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The Implementation of an E-Module to Improve Students' Knowledge and Learning Achievement in the Elements of Refrigeration Instalation Systems

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Abstract

The availability of innovative, interactive, and student-centered learning media to facilitate the understanding of marketing techniques, air conditioning, and cooling systems, particularly the components of refrigeration installation systems, remains insufficient. It happened since interactive and contextual learning media at school were limited. This study aimed to develop and apply an E-module as an effective learning medium to improve students' learning achievement in the element of refrigeration installation. The presented research adopted the ADDIE, which comprises five steps: analysis, design, development, implementation, and evaluation. The subjects of this study were XI-grade students from two different vocational schools in Central Java. The participants were divided into an experimental group (utilizing an E-Module) and a control group (receiving conventional instruction). The instruments employed included expert validation sheets, practicality questionnaires, and learning outcome tests. The data showed that the E-module was very feasible, with a practical score gained 94% and the N-Gain of the experiment class achieved 0.74 (high level category). Furthermore, the t-test showed a difference between the experimental and control classes. In conclusion, E-module was declared very feasible, practical, and effective enough to be used in vocation learning, especially on improving students' knowledge in refrigerator installation system of cooling technique and air conditioning system such as sytem component of instalation refigerator, conceptual knowledge (understanding colling and workflow sytem), and procedural knowledge (explaining the steps for installing and maintaining the refrigeration system).

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INTRODUCTION

The advanced technology and industry in Industrial Revolution 4.0 have created significant employment needs, especially in the field of cooling systems and air conditioning. The workforce demands graduates who possess not only theoretical knowledge but also practical skills that are relevant to industry needs. Ling Li (2022) emphasized that developed technology needed an employer who gained knowledge and relevant practical skills that are in line with the cooling and air conditioning system. One of the crucial competencies was mastering the refrigerator installation system, which has a complex characterization and high technical requirements. Therefore, a learning approach that can bridge this gap is essential, including the development of instructional media based on information technology.

One of the biggest challenges in the refrigerator installation system at Vocational High School (SMK) is the low level of students' learning achievement. It is caused by the contextual learning media that are interactive and suitable for students' needs, and are limited. Pramana, Adiarta, and Ratnaya (2021) elaborated that, compared with conventional media, developed contextual learning media can impact students' achievement. Furthermore, the traditional learning methods remain dominant, and the limited time allocated for practicum sessions in the workshop contributes to students' difficulties in understanding the material. Meanwhile, students need learning media that can be accessed flexibly and support self learning.

This issue is further exacerbated by the high complexity of the subject matter and the time constraints associated with practicum-based learning. Many students faced difficulty in understanding the connection among the component systems, the cooling workflow, the principle of physics, and thermodynamics. In addition, students tend to be passive in the learning process due to the absence of interactive learning media that can stimulate students' engagement and passion. In response to these challenges, the development of innovative, student-oriented learning media has become essential.

Adopting digital-based learning media such as E-module has become an alternative strategy that is adaptable to learning challenges in the 21st century. This E-module was designed to present the material visually and interactively, and can be flexibly accessed through a digital device. Previous research elaborated that the use of the E-module has been proven to improve students' achievement in cognitive, affective, and psychomotor aspects. Furthermore, the E-module also facilitates self learning and strengthens the knowledge transfer process through integrated multimedia. The integrated E-module with multimedia was an innovative strategy because it presented technical material in a more attractive, interactive, and accessible way (Budi et al. 2023).

The teachers tend to focus on verbal explanation and use the textbook as the primary source in teaching the refrigeration installation system. Meanwhile, technical materials that gained abstract concepts need strong visual media and a contextual learning approach. Furthermore, the limited time in the school workshop provides minimal opportunities for students to develop a thorough understanding of the material. In this condition, students need learning media that are flexible, attractive, accessible, and appropriate for students' learning styles.

The implementation of interactive E-modul based on multimedia becomes an effective strategy in responding to vocational learning challenges. Safitri & Dafit (2025) elaborated that an interactive E-modul helps learning activities, which showed high validation scores from teachers and students (91.5% and 90% respectively). This score proved significant success in improving learning output compared to the conventional method. This finding emphasized the importance of multimedia, such as text, picture, animation, and video, in the module to improve learning engagement, concept understanding, and support self-learning.

Previous research elaborated that the E-module brings improvement in knowledge and students' learning achievement. In addition, it also has a highly positive effect if it is developed with a suitable approach and is built based on

students' character. A need-based approach offers a potential solution, wherein the E-Module is designed with consideration of students' learning styles, interests, and learning difficulties.

