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Development of RANDAI-STEM Integrates Teaching Module to Enchance Scientific Communication Skills among Fase D Student

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Abstract: 21st-century education demands that students not only master content but also possess scientific communication skills, thereby requiring innovative learning approaches to develop these competencies. The STEM approach, which integrates science, technology, engineering, and mathematics, along with the RANDAI learning model culturally-based and problem-solving oriented is considered effective in fostering such skills. This development research employed the Plomp model, consisting of three phases: preliminary research, prototyping, and assessment. The object of the study was a RANDAI Teaching Module integrated with STEM, with Grade VIII students as the subjects. The instruments used included tools for assessing validity, practicality, and effectiveness to measure students' scientific communication and argumentation skills. Data analysis for validity and practicality employed descriptive analysis, while effectiveness was analyzed using ANOVA tests with SPSS software. The results showed that the module is valid with a score of 87.33%, highly practical with scores of 92.44% from teachers and 91.24% from students, and effective in enchance students' scientific communication skills.

Keywords: RANDAI Model; Scientific Communication; STEM; Teaching Module

Introduction

Education in Indonesia is currently undergoing continuous transformation to meet the challenges of the 21st century, which requires students to possess skills beyond mere mastery of subject matter. The *Merdeka Curriculum* and various learning innovations emphasize the importance of developing competencies such as critical thinking, collaboration, and communication (Yunita, Zainuri, Ibrahim, & Mulyadi, 2022). One of the skills that is gaining increasing attention in science education is scientific communication. This skill is important to develop because it enables students to convey ideas, findings, and scientific information clearly, logically, and based on evidence (Munawaroh & Wahidin, 2022)

Scientific communication does not only involve the ability to write reports or prepare presentations, but also includes skills such as speaking, listening, and engaging in scientific discussions. In the context of science learning, students are expected to communicate experimental processes, explain observational results, and relate their findings to relevant scientific concepts (Aini, 2023). This helps them build a deeper understanding while also developing their ability to participate in scientific discussions, both within the school environment and in the broader community (Sarwanto, 2016)

Students' scientific communication skills need to be improved. Many students have not yet demonstrated proficiency in scientific communication. (Khoriah, Suyatna, Abdurrahman, & Tri Jalmo, 2023) Research shows that students' scientific communication skills fall into the low category, with a percentage below 50% (Nurlaelah, Widodo, Rejeki, & Rahman, 2020). Other studies indicate that scientific communication skills fall into the moderate category. However, their implementation in practice has not yet been optimal (Mayani, Maknum, & Ubaidillah, 2023). Therefore, efforts are needed to improve students' scientific communication skills through the use of instructional tools, as well as to enhance their argumentation skills through well-designed learning materials.

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One way to train students' scientific communication skills is by developing instructional materials based on an appropriate learning model. One approach that can be applied is STEM, which encourages students to think critically and creatively by integrating knowledge from science, technology, engineering, and mathematics (Fajrina, Lufri, & Ahda, 2020).

In its implementation, the STEM approach can be integrated within a structured learning model. The RANDAI model, grounded in Minangkabau cultural values, is an instructional framework derived from problem-based learning principles. The procedural steps (syntax) of the RANDAI model consist of R*eciting the problem*, *Analyzing the problem*, *Narrating the solution*, *Doing the solution*, *Assessing the solution*, and *Implementing*. This model is designed to provide a clear problem orientation, promote collaborative learning, and cultivate critical thinking skills, thereby enhancing students' problem-solving capabilities and scientific literacy (Arsih, Zubaidah, Suwono, & Gofur, 2020).

This study focuses on the development of instructional materials designed to enhance students' scientific communication skills through the RANDAI learning model integrated with the STEM approach. Previous research has demonstrated that the STEM approach effectively cultivates critical thinking and problem-solving skills, improves conceptual understanding and learning outcomes, as well as fosters collaboration (Reni & Hartoyo, 2020).

To date, there is no existing teaching module that integrates the STEM disciplines—science, technology, engineering, and mathematics—with a problem-based learning model that is culturally anchored in Minangkabau traditions, specifically the RANDAI model. Therefore, this study aims to develop a RANDAI teaching module integrated with STEM that is valid, practical, and effective in enhancing students' scientific communication skills.

