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Development of Chemistry Module Using Dick and Carey Models Integrated with *Melala* Local Wisdom Assisted by Augmented Reality

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Abstract
This study aimed to develop a chemistry module that integrates *Melala* local wisdom and is enhanced by augmented reality (AR) technology. The development process followed the Dick and Carey model, comprising ten stages ranging from identifying instructional goals to designing and conducting summative evaluations. A limited-scale trial was conducted during the "Design and Conduct Formative Evaluation of Instruction" phase. Three types of assessments were performed: a validity test using Aiken's V, a reliability test, a practicality test using a practicality percentage formula, and an effectiveness test using N-gain to measure improvements in students' scientific literacy and scientific creativity. The results indicated that the teaching module, chemistry module, AR media, student worksheets (LKPD), and assessment instruments were valid, with values ranging from 0.80 to 0.85. Reliability testing showed that all instruments achieved a Percentage of Agreement (PA) above 75%, confirming their reliability. Practicality testing involved two groups: students and chemistry teachers. Analysis revealed that the *Melala* local wisdom-based, AR-enhanced module was practical to use, with a student practicality score exceeding 90%. Similarly, the practicality score from chemistry teachers reached 90%. Finally, effectiveness testing demonstrated a moderate improvement in students' scientific literacy and scientific creativity, with an average N-gain exceeding 0.30. This development offers significant benefits for school chemistry teachers, as the module enables chemistry concepts to be linked to local culture while enhancing students' scientific literacy and creativity.

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Introduction

Chemistry learning plays a crucial role in shaping students' ability to understand natural phenomena through a scientific approach. Learning chemistry requires not only mastery of concepts, principles, and theories but also the development of 21st-century critical thinking skills (Guo & Woulfin, 2016; Jusuf et al., 2020). The learning process needs to be designed so that students can construct knowledge meaningfully through contextual learning. Contextual learning is believed to improve conceptual understanding, strengthen knowledge transfer, and foster motivation to learn. Contextual chemistry learning is an important approach to achieving meaningful, applicable learning that develops student competencies. However, the implementation of conceptual learning in schools still faces various obstacles.

The characteristics of chemical materials, which include macroscopic, microscopic, and symbolic representations, often cause students to have difficulty understanding the

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relationships among concepts (Ikhsan et al., 2025). These difficulties can become more complex when constructing concepts based on phenomena that are close to their lives (Nuraini et al., 2025). Limitations in linking chemical concepts to everyday life can cause students to view chemistry as an abstract and less relevant subject (Suparya et al., 2022). This situation results in a shallow understanding of concepts, difficulty applying knowledge in new situations, and low student engagement in the learning process. A learning approach that bridges abstract chemical concepts and real-world phenomena is necessary for students to develop a more meaningful and applicable understanding (Winangun, 2024). One way to link chemistry learning with local wisdom.

Local wisdom encompasses various community activities, knowledge, and practices that are closely related to students' lives and can be studied scientifically. In this context, local wisdom *Neck* has the potential to be integrated into chemistry learning, as the processes and phenomena it encompasses can be linked to relevant chemical concepts (Sapitri et al., 2020). Integrating *Melala* as a learning context can provide opportunities for students to understand chemical concepts (Fitriah et al., 2025). Students understand abstract concepts and, through integration, can grasp authentic phenomena that are close to their socio-cultural environment. In addition to using local wisdom as a learning context, the abstract nature of chemical concepts also requires technological support to help students visualize phenomena at the submicroscopic level (Sura et al., 2026; Syahda & Deta, 2023).

The technology with potential for use is Augmented Reality (AR), which allows two- or three-dimensional virtual objects to be displayed and integrated with the real environment interactively (Abdinejad et al., 2020). AR can be used to represent concepts that are difficult to observe directly, such as molecular structure and geometry, particle interactions, and submicroscopic changes. These visualizations can help bridge the gap between macroscopic, submicroscopic, and symbolic representations (Kesim & Ozarslan, 2012). The integration of AR with the context of *Melala*'s local wisdom has the potential to provide a learning experience that is not only contextual but also interactive and visual. The use of AR can serve as an alternative for supporting chemistry learning by connecting local phenomena to scientific representations of underlying chemical concepts (Keller et al., 2021).

Several studies on the development of local wisdom-based teaching materials have shown positive impacts on the learning process (Wahyudi et al., 2025). This study shows that electronic modules based on local wisdom can improve students' cultural literacy and critical thinking skills (Hastuti et al., 2020). Developed science learning tools based on local wisdom have been proven effective in improving students' scientific literacy. Research (Winangun, 2024) also showed that case-based e-modules and local wisdom can increase learning interactivity, as well as critical thinking and problem-solving skills. Other research shows that learning media that integrate science with local wisdom can improve students' science process skills and scientific attitudes (Wilujeng, 2019).

Given the potential of *Melala* local wisdom and Augmented Reality (AR), teaching materials are needed to systematically integrate the two into chemistry learning. One alternative to develop is an AR-assisted chemistry module integrated with *Melala* local wisdom (Tarng et al., 2022). This module is designed to link the phenomena and processes found in *Melala* to relevant chemical concepts. AR visualizations are used to represent abstract aspects of chemistry, particularly at the submicroscopic level (Cai et al., 2014; Irwansyah et al., 2020; Liu et al., 2023; Mitchell et al., 2017). The teaching module is a learning resource that guides students in exploring phenomena, constructing concepts, and applying chemical knowledge in

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authentic contexts (Nechypurenko, et. al., 2018). Producing a systematic, integrated chemistry module based on *Melala* local wisdom using Augmented Reality (AR) requires a development model that can guide each design stage in a structured manner.

