obtained in the content suitability aspect demonstrates that the learning materials are consistent with the learning objectives and competencies specified in the curriculum. Furthermore, the integration of Papuan local wisdom into colloidal system concepts contributes to the contextual relevance of the instructional materials. Rather than presenting chemistry concepts in an abstract manner, the e-module relates scientific explanations to familiar local phenomena such as papeda, barapen, Papuan batik, the Youtefa Red Bridge, and musamus. This contextualization enables students to associate scientific concepts with authentic experiences, thereby facilitating meaningful conceptual understanding.

These findings are consistent with the theory of Contextual Teaching and Learning (CTL), which states that learning becomes more meaningful when students connect new knowledge with real-life situations (Johnson, 2002). In chemistry education, contextual learning has been shown to improve conceptual understanding because students are able to relate microscopic and symbolic representations of chemistry to observable phenomena in their own environment. Therefore, integrating Papuan local wisdom into the developed e-module represents an effective strategy for contextualizing colloidal system learning.

The presentation aspect, which achieved a score of 88%, indicates that the organization of the learning materials follows systematic instructional principles. The e-module is structured sequentially, beginning with learning objectives, concept maps, contextual explanations, student learning activities, formative exercises, and evaluation tasks. Such organization facilitates students' independent learning while promoting gradual conceptual development. According to Branch (2009), one of the essential characteristics of well-designed instructional materials is the logical sequencing of learning components that enables learners to construct knowledge progressively.

Meanwhile, the language aspect obtained 87%, which is also categorized as Highly Valid. This result indicates that the language used throughout the e-module is communicative, scientifically accurate, and appropriate for senior high school students. The use of clear explanations combined with contextual examples derived from Papuan culture contributes to better readability while maintaining scientific precision. Appropriate language plays an important role in digital instructional materials because it minimizes misconceptions and facilitates students in understanding scientific terminology.

The present findings support previous studies reporting that local wisdom-based instructional materials possess high theoretical feasibility. Siregar et al. (2022) reported that chemistry e-modules integrating Papuan local wisdom achieved excellent validity as instructional materials. Likewise, Kelana and Irawan (2024) demonstrated that integrating Papuan cultural contexts into chemistry learning improved the quality of instructional materials while increasing students' conceptual understanding. Collectively, these studies reinforce the present findings that contextualizing chemistry concepts through local wisdom contributes positively to the quality of instructional materials.

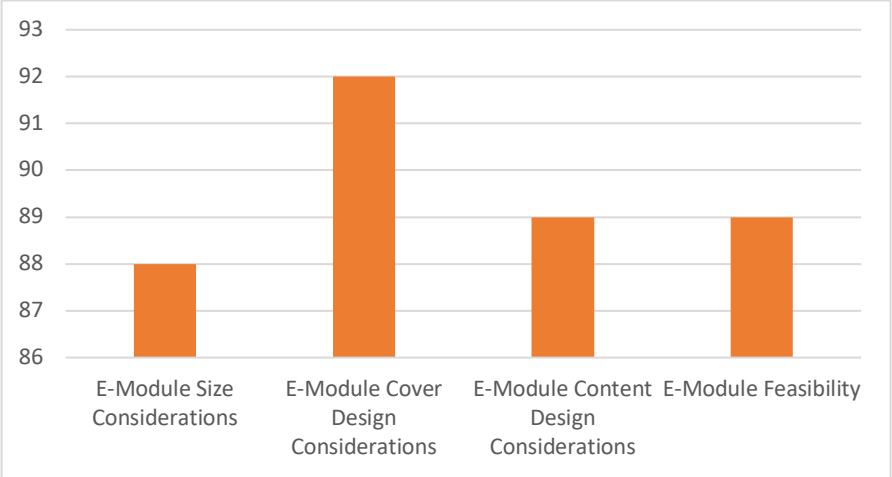

Figure 5. Percentage of Media Expert Validation Results

The media validation results presented in Figure 5 indicate that the developed e-module obtained an average score of 89%, which is categorized as Highly Valid. The assessment results ranged from 88% to 92%, with the highest score achieved in the cover design aspect (92%), followed by content design (89%) and module size (88%). These findings indicate that the visual appearance, layout, and multimedia components of the e-module have met the quality standards expected for digital instructional materials.

