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Developing a Practicum Module for Air Conditioning (AC) Systems in Refrigeration Engineering Course

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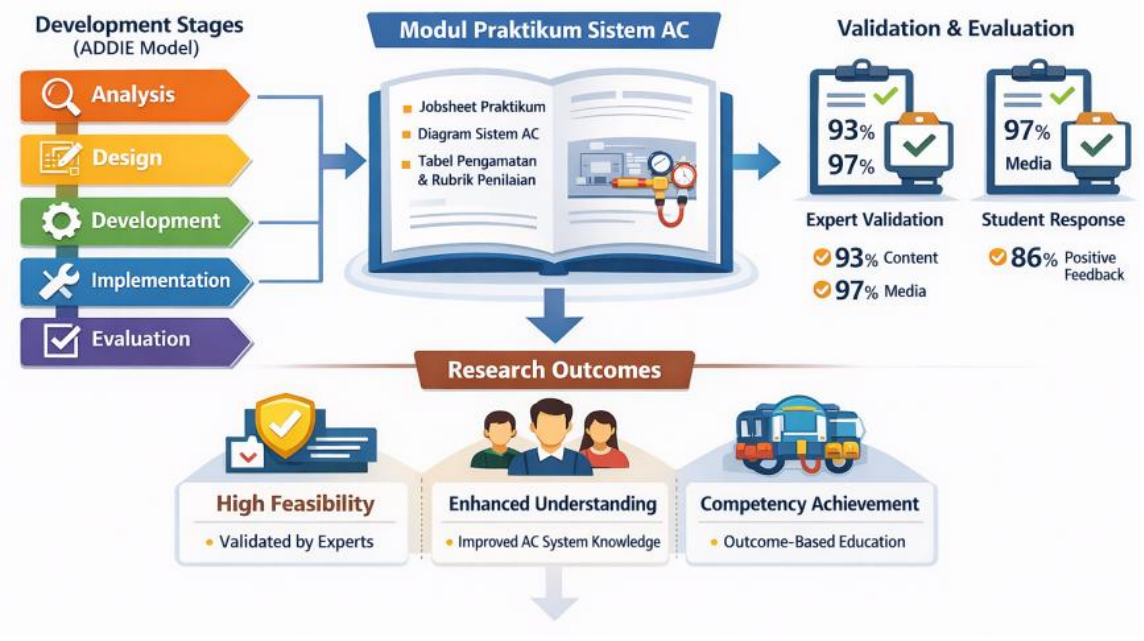
Graphical Abstract



Highlights

- The Air Conditioning (AC) system practicum learning module was developed using the ADDIE model to ensure relevance to vocational learning needs.
- The structured practicum module includes jobsheets, AC system diagrams, observation tables, data analysis, and authentic assessment rubrics.
- Expert validation results indicate very high feasibility, with 93% for content and 97% for media.
- Student feedback was positive, demonstrating that the module supports system understanding and guides practicum activities.
- The module contributes to improving the quality of practicum learning, particularly by bridging the gap between theory and practice in AC systems.

ARTICLE INFO

Keywords:
ADDIE Model, *Air Conditioning* (AC), Practicum Module

ABSTRACT

This study aims to develop a feasible practicum module for air conditioning (AC) systems, evaluate its feasibility through expert validation, and analyze student responses to the developed module. The research employed a Research and Development (R&D) approach using the ADDIE model, which consists of five stages: analysis, design, development, implementation, and evaluation. The development process included needs analysis, initial module design, product development, expert validation

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(content and media), and student trials. The research subjects comprised subject-matter experts, media experts, and students as module users. Data were collected using validation sheets and student response questionnaires and analyzed using both qualitative and quantitative descriptive methods. The results indicate that the content and language aspects achieved a feasibility score of 93% (highly feasible), while the media aspect reached 97% (highly feasible). Student responses showed a score of 86.09%, which also falls into the highly feasible category. Therefore, the developed AC system practicum module demonstrates a high level of feasibility and strong potential as an effective learning resource to support practical activities.

1. Introduction

Global warming has become a critical global issue, characterized by a continuous increase in the Earth's average surface temperature. This phenomenon is primarily caused by solar radiation reaching the Earth's atmosphere, where part of it is converted into thermal energy and absorbed by both the atmosphere and the Earth's surface [1]. The rising ambient temperature has significantly influenced human activity patterns, leading to reduced outdoor activities and increased reliance on indoor environments. As a result, air conditioning (AC) systems have become essential for maintaining indoor thermal comfort, particularly in tropical and subtropical regions. AC systems are widely used due to their effectiveness in regulating temperature and improving indoor environmental quality [2].