The E-module has become an alternative learning medium since it is designed with integrated texts, pictures, animations, videos, and simulations that can stimulate students to be active. The use of E-Modules can enhance learning motivation, reinforce students' conceptual understanding, and promote self-directed learning. However, an effective E-module must align with students' needs. Developing an e-module without considering students' needs and character will bring difficulty in fulfilling the learning purpose.

The background of this research is to evaluate the implementation of E-Modules as a learning medium to improve students' knowledge on the topic of cooling installation systems. This study focuses on enhancing students' factual, conceptual, and procedural knowledge through the development of a need-based E-Module. Thus, this research is expected to provide a real contribution to the development of technology-based learning tools in vocational education.

RESEARCH METHOD

This research adopted research and development (R&D) that comprises five steps. Susilo, Wijanarko, and Sutopo (2023) elaborated that R&D research in vocational high school learning media used a systematic stage: analysis of students' needs, constructing a prior-prototype, expert validation, product revision, and limited test. This entire process ensures that the final product is feasible, contextually relevant, and effective in improving students' learning outcomes. In line with Budiman et al (2017), research and development (R&D) comprises many systematic steps, starting from collecting information, planning, creating a prototype, expert validation, product revision, and limited testing to produce feasible and effective learning media that meet vocational students' needs.

Salitong et al (2022) showed that E-module-based cases applied ADDIE and proved to be valid, practical, and effective in a learning context. The researcher adopted the ADDIE model that comprises five stages: (1) analysis, (2) design, (3) development, (4) implementation, and (5) evaluation.

The primary focus of this research is to enhance students' learning achievement in understanding the elements of the refrigeration installation system, encompassing aspects of factual knowledge (system components), conceptual knowledge (the working mechanisms of the refrigeration installation system), and procedural knowledge (installation and maintenance steps). The flowchart of the developed product can be seen as follows picture 1.

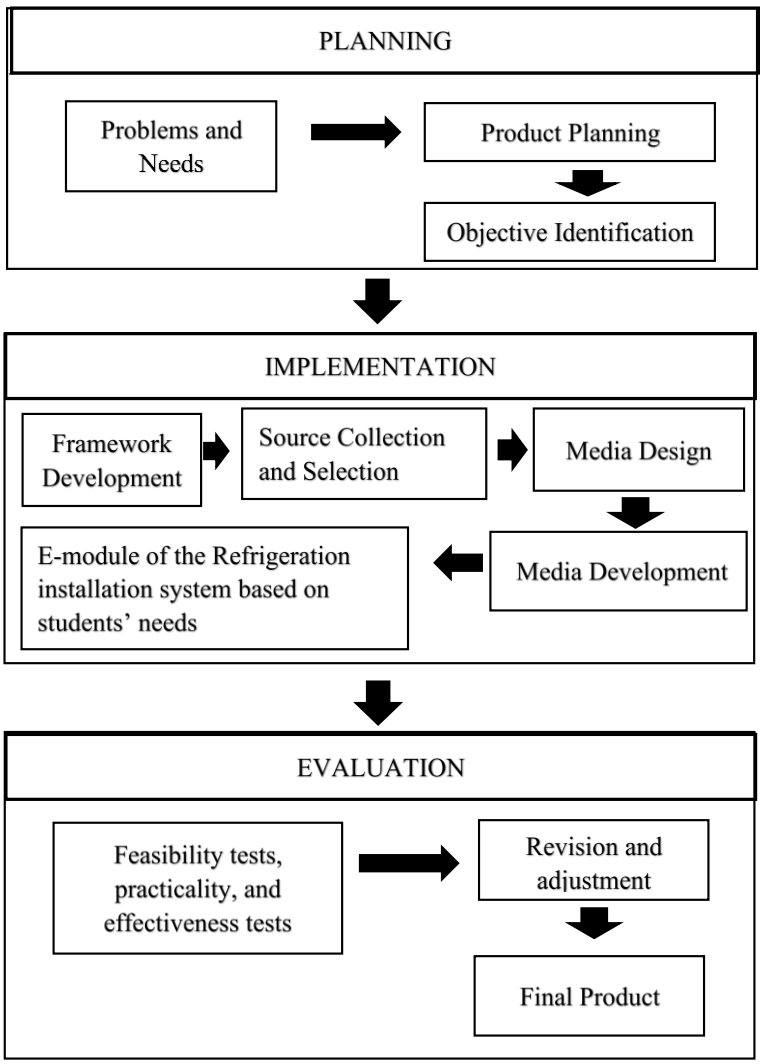
The research was carried out from 5 June to 21 June 2025 at SMK Wishuda Karya, Kudus. Three material experts and three media experts assessed the feasibility of the tools. Furthermore, the data for the practicality test was collected by seven teachers of the refrigeration installation system. Meanwhile, data for the media effectiveness test were taken from 24 students in the experimental class and 24 students in the control class.

