Case-Based Module Development to Enhance 4Cs in Laboratory Management Engineering Students

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Abstract. Critical thinking, creativity, communication, and collaboration (4Cs) are essential competencies that students must acquire in the 21st-century education era. The 4Cs skills can be trained through case method-based learning presented in lecture modules. This study aims to develop a case method-based module to improve the 4Cs skills of students in the laboratory management engineering program. This research employed a Research and Development (R&D) design using the ADDIE model, which consists of Analysis, Design, Development, Implementation, and Evaluation stages. The research subjects were students enrolled in laboratory management courses. The research instruments included validation sheets, practicality questionnaires, and 4Cs skill observation sheets, analyzed using descriptive techniques. The feasibility test of the module was carried out through product validation by two experts and limited trials involving students. The results indicate that the developed case method-based module met the criteria of validity, practicality, and effectiveness in enhancing students' 4Cs skills. Therefore, this module can serve as an innovative teaching material to support learning in higher education.

Keywords: Case-based learning; Laboratory Management Engineering; Module; 4Cs.

1 Introduction

Higher education is an educational institution that is expected to produce graduates with strong academic abilities in their respective fields. Therefore, universities must always keep up with the development of science and technology, especially in preparing graduates with qualified skills. Among the competencies required in the 21st century, critical thinking, creativity, communication, and collaboration—often referred to as the "4Cs"—are essential)[1][2].

These skills do not automatically exist in individuals but must be intentionally trained through innovative learning strategies [3][4][5]. One of the innovative approaches is the development of lecture modules that integrate student-centered learning activities to enhance the 4Cs [6].

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In the Laboratory Management Engineering program, students are expected to acquire competencies related to laboratory planning, management, and safety. However, initial observations showed that teaching materials used in the laboratory management course are still dominated by theoretical explanations and procedural content. They rarely incorporate real-life cases or structured activities that allow students to practice critical thinking, collaboration, and creativity.

The case method is a suitable solution to this challenge. It emphasizes problem-solving and student-centered learning[7]. Studies have shown that the case method can improve critical thinking [8], creativity, collaboration, and communication [9][10]. Therefore, integrating case method into lecture modules is expected to provide meaningful learning experiences for students while strengthening their 4Cs competencies.

This research aims to develop a case method-based module for the laboratory management engineering course that meets the criteria of validity, practicality, and effectiveness in enhancing students' 4Cs.

2 Research Method

This research used a Research and Development (R&D) approach with the ADDIE model consisting of Analysis, Design, Development, Implementation, and Evaluation

2.1 Analysis

The analysis stage involved reviewing the laboratory management curriculum, interviewing lecturers, and assessing student needs. The analysis stage involved reviewing the laboratory management curriculum, interviewing lecturers, and assessing student learning needs to identify problems in existing learning materials and learning processes.

2.2 Design

The design stage included planning the structure of the module, which consisted of:

1. Format & graphics: module cover, layout, and readability.
2. Content: real-life laboratory management cases.
3. Language: clarity, consistency, and academic appropriateness.

2.3 Development

The module was developed according to the design and validated by two experts (a subject matter expert and a media expert). Revisions were made regarding clarity of instructions, integration of visuals, and enrichment of case studies. The module is ready to use if the validator's average assessment is valid and very valid

2.4 Implementation

A limited trial was conducted with students enrolled in the laboratory management course. Their responses were collected using practicality questionnaires, while the improvement of their 4Cs was observed through performance tasks.

2.5 Evaluation

Evaluation was based on the results of expert validation, student practicality responses, and observations of students' 4Cs competencies. The module validation decision-making criteria can be seen in Table 1.

The validation results are calculated using the average score formula, namely:

$$M = \frac{\sum fx}{N} \quad (1)$$

Information:
M = Average score
Fx = Score earned
N = Number of validation components

Table 1. Validity Category

Score Interval	Validity Category
$3.25 \leq x < 4$	Highly Valid
$2.5 \leq x < 3.24$	Valid
$1.75 \leq x < 2.4$	Less Valid
$1 \leq x < 1.74$	Invalid

Modification Sugiyono [11]

Observation sheets are compiled based on critical thinking, creative, collaboration, and communication skills. The criteria for student skills based on the observation sheet are presented in table 2.

Table 2. Student Skill Criteria Based on Observation Results

Interval	Predicate	Category
86 – 100	A	Highly Competent
81 – 85	B	Competent
76 – 80	C	Lack of competence
< 75	D	Incompetent

Retired Modification (2019)

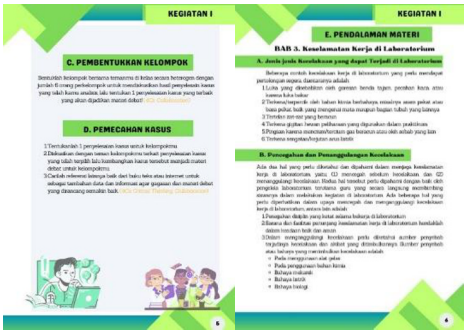
3 Results and Discussion

3.1 Analysis Stage

The analysis stage aimed to identify problems in the existing learning materials and learning process. The results of the needs analysis showed that the existing teaching materials were predominantly theory-based and not connected to real laboratory cases. As a result, these materials were insufficient to develop students' 4Cs competencies optimally. This finding indicates the need for innovative teaching materials that integrate authentic problems and student-centered learning activities to support the development of higher-order thinking skills.