The highest score obtained in the cover design reflects the attractiveness of the e-module's visual appearance. The cover incorporates several iconic elements of Papuan local wisdom, including the Youtefa Red Bridge, Papuan batik, papeda, barapen, and musamus, which immediately introduce students to the contextual nature of the learning materials. Such visual representation is important because it establishes students' initial interest while simultaneously communicating the cultural identity embedded within the instructional product.

The content design aspect also achieved a high score (89%), indicating that the arrangement of text, illustrations, typography, color composition, navigation, and multimedia elements effectively supports readability and learning comfort. According to Mayer's Cognitive Theory of Multimedia Learning (Mayer, 2021), students learn more effectively when verbal information is integrated with meaningful visual representations because information is processed simultaneously through visual and auditory cognitive channels. Therefore, the integration of photographs, illustrations, and contextual images of Papuan local wisdom serves not only aesthetic purposes but also facilitates students in constructing conceptual representations of colloidal systems.

From another perspective, the well-organized interface of the developed e-module may also reduce extraneous cognitive load, allowing students to focus more on understanding scientific concepts rather than learning how to operate the instructional media. According to Sweller's Cognitive Load Theory (Sweller et al., 2019), instructional materials should minimize unnecessary cognitive demands by presenting information clearly and systematically. The positive evaluation obtained in the media validation suggests that the developed e-module successfully meets this principle through its consistent layout, intuitive navigation, and balanced multimedia presentation.

Overall, the results of both content and media validation demonstrate that the developed chemistry e-module fulfills the criteria of highly valid instructional materials. More importantly, the validation process confirms that the integration of Papuan local wisdom has been implemented systematically throughout the instructional design, including learning objectives, concept explanations, contextual examples, student activities, exercises, and evaluation tasks. Consequently, the developed e-module not only satisfies academic quality standards but also represents a culturally responsive instructional resource capable of connecting scientific concepts with students' sociocultural experiences. This characteristic

distinguishes the developed e-module from conventional chemistry teaching materials, in which local culture is generally presented only as supplementary examples rather than as an integral component of the learning process.

Practicality of the Developed Chemistry E-Module Based on Papuan Local Wisdom

Following expert validation, the developed chemistry e-module was implemented in classroom learning to evaluate its practicality from the perspectives of students and teachers. Practicality refers to the extent to which an instructional product is easy to use, attractive, understandable, and beneficial for supporting the teaching and learning process. In this study, practicality was evaluated through a limited-scale trial, a large-scale trial involving students, and a teacher response questionnaire after the implementation of the e-module.

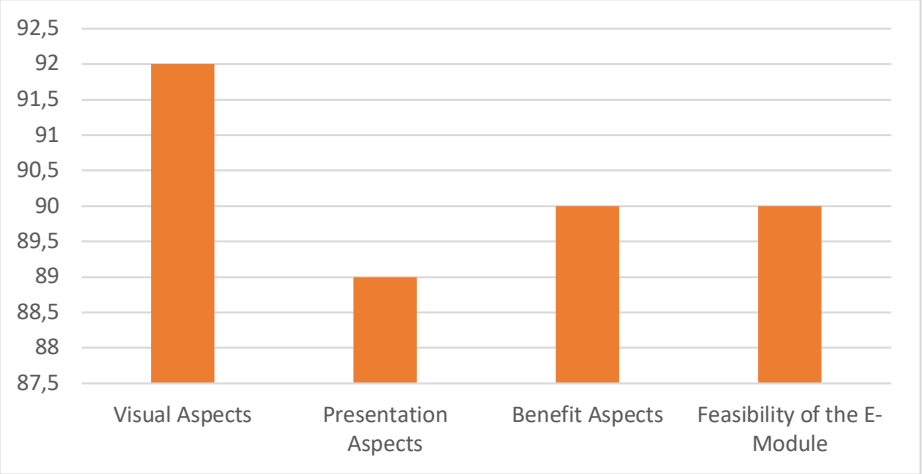

Figure 6. Percentage of Student Responses in the Limited-Scale Trial

The results of the limited-scale trial involving 10 students of Grade XI IPA 2 showed that the developed chemistry e-module obtained an average practicality score of 90%, which falls into the Highly Practical category. The highest score was obtained for the display aspect (92%), followed by the benefit aspect (90%), while the presentation aspect obtained 89%. These results indicate that students responded positively to the visual appearance, instructional organization, and usefulness of the developed e-module in supporting their understanding of colloidal systems.

