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Innovation in Refrigeration and Air Conditioning Engineering Teaching Materials at Makassar Aviation Polytechnic

Andi Fadhilah Nugrah[1], Sheilla Novita[2], Sugiyanto[3], Muhamad Nur[4] , Dian Firdiani[5]
Politeknik Penerbangan Makassar[1,2,3,4], Universitas Muhammadiyah Enrekang[5]

***Korespondensi:**
fadhil.nugrah@poltekbangmakassar.ac.id

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ABSTRACT

The objective of the research to develop and standardize teaching materials for refrigeration and air conditioning engineering courses to enhance the quality of learning and competency development among cadets. In vocational education—particularly within the aviation sector—standardized and industry-relevant instructional content is essential to equip students with the theoretical knowledge and practical skills required for success. The growing complexity of aviation technologies further emphasizes the need for immediate improvements in educational resources. Using a qualitative research approach, data were collected through observation and questionnaires to conduct a comprehensive needs analysis. Cadet feedback highlighted gaps in the adequacy, accessibility, and effectiveness of current teaching materials. In response, the research followed key stages: identifying cadet learning needs, developing targeted instructional modules, and testing the materials to ensure alignment with educational and industry standards. The evaluation results indicated that the developed teaching modules are highly feasible for classroom use. The material content received an average score of 3.73, reflecting strong alignment with curriculum objectives. The instructional media scored 3.60, indicating effective visual and design elements, while user evaluations averaged 3.55, confirming practical usability and clarity. This study contributes significantly to vocational education in refrigeration and air conditioning engineering by providing high-quality, standardized teaching materials. These resources support cadets in developing the competencies needed to meet the evolving demands of the aviation industry. The outcomes offer valuable insights for educators, curriculum designers, and policymakers working to improve technical training programs in similarly specialized fields.

INTRODUCTION

Learning is a complex process where the role of the lecturer or instructor is pivotal in determining the success of teaching and learning activities. A professional lecturer or instructor is not just a facilitator, but a guide who must have a deep understanding of the characteristics of the content of the learning message to be delivered. This understanding includes the selection of appropriate learning strategies, effective interaction with cadets, efficient classroom management, and selecting relevant learning materials and media. In addition, accurate evaluation tools are needed to measure the achievement of cadets' competencies holistically. In the context of vocational education, particularly in refrigeration and air conditioning engineering, a challenge often faced is the complexity of concepts and practical applications of refrigeration

and air conditioning systems. Many cadets struggle to understand basic principles such as the refrigeration cycle, energy efficiency, and temperature management due to the lack of teaching materials designed according to their needs. This impacts their limitations in applying these concepts to real scenarios, especially in the aviation industry, which requires high precision and reliability.

According to Miller (2021), incorporating interactive and practice-based learning materials can improve motivation and learning outcomes. In this context, learning modules are a significant source of information and a tool that facilitates more engaging learning. As Anderson (2017) suggested, these modules help create consistent learning quality standards across educational institutions, including aviation polytechnics. This uniformity is critical to ensure cadets receive an education that meets the demands of aviation industry standards. Furthermore, Brown (2020) highlights that learning modules allow cadets to learn independently according to their pace and learning style. The module can also be a consistent reference that helps reduce confusion in understanding complex material. In developing the refrigeration and air conditioning engineering learning module, it is essential to integrate aviation industry standards, such as aircraft refrigeration system management and operational space temperature management. Smith (2018) asserts that a good module should include clear learning objectives, organized material structure, and learning activities that encourage the active participation of cadets so that they can connect theory with real-world applications.

Thoroughly and systematically designed learning materials significantly impact creating an effective learning atmosphere. When learning materials are enriched with adequate media and learning resources, this not only increases cadets' learning motivation but also creates a dynamic and interactive learning atmosphere. Interesting learning materials and relevant and quality illustrations can encourage cadets to use them as independent learning resources. Thus, the material is not only a passive reading material but also an effective tool in improving cadets' understanding and skills in specific courses. However, in the context of refrigeration and air conditioning engineering education in polytechnics, especially those related to the aviation industry, there is a significant gap. Available teaching materials are often less relevant to the specific needs of cadets in understanding the application of refrigeration and air conditioning engineering in the world of aviation. For example, many modules do not highlight the application of refrigeration technology in aircraft or air conditioning in airport facilities, which have different characteristics compared to engineering applications in other sectors. This makes it difficult for cadets to relate theory to practice in the real world of work.