Table 3. Module Development

Note	Display
Cover	 Module cover design
Fill	 Module content design

Note	Display
Syntax of case method	 Presentation of *case method syntax*
Syntax of case method and design of work	 Problem-solving design and work design activities
Discussion Syntax	 Classroom discussion activities

Note	Display
Competency Test	 Final competency test of the module

3.2 Design Stage

At the design stage, the module was planned by determining the learning structure, case method syntax, and presentation format. The designed module consisted of three main aspects, namely format and graphics, content, and language. The learning activities were structured according to the case method stages, including case presentation, group discussion, problem analysis, presentation, and reflection. This design was intended to create a learning environment that actively engages students in critical thinking, collaboration, communication, and creativity.

3.3 Development Stage

At the development stage, the module was developed according to the design plan and validated by two experts, namely a subject matter expert and a media expert. The validation results are presented in Table 3. The average validation score was 2.95, which falls into the valid category. The highest score was obtained in the format and graphics aspect, indicating that the module layout and visual design were appropriate. The content and language aspects were categorized as valid, suggesting that the material accuracy and language quality were adequate but still required minor improvements. Several revisions were made based on the experts' suggestions, including improving the use of images, refining ineffective sentences, adjusting spacing, and revising the bibliography. After revisions, the module was declared valid and feasible for implementation.

3.4 Implementation Stage

The implementation stage involved a limited trial with students enrolled in the laboratory management course. During the learning process, students analyzed cases, worked in groups, and presented their solutions. Students' responses to the developed module

were collected using practicality questionnaires. The practicality test results are presented in Table 4. The average practicality score was 92.77, which is categorized as highly practical. This result indicates that the module was easy to use, well-organized, and helpful in supporting learning activities. The high practicality score suggests that the developed module effectively facilitated student engagement and collaborative learning.

3.5 Evaluation Stage

The evaluation stage focused on assessing the effectiveness of the module in enhancing students' 4Cs skills. Students' performance was observed using 4Cs observation sheets. The observation results are presented in Table 5. The average 4Cs score was 85.05, which is categorized as competent. Communication and collaboration skills reached the highly competent category, indicating that group discussions and case presentations successfully facilitated interaction and teamwork. Critical thinking and creativity skills were categorized as competent, suggesting that the case analysis activities helped students develop higher-order thinking and problem-solving abilities. These results confirm that the developed module effectively improved students' 4Cs competencies.

Table 4. Module Validation Results

Aspects	Average	Category
Module Format and Graphics Aspects	3.60	Valid
Content Aspects	2.62	Valid
Language Aspects	2.65	Valid
Average	2.95	Valid

The validation results in Table 4 show that the developed module achieved a valid category in all assessed aspects. The format and graphics aspect obtained the highest score, indicating that the module layout and visual design supported readability and learning comfort.

The content aspect was categorized as valid, showing that the learning materials and case examples were relevant to the syllabus and learning objectives. The language aspect also achieved a valid category, indicating that the instructions and materials were clear and appropriate for students' academic level.

Overall, these results confirm that the developed case method-based module is feasible for implementation and meets the required quality standards in terms of format, content, and language.

The validation results are in line with previous studies reporting that instructional modules developed using the ADDIE model generally achieve good validity in terms of format, content, and language [12], [13]. This indicates that the systematic design process contributes to the quality of the developed learning materials.

Table 5. Module Practicality Questionnaire Results

Aspects	Average	Category
Eligibility Aspects of Content	95.83	Highly Practical
Planning Aspects	87.50	Highly Practical
Pedagogic Aspects	95.00	Highly Practical
Average	92.77	Highly Practical

The results in Table 5 indicate that the developed module achieved a highly practical category in all assessed aspects. The content eligibility aspect obtained a high score, showing that the material is relevant and well organized. The planning aspect also reached a highly practical level, indicating that learning activities and time allocation were well structured and easy to implement.

The pedagogic aspect obtained the highest score, reflecting that the learning strategies and guidance effectively supported active and collaborative learning. Overall, these results confirm that the developed module is practical, easy to use, and suitable for classroom implementation.

Table 6. Results of Observation of Students' 4Cs Skills

4Cs Skills	Group B	Category
Think Critical	83.11	Highly Competent
Communication	87.25	Highly Competent
Collaboration	86.40	Highly Competent
Creative	84.22	Highly Competent
Rata-rata	85.05	Highly Competent

The results presented in Table 6 show that students' 4Cs skills achieved good to high categories in all assessed aspects. This indicates that the developed module was effective in facilitating critical thinking, collaboration, communication, and creativity through case-based learning activities.

The improvement of students' 4Cs skills suggests that the learning activities provided meaningful learning experiences and encouraged active problem solving and teamwork. Therefore, the developed module can be considered effective in enhancing students' 4Cs competencies in laboratory management learning.

The high practicality scores are consistent with the findings of Hossain et al. (2018), who reported that case-based modules are easy to use and support active learning. Furthermore, the improvement of students' 4Cs skills is in accordance with [9] Andayani et al., who found that the case method effectively enhances students' critical thinking and collaboration skills in higher education.

4 Conclusion

The development of the case method-based module for the laboratory management engineering program resulted in a product that is valid and practical based on expert validation and practicality questionnaire results. Furthermore, the evaluation results indicate that the module is effective in supporting the improvement of students' 4Cs competencies. Therefore, the developed module is feasible to be implemented as a learning resource in laboratory management courses. By engaging students with real-life laboratory management cases, the module successfully encouraged critical thinking, creativity, collaboration, and communication.

Further studies are recommended to apply the module in other courses or to measure its long-term impact on students' learning achievements and professional readiness.

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