Method

Time and location

This research was conducted form August 2025 to July 2026 at SMP Negeri 3 Lubuk Basung. The study took place in the school classroom and science laboratory, which provided the necessary facilities for implementing the STEM-based RANDAI learning module.

Type of rsearch

The development of the teaching module will employ the Plomp development model, which consists of three phases: the preliminary research phase, the development or prototyping phase, and the assessment phase (Plomp & Nieveen, 2013).

Research Stage

Preliminary Research Phase: An analysis of the needs of students and teachers in the science learning process at SMP Negeri 3 Lubuk Basung was conducted to determine the profile of science instruction. This included assessing teachers' understanding of the STEM approach and the RANDAI learning model, as well as evaluating students' initial argumentation skills through classroom observations and diagnostic tests. Overall, this phase involved curriculum analysis, instructional material analysis, student analysis, concept analysis, and a comprehensive literature review.

Prototyping Phase: The design and development of instructional materials were carried out based on the results of the needs analysis of students and teachers,. A self-evaluation was then conducted to review and refine the components of the instructional materials. (*Prototype* 1), An expert review was conducted to obtain feedback and suggestions for improving the product until it was considered valid and suitable for instructional use. (*Prototype* 2). Kriteria validitas dapat dilihat pada Tabel 1. One-to-one and small group evaluations were conducted to obtain students' responses and perceptions of the product. (Prototype 3 and 4) prior to entering the assessment phase.

Table 1. Range of Validity Scores

Range of Validity Scores	Criteria
90-100	Very valid
80-89	Valid
65-79	Moderately valid
55-64	Low validity
≤54	Not valid

(Purwanto, 2009)

Assesment Phase: The final stage is the evaluation phase of the teaching module, which involves assessing the practicality and effectiveness of the module through its implementation in the learning process. The practicality score of the module is obtained by administering practicality questionnaires to the students and teachers who use the product during instruction. The criteria for practicality scores can be seen in Table 2.

Table 2. Range of Practicality Scores

Range of Practicality Scores	Criteria
90-100	Very Practical
80-89	Practical
65-79	Moderately Practical
55-64	Low Practical
≤54	Not Practical

(Purwanto, 2009)

The effectiveness test was obtained from the results of students' scientific communication skills test conducted at the end of the learning process using the developed product through a quasi-experimental design, which involved the following steps: a) conducting a homogeneity test to determine the sample classes, b) administering a pretest to assess students' initial argumentation skills, c) implementing the learning process using the product, d) administering a posttest to measure students' final argumentation skills, and e) analyzing the data. Throughout the learning process, the implementation of the STEM-RANDAI syntax was observed by a team of observers and documented. The design of the effectiveness test through quasi-experiment is presented in Table 3.

Tabel 3. Quasi Experiment Design fo Effectiveness Evaluation

Class	Pretest	Perlakuan	Postest
Experimental	Q_1	RANDAI-STEM Teaching Module	Q_2
Positive Control	Q_3	RANDAI Teaching Module	Q_4
Negative Control	Q_5	Conventional Teaching Module	Q_5

The criteria for scientific communication skills scores are as Table 4.

Table 4. Criteria for Scientific Communication Skills Scores

Range of Scientific Communication Scores	Criteria
90-100	Execellet
80-89	Good
65-79	Moderate
55-64	Fair
≤54	Poor

(Purwanto, 2009)

Data Analysist

To test the effectiveness of the teaching module in improving students' argumentation skills, an ANOVA test was conducted after first ensuring that the data met the assumptions of normality and homogeneity of variance. A significance level (p-value) of 0.05 was used as the decision criterion. If the p-value is less than 0.05, the teaching module is considered effective in enhancing students' scientific communication skills. Subsequently, a post-hoc test using LSD (Least Significant Difference) was conducted to determine which sample classes differed significantly. If the significance value is less than 0.05, it indicates a statistically significant difference between the compared groups.