One model that can be used is Dick and Carey's model, which views learning as a system of interrelated components. This model emphasizes the development process, starting from identifying learning objectives, analyzing learning and student characteristics, formulating learning objectives, developing assessment instruments, developing learning strategies, developing and selecting teaching materials, and implementing evaluation and revision (Dick Walter & Carey Lou, 1985). The characteristics of the Dick and Carey model are relevant to developing chemistry modules because they enable the integration of *Melala*'s local-wisdom context, chemical concept representation, and AR technology, designed in a targeted manner based on students' goals and needs. Through systematic and evaluative development stages, the resulting module is expected to demonstrate adequate feasibility and practicality and to support a contextual, interactive, and meaningful chemistry learning process.

Based on the identified problems and potential solutions, this study aims to develop a chemistry learning module integrating *Melala* local wisdom, Problem-Based Learning (PBL), and Augmented Reality (AR) using the Dick and Carey instructional development model, and to evaluate its validity, practicality, and effectiveness in supporting students' scientific literacy and scientific creativity. The novelty of this study lies in the systematic transformation of authentic chemical phenomena embedded in the *Melala* tradition into contextual scientific problems and interactive learning activities. Unlike conventional local-wisdom-based learning materials that primarily present cultural knowledge as contextual information, the proposed module positions *Melala* practices as a foundation for scientific inquiry, problem-solving, and the interpretation of chemical phenomena through macroscopic, submicroscopic, and symbolic representations, all supported by AR. This approach is expected to provide empirical insights into how culturally contextualised learning and molecular visualisation can complement each other in chemistry education. Furthermore, the study examines not only the overall effectiveness of the developed module but also variations across scientific creativity indicators, including the limited improvement in originality, to identify aspects of learning that require further instructional support. The findings are expected to contribute to the development of culturally responsive chemistry learning while providing practical guidance for designing contextual, interactive, and scientifically meaningful learning experiences.

Research Method

Types of Research

The Research and Development (R&D) method uses the Dick and Carey model, a systematic and procedural learning development model designed to produce valid, practical, and effective learning products. This model outlines the stages of Instructional System Development (ISD): analysis, design, development, implementation, and evaluation.

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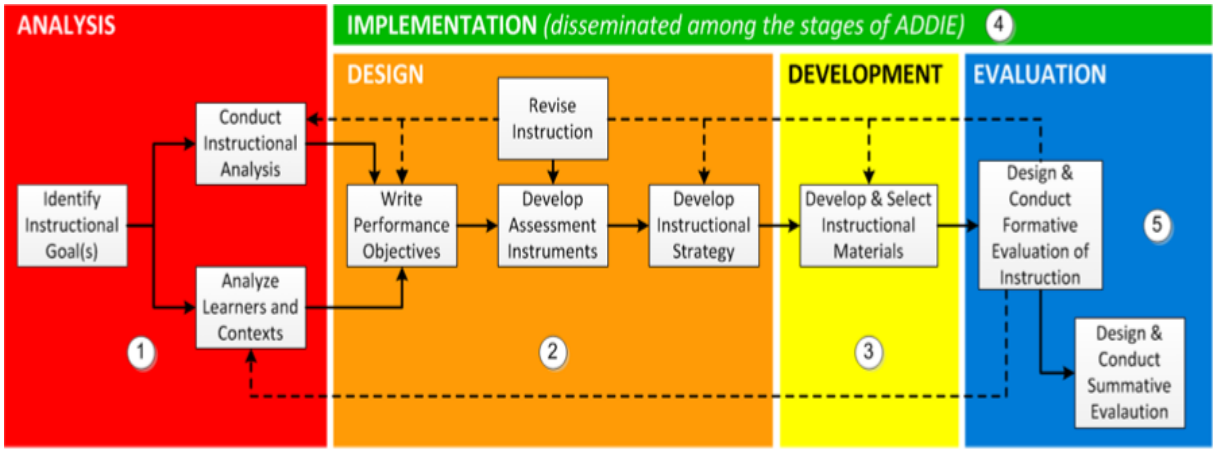


Figure1. Steps Dick and Carey Model

Population and Sample

The population of this study was 12th-grade students of SMAN 3 Sumbawa Besar. The limited-scale trial sample consisted of one class, namely class 12 IPA 1, which had received material on reaction rate factors and was familiar with the *Melala* tradition. SMAN 3 Sumbawa Besar is one of the schools that preserves the *Melala* culture by continuously introducing it to students. This class was deemed suitable for use in the limited-scale trial.

Research Procedures

This study adopted the Dick and Carey instructional design model as a framework for developing the *Melala* local-wisdom-based chemistry learning module integrated with Augmented Reality (AR). The development process was implemented through nine stages, including identifying instructional goals, conducting instructional analysis, analyzing learners and learning contexts, writing performance objectives, developing assessment instruments, developing instructional strategies, developing instructional materials, conducting formative evaluation, and revising instructional materials. Formative evaluation involved expert validation and limited trials to assess the module's validity and practicality. Feedback from experts, teachers, and students was used to identify areas for improvement and to guide revisions to the instructional materials. The tenth stage, summative evaluation, was not conducted as a separate evaluation stage within the scope of this study. Therefore, the implementation of the Dick and Carey model was limited to the development, formative evaluation, and revision stages (Dick & Carey, 1985).