This research aims to fill the gap by developing a learning module specifically designed to meet vocational education needs in refrigeration and air conditioning engineering. The module integrates aviation industry standards and practices, including the management of in-flight refrigeration systems, energy efficiency, and air conditioning management in airport operational spaces. The module is not just a collection of theoretical knowledge, but a practical guide to honing the skills of cadets, preparing them to face the demands of the aviation industry. Examples of learning materials that can be used include learning modules, learning audio, learning videos/CDs, and Computer-Assisted Instruction (CAI). Each type of learning material is designed to facilitate various learning styles of cadets, whether visual, auditory, or kinesthetic. With the variation in learning materials, cadets are expected to be more motivated to learn independently and increase the learning process's effectiveness and efficiency.

Based on the background description above, the author strongly advocates for the development of a specific course textbook, namely "Refrigeration and Air Conditioning Engineering," at the Makassar Aviation Polytechnic. This textbook is not just a resource, but a crucial guide for lecturers/instructors in teaching the course, making learning more focused, structured, and aligned with the aviation industry's needs. It is designed to not only deliver theory but also practical applications that are directly relevant to industry needs. Thus, cadets who learn from this textbook are expected to master the competencies needed in the world of work, especially in the field of refrigeration and air conditioning engineering. The development of this textbook is a significant step towards improving the quality of education at the Makassar Aviation Polytechnic and supporting the institution's efforts in creating competent and work-ready human resources.

METHOD

This research uses a qualitative approach to explore the need for teaching materials in the Refrigeration Engineering course at Makassar Aviation Polytechnic. This approach was chosen because it can provide an in-depth understanding of the needs and perceptions of users of teaching materials, especially

cadets who take the course. Data was collected through observations and questionnaires, aiming to identify information on cadets' needs for teaching materials that can support the achievement of the desired learning targets. The data obtained will be used to standardize teaching materials between Technical Implementation Units (UPT) under the Air Transportation Human Resources Development Center (PPSDMPU) to create uniformity in learning quality.

The main subjects of this research, including the Head of the Airport Technology Study Program (Kaprodi TBU), lecturers, and cadets from the TBU study program class XB, were all integral to the collaborative nature of this study. Their deep insights and direct involvement as users of the teaching materials made them the right resource persons. The sample size of the cadets involved was 24 people, according to the number of cadets in one class at Makassar Aviation Polytechnic, ensuring data consistency and a focus on intensive learning interactions in the classroom.

This study used two main types of data sources, namely primary data obtained from the Head of the Study Program, lecturers, and cadets, and secondary data in the form of academic documents such as teaching materials, Semester Learning Plans (RPS), and other learning records. The data collection process was carried out through direct observation of the cadets' learning process and the distribution of questionnaires to obtain quantitative data on the perceptions and needs of teaching materials. Observations focused on classroom interactions and the use of teaching materials, while the questionnaire was designed to explore cadets' views on the effectiveness of the teaching materials used. In this study, the researcher, who has [specific qualifications or experience], also acted as the main instrument, as direct involvement in the data collection and analysis process allowed flexibility in exploring further information from the informants. The researcher used observation guides and questionnaires to ensure the data collected was in line with the research objectives.

The data analysis follows a qualitative research procedure consisting of four main stages: define, design, develop, and disseminate. In the define stage, the researcher defines the research objectives and the problems to be clarified, including determining indicators of open material needs. The design stage involves designing research instruments and the proposed teaching material format. Furthermore, the development stage is used to analyze data and develop teaching materials that align with cadets' needs, including content, media, and teaching methods. Finally, the dissemination stage aims to disseminate the research results in the form of open materials that have been developed for lecturers and Heads of Study Programs in various UPTs. The practical application of this research, in the form of standardized teaching materials, is expected to significantly improve the quality of Refrigeration Engineering learning in the Makassar Aviation Polytechnic environment and support the improvement of cadet competence in refrigeration and air conditioning engineering.

RESULTS AND DISCUSSION

This research was conducted with the aim of creating a product in the form of a cooling engineering module that is carried out using a 4D model. The development flow of the 4-D model, namely the *define, design, develop and disseminate stages.*

a. *Define* (Definition)

The analysis and problem identification stage is a very important initial step in the research and development process of educational products, especially in the context of preparing teaching materials. This stage aims to collect various relevant information in order to deeply understand the existing needs and challenges faced in the learning process. This initial analysis involves identifying real problems that arise during the implementation of teaching and learning activities. The identification process is carried out through direct observation in the learning environment, which allows researchers to directly see the learning conditions and evaluate the effectiveness of the teaching methods applied.