The high score obtained in the display aspect demonstrates that the visual design of the e-module successfully attracted students' attention. The combination of contextual illustrations, photographs of Papuan local wisdom, color composition, icons, and digital navigation created an attractive learning environment that encouraged students to explore the instructional materials independently. According to Keller's ARCS Motivation Model (Keller, 2010), attractive instructional design contributes to the attention component of learning motivation, which is essential for sustaining students' engagement throughout the learning process. Therefore, the positive response toward the display indicates that the visual appearance of the e-module successfully stimulated students' interest in learning chemistry.

The benefit aspect, which achieved a score of 90%, indicates that students perceived the e-module as helpful in understanding colloidal concepts. Integrating Papuan local wisdom into chemistry learning enabled students to relate scientific explanations to familiar cultural phenomena, thereby reducing the abstract nature of colloidal systems. This finding supports the principles of meaningful learning theory proposed by Ausubel (2000), which states that learning becomes more effective when new knowledge is connected to learners' prior experiences and existing cognitive structures.

Similarly, the high score obtained in the presentation aspect (89%) indicates that the instructional sequence facilitated students' independent learning. Learning objectives, concept explanations, contextual examples, student activities, and formative exercises were organized

systematically, allowing students to study according to their own learning pace. Such characteristics are essential features of digital instructional materials because they encourage self-directed learning while reducing students' dependence on teacher explanations.

After revisions were made based on the limited-scale trial, the e-module was subsequently implemented in a large-scale trial involving 30 students of Grade XI IPA 1.

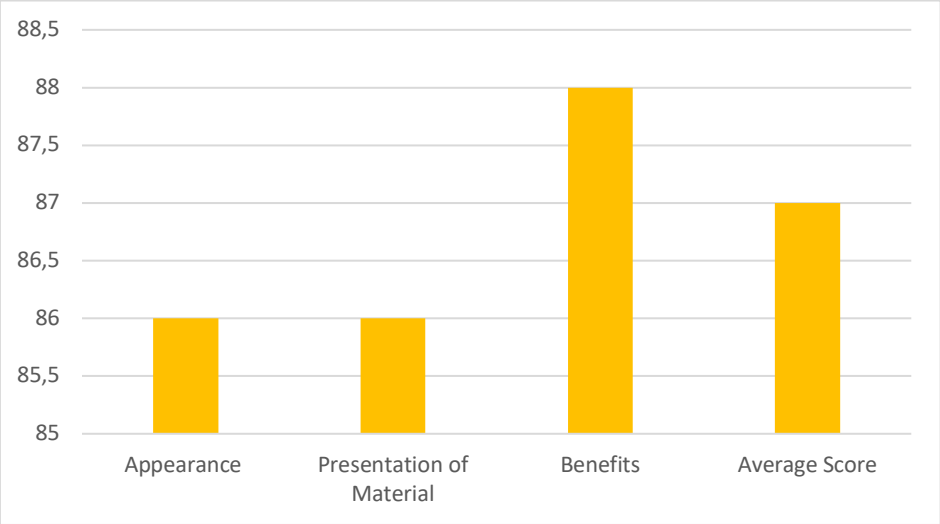

Figure 7. Percentage of Student Responses in the Large-Scale Trial

The results of the large-scale trial showed that the developed e-module obtained an average practicality score of 87%, which is also categorized as Highly Practical. The benefit aspect received the highest score (88%), whereas both the display and presentation aspects obtained 86%. Although the average practicality score in the large-scale trial was slightly lower than that of the limited-scale trial, all assessed aspects remained within the Highly Practical category. This finding indicates that the developed e-module consistently maintained its quality when implemented in a larger learning environment involving students with more diverse academic backgrounds and learning characteristics. Such consistency demonstrates that the developed instructional material possesses good usability and can be implemented effectively under authentic classroom conditions.