Data Analysis Techniques

The data analysis used in the development of an AR-assisted local wisdom-integrated chemistry module includes Aiken's V and the practicality percentage. Aiken's V is used to assess the validity of the developed product, while the practicality percentage is used to assess its practicality. The following is the formula for Aiken's V and the practicality percentage:

1) Validity Analysis of Aiken's V

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

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Table 1. Aikens V Criteria (Retnawari, 2016)

Value Range	Validation Level
V ≥ 0.4	Less Valid
0,4 >V <0,8	Valid
V ≥ 0.8	Very Valid

2) Reliability Analysis

The reliability analysis in this study uses the Borich method, which is known as the *Percentage of Agreement* (PA).

$$PA = \left(1 - \frac{A - B}{A + B}\right) X\ 100\ \%$$

PA ≥ 75% → the instrument or device is declared reliable
PA < 75% → the instrument or device is declared unreliable

3) Practicality Percentage

$$\%\ Practicality\ = \frac{total\ score\ from\ assessors}{maximum\ score}\ x\ 100\%$$

Table 2. Practicality Percentage Criteria (Destiara, 2020)

N	Validation Criteria	Validation Level
1	0% - 20%	Not practical
2	21% - 40%	Less practical
3	41% - 60%	Quite practical
4	61% - 80%	Practical
5	81% - 100%	Very practical

This study assesses effectiveness using N-gain analysis to determine the improvement in scores from the limited-scale trial. The N-gain formula used is as follows:

$$g = \frac{S_{post} - S_{pre}}{S_{max} - S_{pre}}$$

Table 3. Interpretation of N-gain values based on the theory of Hake (1998)

Value range	Category
g ≥ 0.7	High
0.3 ≤ g < 0.7	Medium
g < 0.3	Low

Research Findings and Discussion

The results of this study present comprehensive data on the validity and practicality of the integrated *Melala* local-wisdom chemistry module, assisted by *Augmented Reality.* The module

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was developed systematically using the Dick and Carey model. Phenomena and processes in local wisdom are integrated into chemistry concepts relevant to students. The chemistry context is close to their social and cultural environment. AR technology is used to help visualize abstract chemistry concepts, particularly at the submicroscopic level, and to connect macroscopic, submicroscopic, and symbolic representations. The developed product is then validated and tested for practicality to determine its suitability as a teaching material in chemistry.

Stages of Development of the Dick and Carey Model

Development of chemistry modules integrated with *Melala* local wisdom, augmented reality-assisted learning through several stages. The first stage is identifying learning objectives. The results of this stage identified the main development objective: a chemistry module integrated with *Melala* local wisdom and AR. This stage conducted a performance analysis that showed the gap between expected abilities and actual student abilities. The analysis showed that students had low scientific literacy and creativity. The percentages for scientific literacy and scientific creativity were 37.79% and 49.86%, respectively. These results emphasize the need for culture-based learning tools that support the improvement of both competencies. The next stage was to conduct a preliminary survey on teachers' needs and perceptions regarding the integrated learning of *Melala* local wisdom in two sub-districts, namely Sumbawa and West Sumbawa, along with the survey results.

Table 4. Teachers' Perceptions of Integrated Local Wisdom Learning

No	Indicator	Percentage (%)	Criteria
1	Relevance to Chemistry Curriculum & Material	90.2	Very good
2	Benefits for Students	69.8	Good
3	Preservation of culture and environment	67.9	Good
4	Teacher Readiness	65.9	Good
5	School and community support	67.3	Good

These results indicate that learning, integrated with local wisdom, receives positive support from teachers and is relevant to the school curriculum. Local wisdom can be instilled in students and foster a sustainable school culture (Fathurrochman et al., 2026; Ferdi Hasan et al., 2026; Toharudin & Kurniawan, 2019; Usmeldi & Amini, 2020).

The second stage is analyzing competencies and materials as the basis for developing learning objectives. This stage is carried out after the general objectives have been established. At this stage, the Learning Outcomes (CP) of the Independent Curriculum (BSKAP No. 032/H/KR/2024) are broken down into more specific, logical, and structured learning steps as the basis for developing Learning Objectives (TP) and learning tools. The following are the Learning Outcomes outlined in the second stage:

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Element	Learning Outcomes
Chemical Understanding	At Phase F, students are able to understand the structure, properties, and interactions of particles in matter; chemical calculations; chemical laws and their application in everyday life; redox reactions and chemical equilibrium; thermochemistry and electrochemistry; as well as chemical compounds and their uses in various aspects of life. This understanding supports the development of scientific inquiry and problem-solving skills.
Process Skills	1. Systematically observe chemical phenomena. 2. Ask questions and make predictions about relationships between variables. 3. Plan and conduct scientific investigations. 4. Process, analyze, and interpret data and information. 5. Evaluate research findings and reflect. 6. Communicate research findings based on scientific evidence.