However, the widespread use of AC systems is often accompanied by improper design, incorrect capacity selection, and inefficient operation. Factors such as room size, occupancy, and cooling load are frequently overlooked, causing AC units to operate beyond optimal conditions. This leads to increased energy consumption, higher operational costs, and reduced equipment lifespan. Therefore, proper operation and maintenance of AC systems are essential to improve energy efficiency, ensure user comfort, and maintain healthy indoor environments [3].

Previous studies have shown that energy inefficiency in buildings is often caused by mismatches between AC capacity and actual cooling demand. The substantial energy losses caused by improper AC capacity selection, emphasizing the necessity of aligning system capacity with room characteristics and usage patterns to enhance overall efficiency [4]. These findings highlight the need for professionals who possess strong competencies in AC system design, operation, maintenance, and troubleshooting. These are particularly relevant for graduates of Vocational Mechanical Engineering Education programs, who are expected to serve not only as practitioners but also as educators capable of transferring industry-relevant knowledge and skills related to Refrigeration and AC systems [5].

In this context, the Refrigeration and AC Engineering course plays a strategic role in preparing students to meet both industrial and educational demands. AC systems constitute a core component of this course, with learning objectives encompassing an understanding of system operating principles, identification of key components, application of piping installations, and development of technical skills related to refrigerant charging and system operation [6]. Practical learning is a fundamental component of this course, as it enables students to apply theoretical knowledge in real-world situations and develop technical skills.

Practical learning has been widely recognized as an effective approach to enhancing students' understanding and skill acquisition. It is stated that practical activities allow students to engage actively in experimental processes and experience directly the application of theoretical knowledge [7]. Despite its importance, practical learning is often not supported by structured and competency-based modules. As a result, laboratory activities tend to focus only on procedural tasks rather than analytical thinking and problem-solving skills [8]. This limitation hinders the development of students' competencies. A practicum module is a structured instructional resource that integrates learning objectives, content, and guided activities [9]. In technical disciplines such as Refrigeration and AC, such modules are essential to bridge the gap between theory and practice. Practicum modules not only provide clear procedural guidance but also promote conceptual understanding, critical thinking, and skill mastery.

Therefore, this study aims to develop an AC system practicum module that is structured, applicable, and aligned with Outcome-Based Education (OBE) principles. Rapid advancements in Refrigeration and AC technologies demand continuous improvement in the quality of practical instruction [10]. However, the Refrigeration and AC Engineering course currently lacks a comprehensive and structured practicum module specifically focused on AC systems. This gap highlights the need for the development of an applicative, competency-oriented practicum module that aligns with OBE principles and contemporary industry requirements. The module is expected to improve the quality of practical learning and enhance students' competencies in Refrigeration and AC engineering, thereby better preparing graduates to meet professional and educational demands in a rapidly evolving technological landscape.

2. Materials dan Methods

This study employed a Research and Development (R&D) approach to produce a practicum module for AC systems. The research was conducted at the Mechanical Engineering Vocational Education Laboratory, Malikussaleh University. The development process followed the ADDIE model, which consists of five stages: analysis, design, development, implementation, and evaluation [11]. This model was selected due to its systematic and iterative nature, allowing continuous improvement based on feedback. This study involved clearly defined research subjects, a structured development procedure, and the use of validated instruments and data collection techniques to assess the quality and feasibility of the developed module. The overall research framework, including the development stages

adopted in this study, is illustrated in the ADDIE development flow model proposed by Molenda and Reiser (2003).

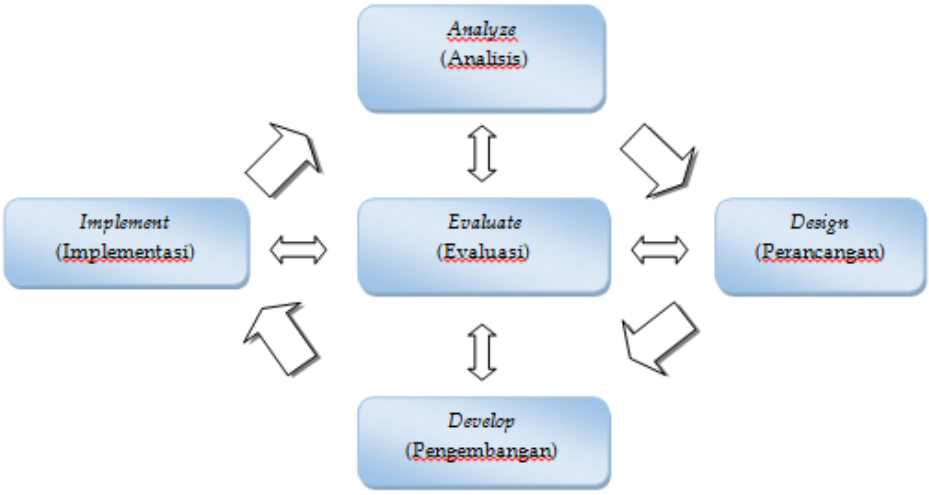

Figure 1. ADDIE Development Model

The data were collected using expert validation sheets and student response questionnaires. They were analyzed using descriptive qualitative and quantitative methods. Scores obtained from questionnaires were converted into percentages to determine feasibility levels. The feasibility percentage was calculated using the following formula:

$$P = \frac{\Sigma x}{\Sigma xi} \text{ x } 100\% \quad (1)$$

where ∑x represents the total obtained score and ∑xi represents the maximum possible score.

Feasibility criteria were classified into five levels: highly feasible, feasible, moderately feasible, not feasible, and highly not feasible presented in Table 1.

Table 1. Level of Achievement and Feasibility Quality [12]

No.	Validity Level (%)	Remark
1.	81-100	Highly Feasible
2.	61-80	Feasible
3.	41-60	Moderately Feasible
4.	21-40	Not Feasible
5.	0-20	Highly Not Feasible

Based on Table 1. above, percentage levels of ≤20% are classified as not feasible, while percentages between 81% and 100% are classified as highly feasible.

2.1 Research Subjects

The validation process involved one subject-matter expert and one media expert. The product trial involved 20 students of the Vocational Mechanical Engineering Education Study Program enrolled in the Refrigeration and AC Engineering course. The students acted as module users and provided evaluations and feedback regarding the feasibility and usability of the developed AC system practicum module [13].

2.2 Methodological Research Procedure

Based on the ADDIE model, this study's procedure had five stages. Through observations and interviews, the analysis stage identified learning problems. The design stage focused on structuring the module, developing instructional materials, job sheets, and assessment instruments. Module preparation, expert validation, and revisions comprised the development stage. The implementation stage was conducted through a trial of the module with students during practical sessions. The evaluation stage served as the final phase, focusing on an initial assessment of the module's acceptability and feasibility. However, this stage was not intended to measure long-term learning outcomes; therefore, further studies are required to evaluate the effectiveness of the developed module and to refine it based on validation data and student responses.

3. Results and Discussion

3.1. Analysis Stage

At this stage, an analysis was conducted to identify the initial problems related to the implementation of practical activities in the Refrigeration and AC Engineering course, through direct observation accompanied by interviews with the course instructor to collect the required data and information [14-15]. The interviews aimed to capture the current conditions and identify various challenges encountered during the practical sessions. Afterwards, the next step involved determining the requirements needed for the development of the practicum module, and found the primary reference for designing a more focused, structured, and learner-oriented practicum module.

The analysis identified several key issues. Practical activities were predominantly qualitative and lacked clear technical guidelines. Additionally, no structured practicum module was available to support AC system learning.

3.2. Design Stage

The module was designed with a systematic structure consisting of three main sections: introduction, main content, and closing section. It includes theoretical explanations, job sheets, report templates, and supporting materials. The following sections describe the design stage of the practicum module:

Table 2. Framework of the AC System Practicum Module [16-17]

Module Parts	AC System Practicum Module
Initial Parts	1. Front Cover 2. Preface 3. Contents 4. Figures 5. Introduction
Main Parts	1. Theoretical Background 2. Jobsheet
End Parts	1. Template of Report 2. Glosarium 3. References 4. Author Biography 5. Lecturer Biography 6. Back Cover

Table 2 shows that the AC system practicum module was designed with a systematic structure, comprising an introductory section, a main content section, and a concluding section to support the effective and well-organized implementation of practical activities.

3.3. Development Stage

Product validation was conducted as part of the development stage to assess the content quality and visual design of the developed module.

a. Content Validation

Prior to implementation, the module was validated by a subject-matter expert from the Mechanical Engineering Vocational Education Study Program at Malikussaleh University. The evaluation focused on content, feasibility, and language to ensure clarity and quality. Data were collected using a validation sheet and are presented in the following table.

Table 3. Results of Subject-Matter Expert Validation on Content Feasibility

No	Indicators	Score
1.	Alignment of Learning Materials with Learning Competencies	90
2.	Accuracy	96
3.	Relevance	93
4.	Benefit	93
Total Score		372
Total Mean		93
Total Percentage		93%
Assessment Interpretation of the AC Practicum Module in the Refrigeration and AC Engineering Course		Highly Feasible

The content validation results showed a score of 93%, indicating that the module is highly feasible. Minor revisions were recommended to improve accuracy and relevance.