The consistently high responses from students suggest that the developed e-module fulfills three essential characteristics of quality digital instructional materials, namely ease of navigation, clarity of instructional content, and meaningful contextualization. Students were able to operate the e-module independently, understand the learning materials, and connect scientific concepts with examples derived from Papuan local wisdom. These characteristics contribute significantly to students' learning autonomy while promoting active participation during classroom learning.

The findings are consistent with previous studies indicating that digital teaching materials integrating local wisdom improve students' motivation and engagement because learning becomes more contextual and relevant to their sociocultural environment (Siregar et al., 2022; Illahi & Rachmadyanti, 2023). Consequently, the developed e-module can be considered an effective digital learning resource that supports independent and meaningful chemistry learning.

Practicality was also evaluated from the perspective of the chemistry teacher as the primary user responsible for implementing the instructional materials in classroom learning.

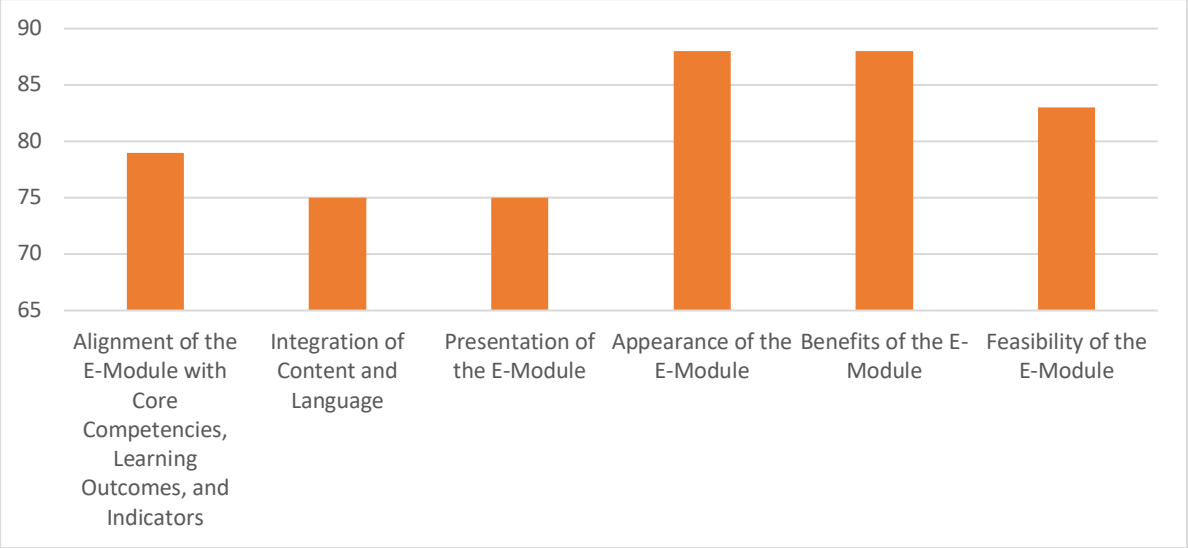

Figure 8. Percentage of Teacher Responses toward the Developed Chemistry E-Module

Based on Figure 8, the teacher response questionnaire yielded an average practicality score of 83%, which is categorized as Highly Practical. The highest scores were obtained in the display and benefit aspects (88%), followed by the alignment with learning objectives and competencies (79%), while the content organization, language, and presentation obtained 75%. The teacher's positive evaluation indicates that the developed e-module is appropriate for classroom implementation because it supports instructional delivery through contextual learning materials and interactive multimedia. The teacher also considered that integrating Papuan local wisdom into colloidal system learning increased the relevance of chemistry instruction by connecting scientific concepts with students' everyday experiences.

