



## Needs Analysis for the Development of a Stem-Based General Chemistry E-Module Integrated with PhET Simulations on Chemical Bonding

Fatma Suryani Harahap<sup>1\*</sup>, Eko Susetyarini<sup>2</sup>, Baiduri Baiduri<sup>3</sup>, Elly Purwanti<sup>4</sup>

<sup>1-4</sup> Universitas Muhammadiyah Malang - Doctoral Program in Education, Indonesia

\* Corresponding Author: **Fatma Suryani Harahap**

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### Article Info

**ISSN (Online):** 2582-7138

**Impact Factor (RSIF):** 8.04

**Volume:** 07

**Issue:** 03

**May-June 2026**

**Received:** 12-03-2026

**Accepted:** 10-04-2026

**Published:** 08-05-2026

**Page No:** 529-537

### Abstract

This study represents the initial stage of e-module development using the ADDIE model, namely the needs analysis stage. The purpose of this study was to identify students' and lecturers' needs for the development of a STEM-based General Chemistry e-module integrated with PhET Simulations on chemical bonding. The needs analysis was conducted through curriculum analysis, analysis of student characteristics, analysis of learning media, a student needs questionnaire, and interviews with the course lecturer. The study was conducted in the Chemistry Education and Biology Education Study Programs at Universitas Muhammadiyah Tapanuli Selatan, involving 18 students as questionnaire respondents. The questionnaire instrument consisted of 20 statement items mapped into four C4 dimensions: critical thinking, collaboration, creativity, and communication. The analysis showed that the overall mean student response was 4.02 on a 5-point scale, or 80.39%, with a positive response rate of 83.61%. The collaboration dimension obtained the highest score (M = 4.14; 82.89%), followed by critical thinking (M = 4.01; 80.22%), creativity (M = 3.97; 79.33%), and communication (M = 3.96; 79.11%). These findings indicate that students have good initial readiness, but they still need more interactive teaching materials to strengthen their ability to solve HOTS problems, generate new ideas, develop alternative solutions, and explain chemistry concepts orally. Lecturer interview results also indicated the need for innovative teaching materials capable of visualizing abstract concepts in chemical bonding, integrating STEM activities, and facilitating students' C4 skills. Thus, the development of a STEM-based General Chemistry e-module integrated with PhET Simulations is considered relevant and necessary as a follow-up to the design and development stages of the ADDIE model.

**DOI:** <https://doi.org/10.54660/IJMRGE.2026.7.3.529-537>

**Keywords:** E-module, Chemical Bonding, PhET Simulations, STEM, C4 Skills

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### 1. Introduction

General Chemistry is a foundational course for students in science education programs because it contains basic concepts that serve as prerequisites for studying advanced chemistry topics. One topic that often causes conceptual difficulty is chemical bonding because this concept is abstract, complex, and prone to misconceptions<sup>[1,2]</sup>. This topic requires students to understand the relationships among atomic structure, electron configuration, bond formation, molecular geometry, polarity, and the properties of substances. These concepts are not only macroscopic but also involve submicroscopic and symbolic representations; therefore, students need learning media that can clarify conceptual visualization<sup>[3,4]</sup>. General Chemistry learning in higher education should not only emphasize conceptual mastery but also develop 21st-century skills.

C4 skills, namely critical thinking, collaboration, creativity, and communication, are important for preparing prospective science educators who can analyze problems, work collaboratively, generate ideas, and communicate concepts scientifically<sup>[5, 6]</sup>. In the context of chemical bonding instruction, these skills can be developed through activities such as phenomenon analysis, simulation exploration, problem-based discussion, solution design, and presentation of learning outcomes. The STEM model provides a learning framework that enables students to connect science concepts with technology, engineering, and mathematics in an integrated way<sup>[7, 8]</sup>. STEM integration can make chemical bonding learning more contextual because students do not merely learn definitions and formulas but also relate concepts to phenomena, products, or everyday life problems. Meanwhile, PhET Simulations can help visualize abstract concepts through interactive simulations, allowing students to explore, test predictions, and build conceptual understanding more actively<sup>[9, 10]</sup>.

However, e-module development cannot proceed directly to the production stage of teaching materials. In accordance with the ADDIE model, the analysis stage is an important initial step to ensure that the product being developed truly aligns with user needs, student characteristics, curriculum requirements, and the conditions of learning media used. Needs analysis also helps researchers determine the priority features, learning strategies, and types of activities that should be incorporated into the e-module.