Result and Discussion

Result

Preliminary Reserch Phase)

The preliminary investigation phase was conducted to analyze issues in science learning, including curriculum analysis, concepts, students, teaching materials, as well as teachers and students. The results of this investigation served as the basis for designing a RANDAI-based teaching module integrated with STEM for Phase D students. The following table presents a summary of the preliminary investigation results.

Table 5. Result of Preliminary Research

Aspect	Findings
Curriculum Analysis	The analysis references the Merdeka Curriculum, emphasizing the achievement of science learning outcomes encompassing both conceptual mastery and process skills such as observation, inquiry, and scientific communication aligned with 21st-century competencies.
Concept Analysis	The content is concentrated on the human digestive system, including nutrition, enzymatic functions, organ structure, digestive disorders, and the application of technology, systematically structured to facilitate integrated science-based learning..
Teacher and Student Analysis	The instructional approach predominantly remains passive, characterized by reading, note-taking, and listening activities, with limited opportunities for experiential learning and discourse. Students exhibit challenges in comprehending complex terminology and rote memorization. The implementation of STEM pedagogy remains suboptimal despite expressed interest from both educators and learners
Process and Teaching Material Analysis	The teaching materials remain conventional—primarily textbooks and student worksheets—with limited variety and engagement. They have yet to integrate local cultural values and the STEM approach. Enrichment is needed through enhanced illustrations, student-centered activities that actively involve learners, and visually appealing design..

Prototyping Phase

At this stage, the initial design of the science teaching module based on the RANDAI Model integrated with STEM was developed, grounded in the results of the preliminary investigation analysis. The module creation followed a predetermined framework, including a cover with module identification, material title, author name, illustrations of the digestive system, student-chosen colors, SmartArt representations of the RANDAI and STEM models, and the Merdeka Curriculum logo. The module profile emphasizes a learning concept that integrates local cultural values of RANDAI with STEM reinforcement. The Student Worksheet (LKS) contains material on the digestive system and problem-solving activities using RANDAI and STEM steps. After the design phase, a self-evaluation was conducted, identifying the need to add instructions for using the LKS and a student identity page to clarify guidance for both teachers and students. Subsequently, the teaching module was evaluated by five validators through an expert review covering aspects of the cover, content feasibility, presentation, language, and graphics using a validity questionnaire. The validity test results are summarized in Table 6.

Table 6. Validity Test Results of the Science Teaching Module Based on RANDAI Integrated with STEM

Aspect	Validity Score	Criteria
Cover	85.00	Valid
Content Feasibility	88.70	Valid
Content Presentation	83.33	Valid
Language	90.80	Very valid
Graphics	90.80	Very valid
Average	87.73	Valid

The one-to-one evaluation involved three students with varying ability levels who read the science teaching module based on the RANDAI model on the topic of the digestive system and provided feedback. The results indicated that the cover appearance, design, color scheme, layout, font type and size, easily understood language and terminology, clear instructions, quality images and illustrations, as well as the RANDAI syntax steps integrated with STEM in the Student Worksheet (LKS) were all maintained.

The small group evaluation was conducted with six students of varying ability levels who read the module and provided similar feedback. The results of this evaluation confirmed that all aspects of the module, including the cover, design, language, instructions, illustrations, and syntax, were appropriate and maintained as guidelines for improvement before proceeding to the assessment phase.

Assessment Phase

Practicality Test of the Teaching Module

The practicality of the teaching module was assessed by two science teachers and 30 students using a practicality questionnaire. The results of the assessments from both groups were described and summarized in Table 7.

Table 7. Summary of Practicality Assessment Results

Aspect	Teacher's Practicality		Student' Practicality	
	Score	Criteria	Score	Criteria
Ease of Use	91.66	Very Practical	90.41	Very Practical
Learning Time Efficiency	93. 37	Very Practical	92.08	Very Practical
Benefits	92.29	Very Practical	91.25	Very Practical
Average	92.44	Very Practical	91.24	Very Practical

Effectiveness Test of the Teaching Module on Students' Scientific Communication Skills

Assessment of scientific communication skills through pre- and post-tests conducted on 90 students showed improvement across all classes. The experimental class exhibited the highest increase, from 50.13 to 66.8, followed by the positive control and negative control classes. Table 8 presents the students' scientific communication skill scores.