Although the content organization, language, and presentation aspects obtained relatively lower scores compared with the other aspects, they remained within the practical category. These findings provide constructive feedback for further refinement of the instructional product while simultaneously indicating that the developed e-module already meets the minimum quality standards required for classroom implementation.

Overall, the practicality evaluation demonstrates that the developed chemistry e-module received highly positive responses from both students and teachers. The consistently high practicality scores obtained across limited-scale trials, large-scale trials, and teacher evaluations indicate that the e-module is easy to use, attractive, understandable, and beneficial for supporting chemistry learning. More importantly, the integration of Papuan local wisdom throughout the instructional materials contributes to students' learning engagement by presenting chemistry concepts within authentic cultural contexts that are familiar to learners.

The present findings reinforce previous studies reporting that contextual digital instructional materials improve learning quality because they simultaneously enhance conceptual understanding, student motivation, and cultural relevance (Siregar et al., 2022; Kelana & Irawan, 2024). Therefore, the developed chemistry e-module demonstrates not only high theoretical validity but also strong empirical practicality, indicating that it is suitable for broader implementation in chemistry learning.

Finally, the combination of high validity and high practicality confirms that the developed instructional product fulfills the two fundamental quality criteria of educational product development. High validity indicates that the product is theoretically appropriate, whereas high practicality demonstrates that it can be implemented effectively in authentic classroom settings. Accordingly, the developed chemistry e-module provides a strong foundation for future studies evaluating its effectiveness in improving students' conceptual understanding, scientific literacy, critical thinking skills, and appreciation of Papuan local wisdom.

Educational Implications of the Developed Chemistry E-Module Based on Papuan Local Wisdom

The findings of this study have several important implications for chemistry education, particularly in the development of contextual digital instructional materials. The high validity and practicality achieved by the developed e-module indicate that integrating Papuan local wisdom into chemistry learning is not only theoretically appropriate but also feasible for implementation in authentic classroom settings. This finding suggests that local cultural contexts can be systematically incorporated into digital teaching materials without reducing the scientific accuracy of chemistry concepts. On the contrary, contextualization through local wisdom enriches the learning experience by connecting abstract scientific knowledge with students' everyday lives.

From a pedagogical perspective, the developed e-module supports the implementation of student-centered learning, where students actively construct conceptual understanding through exploration of contextual learning materials rather than relying solely on teacher explanations. The integration of images, contextual examples, multimedia resources, formative exercises, and evaluation activities provides opportunities for students to learn independently while engaging in meaningful learning experiences. Such learning characteristics are consistent with constructivist principles, which emphasize that knowledge is developed through active interaction between learners and their learning environment (Piaget, 1972; Vygotsky, 1978).

Another important implication relates to the preservation of local culture through science education. In many classrooms, chemistry is often perceived as a collection of abstract concepts disconnected from students' daily experiences. The present study demonstrates that local wisdom can function as an authentic learning context through which scientific concepts become more relevant and understandable. By integrating Papuan cultural practices, traditional foods, indigenous architecture, and local environmental phenomena into chemistry learning, the developed e-module simultaneously strengthens students' conceptual understanding and appreciation of their cultural heritage. This finding supports previous research emphasizing that ethnoscience-based instruction contributes not only to scientific literacy but also to cultural identity and environmental awareness (Aikenhead & Michell, 2011; Snively & Corsiglia, 2001).

The developed e-module also contributes to the growing implementation of digital learning in Indonesian secondary education. Digital instructional materials are increasingly required to support independent learning and flexible access to learning resources. The present study demonstrates that well-designed digital teaching materials integrating multimedia and local wisdom can improve learning quality while remaining culturally relevant. Consequently, the developed e-module may serve as an alternative instructional resource for chemistry teachers seeking to implement contextual and technology-enhanced learning in accordance with the demands of twenty-first-century education.