Furthermore, language feasibility validation was conducted to evaluate the appropriateness of the language used in the developed module. The assessment data were collected using a material expert validation instrument and are presented in the following table:

Tabel 4. Results of Material Expert Validation on Language Feasibility

No	Indicators	Score
1.	Simplicity	100
2.	Communicative	80
3.	Interactive	90
4.	Compliance with Indonesian Language Conventions	95
5.	Use of Symbols or Icons	100
Total Score		465
Total Mean		93
Total Percentage		93%
Assessment Interpretation of the AC Practicum Module in the Refrigeration and AC Engineering Course		Highly Feasible

The language aspect also achieved a score of 93%. The module is clear and understandable, although improvements are needed to enhance communicative quality. However, the communicative aspect still needs improvement to make the delivery of the material more engaging, as well as the subject-matter expert provided suggestions for improvement, including standardizing the module format and refining the reference list, writing style, and cover design to ensure compliance with academic writing conventions.

b. Media Validation

This validation process aims to evaluate the visual quality and design suitability of the developed module. The assessment data were obtained through a media expert validation instrument and are subsequently presented in the following table:

Tabel 5. Results of Media Validation

No	Indicators	Score
1.	Cover Design and Size	100
2.	Content Design	94
Total Score		194
Total Mean		97
Total Percentage		97%
Assessment Interpretation of the AC Practicum Module in the Refrigeration and AC Engineering Course		Highly Feasible

Media validation yielded a score of 97%, indicating excellent visual design and layout. Suggestions included improving image captions for better clarity. These results indicate that the module has met the criteria for learning media feasibility in terms of cover design, module size, and content layout, and is therefore deemed suitable for use as a supporting learning medium in the Refrigeration and AC course. Nevertheless, the media expert also

recommended that the image captions be clarified and refined to further enhance the clarity and overall quality of the module presentation.

3.4. Implementation Stage

The product trial was conducted during the implementation stage by testing the AC system practicum module with 20 students. Students studied the module prior to the practicum and completed a response questionnaire after the session to evaluate material clarity, instructional completeness, and ease of use. The collected data were analyzed to determine the module's feasibility based on students' perceptions as end users. The results indicate that the module effectively supports the practicum learning process.

Tabel 6. Results of Users (Students) Feedback on Content of Module

No.	Name of User	Score	Percentage (%)
1.	IM	51	92,73
2.	AS	49	89,09
3.	ES	50	90,91
4.	SS	49	89,09
5.	M	46	83,64
6.	F	47	85,45
7.	AI	48	87,27
8.	FR	47	85,45
9.	HAP	48	87,27
10.	MGA	51	92,73
11.	H	53	96,36
12.	RN	44	80,00
13.	MI	48	87,27
14.	MA	46	83,64
15.	CC	40	72,73
16.	AG	45	81,82
17.	MG	42	76,36
18.	IA	52	94,55
19.	RN	44	80,00
20.	ZY	47	85,45
Total Score		947	
Maximum Score		1100	
Percentage		86,09%	
Feedback of Users		Very Good	

The module was tested with 20 students. The results showed a feasibility score of 86.09%, indicating that the module is highly feasible and effective in supporting practical learning.

3.5. Evaluation Stage

At this stage, revisions were made based on expert feedback to improve both content and design. These improvements enhanced the overall quality and usability of the module.

All feedbacks from the validators were carefully analyzed and used as a basis for revising both the content and the media design aspects.

4. Conclusion

This study demonstrates that the developed module for the AC practicum is valid, feasible, and effective for use in vocational mechanical engineering education. Expert validation confirmed that the module meets key standards in terms of content accuracy, instructional feasibility, and linguistic clarity, indicating its suitability as a structured learning resource. The implementation results further reveal that the module enhances students' understanding, engagement, and practical competencies in AC systems. Furthermore, the module aligns with OBE principles and contributes to bridging the gap between theory and practice. It is therefore recommended for use as a supporting learning resource in Refrigeration and AC Engineering courses. The module also encourages students to think critically about AC system performance, such as the relationships among pressure, temperature, and cooling efficiency.

Despite these positive outcomes, this study has certain limitations, including its limited sample scope and institutional context. Future research is recommended to expand implementation across different institutions, incorporate larger sample sizes, and explore the integration of digital or interactive learning technologies to further improve effectiveness [18].

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CRediT Authorship Contribution Statement

Putri Meurah Intan: Conceptualization, Methodology, Investigation, Data Curation, Writing Original Draft, Writing – Review & Editing, and Visualization; Azhar Syahputra: Conceptualization, Investigation, Data Curation, Formal Analysis, Supervision, Writing – Review & Editing; Muhammad Yusuf: Conceptualization, Methodology, Formal Analysis, Supervision, Writing – Review & Editing

Conflicts of Interest

The authors declare no conflict of interest.

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