Table 8. Students' Scientific Communication Skills Scores

Indicator	Experimental		Positive Control		Negative Control	
	Pretest	Posttest	Pretest	Posttest	Pretest	Posttest
Information retrieval	60.33	72.00	58.66	71.66	60.00	68.66
Scientific reading	62.33	80.66	62.00	73.33	62.00	69.33
Listening and observing	46.00	70.66	37.33	69.33	48.00	66.66
Scientific writing	53.66	65.33	51.00	62.00	49.00	58.33
Knowledge presentation	47.33	60.66	50.33	57.66	42.66	51.00
Information representation	35.00	60.33	30.00	57.66	33.00	51.66
Average	50.13	66.80	47.93	64.06	47.93	59.66
Criteria	Poor	Moderate	Poor	Moderate	Poor	Fair

The distribution of scientific communication scores based on the number of students for each of the six scientific communication skill indicators can be seen in Table 9.

Table 9. Frequency Distribution of Scientific Communication Skills Scores

Score	Criteria	Number of Student					
		Experiment		Positive Control		Negative Control	
		Pretest	Posttest	Pretest	Posttest	Pretest	Posttest
<90	Excellent	0.00	1.00	0.00	0.00	0.00	0.00
80-90	Good	0.00	5.00	0.00	5.00	0.00	1.00
56-79	Moderate	5.00	6.00	2.00	9.00	2.00	5.00
55-64	Fair	10.00	18.00	12.00	11.00	9.00	13.00
>54	Poor	15.00	0.00	16.00	5.00	19.00	11.00
Average		50.13	66.80	47.93	64.06	47.93	59.66
Criteria		Poor	Moderate	Poor	Moderate	Poor	Fair

Next, prerequisite tests were conducted, including normality and homogeneity tests, which indicated that the data were normally distributed and homogeneous. Subsequently, an ANOVA test was performed to determine whether there were significant differences among the mean scientific communication scores of the three sample classes. The results of the ANOVA test are presented in Table 10.

Table 10. ANOVA Test of Students' Scientific Communication Skills

	Sum of Square	df	Mean Square	F	Sig
Between Groups	452.356	2	226.178	7.951	<0.001
Within Groups	2474.800	87	28.446		
Total	2927.156	89			

Based on the results of the ANOVA test, a significance value (p-value) of < 0.001 was obtained. Since this value is less than 0.05, it can be concluded that there is a statistically significant difference among the mean scores of the three sample classes. Subsequently, an LSD (Least Significant Difference) test was conducted as Table 11.

Tabel 11. LSD Test for Scientific Scientific Communication Skill

Class	Comparison Class	Sig	Description
Experiment	Positive Control	0,699	Not significant
	Negative Control	<0,001	Statistically significant
Positive Control	Experiment	0,699	Not significant
	Negative Control	0,002	Statistically significant
Negative Control	Experiment	<0,001	Statistically significant
	Positive Control	0,002	Statistically significant

Discusion

Validity of Teaching Module

The development of this module was aligned with the Learning and Assessment Guidelines of the Merdeka Curriculum. Its validity was assessed through expert evaluation across several dimensions, including content quality, linguistic clarity, presentation structure, visual design, and cover layout. Revisions were systematically carried out based on the validators' recommendations, leading to the module being deemed valid for instructional use.

Cover

The module cover was deemed valid as it met the required criteria by effectively reflecting the content and learning objectives, particularly for the digestive system topic in Phase D. The title is clear and informative, supported by thematic illustrations and SmartArt that outline the learning flow. The layout, font style, and color choices were carefully selected to be visually appealing and easily readable. A well-designed visual presentation plays a crucial role in enhancing students' engagement and focus during the learning process (Huth, Koch, Awad, Weiskopf, & Kurzhals, 2024).

Content Presentation

The content of the module is systematically structured following the stages of the RANDAI syntax integrated with the STEM approach. The initial stage involves problem orientation using contextual storytelling (*kaba*), which stimulates students' active engagement and critical thinking. The sequence of content presentation supports a learning process that progresses from exploration to evidence-based problem solving. This contextual and sequential organization of learning facilitates the development of students' deep understanding (Apriliani & Alberida, 2023).