An important contribution of this study lies in its systematic integration of Papuan local wisdom throughout the instructional design. Unlike many previous instructional materials that introduce local culture merely as supplementary examples, the developed e-module embeds local wisdom into learning objectives, concept explanations, student activities, formative assessments, and evaluation tasks. Therefore, local wisdom functions as the primary context for conceptual learning rather than simply enriching the visual appearance of instructional materials. This characteristic represents the principal novelty of the developed e-module and distinguishes it from previous local wisdom-based chemistry teaching materials.

Despite these positive findings, this study has several limitations. The product evaluation focused primarily on validity and practicality and has not yet examined the effectiveness of the developed e-module in improving students' conceptual understanding, scientific literacy, critical thinking skills, or higher-order thinking skills through experimental implementation. Furthermore, the implementation was conducted in a single school, limiting the generalizability

of the findings to broader educational contexts. Therefore, future studies are recommended to investigate the effectiveness of the developed e-module through quasi-experimental or experimental research involving larger and more diverse student populations.

Overall, the findings demonstrate that the chemistry e-module based on Papuan local wisdom possesses considerable potential to support contextual chemistry learning in Indonesian secondary schools. By integrating local cultural knowledge with digital instructional technology, the developed e-module contributes not only to improving instructional quality but also to promoting culturally responsive science education that is relevant to students' sociocultural backgrounds.

CONCLUSION

This study successfully developed a chemistry e-module based on Papuan local wisdom for the topic of colloidal systems using the ADDIE development model. The developed e-module integrates scientific concepts with various elements of Papuan local wisdom, including traditional foods, cultural practices, local architecture, and environmental phenomena, thereby providing contextual learning experiences that connect chemistry concepts with students' daily lives. The results of expert validation indicate that the e-module achieved a Highly Valid category in both content and media aspects, demonstrating that the instructional material meets the academic, instructional, and visual quality standards required for classroom implementation. Furthermore, the practicality evaluation conducted through limited-scale trials, large-scale trials, and teacher responses consistently showed that the developed e-module falls within the Highly Practical category, indicating that it is easy to use, attractive, and beneficial for supporting chemistry learning.

The findings of this study confirm that integrating Papuan local wisdom into digital instructional materials not only enhances the contextual relevance of chemistry learning but also contributes to the development of culturally responsive science education. Unlike conventional chemistry teaching materials that generally present local culture only as supplementary examples, the developed e-module systematically embeds Papuan local wisdom throughout the learning objectives, concept explanations, student learning activities, formative exercises, and evaluation tasks. This characteristic represents the principal contribution of the present study by demonstrating that local wisdom can function as an authentic learning context while maintaining scientific accuracy and instructional quality. Therefore, the developed e-module has considerable potential to support more meaningful, contextual, and culturally relevant chemistry learning in Indonesian secondary schools.

Although the developed product has demonstrated high validity and practicality, this study was limited to product development and preliminary implementation. Therefore, future research is recommended to examine the effectiveness of the developed e-module in improving students' conceptual understanding, scientific literacy, higher-order thinking skills, learning motivation, and appreciation of local culture through experimental or quasi-experimental research involving broader educational settings.

REFERENCES

Aikenhead, G. S., & Michell, H. (2011). Bridging cultures: Indigenous and scientific ways of knowing nature. Pearson.

Akbar, S. (2013). Instrumen perangkat pembelajaran. PT Remaja Rosdakarya.

Arianto, E., Kelana, A. H., Almafahir, A., & Solehah, S. I. (2026). Kepemimpinan strategis dalam transformasi kurikulum STEM: Mengelola inovasi pembelajaran sains di era digital. Goresan Pena.

Ausubel, D. P. (2000). The acquisition and retention of knowledge: A cognitive view. Kluwer Academic Publishers.

Branch, R. M. (2009). *Instructional design: The ADDIE approach*. Springer. https://doi.org/10.1007/978-0-387-09506-6

Fadillah, M. R., Nafsani, S. Z., Pratama, K., Ramlan, A. M., & Kelana, A. H. (2026). Pemanfaatan teknologi pendidikan berbasis media digital dalam penguatan karakter religius siswa di MTs Darul Ulum. *BATARA: Journal of Learning Technology and Digital Society, 1*(1), 50–59.