The results of the observation showed several crucial problems in the learning process of the Refrigeration Engineering course. One of the main problems identified was the limited teaching materials available, especially learning modules that can be used by cadets as a guide for independent learning. Currently, the learning process tends to be focused on the role of lecturers as the main source of information. This makes it difficult for cadets to understand the material in depth without a structured learning guide. Dependence on lecturers also limits opportunities for cadets to develop independent learning skills, which are very important in improving learning competence and independence.

In addition, observations also revealed that the level of cadets' understanding of the material being taught was still low. This was caused by the lack of adequate teaching materials, so that cadets did not have enough references to study the material outside of face-to-face hours. As a result, cadets could not learn effectively outside of class and tended to be passive in the learning process. This problem indicates that more structured teaching materials are needed, such as comprehensive learning modules, to support a more effective teaching and learning process.

To strengthen the data from the observation results, this study also involved the stages of analyzing the needs of students. This analysis was carried out by distributing questionnaires to cadets. The questionnaire was designed to explore information about the cadets' needs for teaching materials, their level of understanding of the material being taught, and the obstacles they faced during the learning process. Questions in the questionnaire covered aspects such as the quality of the material being taught, the lecturer's teaching methods, and the availability of supporting teaching materials. Through this questionnaire, researchers hope to obtain more detailed data on the needs of cadets and their perceptions of the current learning process. The data collected through the questionnaire will be analyzed to identify the gap between the ideal needs of cadets and the actual conditions of current learning. In addition, the questionnaire also serves to collect direct feedback from cadets regarding the teaching materials they need. Thus, the results of this analysis will be the basis for developing learning modules that are more relevant and in accordance with the needs of cadets. The developed modules are expected to be teaching materials that not only support face-to-face learning, but also allow cadets to learn independently and improve their understanding of the material more comprehensively.

Overall, this analysis stage provides very important insights for the development of more effective learning modules. By identifying the problems faced, researchers can formulate more targeted solutions, including the preparation of more structured and comprehensive teaching modules. This module will later be adjusted to the needs of cadets and learning conditions in the Makassar Aviation Polytechnic environment, so that it can improve the quality of learning and help cadets achieve the expected competencies.

Table 1 User questionnaire results

Data	Amount
Question Items	23
N Valid	24
Miss	0

Table 1 shows that there is input data from 24 cadets as input data declared valid. Questions totaling 23 with missing data are 0 or no data processing errors were found. Based on the results of the questionnaire, in general, the results of observations on aspects of personal attitude, self-ability, understanding of material, cognitive ability with less positive conditions. Thus, it can be concluded that on average they have a good personal attitude but do not have good self-ability, understanding of material and cognitive ability. The formulation of learning objectives or indicators of learning achievement is made based on learning outcomes listed in the syllabus. Basic competencies can be broken down into several materials.

Table 2 Learning Outcomes

No.	Learning Outcomes
1	Cadets are able to explain the basics of refrigeration and air conditioning systems
2	Cadets are able to explain the working principles and classify the types of air conditioning systems.
3	Cadets are able to apply and adjust the psychrometric air conditioning system.
4	Cadets are able to carry out maintenance and solve problems on various types of central air conditioning systems.
5	Cadets are able to calculate cooling load requirements
6	Cadets are able to calculate the load on the air circulation system in a building.
7	Cadets are able to implement and determine air distribution systems

b. ***Design*** **(Design)**

In addition to compiling a competency map, a crucial step that serves as a guiding light in the learning process, the design stage also includes planning module content. This involves selecting relevant materials, such as basic concepts of cooling systems, working principles, principal components, and maintenance and troubleshooting

techniques. Each topic is described systematically and equipped with illustrations, technical drawings, and diagrams to facilitate cadets' understanding. The module structure is designed to include several main parts, namely: Introduction containing learning objectives and instructions for using the module, Learning Materials presented in several sub-chapters, Exercises, and Evaluations consisting of practice questions and formative tests, Summaries to strengthen understanding, and References that list supporting reading sources.