Based on this background, this study aims to identify the needs for developing a STEM-based General Chemistry e-module integrated with PhET Simulations on chemical bonding. Specifically, this study analyzes: (1) curriculum needs related to chemical bonding, (2) student characteristics in terms of C4 skills, (3) the condition and needs of learning media, (4) student needs responses based on the questionnaire, and (5) lecturer needs based on interviews.

## 2. Method

This study used a descriptive approach with a needs analysis design as part of the Analyze stage in the ADDIE model. This stage focused on obtaining an initial overview of students' and lecturers' needs before the e-module was designed and developed. The study was conducted in the Chemistry Education and Biology Education Study Programs at Universitas Muhammadiyah Tapanuli Selatan. The questionnaire respondents consisted of 18 students who had taken or were taking General Chemistry. In addition, interviews were conducted with the General Chemistry course lecturer to explore the actual learning conditions, obstacles in developing C4 skills, and the need for innovative teaching materials.

Data collection techniques included curriculum document analysis, learning media analysis, distribution of a student needs questionnaire, and lecturer interviews. The student questionnaire consisted of 20 statement items using a five-point Likert scale: strongly disagree (1), disagree (2), neutral (3), agree (4), and strongly agree (5). The questionnaire items were mapped into four C4 dimensions: critical thinking, collaboration, creativity, and communication. The lecturer interview guide included questions about learning methods, student activeness, critical thinking ability, teamwork, creativity, communication, the use of technology-based media, C4 development, learning obstacles, and the need for a STEM-based e-module. Quantitative data were analyzed by calculating response frequencies, mean scores, achievement percentages, and percentages of positive responses. Achievement percentages were calculated by comparing the mean score with the maximum score on the Likert scale. Qualitative data from the interviews were analyzed through data reduction, theme coding, data presentation, and conclusion drawing. The percentage interpretation categories used were: 0-20 very low, 20.1-40 low, 40.1-60 moderate, 60.1-80 high, and 80.1-100 very high.

**Table 1:** Student respondent profile

Study Program	Number of Students	Percentage
Chemistry Education	10	55.56%
Biology Education	8	44.44%
Total	18	100%

Source: Primary research data, 2026.

**Table 2:** Components of needs analysis

Component	Data focus	Analysis purpose
Curriculum analysis	Learning outcomes, breadth of chemical bonding material, and learning activity requirements	To determine content suitability and the direction of e-module design
Analysis of student characteristics	C4 readiness, learning activeness, and the need for concept visualization	To determine activity strategies and scaffolding
Learning media analysis	Types of media used, media limitations, and opportunities for technology integration	To determine media format and interactive features
Student needs questionnaire	20 Likert-scale statement items on C4 dimensions	To measure students' needs and readiness tendencies
Lecturer interview	10 questions about General Chemistry learning and e-module needs	To strengthen quantitative findings and learning context
Lecturer interview	10 questions about General Chemistry learning and e-module needs	To strengthen quantitative findings and learning context

Source: Prepared based on the needs analysis research design

### 3. Results and Discussion

#### 3.1. Results

##### 3.1.1. Curriculum Analysis and Characteristics of Chemical Bonding Material

Curriculum analysis showed that chemical bonding is a core topic in General Chemistry because it is directly related to the understanding of structure and properties of substances. This material requires students to understand the concepts of ionic bonding, covalent bonding, metallic bonding, Lewis structures, molecular geometry, polarity, and the relationship between bond type and the physical and chemical properties of substances. The abstract nature of the material makes visualization an important need in learning because students' difficulties with chemical bonding are often related to structural representation, polarity, and the relationship among

macroscopic, submicroscopic, and symbolic levels [11, 12]. From the perspective of teaching material development, chemical bonding is suitable for integration with the STEM approach. The science component appears in the concepts of atomic structure and bond formation; technology appears in the use of PhET Simulations; engineering can be realized through tasks that require students to design molecular models or solutions based on compound characteristics; and mathematics is used in the analysis of valence electron patterns, ionic charges, and structural representations. Therefore, the e-module to be developed needs to include exploration activities, data analysis, prediction, discussion, and reflection so that STEM integration is not merely a label but becomes a true interdisciplinary learning experience [13, 14].