Figure 2. Merdeka Curriculum Learning Outcomes

The third stage is analyzing student characteristics and the learning context. From this stage, information was obtained that students' initial academic abilities were in the moderate category, based on interviews with teachers. Some students are accustomed to theoretical learning and have never connected culture with scientific concepts. Analysis of the learning context shows that chemistry learning is still dominated by general examples and makes little use of local culture in Sumbawa. The school supports learning innovation but does not yet have integrated teaching tools (modules, student worksheets, and evaluation instruments) that connect chemistry concepts with local wisdom in Sumbawa.

The fourth stage is formulating learning objectives. At this stage, the selected learning outcomes are broken down into learning objectives that will be used in the teaching and learning process. The fifth stage is the development of assessment instruments. At this stage, knowledge of *Melala* local wisdom is structured as questions to measure students' scientific literacy and creativity. The following are the results of questions integrated with local wisdom:

Scientific Literacy Competency	Competency Indicator	Question Indicator	Question	Answer
Explaining scientific phenomena.	Remembering and applying relevant scientific knowledge.	Students can recall the type of colloid found in coconut milk in the Melala tradition. (C1).	1. Coconut milk is a main ingredient in making Sumbawa oil. It is a mixture of oil and water that appears homogeneous but can separate when left to stand. What type of mixture is this? a. Suspension b. True solution c. Emulsion colloid d. Homogeneous mixture **Reasoning:**	c. Emulsion colloid **Reasoning:** Coconut milk is an emulsion, a colloid in which oil droplets are dispersed in water, the dispersion medium.
Interpreting data and evidence scientifically.	Interpreting presented data.	Students can interpret scientific concepts about emulsions to predict the coalescence of oil droplets during heating.	2. Observe the following images. 	a. The emulsion breaks down more quickly because oil droplets frequently collide and coalesce.

Figure 3. Integrated *Melala* Local Wisdom Questions

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The sixth stage is developing an integrated PBL-based instructional strategy with *Melala* and AR. The developed chemistry learning module integrated *Melala* local wisdom, Problem-Based Learning (PBL), and Augmented Reality (AR) to facilitate students' understanding of chemical concepts through contextual and interactive learning activities. The learning process was organized according to the five stages of PBL: (1) orienting students to contextual problems, (2) organizing students for learning, (3) guiding individual and group investigations, (4) developing and presenting solutions, and (5) analyzing and evaluating the problem-solving process.

At the beginning of the learning activities, the teacher introduced authentic problems related to chemical phenomena observed in the *Melala* tradition. Students were then organized into small groups and provided with the learning module and student worksheets (LKPD), which contained contextual problems, guiding questions, and investigation activities. During the investigation stage, students accessed AR visualizations to explore chemical concepts associated with the observed phenomena. The AR content was designed to support the interpretation of chemical processes by connecting observable macroscopic phenomena with submicroscopic representations and relevant chemical concepts.

The teacher facilitated the learning process by providing instructions for accessing the AR content, guiding group discussions, and encouraging students to relate their observations to scientific explanations. Students interacted with the AR objects, recorded their observations in the LKPD, discussed possible explanations, and formulated solutions to the contextual problems. Each group subsequently presented its findings, while the teacher facilitated reflection and evaluation to strengthen students' conceptual understanding and scientific reasoning. Thus, AR functioned as a visualization and investigation tool within the PBL process rather than merely serving as an additional digital learning resource.

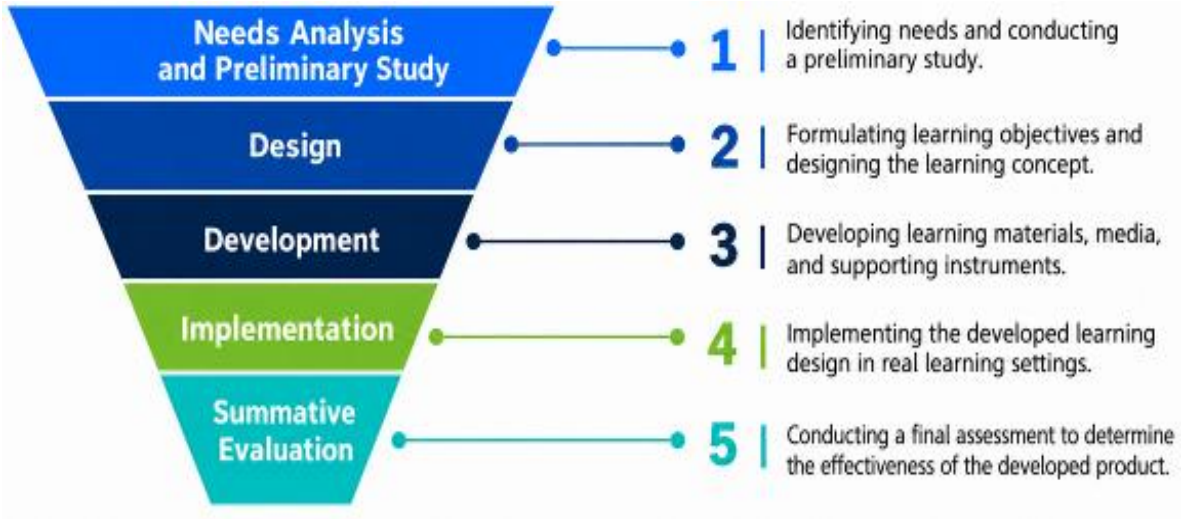


Figure 4. Steps of Chemistry Learning Strategy

The seventh stage focuses on the development and selection of teaching materials. At this stage, the module format and structure are selected and then developed by integrating PBL, local wisdom, and AR technology. The developed modules are also complemented by student worksheets (LKPD) and post-learning evaluations. The following is a preview of the developed modules.