This module is meticulously designed to be flexible, ensuring its adaptability to both face-to-face learning and independent learning settings. To cater to the diverse learning styles of cadets, the module is equipped with a variety of learning media, including text, images, videos, and interactive simulations. This approach not only ensures that cadets gain theoretical understanding but also provides them with opportunities to practice the knowledge they have learned. After the initial design is complete, the next stage is the creation of a module prototype, which is then tested. This trial aims to obtain feedback from the lecturers and cadets to improve the module. The input will be used to adjust and improve the module before it is widely implemented. With this approach, the module is expected to enhance the learning quality, helping cadets achieve the expected competencies in the Refrigeration Engineering course. The competency map that has been prepared will be visualized in the form of a chart, which shows the relationship between basic competencies, achievement indicators, and learning materials so that it becomes a clear guide for lecturers in the learning process.

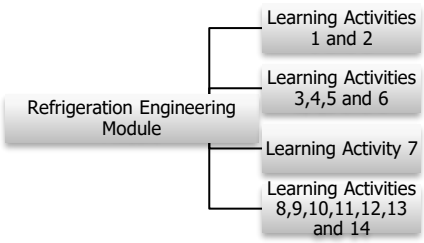

Figure 1. Planning Design

The formulation of the material is adjusted to the basic competencies in the syllabus as seen below.

Table 3 Material Formulation

Learning Outcomes	Basic Material
Cadets are able to explain the basics of refrigeration and air conditioning systems	Basic understanding of refrigeration and air conditioning systems
Cadets are able to explain the working principles and classify the types of air conditioning systems.	Types of air conditioning systems
Cadets are able to apply and adjust the psychrometric air conditioning system.	Psychometry and air freshening system
Cadets are able to carry out maintenance and solve problems on various types of central air conditioning systems.	Ventilation system and distribution system
Cadets are able to calculate cooling load requirements	Cooling load calculation and estimation
Cadets are able to calculate the load on the air circulation system in a building.	Factors affecting cooling load
Cadets are able to implement and determine air distribution systems	Estimated cooling load calculation

c. *Develop* (Development)

The development stage is a crucial phase in preparing learning modules, where previously designed products will be refined based on expert input and suggestions. This process includes two main steps, namely expert validation and development trials. Expert validation aims to evaluate the feasibility of the material and the quality of the module that has been prepared so that the module can be accepted and used effectively as teaching materials. In this stage, two experts from the Airport Technology Study Program of Makassar Aviation Polytechnic, along with the valuable input of our audience, assessed the module using a questionnaire instrument consisting of 16 questions, with a score range of 1 to 4. The aspects evaluated by the experts include five main dimensions: self-instruction, self-contained, stand-alone, adaptive, and user-friendly. These dimensions focus on the extent to which the module allows cadets to learn independently, includes complete learning materials, stands alone without additional references, can adapt to the various learning needs of cadets, and is easy to use.

After receiving expert assessments, the average value of the respondents' scores is calculated and converted into a feasibility conversion table to determine the level of module feasibility based on expert perceptions. The resulting feasibility category will indicate whether the module is feasible or requires further revision. This iterative process ensures that the validated module will undergo a development trial involving cadets as respondents to obtain direct feedback on the clarity of the material and ease of use. Based on the validation and trial results, revisions will be made

to improve various aspects of the module to meet the specified feasibility standards. This revision includes improvements to content, structure, visual design, and other features that support learning effectiveness. Thus, through this development stage, it is hoped that the resulting module can be an effective, relevant teaching material that can improve the understanding and skills of cadets in the Refrigeration Engineering course.

Table 4 Results of Material Expert Validation

Aspect Evaluation	Score Expert		Average Total	Category
	1	2		
Self-instruction	3.7	3.7	3.71	Very Worth It
Self contained	4	4	4	Very Worth It
Stand alone	3.5	3	3.25	Worthy
Adaptive	4	4	4	Very Worth It
User friendly	3.5	4	3.75	Very Worth It
Average Score Total			**3.73**	**Very Worth It**

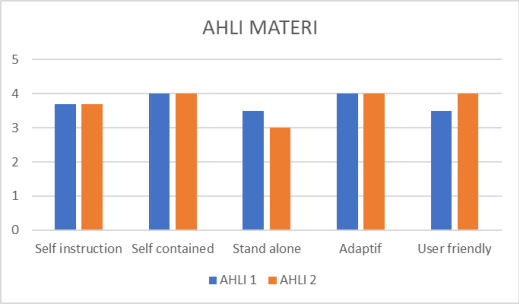

Figure 2 Results of Material Expert Validation

Table 5 Suggestions and Input from Material Experts

No.	Suggestions and Feedback	Follow-up
1	Word selection should be given more attention	Some words and sentences have been changed and readjusted.
2	Complete the picture.	Added required images
3	The material is further detailed	Materials provided