**Table 3:** Results of curriculum analysis and development implications

Curriculum aspect	Analysis findings	Implications for the e-module
Conceptual complexity	Chemical bonding is abstract and involves submicroscopic representations	Interactive visualization through simulations is needed
Learning outcome requirements	Students need to explain, analyze, and relate bonding concepts to properties of substances	HOTS tasks and phenomenon-based exercises are needed
Need for STEM integration	Bonding concepts can be connected to phenomena involving materials, molecules, and substance properties	Problem contexts, exploration, and solution design are needed
Need for C4 skills	Learning needs to strengthen critical thinking, collaboration, creativity, and communication	Discussion activities, mini-projects, presentations, and reflection are needed

##### 3.1.2. Results of the Student Needs Questionnaire

The questionnaire data showed that the need for e-module development tended to be positive. The overall mean score was 4.02 on a 5-point scale, or 80.39%, with positive responses of agree and strongly agree reaching 83.61%. This

means that students have good initial readiness to participate in activity-based learning, although several indicators still need to be strengthened through more systematic and interactive teaching materials.

**Table 4:** Overall distribution of student questionnaire responses

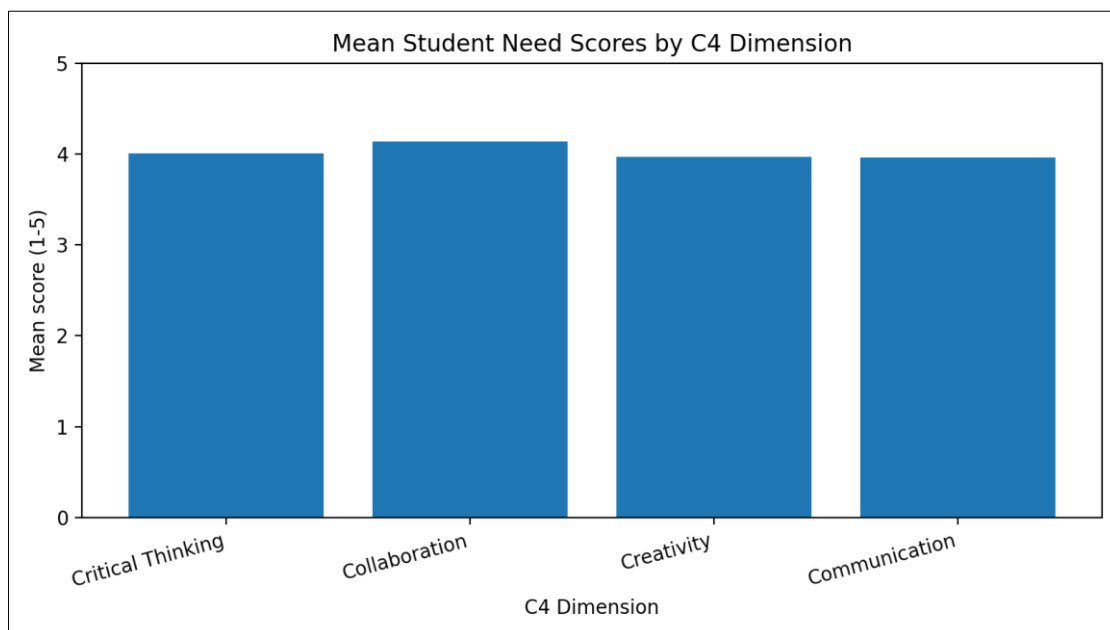
Response category	Frequency	Percentage
Strongly agree	75	20.83%
Agree	226	62.78%
Neutral	50	13.89%
Disagree	9	2.50%
Strongly disagree	0	0.00%
Total responses	360	100%