The data was collected using an expert validation sheet (media feasibility test), teacher as user (media practicality test), and multiple-choice test (media effectiveness test). The researcher applied an experimental test with pre-test and post-test control group design. This study has two groups of participants: an experiment group that receives e-module, and a control group without e-module treatment. Both group was given a pre-test and post-test to ensure the E-module's effectiveness in students' learning achievement. The data analysis technique included data validation, practicality, and effectivity that is tested using descriptive statistics and inferential statistics such as normality test, homogeneity test, and t-test (paired sample t-test) to know the significance of students' learning output in the topic of refrigeration installation.

The feasibility instrument of E-module is validated using Content Validity Ratio (CVR) from Lawshe, and the reliability test used Intraclass Correlation Coefficient. The practicality instrument of E-module is validated using biserial point correlation coefficient, and the reliability is tested using KR20. The effectiveness of the instrument, in the form of test questions,

was evaluated through item analysis, which included assessments of validity using the point-biserial correlation coefficient, reliability using the Kuder-Richardson Formula 20 (KR-20), as well as analyses of item difficulty and difference indices.

The feasibility of the E-Module media was analyzed descriptively using quantitative methods, based on the conversion of responses into a five-point Likert scale. The practicality of the E-Module was assessed using descriptive quantitative analysis based on the average percentage of practicality. The effectiveness of the E-Module was evaluated using the N-Gain score, categorized as low ($g < 0.3$), medium ($0.3 \leq g < 0.7$), and high ($g \geq 0.7$). A significance test for differences in learning outcomes between the experimental and control groups was conducted using an independent samples t-test at a 5% significance level.



Picture 1. *Flowchart* of Product Development

RESEARCH RESULT AND DISCUSSION

1. Research Result and Development Results Using the ADDIE Model
   a) In the analysis stage, a needs assessment for the development of instructional materials was conducted, including an analysis of student needs, competencies related to refrigeration system installation, learning outcomes, and the learning environment. This stage aimed to identify problems in existing instructional materials and assess their relevance to industrial needs and students' characteristics.
   b) The Design stage involved formulating learning objectives, designing learning

scenarios, preparing materials, and developing assessment tools. This design was conceptual and served as the foundation for product development.

c) In the development stage, the conceptual design was transformed into prepared materials which were ready for implementation. Validation was performed by experts in media and materials, all of whom possess relevant backgrounds and experience in refrigeration and air conditioning.

d) The Implementation stage aimed to evaluate the practicality and effectiveness of the product, based on validation results and classroom implementation. The product was tested with students to assess its impact on knowledge learning outcomes. Teachers, as the users, also provided feedback on its practicality through a structured questionnaire.

e) The Evaluation stage was conducted to determine which development objectives level was achieved, through revisions based on user feedback and validation results. This comprehensive evaluation included assessments of the product's feasibility, practicality, and effectiveness in improving students' learning achievement.

2. E-module Feasibility

Based on the data analysis, the overall average score was 4.34, or categorized as highly feasible. Therefore, based on the validation results, it can be concluded that the refrigeration system installation E-Module is valid with minor revisions and does not require significant modifications. Since it is based on student needs, the developed E-module is deemed suitable for use to enhance students' knowledge acquisition.

3. E-module practicality test

Based on analysis data, the researcher found the average feedback rate of 94%. Compared to the practicality level criteria, user responses (teachers) fell within the 75%–100% range, or declared that the E-module classified as "highly practical". Therefore, it can be concluded that the refrigeration system installation E-Module is suitable for use as an instructional medium in the subject of Heating, Ventilation, and Air Conditioning within the Electrical Engineering Education Program.

4. E-Modul Effectiveness Test

Based on the effectiveness data analysis and the interpretation of N-Gain, the experimental class achieved a Gain score of 74%. It indicated that the implementation of the refrigeration system installation E-Module, which was developed based on students' needs, is reasonably effective in improving the knowledge learning outcomes of Grade XI Electrical Engineering 1 students at SMK Wishuda Karya Kudus in the 2024/2025 academic year. In contrast, the control class, which used conventional teaching methods, achieved a Gain score of 36%. It suggests that the traditional approach was ineffective in enhancing the knowledge learning outcomes.

Based on the significance analysis, the results of the independent samples t-test using the mean N-Gain scores showed that the N-Gain data had a Sig. (2-tailed) value of 0.000, which is lower than the significance level of 0.05. This indicates that the N-Gain_Present data in this study are statistically significant and reflect a reasonably effective distribution. In other words, for the experimental group, after receiving treatment, it proved to be both significantly and effectively impactful in improving students' knowledge.