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Figure 5. Display of the *Melala* Local Wisdom Module Assisted by Augmented Reality

The eighth stage is to design and conduct a formative evaluation. This stage aims to assess the module's validity and practicality and identify areas for improvement. The first test is a validation test or expert appraisal, which aims to ensure the product is valid and reliable. Second, the practicality test is conducted using a learning implementation questionnaire that includes responses from teachers and students.

Validity Results

Validity data was obtained through assessments by three expert lecturers in the fields of material, media, and language. Validation included teaching modules, developed chemistry modules, LKPD, AR media, and question instruments to measure students' scientific literacy and scientific creativity skills linked to local wisdom and Augmented Reality. This validation aims to determine the feasibility of the *Melala* local-wisdom-integrated chemistry module, assisted by Augmented Reality (AR), before it is used in learning. This module is intended for high school students and covers colloids and the factors that affect reaction rates. The module uses PBL model syntax, based on local wisdom linked to the *Melala* Tradition (making Sumbawa oil), and utilizes three-dimensional AR technology created using the Assemblr Edu application.

The first validation result of the teaching module showed that the developed module obtained an average Aiken's V score of 0.86, categorized as very valid. Across all aspects, the general information received a score of 0.87, categorized as very valid. These results indicate that the module identity, initial competencies, student characteristics, facilities and infrastructure, and learning model have been compiled in accordance with applicable provisions. The completeness of the core components obtained a score of 0.81, categorized as very valid, indicating high suitability to learning objectives, meaningful understanding, trigger questions, assessments, learning activities, and enrichment and remedial activities. The completeness of the appendix components was rated 0.89, categorized as very valid. This indicates that the learning module, LKPD, glossary, and bibliography have met the eligibility criteria, although they can still be improved. Overall, a high Aiken's V score indicates that

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validators agree on the suitability of the compiled components of the teaching module. A high score indicates that the teaching module, integrated with local wisdom, can be revised to improve the compiled module. The following is a table of the validity of the Teaching Module.

Table 5. Results of Teaching Module Validation

Aspect	V	Category
General Information	0,87	Very Valid
Completeness of Core Components	0,81	Very Valid
Completeness of Attachment Components	0,89	Very Valid
Rate-Rate	**0,86**	**Very Valid**

The second validation result is a chemistry module based on the PBL model, which is integrated with local wisdom *Melala*, and supported by *Augmented Reality*, which shows an average Aiken's V value of 0.84, categorized as very valid. In detail, the content and material feasibility aspect obtained a value of 0.80 in the valid category, while the module construction and systematics aspect obtained a value of 0.81 in the valid category. In the aspect of integrating *Melala* local wisdom, the measurement of scientific literacy and scientific creativity in the module obtained a value of 0.81 and was categorized as valid. The language, presentation, and assessment aspects each obtained a value of 0.81 and met the valid criteria. This level of validity also indicates that PBL, *Melala* local wisdom, and AR technology can be adequately integrated into one chemistry teaching material (Rahmasari & Kuswanto, 2023; Sudirman et al., 2020; Yasir et al., 2025) PBL provides a learning framework that encourages students to understand concepts through contextual problems. Meanwhile, *Melala* provides a cultural context that connects chemistry material to phenomena close to their lives. The validator's suggestions and input remain an important basis for revising components that received relatively low scores to optimize the quality of the module's content, systematics, cultural integration, presentation, and assessment before it is used in the practicality testing phase. The following table shows the results of the chemistry module validation.

Table 6. Validation Results of the Integrated Local Wisdom Chemistry Module Assisted by Augmented Reality

Aspect	V	Category
Suitability of Content and Material	0,80	Valid
Construction and Systematics of Modules	0,81	Valid
Integration of Local Wisdom *Melala*	0,81	Valid
Scientific Literacy and Creativity	0,96	Very Valid
Language and Presentation	0,81	Valid
Assessment	0,81	Valid
Rate-Rate	**0,84**	**Very Valid**

The overall validation results for AR media obtained an average Aiken's V score of 0.81 and were categorized as valid. The module cover design aspect obtained the highest score of 0.89, categorized as very valid, while the neatness and consistency of layout and visual quality aspects each obtained a score of 0.81 and were categorized as valid. The readability and AR integration aspects in the module design each obtained a score of 0.78,

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also categorized as valid. These results indicate that the module has a display, structure, and visual quality that are suitable for use as teaching materials. The high score for the cover design aspect indicates that the validator assessed the module's visual identity and initial appeal as very good. The relatively low scores for readability and AR integration indicate there is still room for improvement, particularly in text clarity, layout consistency, and instructions for using the AR feature. Overall, the validation results indicate that AR media can be used in the next stage after minor improvements as suggested by the validator. The following table shows the validation results for Augmented Reality teaching media.