Source: Primary research data, 2026

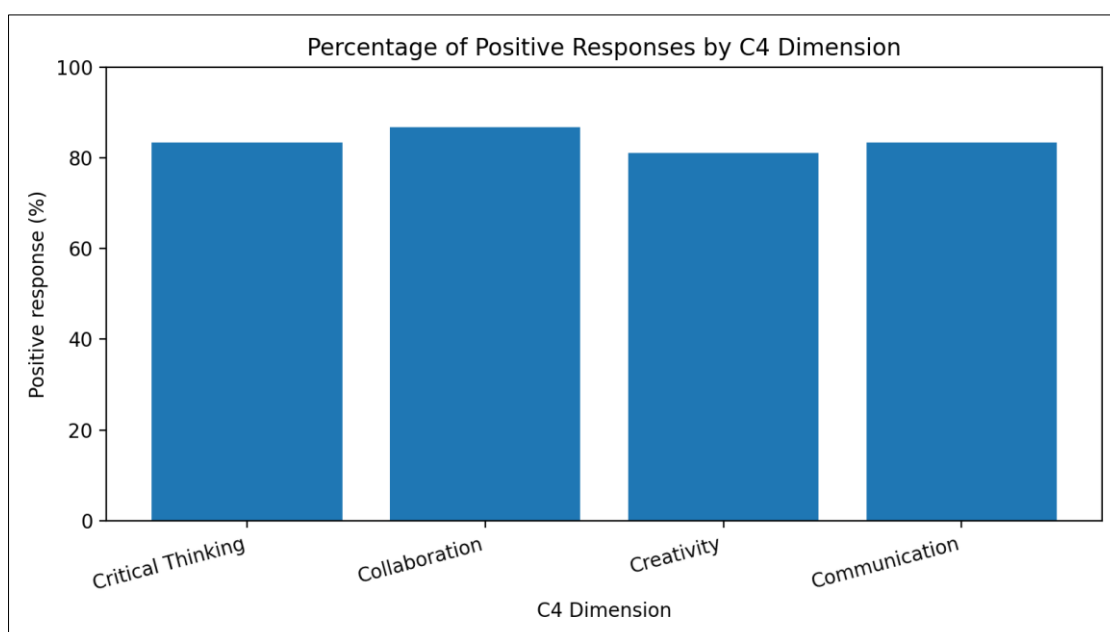
**Table 5:** Mean questionnaire scores by C4 dimension

C4 Dimension	Items	Mean	Percentage	Positive response	Category
Critical thinking	1-5	4.01	80.20%	83.30%	Very high
Collaboration	6-10	4.14	82.90%	86.70%	Very high
Creativity	11-15	3.97	79.30%	81.10%	High
Communication	16-20	3.96	79.10%	83.30%	High

Source: Primary research data, 2026



**Fig 1:** Mean student need scores by C4 dimension



**Fig 2:** Percentage of positive responses by C4 dimension

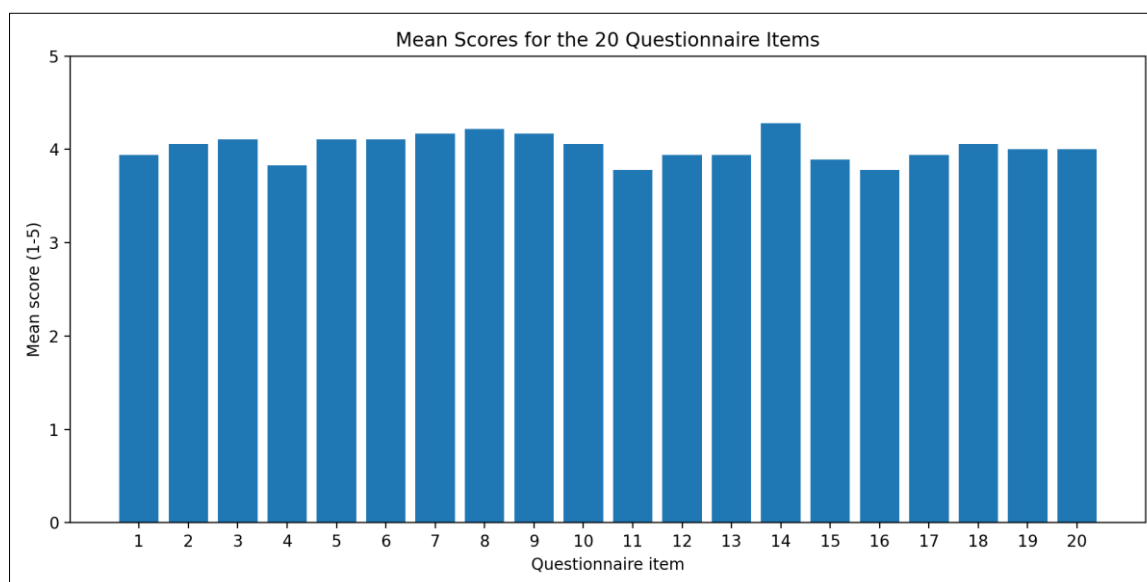
The collaboration dimension obtained the highest mean score, namely 4.14 or 82.89%. This indicates that students are relatively ready to participate in learning activities involving group discussion, teamwork, and joint task completion. Such collaborative readiness is important because STEM learning and project-based learning require social interaction, role distribution, problem solving, and collective decision-making<sup>[15, 16]</sup>. The critical thinking dimension was also in the very high category, with a mean score of 4.01 or 80.22%;