The module assessment for material experts is divided into five main aspects, each getting a different average score based on the assessment results. The first aspect, Self Instruction, receives an average score of 3.71. This means that the module is included in the very feasible category because it can provide clear and adequate instructions for users to understand independently. The second aspect is self-contained, which received an average score of 4. This shows that the module is complete and covers all the necessary materials without requiring additional sources, so it is feasible. The module received an average score of 3.25 in the stand-alone aspect. This is also feasible, indicating that the module can stand alone and be used effectively without additional materials or further explanation.

The Adaptive aspect of the module, which received an average score of 4, indicates its high level of flexibility. This adaptability allows the module to be adjusted to various conditions and user needs, making it very feasible. The User-Friendly aspect, with an average score of 3.75, underscores the module's ease of use. This score indicates that the module is straightforward to use and provides a good user experience, falling into the very decent category. The media validation process was carried out by two experts who were lecturers from the Airport Technology Study Program of Makassar Aviation Polytechnic. The questionnaire used in the assessment process consisted of 30 items with a score range per item of 1-4. Media experts' assessment aspects included factors such as book size, design, and module content. This validation aims to ensure that the module not only meets academic standards but is also practical and easy to use by users so that it can provide maximum benefits in the learning process.

Table 6 Media Expert Validation Results

Aspect Evaluation	Score Expert		Total average	Category
	1	2		
Book size	3.5	4	3.75	Very Worth It
Design aspects	3.5	3.6	3.55	Very Worth It
Content aspects	3.7	3.5	3.62	Very Worth It
Average Score Total			**3.60**	**Very Worth It**

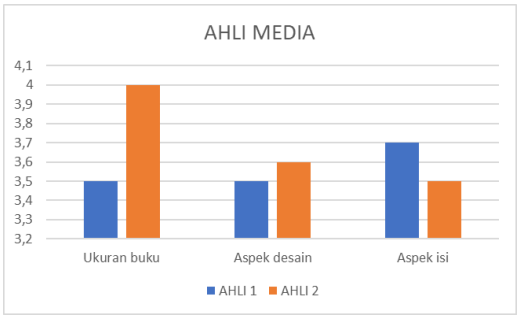

Figure 3 Results of Material Expert Validation

Table 5 Suggestions and Input from Material Experts

No.	Suggestion And Input	Action Carry on
1	The cover data is complete	Complete the study program name cover
2	Pay attention to the margins on each page.	All margins are equalized
3	Spaces on different modules	Space revision
4	Pay attention to each chapter and sub-chapter	Chapters and subchapters are revised according to the rules

Media expert assessment is divided into three main aspects, each getting a different average score based on the assessment results. The first aspect is the size of the book, which receives an average score of 3.75. This shows that the book is very worthy in terms of size, meets the expected standards, and makes it easy for readers to use. The second aspect is design, which received an average score of 3.55. This means that the book's design is very decent, with an attractive appearance and layout that makes it easy for readers to understand the material. The last aspect is the content, which gets an average score of 3.62. This shows that the content of the book is very worthy, providing clear, comprehensive, and easy-to-understand information for readers. After the module has been validated by material and media experts and declared suitable for use as learning material, the module is not just tested, but specifically validated for cadets. This trial aims to obtain responses from end users, thus ensuring that the module is academically and practically feasible and well received and used by cadets in their learning process.

Table 7 User Validation Results

Aspect Evaluation	Average Total	Category
Media Aspects	3.49	Very Worth It
Material Aspect	3.54	Very Worth It
Learning Aspects	3.61	Very Worth It
Average Score Total	**3.55**	**Very Worthy**