Table 7. Validation Results of Augmented Reality Teaching Media

Aspect	V	Category
Module cover design	0,89	very valid
Neatness & Layout Consistency	0,81	valid
Readability	0,78	valid
Visual Quality	0,81	valid
AR Integration in Module Design	0,78	valid
Rate-Rate	**0,81**	**valid**

The validation results show that the LKPD, integrated with local wisdom and assisted by Augmented Reality (AR), obtained an average Aiken's V of 0.84 and falls within the very valid category. The PBL orientation aspect obtained the highest value, namely 0.9, followed by the presentation feasibility aspect with 0.83; both are in the very valid category. The language and display feasibility each obtained a value of 0.83, while content feasibility obtained 0.81. All three are included in the valid category. These results indicate that the LKPD has content aligned with the learning objectives, a systematic presentation, easy-to-understand language, and a display that supports students' learning activities. The integration of local wisdom presents a learning context that is closer to students' experiences, while AR helps visualize abstract chemical concepts more interactively (Kozov & Ivanova, 2023; Singh & Kaur, 2025; Suhail et al., 2024). The high score in the PBL orientation aspect also indicates that the LKPD is designed to encourage students to identify problems, seek information, discuss, and develop solutions in line with the local context. Overall, the validation results indicate that the LKPD, integrated with local wisdom and supported by AR, is well-suited for the learning trial phase, provided minor improvements are made based on the validators' suggestions. The following table shows the validation results of the LKPD integrated with local wisdom assisted by Augmented Reality.

Table 8. Valid Results of Integrated Local Wisdom and Augmented Reality LKPD

Aspect	V	Category
Content Eligibility	0.81	Valid
Presentation Eligibility	0.83	very valid
language qualifications	0.83	Very valid
display suitability	0.83	Very valid
Orientation to PBL	0.91	very valid
Rate-rate	**0.84**	**very valid**

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The validation results using Aiken's V indicated that the scientific literacy pretest had an average score of 0.80 and was classified as valid. The scientific creativity pretest instrument had an average score of 0.77 and was classified as valid. In the scientific literacy instrument, the question construction aspect obtained a score of 0.80, the material aspect 0.72, conformity with PISA indicators 0.78, and the language aspect the highest score, namely 0.89, in the very valid category. In the scientific creativity instrument, the highest score was obtained in the question construction aspect at 0.82, followed by the language aspect at 0.78, conformity with indicators at 0.74, and the material aspect at 0.72. All aspects were included in the valid category. These results indicate that both instruments are well-suited in terms of construction, materials, measured indicators, and language use, and are therefore suitable for measuring students' initial abilities. The relatively low validity value for the material aspect indicates that several items still need refinement, particularly in terms of context, material depth, and cognitive demands, to better align with the competencies to be measured. The alignment of the scientific literacy questions with the PISA indicators indicates that this instrument is well-suited to encourage students to use scientific knowledge to explain phenomena, interpret scientific information or evidence, and solve context-based problems. Overall, the validation results indicate that the scientific literacy and scientific creativity pretest instruments are suitable for research use, with minor improvements based on validator input. The following table shows the validation results of the Scientific Literacy (LS) and Scientific Creativity (KI) pretest questions.

Table 9. Validation Results of Scientific Literacy (SL) and Scientific Creativity (SC) Pretest Questions

Aspect	V SL	Category	V SC	Category
Question construction	0.80	valid	0.82	valid
Material	0.72	valid	0.72	valid
Compliance with indicators	0.78	valid	0.74	valid
Language	0.89	very valid	0.78	valid
Rate-rate	**0.80**	**valid**	**0.77**	**valid**

The validation results using Aiken's V showed that the scientific literacy posttest instrument obtained an average score of 0.82, categorized as valid. The scientific creativity posttest instrument had an average score of 0.78 and was classified as valid. In the scientific literacy instrument, the scores were: question construction 0.84, material 0.81, conformity with PISA indicators 0.70, language 0.85, and suitability of questions with local wisdom 0.89, with the highest score. In the scientific creativity instrument, the score for the question construction aspect reached 0.80, material 0.78, conformity with indicators 0.70, language 0.85, and suitability of questions with local wisdom 0.83.

These results indicate that both posttest instruments are of good quality in terms of question structure, material coverage, language use, indicator suitability, and integration of local-wisdom context. The relatively high score on the suitability aspect of local wisdom indicates that the questions can connect scientific concepts to phenomena or practices in students' lives. Thus, these questions have the potential to support more contextual and meaningful learning. The lowest score on the suitability aspect of the PISA indicators indicates that several items still need refinement to be more robust in measuring the ability to explain phenomena scientifically, evaluate and design investigations, and interpret scientific

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data and evidence. Overall, the validation results indicate that the posttest instruments for scientific literacy and scientific creativity are suitable for measuring students' abilities after the learning process, with continued minor improvements as suggested by the validator. The following table presents the validation results for the posttest questions on Scientific Literacy (SL) and Scientific Creativity (SC).

Table 10. Validation Results of the Post-Test Questions for Scientific Literacy (SL) and Scientific Creativity (SC)

Aspect	V SL	Category	V SC	Category
question construction	0.84	valid	0.80	valid
Material	0.81	valid	0.78	valid
conformity with indicators	0.70	valid	0.70	valid
Language	0.85	very valid	0.85	Very valid
Suitability of Questions with Local Wisdom	0.89	Very valid	0.83	valid
rate-rate	**0.82**	**valid**	**0.78**	**valid**

Reliability Analysis Results

Reliability analysis was conducted to determine the consistency and level of agreement between validators regarding the developed tool. Reliability was tested using the Borich method by calculating the Percentage of Agreement (PA). This test involved three validator assessors, with PA calculated for each pair of validators: Validator 1–Validator 2, Validator 1–Validator 3, and Validator 2–Validator 3. The PA values from the three pairs were then averaged to obtain the overall level of agreement. The results of the reliability analysis are presented in Table 11.