Hidayah, N., Sumarno, & Dwijayanti, I. (2023). Analisis bahan ajar terhadap kebutuhan guru dan peserta didik. *Jurnal Ilmiah Pendidikan Dasar*, 128–142.

Hilmy, M., Tyas, I. C., & Ratri, A. A. (2023). Pengembangan modul berbasis kearifan lokal budaya masyarakat Osing Banyuwangi pada mata kuliah Ilmu Sosial Budaya di Politeknik Negeri Banyuwangi. *Didaktis: Jurnal Pendidikan dan Ilmu Pengetahuan*, 23(2), 196–203.

Illahi, A. P. N., & Rachmadyanti, P. (2023). Pengembangan e-modul IPS berbasis kearifan lokal Kabupaten Jombang bagi siswa kelas V SD. *Jurnal Penelitian Pendidikan Guru Sekolah Dasar, 11*(7).

Irawan, S., Kopeuw, A. J., Daullu, M. A., Haay, H. A., & Yoku, R. (2025). Pengenalan sains (matematika) dalam seni rupa Papua bersama anak-anak Sekolah Dasar Rumah Baca Ayapo: Pengabdian. *Jurnal Pengabdian Masyarakat dan Riset Pendidikan, 4*(2), 7547–7552. https://doi.org/10.31004/jerkin.v4i2.2880

Jannah, Kaspul, & Utami, N. H. (2022). Kepraktisan modul elektronik menggunakan aplikasi Sigil berorientasi pendekatan saintifik materi perubahan lingkungan kelas X jenjang sekolah menengah atas. *Jurnal Al-Azhar Indonesia Seri Sains dan Teknologi, 8*(2), 155–160. https://doi.org/10.36722/sst.v8i2.1318

Johnson, E. B. (2002). Contextual teaching and learning: What it is and why it is here to stay. Corwin Press.

Karubaba, M., Kelana, A. H., Irawan, S., Inggamer, M. M., & Kopeuw, A. J. (2026). Peningkatan keterampilan proses sains: Implementasi e-modul kimia materi redoks berbasis budaya Papua. *JagoMIPA: Jurnal Pendidikan Matematika dan IPA, 6*(2), 737–748. https://doi.org/10.53299/jagomipa.v6i2.4282

Kelana, A. H. (2026). *Pembelajaran IPAS sekolah dasar berbasis kearifan lokal*. CV Eureka Media Aksara.

Kelana, A. H., & Irawan, S. (2024). Pengembangan e-modul pembelajaran kimia pada materi koloid berbasis kearifan lokal Papua untuk meningkatkan hasil belajar peserta didik. *Journal of Innovation Research and Knowledge, 4*(7), 4365–4374. https://doi.org/10.53625/jirk.v4i7.9074

Kelana, A. H., Fadhli, Y. D., Irawan, S., Tabuni, N., & Karubaba, M. (2025). Integrasi etnosains pinang dalam pembelajaran IPAS sekolah dasar sebagai upaya penguatan literasi sains berbasis budaya Papua. *Pendas: Jurnal Ilmiah Pendidikan Dasar, 10*(4), 180–193. https://doi.org/10.23969/jp.v11i01.38617

Kelana, A. H., Irawan, S., Karubaba, M., Sahar, A., & Daullu, M. A. (2025). Peningkatan keterampilan berpikir kritis peserta didik dengan menggunakan e-modul kimia pada materi koloid berbasis kearifan lokal Papua. *SCIENCE: Jurnal Inovasi Pendidikan Matematika dan IPA, 5*(1), 312–320. https://doi.org/10.51878/science.v5i1.4578

Keller, J. M. (2010). *Motivational design for learning and performance: The ARCS model approach*. Springer.

Maktum, R., Tahir, M., & Dewi, N. K. (2025). Pengembangan modul pembelajaran berbasis kearifan lokal suku Sasak pada materi IPAS kelas IV di SDN 27 Cakranegara. *Pendas: Jurnal Ilmiah Pendidikan Dasar, 10*(2), 221–233. https://doi.org/10.30743/pendas.v10i2.7628

Mayer, R. E. (2021). *Multimedia learning* (3rd ed.). Cambridge University Press.