however, the item related to solving HOTS chemistry problems obtained a lower score than other items. Creativity and communication were in the high category, at 79.33% and 79.11%, respectively. These findings are important because the e-module to be developed should not only provide content but also challenge students to generate new ideas, develop alternative solutions, and communicate chemistry concepts orally and in writing.

**Table 6:** Mean score of each questionnaire item

No.	Statement summary	Mean	Percentage	Positive response	Category
1	Analyzing chemistry concepts in depth	3.94	78.90%	72.20%	High
2	Explaining relationships among chemistry concepts	4.06	81.10%	83.30%	Very high
3	Evaluating answers to chemistry problems	4.11	82.20%	94.40%	Very high
4	Solving HOTS chemistry problems	3.83	76.70%	72.20%	High
5	Relating chemistry concepts to everyday phenomena	4.11	82.20%	94.40%	Very high
6	Actively participating in group discussion	4.11	82.20%	83.30%	Very high
7	Working together with group members	4.17	83.30%	83.30%	Very high
8	Being responsible for group tasks	4.22	84.40%	88.90%	Very high
9	Discussing to find solutions	4.17	83.30%	88.90%	Very high
10	Resolving differences of opinion	4.06	81.10%	88.90%	Very high
11	Generating new ideas in chemistry learning	3.78	75.60%	66.70%	High
12	Finding more than one way to solve problems	3.94	78.90%	83.30%	High
13	Not merely following examples given by the lecturer	3.94	78.90%	83.30%	High
14	Being interested in trying new ways of learning	4.28	85.60%	94.40%	Very high
15	Developing alternative solutions	3.89	77.80%	77.80%	High
16	Explaining chemistry concepts orally	3.78	75.60%	66.70%	High
17	Being confident in expressing opinions	3.94	78.90%	88.90%	High
18	Writing reports systematically	4.06	81.10%	88.90%	Very high
19	Communicating ideas clearly	4.00	80.00%	88.90%	High
20	Actively asking or answering questions	4.00	80.00%	83.30%	High

Source: Primary research data, 2026.

**Fig 3:** Mean scores of the 20 questionnaire items

At the item level, the lowest scores were found in the ability to generate new ideas in chemistry learning and the ability to explain chemistry concepts orally, each with a mean score of 3.78 or 75.56%. The item on solving chemistry problems that require higher-order thinking obtained a mean score of 3.83 or 76.67%, while the ability to develop alternative solutions obtained a mean score of 3.89 or 77.78%. These four items

provide the basis for prioritizing e-module development, namely the need for activities that encourage students to solve problems, conduct simulation-based exploration, create conceptual explanations, and communicate analysis results. This priority is in line with the urgency of developing 21st-century skills in chemistry learning, especially critical thinking, creativity, communication, and collaboration<sup>[17, 18]</sup>.

**Table 7:** Comparison of mean scores by study program

Study Program	n	Critical thinking	Collaboration	Creativity	Communication	Overall
Biology Education	8	3.98	4.18	3.95	4.00	4.03
Chemistry Education	10	4.04	4.12	3.98	3.92	4.01

Source: Primary research data, 2026.

The mean scores of Chemistry Education and Biology Education students were relatively balanced. Biology Education students obtained an overall mean score of 4.03, while Chemistry Education students obtained 4.01. This similar tendency indicates that the need for a General

Chemistry e-module is not only relevant for Chemistry Education students but also for Biology Education students, who need basic chemistry understanding to support biological studies.