Table 11. Research Reliability Results

Instrument	Reliability Per Aspect		Reliability	Category
Teaching Module	General Information	91.70%	91.49%	Reliable
	Completeness of Core Components	92.97 %		
	Completeness of Attachment Components	89.80 %		
Chemistry Module	Suitability of Content and Material	91.43 %	94.69%	Reliable
	Construction and Systematics of Modules	100 %		
	Integration of Local Wisdom *Melala*	93.65 %		
	Scientific Literacy and Scientific Creativity	96.83 %		
	Language and Presentation	100 %		
	Assessment	86.24 %		
Teaching Media	Module cover design	90.48 %	91.64%	Reliable
	Neatness & Layout Consistency	86.24 %		
	Readability	89.42 %		

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Instrument	Reliability Per Aspect		Reliability	Category
LKPD	Visual Quality	95.24 %	96.72%	Reliable
	AR Integration in Module Design	96.83%		
	Content Eligibility	95.24 %		
	Presentation Eligibility	97.62 %		
	language qualifications	97.28 %		
	display suitability	97.28 %		
	Orientation to PBL	96.19 %		
Pretest Questions Science Literacy	Question Construction	96.98 %	96.87%	Reliable
	Material	93.85 %		
	Compliance with PISA Indicators	96.83 %		
	Language	99.80 %		
Pretest Questions Scientific Creativity	Question Construction	98.10 %	98.93%	Reliable
	Material	97.62 %		
	Compliance with Indicators	100.00 %		
	Language	100.00 %		
Posttest Questions Science Literacy	Question Construction	96.19 %	97.49 %	Reliable
	Material	97.62 %		
	Compliance with PISA Indicators	96.83 %		
	Language	96.83 %		
Posttest Questions Scientific Creativity	Question Construction	100.00 %	98.73 %	Reliable
	Material	100.00 %		
	Compliance with Indicators	96.83 %		
	Language	96.83 %		

The results of the reliability analysis using the Borich method showed that all instruments had a Percentage of Agreement (PA) above the minimum threshold of 75% and were therefore declared reliable. In sequence, the reliability values of each instrument were: teaching module 91.49%, chemistry module 94.69%, teaching media 91.64%, LKPD 96.72%, science literacy pretest 96.87%, scientific creativity pretest 98.93%, science literacy posttest 97.49%, and scientific creativity posttest 98.73%. The highest value was observed in the scientific creativity pretest instrument, while the lowest was observed in the teaching module.

The high PA value indicates strong agreement among validators in assessing the content, construction, presentation, language, and integration of local wisdom in *Melala* and AR, as well as the instrument's suitability with indicators of scientific literacy and scientific creativity (Kocisova, 2025; Tang et al., 2015). Several aspects, such as the assessment of the chemistry module and the neatness of the teaching media's layout, received relatively low scores. However, all scores still exceeded the reliability criteria. Thus, all research tools and instruments demonstrated adequate consistency in assessment and could be used in the next phase of the research.

Practicality Analysis Results

The practicality analysis aims to assess the ease of use, implementation, and acceptability of the developed learning tools based on user responses during learning. This

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assessment includes ease of use, clarity of presentation, time efficiency, and the device's usefulness in supporting learning activities. The results are used to determine the extent to which the tools can be effectively implemented in real-life learning. The following data on the practicality of the student modules is presented in Table 12.

Table 12. Practicality Data for Student Modules

Aspect	Mark (%)	Criterion
Learning achievement	94.66	Very Practical
Language	91.16	Very Practical
Material	91.67	Very Practical
Module View	95.98	Very Practical
Rate-Rate	93.37	Very Practical

The practicality analysis results show that the *Melala* local wisdom-based module, with the help of Augmented Reality, received a very positive response in all assessment aspects. The learning achievement aspect received a score of 94.66%. This result indicates that the module can encourage curiosity, cooperation, and students' abilities in observing, analyzing, and drawing conclusions. This module also helps them understand the material on colloids and reaction rates. The linguistic aspect received a score of 91.16%, indicating that the sentences, terms, and language in the module are easy to understand and conform to applicable language rules.

The material aspect received a score of 91.67%. This result indicates that the material can connect community science knowledge with scientific knowledge, integrate local culture, and present material and questions appropriate to students' abilities. The highest score was in the module's appearance aspect, at 95.98%. The images, layout, color harmony, and font size in the module were deemed attractive and easy to read. Overall, all aspects received scores above 90%, so the module is classified as very practical and easy to use in learning.

The practicality of the module is also assessed from the teacher's perspective to ensure that the developed tools are not only easy for students to use but also applicable in learning (Wulandari et al., 2026). Teacher assessments included the suitability of the concept and curriculum, clarity of structure and instructions for use, technical and design feasibility, and content and readability. Assessment instruments included measures of the relevance of *Melala* local wisdom to scientific literacy and scientific creativity outcomes, the clarity of objectives and instructions for using AR features, the suitability of the design to school conditions, and the readability of the material and chemical symbols. The results of teacher assessments were then used to strengthen conclusions regarding the module's practicality in classroom learning. Data on the module's practicality according to chemistry teachers are presented in Table 13.