OECD. (2023). PISA 2022 assessment and analytical framework. OECD Publishing.

Oktaviana, et al. (2017). Pengembangan modul fisika berintegrasi kearifan lokal membuat minyak lala untuk melatih karakter sanggam. *Berkala Ilmiah Pendidikan Fisika, 5*(3), 271–285. https://doi.org/10.20527/bipf.v5i3.4103

Piaget, J. (1972). The psychology of the child. Basic Books.

Pinantih, S. A., & Putra, D. K. (2021). Pengembangan media komik digital berbasis pendekatan saintifik pada muatan IPA. *Jurnal Penelitian dan Pengembangan Pendidikan, 5*(1), 115–121.

Riduwan. (2012). Skala pengukuran variabel-variabel penelitian. Alfabeta.

Saputro, B. (2021). Best practices penelitian pengembangan (Research and Development) bidang manajemen pendidikan IPA. Academia Publication.

Siregar, T., Karubaba, M., Siallagan, J., & Inggamer, M. M. (2022). Development of chemical e-modules based on Papua local wisdom on reduction and oxidation reaction materials to increase student learning outcomes. *Jurnal Ilmu Pendidikan Indonesia, 10*(3), 118–128. https://doi.org/10.31957/jipi.v10i3.2409

Snively, G., & Corsiglia, J. (2001). Discovering indigenous science: Implications for science education. *Science Education, 85*(1), 6–34. https://doi.org/10.1002/1098-237X(200101)85:1<6::AID-SCE3>3.0.CO;2-R

Subiyanto, S., & Siregar, T. (2018). Pengembangan modul pembelajaran kimia pada materi sistem periodik unsur berbasis kearifan lokal Papua peserta didik kelas X SMA Negeri 4 Jayapura. *Jurnal Ilmu Pendidikan Indonesia, 6*(3), 71–82. https://doi.org/10.31957/jipi.v6i3.604

Sugihartini, N., Putrama, I. M., & Sunarya, I. M. G. (2017). Pengembangan e-modul mata kuliah strategi pembelajaran. *Jurnal Pendidikan Teknologi dan Kejuruan, 14*(2), 221–230.

Sugiyono. (2022). *Metode penelitian kuantitatif, kualitatif, dan R&D*. Alfabeta.

Sugrah, N., Saraha, A. R., & Djumat, H. H. (2017). Pengaruh model pembelajaran problem based learning (PBL) terhadap keterampilan berpikir kritis peserta didik kelas XI IPA SMA Negeri 4 Kota Ternate. *Jurnal Saintifik@MIPA, 1*(1), 20–25.

Sulistyowati, R. W., Harmawati, D., & Kelana, A. H. (2025). Analisis kompetensi profesional guru PAUD dalam pengajaran sains di Distrik Merauke. *Jurnal Pendidikan Indonesia: Teori, Penelitian, dan Inovasi, 5*(2). https://doi.org/10.59818/jpi.v5i2

Sweller, J., Ayres, P., & Kalyuga, S. (2019). Cognitive load theory. Springer.

Undang-Undang Republik Indonesia Nomor 20 Tahun 2003 tentang Sistem Pendidikan Nasional.

UNESCO. (2023). Global education monitoring report 2023. UNESCO.

Vygotsky, L. S. (1978). Mind in society: The development of higher psychological processes. Harvard University Press.

Wagiran. (2012). Pengembangan karakter berbasis kearifan lokal *Hamemayu Hayuning Bawana* (Identifikasi nilai-nilai karakter berbasis budaya). *Jurnal Pendidikan Karakter*, 2(3), 329–339.

Wati, D. K., Saragih, S., & Murni, A. (2022). Kevalidan dan kepraktisan bahan ajar matematika berbantuan FlipHTML5 untuk memfasilitasi kemampuan pemahaman siswa kelas VIII SMP/MTs pada materi koordinat Kartesius. *Journal of Research in Mathematics Learning, 5*(2), 177–188. https://doi.org/10.33474/jrml.v5i2.12897