### 3.1.3. Lecturer Interview Results and Learning Media Analysis

The lecturer interview focused on the conditions of General Chemistry learning, students' C4 skills, the use of technology-based media, learning obstacles, and the need for innovative teaching materials. The interview guide included ten main questions, ranging from the learning methods used,

student activeness, critical thinking ability, teamwork, creativity, communication, the use of technology-based media such as PhET Simulations, to the need for a STEM-based e-module. Based on these focuses, lecturer needs can be formulated into several main themes as presented in Table 8.

**Table 8:** Synthesis of lecturer needs based on interviews

Interview theme	Meaning of findings	Development implications
Learning methods	Learning still requires varied activities so that students do not merely receive conceptual explanations	The e-module needs to include exploration, discussion, and reflection activities
Student activeness	Student activeness needs to be improved, especially in asking questions, answering, and expressing ideas	The e-module needs to provide prompting questions and activity sheets
Critical thinking	Students need to be trained to analyze and solve HOTS-oriented chemistry problems	The e-module needs to contain contextual problems and analytical exercises
Collaboration	Group work needs to be guided so that students have clear roles and responsibilities	The e-module needs to include STEM-based group tasks
Creativity	Students need opportunities to generate ideas and alternative solutions	The e-module needs to provide mini-projects or design challenges
Communication	Students need to practice explaining concepts orally and in writing	The e-module needs to include presentations, short reports, and reflections
Technology-based media	PhET Simulations are considered relevant for helping visualize abstract concepts	The e-module needs to integrate links, guidance, and PhET exploration questions
Teaching material needs	Lecturers need innovative teaching materials that are systematic, interactive, and easy to use	The development of a STEM-based e-module integrated with PhET should be continued

*Source:* Synthesized from the lecturer interview guide and research context.

The learning media analysis showed that the e-module development should be directed toward digital teaching materials that do not merely contain textual explanations but also provide a staged learning experience. In chemical bonding, the e-module needs to present concept maps, prerequisite material, supporting videos or images, links to PhET Simulations, exploration steps, prediction questions, HOTS exercises, collaborative tasks, and self-assessment.

With this structure, the e-module can serve as a bridge between lecturer explanations, students' independent exploration, and STEM-based learning activities. The development of e-modules containing interactive and guided activities is relevant in chemistry learning because it can support motivation, conceptual understanding, and student engagement<sup>[19–21]</sup>.

### 3.1.4. Implications for the Design of a STEM-Based E-Module Integrated with PhET

**Table 9:** Recommended e-module components based on needs analysis

E-module component	Content design	Targeted skills
Problem orientation	Chemical bonding phenomena in everyday life	Critical thinking and communication
PhET exploration	Simulation guide, prediction, observation, and recording of results	Critical thinking and creativity
STEM activity	Tasks connecting bonding concepts with technology/materials/simple engineering	Creativity and collaboration
HOTS exercises	Analysis, evaluation, and contextual problem-solving questions	Critical thinking
Group discussion	Group worksheets with role distribution	Collaboration and communication
Reflection and self-assessment	Reflective questions and understanding checks	Communication and metacognition
Formative evaluation	Quizzes, short assignments, and feedback	Conceptual reinforcement and C4 skills

*Source:* Primary research data, 2026.

Quantitative and qualitative findings show that the e-module to be developed should not only function as digital reading material. The e-module needs to be designed as a learning device that guides students to engage in active learning activities. At the beginning of each subtopic, students can be given contextual problems to build curiosity. Next, students are directed to use PhET Simulations to observe phenomena, test predictions, and draw conclusions. This principle is in line with studies on computer simulations showing that simulations are effective when combined with learning guidance, exploration tasks, and reflective activities<sup>[21,22]</sup>. STEM integration can be implemented through tasks that

require students to connect chemical bonding concepts with technology and simple engineering, for example by analyzing why a material has certain properties based on bond type or designing a simple explanation of the relationship between molecular structure and polarity. These activities can be conducted in groups so that collaboration and communication develop simultaneously. STEM-based learning experiences can strengthen critical thinking and problem-solving skills when students are exposed to real contexts and project-based activities<sup>[23]</sup>.

The design priorities of the e-module need to focus on four aspects that still need strengthening: HOTS problem solving,

development of new ideas, alternative solutions, and oral communication. Therefore, each e-module unit should contain higher-order questions, open exploration spaces, short presentation tasks, and individual reflection. Such a design is consistent with STEM-based e-module development that emphasizes problem-solving activities, scientific literacy, science process skills, and the strengthening of 21st-century learning skills<sup>[24]</sup>.