Language

The students' cognitive levels were carefully considered in the formulation of clear, unambiguous, and communicative sentences. The sentences were effectively structured to support comprehension of both instructions and learning materials. For scientific terms as well as Minangkabau local terms, the module includes a glossary to facilitate students' understanding. The use of precise language in the instructional materials plays a crucial role in enhancing comprehension and fostering active student engagement throughout the learning process (Prastowo, 2011).

Graphic Design

The module fulfills the graphic design aspects, including the use of legible fonts, relevant illustrations, as well as an appealing layout and color scheme. The images and diagrams incorporated in the module effectively clarify the presented material. The colors blue, orange, and peach are employed to enhance visual comfort. Effective visual design has been demonstrated to support comprehension and facilitate a comfortable learning environment (Dzulkifli & Musfatar, 2013). In addition, studies show that good visual design such as clear fonts, appropriate images and balanced color combination helps students understand the material more easily and stay focused during learning

Praticality of the Teaching Module

Ease of Use

The module is considered highly practical due to its clear and easily understandable instructions presented in communicative language, supported by visual elements that enhance the learning process. Relevant illustrations and a well-organized layout facilitate both teachers and students in comprehending the information. This aligns with the principle of visual clarity, which is essential in instructional materials. (Shoffa, et al., 2023).

Efficiency of Learning Time

The module has been designed with an appropriate time allocation, allowing the complete implementation of the RANDAI model integrated with STEM to be conducted effectively. Teachers reported that the activities within the module assist in managing learning time efficiently. This aligns with Hasan, et al., (2021) a well-designed teaching module supports both teachers and students in optimally achieving learning objectives.

Benefits

The module enhances students' motivation and engagement through a contextual and collaborative approach. Problem-based learning and the integration of Minangkabau cultural values, such as *saliang bakarajo samo* (mutual cooperation), foster communication and teamwork (Arsih, Zubaidah, Suwono, & Gofur, 2021). The module further facilitates the development of critical thinking, argumentation, and evidence-based problem-solving skills through the integration of the STEM approach (Fadhilah, Nurdiyanti, Anisa, & Wajdi, 2022).

Efektiviteness

The effectiveness of the teaching module based on the RANDAI Model integrated with STEM focuses on the extent to which this module can train students' communication skills. These skills help develop students' scientific communication abilities. These skills are assessed through six indicators of scientific communication by Levy, Eylon, & Scherz (2009) measured using essay questions and then analyzed based on student engagement in the learning process. STEM integrated learning has been empirically articulate scientifict ideas and concept through structured problem solving activities, project and discussions (Islamiyah & Wulandari, 2022).

Information retrieval

Information retrieval refers to students' ability to access diverse sources of information, including books, printed articles, and online materials, to construct conceptual understanding, foster information literacy, and develop autonomous learning skills. This competency is pivotal in 21st-century education as it facilitates digital literacy, critical thinking, and learner independence (Sari, 2022). Within the RANDAI model integrated with the STEM teaching module, information literacy is emphasized during the pre-activity and analyzing-the-problem phases, where students independently explore and investigate information sources to deepen their initial understanding of the subject matter and connect it to contextual issues. This competency strongly shapes students' ability to find, evaluate, and use reliable information effectively in the learning process (Donkor, Ifeanyi, & Ezema, 2023).

Scientific Reading

Scientific reading entails the ability to critically read and comprehend scientific texts, including identifying factual information, summarizing main ideas, comparing findings across multiple sources, and linking these insights to previously acquired knowledge (Koray & Çetinkılıç, 2020). This skill is cultivated during the pre-learning and analyzing the problem stages, wherein students engage with various sources and articulate their understanding in worksheets (LKPD). Scientific reading is intrinsically linked to science literacy and constitutes a fundamental basis for effective scientific information retrieval (Susiati, Adisyahputra, & Miarsyah, 2018). It also helps students interpet scientifict literacy and are linked to better reasoning and data interpretation skills. (Cao, Zhang, & Xin, 2024).