The research findings demonstrated that the E-Module significantly contributes to improving students' knowledge acquisition in the domain of refrigeration system installation. This included component-level knowledge (recognizing system components), conceptual understanding (comprehending the refrigeration cycle and system workflow), and procedural knowledge (explaining the steps in installation and maintenance of refrigeration systems). The main advantage of the E-Module lies in its ability to present content in a visual and interactive format, and bridge understanding gaps that are often caused by the limitations of conventional teaching media. These findings align with previous studies by Putri and Ekohariadi (2024) and Suyadnya et al. (2024), who found that E-Modules were effective in enhancing students' cognitive skills and learning engagement. More

specifically, the impact of the E-Module on students can be described as the following aspects:

a) Knowledge Improvement

The developed E-Module incorporates visual content like system diagrams, animated simulations, instructional videos, and interactive practice questions. The use of multimedia presentation makes it easier for students to understand various types of knowledge related to refrigeration system installation. First, factual knowledge such as the names and functions of refrigeration system components (compressor, condenser, evaporator, and expansion valve) can be acquired more efficiently due to the presence of concrete visual illustrations. Second, conceptual knowledge, including the working principles of the refrigeration cycle and the basic principles of thermodynamics, can be understood more deeply through animations and interactive explanations. Third, procedural knowledge such as installation sequences, system testing steps, and basic maintenance and repair procedures was presented through practical videos and simulations. These resources assisted the students in directly connecting theoretical concepts with real-world applications. Previously, many students struggled to relate theoretical knowledge to its practical implementation in the field. However, by employing a learner-centered and context-based instructional approach within this E-Module, the gap between theory and practice has been effectively bridged, resulting in a more meaningful and applicable learning experience.

b) The improvement of learning and self learning activities

During the implementation phase, it was indicated that students became more actively engaged in asking questions, participating in discussions, and independently attempting practice exercises within the E-Module. This reflects an improvement in self-directed learning. The flexible access provided by the E-Module allowed students to revisit and review materials out of regular class hours. These findings align with the research by Suyadnya, Agustini, and Sudarma (2024), which demonstrated that Problem-Based Learning (PBL) based E-Modules can enhance student learning activity and practical skills, particularly in subjects that require simultaneous understanding of conceptual and technical applications.

c) Motivation and Enthusiasm in Learning

The implementation of the E-Module also had a positive impact on students' affective domain. Teachers reported that students exhibited greater enthusiasm compared to when traditional printed textbooks were used. The students felt more engaged and active since the E-module provided engaging design, dynamic presentation, and interactive features such as evaluative quizzes and instructional videos. Complex material that was previously perceived as difficult became easier to understand through the use of visual and auditory approaches.

d) Relevance to the Workforce

In addition to academic improvement, the E-Module supports students in developing more practical and applicable understanding, which is essential in the context of vocational education. Mastery of installation procedures, component identification, tools, and workplace safety serves as crucial preparation for fieldwork practice (PKL) or entry into the industrial workforce. Furthermore, the E-Module also contributes significantly to enhancing the job readiness of vocational high school (SMK) graduates in the field of refrigeration and air conditioning technology.

The developed E-module supports the principles of student-centered learning, allowing students to study at their own pace and following their learning styles. This approach has a positive impact on motivation, participation, and deeper comprehension of the subject matter, particularly for technical content that is both complex and application-oriented.

In conclusion, the implementation of E-module in the subject of Heating, Ventilation, and Air Conditioning (HVAC) has proven to be feasible, practical, effective, and significant in enhancing students' learning outcomes, particularly in the area of refrigeration system installation.

CONCLUSION

The final product from E-module learning media in the refrigeration installation system is

according to students‘ needs. This product adopted research and development (R&D) with the ADDIE model. The result showed that the implementation of E-module is effectively improving students' knowledge in the subject of the refrigeration installation system element. The developed E-Module was rated as highly feasible by subject matter experts, and considered highly practical by implementing teachers, demonstrated strong effectiveness in improving student learning outcomes with an average N-Gain score of 0.74, or it was classified within the high category. The use of the E-Module has positively contributed to the enhancement of students' factual knowledge (e.g., identification of system components), conceptual knowledge (e.g., understanding of workflows and basic refrigeration cycle principles), and procedural knowledge (e.g., installation and maintenance procedures). Furthermore, E-module can stimulate students' learning motivation, active, and independent throughout the instructional process. In other words, E-module is feasible as an alternative learning medium in vocational education that is adaptive to the challenges of 21st-century learning and aligned with workforce demand.

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