### 3.2. Discussion

The results show that the development of a STEM-based General Chemistry e-module integrated with PhET Simulations on chemical bonding has a strong needs basis. This is indicated by the overall mean student response of 4.02 on a 5-point scale, or 80.39%, with a positive response rate of 83.61%. These findings indicate that students have good initial readiness to participate in activity-based learning, such as discussion, group work, exploration, problem solving, and idea sharing. However, this readiness still requires support from more systematic, interactive, and contextual teaching materials so that C4 skills can develop optimally. In this context, the e-module does not only function as a digital reading source but also as a learning device that guides students through clear learning stages, ranging from concept orientation, simulation exploration, discussion, higher-order thinking exercises, to reflection and evaluation. The development of systematic and interactive digital teaching materials is important because e-modules can support independent and flexible learning and facilitate conceptual understanding through structured and multimedia-based content<sup>[25]</sup>. The collaboration dimension obtained the highest score, namely 4.14 or 82.89%. This indicates that students are relatively ready to participate in group-based learning. This readiness is an important asset in implementing the STEM approach because STEM learning requires students to collaborate in identifying problems, dividing roles, discussing solutions, testing ideas, and presenting group work. The STEM approach emphasizes the integration of science, technology, engineering, and mathematics in real-world problem-solving contexts; therefore, collaborative activities are an important part of the learning process<sup>[26]</sup>. Accordingly, the e-module needs to contain structured group activities, such as PhET Simulation exploration with role distribution as observers, data recorders, concept analysts, and discussion presenters. Nevertheless, the creativity and communication dimensions had lower achievement than collaboration. Creativity obtained a mean score of 3.97 or 79.33%, while communication obtained 3.96 or 79.11%. Although both remained in the high category, these results indicate that students still need broader opportunities to generate new ideas, try different ways of learning, develop alternative solutions, and communicate their thinking orally and in writing. Critical thinking, creativity, collaboration, and communication are 21st-century skills that are important to develop in science and chemistry learning so that students can respond more adaptively to academic and real-life problems<sup>[27]</sup>.

Therefore, the e-module needs to include open-ended questions, exploratory tasks, mini-projects, short presentations, reflective writing, and simple report writing. The score on the item related to solving HOTS problems also shows that students still need higher-order thinking practice. Chemical bonding cannot be adequately understood through memorization alone; it requires the ability to analyze,

evaluate, predict, and connect concepts. HOTS questions in this topic may include analyzing the relationship between bond type and substance properties, evaluating Lewis structures, predicting molecular geometry and polarity, and solving phenomenon-based problems. Students' difficulties in understanding chemical bonding are often related to weak ability to represent submicroscopic, symbolic, and macroscopic concepts in an integrated manner<sup>[28]</sup>. Therefore, the e-module needs to provide exercises that require students to use concepts critically in more complex situations. The integration of PhET Simulations is a relevant solution because chemical bonding is abstract and involves submicroscopic concepts such as electrons, bond formation, molecular geometry, and interparticle interactions. If the material is presented only through text, static images, or lectures, students may have difficulty constructing appropriate conceptual understanding. Through PhET Simulations, students can conduct visual and interactive exploration, manipulate variables, observe changes, compare predictions with simulation results, and draw conclusions based on observations. Interactive simulations such as PhET have been shown to help students understand science concepts more actively through visualization, variable manipulation, and direct feedback<sup>[29]</sup>.

In the e-module, PhET Simulations should not merely be included as additional links but should be integrated directly into the learning flow. Students need guidance on what to observe, which variables to manipulate, what data to record, and what conclusions to formulate. This flow can help students build understanding through exploration rather than simply receiving information. The use of computer simulations in science learning is effective when accompanied by inquiry guidance, exploratory questions, and reflective activities that encourage students to construct concepts actively<sup>[30, 31]</sup>. Thus, the use of PhET can support the strengthening of critical thinking, creativity, and scientific communication. The STEM approach also strengthens the e-module design because it connects chemistry concepts with broader contexts. The science component appears in the discussion of chemical bonding concepts; technology appears in the use of PhET Simulations; engineering appears in activities that involve designing simple models or solutions; and mathematics appears in the analysis of patterns, data, and logical reasoning. This integration makes the e-module more meaningful because students do not only learn concepts theoretically but also use them to understand phenomena and solve problems. STEM-based learning can strengthen critical thinking, problem-solving, creativity, and collaboration because students are engaged in authentic and interdisciplinary activities<sup>[16]</sup>.