Scientific Writing

Scientific writing involves the capacity to communicate ideas and learning outcomes in a logical, systematic, and evidence-based manner, encompassing the identification and formulation of scientific problems

(Hidayatullah, Izza, Ardyansyah, & Setiyowati, 2024). In the context of the RANDAI STEM-integrated module, this competency is fostered through the analyzing the problem stage (formulating problem statements), narrating the solution stage (documenting materials, tools, and procedures), and assessing the solution stage (composing structured scientific reports). Mastery of scientific writing not only cultivates critical thinking and problem-solving abilities but also significantly enhances scientific communication proficiency (Oetomo, Widoretno, Ramlia, Prayitno, Sugiarto, & Prabowo, 2025).

Listening and oberseving

Listening and observing constitute essential skills involving attentive reception of scientific information and systematic observation of phenomena, foundational to effective scientific communication (Hidayah, Setiyono, & Hasanudin, 2024). These processes facilitate students' ability to record pertinent information systematically and integrate it with existing knowledge frameworks (Levy, Eylon, & Scherz, 2009). Within the RANDAI module, these skills are developed during the narrating the problem phase, wherein students source information, including via digital videos, to comprehend procedures such as food processing and conducting content analysis. Engagement in active listening and observation through technological media has been demonstrated to enhance conceptual understanding, learner motivation, and practical laboratory skills (Trianto, Hartono, & Akhlis, 2019).

Information Representation

Information representation refers to the ability to present data, concepts, and findings in a visual and structured format, including tables, graphs, diagrams, concept maps, and other visual models, thereby facilitating comprehension and scientific discourse (Mayani, Maknum, & Ubaidillah, 2023). This skill is integrated throughout the RANDAI module, beginning in the pre-learning stage (concept mapping), continuing in narrating the solution (flowchart creation), and extending to doing the solution (tabulation and diagrammatic representation of experimental results). The capacity for effective visual representation plays a crucial role in the communication of scientific knowledge (Zhang & Jenkinson, 2023).

Knowledge Presentation

Knowledge presentation is defined as the ability to articulate ideas, data, and research findings clearly, accurately, and contextually, employing oral, written, and visual formats (Levy, Eylon, & Scherz, 2009). This competency is emphasized in the assessing the solution stage, where students prepare project reports and develop presentation media such as PowerPoint slides or posters, subsequently delivering group presentations before their peers. The implementation of group presentation methods has been empirically shown to enhance students' communication skills within the learning environment (Shivni, Cline, Newport, Yuan, & Bergan-Rolle, 2021) Group presentation helps studemts communicate ideas more clearly, collaborate with peers and develop confidance when presenting their learning outcomes in front of the class (Helawati, 2022).

Conclusion

The developed teaching module was declared valid based on expert evaluations across several aspects, including content, presentation, language, graphic design, and integration with the RANDAI model and STEM approach. The module's validity indicates that its content and structure align with curriculum requirements, student characteristics, and the objectives of 21st-century learning. The module was proven practical through implementation results, demonstrating that both teachers and students could use it easily. It is designed with clear instructions, a systematic learning flow, and visuals that support readability and comprehension. Moreover, the module is efficient to use in learning activities and provides tangible benefits in enhancing student motivation and collaboration.

The teaching module is effective in developing scientific communication skills, as evidenced by the achievement of indicators such as information retrieval, scientific reading and writing, listening and observing, information representation, and knowledge presentation. The activities within the module enable students to construct and communicate their understanding in a logical, systematic, and evidence-based manner.

Based on the findings, it is recommended that future research further explore the long-term impact of the RANDAI model integrated with STEM on students' scientific literacy and problem-solving skills across different educational levels. Additionally, studies could investigate how integrating local cultural values, such as *saliang bakarajo samo*, influences student collaboration and motivation in other subject areas. Finally, potential limitations of this study, such as the small sample size and the focus on a single topic, should be addressed to strengthen the generalizability of the results.

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Author Contributions
The author conducted all stages of the research.

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Conflicts of Interest
The authors declare that there is no conflict of interest in this article.

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