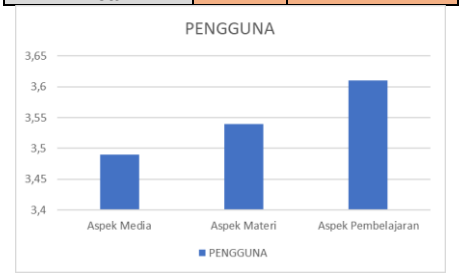

Figure 4 User Validation Results

In the trial of using the module, the assessment was carried out on three main aspects: the media aspect, the design aspect, and the learning aspect. The results of the average score of each element indicate that this module is feasible to use. The module received an average total score of 3.49 in the media aspect. This suggests that the media used in this module effectively supports users' understanding of the material. Good media ensures that information is delivered clearly and attractively, making it easier for users to understand and absorb the material presented. This aspect includes various elements such as images, graphics, and videos that support visually delivered information. Furthermore, in terms of design, this module received an average score of 3.54. This shows that the module design is very feasible regarding visual appearance, layout, and material presentation structure. The design, which includes a visually appealing layout and a clear structure, makes the module attractive, helps improve readability, and makes it easier for users to follow the learning flow. A beautiful visual appearance and neat layout make users more interested in studying the module and easier to understand the content presented.

The module received an average score of 3.61 in the learning aspect. This aspect includes the effectiveness of the module in delivering learning materials, ease of use, and relevance of the content to users' learning needs. For instance, the module includes practical examples and case studies that are directly applicable to the field of refrigeration engineering. A high score in this aspect indicates that the module is very suitable for use as teaching material, making a significant contribution to the teaching and learning process. This module is designed to make it easier for users to understand the concepts taught, with clear explanations and relevant examples. Based on data analysis from all evaluation results by material experts, media experts, and development trials, an average overall score of 3.63 was obtained from a maximum value of 4. This indicates that the module is included in the very feasible category. This assessment covers various aspects essential to ensure the quality and effectiveness of the module as a learning reference source. Importantly, this module is not only practical and easy to use, but also meets academic standards, providing an optimal learning experience for users. Overall, the refrigeration engineering module is not only suitable as a learning reference source for Airport Technology Study Program Cadets in the refrigeration engineering course, but also highly effective. The validation and trials ensure that the Cadets can accept and use this module well. With this module, it is hoped that the Cadets can understand and master refrigeration engineering material better, thereby improving their skills and ability to apply the knowledge they have gained in practical situations in the field.

d. ***Disseminate*** **(Spread)**

The learning module, a result of the collaborative efforts of various material and media experts, has successfully completed its development stages and is now ready for use as teaching material. It has been distributed on a limited basis to campuses under the auspices of BPSDM Air Transportation. The expertise involved in its development ensures that the content is accurate, comprehensive, and delivered in an engaging and user-friendly manner.

Following a rigorous validation process by experts, the module was tested on a group of cadets to gather feedback on its effectiveness and usefulness as a learning material. The results of this trial were overwhelmingly positive, with the cadets expressing a significant improvement in their understanding of the material taught, thereby validating the module's effectiveness. The limited distribution of the module aims to measure the extent to which the module can be applied in a real learning environment before wider distribution. Campuses under the auspices of BPSDM Air Transportation were chosen as the initial distribution locations because they have adequate infrastructure and resources to implement this module.

With this learning module, the Cadets in the Airport Technology Study Program are expected to obtain high-quality learning resources that suit their needs. This module is designed to help them understand the concepts of refrigeration engineering better and be ready to apply this knowledge in practice in the field. The distribution of this module not only provides an opportunity for the development team to gather additional feedback from users but also underscores our commitment to continuous improvement. This feedback will be used to make further enhancements, ensuring that the learning module remains relevant to technological developments and the evolving needs of the aviation industry.

CONCLUSION

The development and testing of the refrigeration engineering teaching material module for cadets in the Airport Technology Study Program has yielded positive results. The module's success in material, media, and user testing underscores its high relevance, clarity, and effectiveness in meeting cadet learning needs. These results indicate that the module can significantly enhance cadet understanding of refrigeration engineering concepts and their practical application in the field. However, this study also has certain limitations. While the module has been validated for its content and usability, further testing in various educational settings could provide deeper insights into how well the module can adapt and be effective with different groups of learners. Additionally, the module's scope could be expanded to cover more advanced topics or broader aspects related to refrigeration engineering.

In terms of broader implications, this study highlights the importance of aligning teaching materials with learners' specific needs and feedback. This approach can have a significant positive impact, especially in vocational education, such as aviation polytechnics, where practical knowledge is crucial. For curriculum developers, these findings emphasize the importance of continuous evaluation and adaptation of teaching resources to ensure that educational materials remain relevant and effective. Future research could focus on exploring this module's impact on cadet performance in real-world applications and its potential for integration into other technical programs. The potential of this module to enhance teaching practices and contribute to educational policy development is an exciting prospect that we look forward to exploring further.

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