Table 13. Chemistry Teacher Practicality Data

Aspect	Mark (%)	Criteria
Suitability of Concept and Curriculum	87.50	Very Practical
clarity of structure and instructions	96.67	Very Practical
Technical Feasibility and Design	87.50	Very Practical
Content feasibility and readability	95.83	Very Practical
Rate-Rate	91.88	Very Practical

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The results of the practicality analysis based on teacher responses indicate that the *Melala* local wisdom-based module, with the help of Augmented Reality, achieved an average practicality score of 91.88%, placing it in the very practical category. The aspects of clarity of structure and instructions received the highest score, namely 96.67%, followed by content suitability and readability at 95.83%. Meanwhile, aspects of concept and curriculum suitability, and technical and design feasibility, each received a score of 87.50%. All aspects are included in the very practical criteria. These results indicate that the module has a clear structure, easy-to-understand instructions for use, content appropriate to learning needs, and a design that supports learning.

The high practicality score indicates that the module is easy for teachers to use in their learning. The clear structure and instructions are key advantages, helping teachers understand the flow of activities, the learning objectives, and how to use AR features systematically. The high content adequacy and readability also indicate that the module's material, terminology, and presentation are easy to understand. Although the suitability of the concept and curriculum and the technical and design feasibility received relatively lower scores than the other aspects, both are still categorized as very practical. Thus, the module is deemed feasible and practical for teachers to use as support for *Melala* local-wisdom-based chemistry learning.

N-gain Analysis Results

In this study, in addition to testing validity and practicality, an N-gain test was conducted to assess improvement in scores in the limited-scale trial class. The following are the results of the N-gain analysis of scientific literacy and scientific creativity.

Table 13. N-gain Results of Limited-Scale Science Literacy

Indicator	Pretest	Posttest	N-Gain	Category
Explaining Scientific Phenomena	30.09	51.95	0.31	Moderate
Interpreting Data	30.61	53.60	0.33	Moderate
Evaluating the Investigation	33.33	53.54	0.30	Moderate

The results showed improvements in all three scientific literacy indicators from pretest to posttest. Students' ability to explain scientific phenomena increased from 30.09 to 51.95 (N-Gain = 0.31), while their ability to interpret scientific data rose from 30.61 to 53.60, producing the highest N-Gain (0.33). This suggests that, after participating in the learning activities, students improved relatively more in interpreting scientific information and drawing conclusions from data. Their ability to evaluate scientific investigations increased from 33.33 to 53.54 (N-Gain = 0.30), the smallest improvement among the indicators. Based on the normalized gain classification, all three indicators showed moderate improvement, with N-Gain values ranging from 0.30 to 0.33. Overall, the findings suggest that the learning activities positively supported students' scientific literacy, particularly their ability to interpret scientific data. However, further instructional improvements are needed to strengthen students' ability to evaluate scientific investigations, critically assess evidence, and formulate scientifically justified solutions. The overall scientific literacy N-Gain should be reported separately, based on total pretest and posttest scores, to distinguish it from improvements at the indicator level. In addition to scientific literacy, students' scientific creativity was assessed using normalized gain analysis, as shown in the following table.

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Table 14. N-gain Results of Limited-Scale Scientific Creativity

Indicator	Pretest	Posttest	N-Gain	Category
Fluency	33.85	66.04	0.49	Moderate
Flexibility	33.33	63.96	0.46	Moderate
Originality	29.17	30.56	0.02	Low

The analysis results show that the increase in students' scientific creativity abilities differed across indicators. The fluency indicator increased by 0.49 (N-Gain). Flexibility increased with an N-Gain of 0.46. Both indicators are in the moderate category. This indicates that learning is quite effective at helping students generate more ideas and develop various approaches or alternatives for solving problems. Conversely, the originality indicator increased by only 0.02, placing it in the low category. These results indicate that the ability to generate novel ideas has not yet developed to its full potential. These findings indicate that learning is more successful in improving fluency and flexibility of thinking than in generating original ideas. Therefore, learning activities need to be strengthened through open-ended tasks, problem-solving with multiple possible answers, exploration of alternative solutions, and greater space for students to develop ideas independently and creatively.

Conclusion

This research produced a chemistry module that integrates *Melala* local wisdom and is supported by Augmented Reality, using the Dick and Carey development model. The validation results showed an Aiken's V value of 0.86 for the teaching module, 0.84 for the chemistry module, 0.81 for AR media, and 0.84 for the LKPD. Thus, all devices fall into a very valid category. The pretest and posttest instruments for measuring scientific literacy and scientific creativity also meet validity criteria. The reliability test results show that all devices and instruments have a Percentage of Agreement above 75%, ranging from 91.49% to 98.93%, and are therefore declared reliable. The practicality test showed that the module obtained average scores of 93.37% from student responses and 91.88% from teacher responses. Both values fall into the very practical category. Thus, the chemistry module integrating *Melala* local wisdom and augmented reality is declared valid, reliable, and highly practical for use as contextual chemistry teaching material on colloids and factors affecting reaction rates. However, the conclusions of this study remain limited to validity and practicality. Therefore, further testing is needed to determine the module's effectiveness in improving students' scientific literacy and scientific creativity.

Recommendations

Further development could be carried out on a broader scale, encompassing the entire Sumbawa Regency, to present more comprehensive data on scientific literacy and scientific creativity. This development could also serve as a guide for creating teaching materials that integrate other aspects of local wisdom from the Sumbawa community while helping preserve Sumbawa's culture.

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