Lecturer interview results strengthened the student questionnaire findings. Lecturers need teaching materials that can support active learning, visualize abstract material, and facilitate the development of C4 skills. This need indicates that e-module development is based not only on student responses but also on the needs of lecturers as learning managers. Therefore, the e-module to be developed needs to function as both teaching material and a learning activity device containing content, PhET exploration guidance, worksheets, STEM activities, group tasks, reflection, and evaluation. The development of STEM-based e-modules and simulation technology is relevant because it can integrate content, learning activities, interactive media, and evaluation into one digital teaching material device<sup>[21]</sup>.

Overall, the needs analysis results provide an empirical basis for the Design stage in the ADDIE model. Questionnaire data show which C4 dimensions are relatively strong and which aspects still need strengthening, while lecturer interviews provide an overview of the need for innovative teaching materials in the classroom. The ADDIE model positions the analysis stage as an important basis for determining user needs, learning characteristics, objectives, strategies, and the form of the product to be developed [32]. Thus, the development of a STEM-based General Chemistry e-module integrated with PhET Simulations is relevant and feasible to proceed to the design and development stages as an effort to provide digital teaching materials that are systematic, interactive, contextual, and aligned with the needs of General Chemistry learning in higher education.

#### 4. Conclusion

Based on the results of the needs analysis, the development of a STEM-based General Chemistry e-module integrated with PhET Simulations on chemical bonding is considered relevant and necessary. Curriculum analysis shows that chemical bonding has abstract characteristics because it involves concepts of atomic structure, electrons, bond types, molecular geometry, and polarity that are not easily understood only through verbal explanation or static images. Therefore, learning this material requires teaching materials that can provide interactive visualization, exploratory activities, and learning experiences that encourage students to build conceptual understanding more actively.

The student questionnaire results showed an overall mean score of 4.02 on a 5-point scale, or 80.39%, with a positive response rate of 83.61%. These findings indicate that students have good initial readiness to participate in activity-based learning, especially in the collaboration dimension, which obtained the highest achievement. However, several aspects still need to be strengthened, particularly creativity, communication, the ability to solve HOTS problems, generate new ideas, develop alternative solutions, and explain chemistry concepts orally. This condition indicates that students need teaching materials that not only present content but also facilitate higher-order thinking practice, discussion, exploration, reflection, and scientific communication.

Lecturer interview results also strengthened the need for innovative teaching materials that are systematic, interactive, and suited to the characteristics of General Chemistry learning. Lecturers need media that can help visualize abstract concepts, guide students to learn actively, and integrate the STEM approach and PhET Simulations into learning activities. Thus, the results of this needs analysis serve as an empirical basis for continuing the study to the design stage in the ADDIE model. The e-module to be developed needs to include problem orientation, PhET exploration, STEM activities, HOTS exercises, collaborative tasks, communication of results, reflection, and evaluation directed toward improving students' C4 skills.

#### 6. Acknowledgement

The authors would like to express their sincere gratitude to the affiliated institutions for providing support and resources for this research. The authors also thank colleagues and reviewers for their valuable feedback and suggestions that improved the quality of this manuscript.

#### Conflicts of Interest

The authors declare no conflict of interest.

#### Author's Contributions

Fatma Suryani Harahap: Conceptualization, Methodology, Data Curation, Investigation, Writing – Original Draft. Eko Susetyarini: Supervision, Validation, Formal Analysis, Writing – Review & Editing. Elly Purwanti: Software, Data Processing, Visualization, Writing – Review & Editing. Baiduri: Data Curation, Investigation, Resources.

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#### How to Cite This Article

Harahap FS, Susetyarini E, Baiduri B, Purwanti E. Needs analysis for the development of a STEM-based general chemistry e-module integrated with PhET simulations on chemical bonding. *International Journal of Multidisciplinary Research and Growth Evaluation.* 2026;7(3):529–537. doi:10.54660/IJMRGE.2026.7.3.529-537.

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