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Development of a Practical Learning Module to Enhance Automotive AC Maintenance Competency in Vocational High Schools

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Abstract

This study aims to enhance the competency of vocational high school students in automotive air conditioning (AC) maintenance by developing a practical learning module. Conducted at SMK Al Asror Semarang, this research utilized the ADDIE development model, encompassing Analysis, Design, Development, Implementation, and Evaluation phases. The analysis identified inadequate facilities and infrastructure as significant factors contributing to students' low achievement levels. To address this issue, a practical learning module was designed based on the Indonesian National Work Competency Standards (SKKNI) and validated by subject matter and media experts. The implementation involved 29 students who participated in both pre- and post-competency assessments. The module's practicality was also evaluated in terms of usability, clarity, relevance, and instructional design. In the final stage, students underwent a practical AC maintenance test assessed by external industry professionals. The results demonstrated a substantial improvement in students' competencies, indicating that the developed module is not only effective but also a valuable instructional resource for enhancing HVACR learning outcomes in vocational education setting.

Keywords: learning Module, ADDIE, competency test, automotive AC maintenance

INTRODUCTION

Several guests complained about limited equipment in the fitness center, and some facilities that reduced the comfort experience. These facilities include elevators that frequently experience intermittent issues. Vocational education graduates are expected to become a ready-to-use workforce, have specific skills, be professional, and be able to compete in the world of work, as well as have an entrepreneurial spirit (Qotimah, K., Basuki, I., & Muslim, S., 2019). The strategic role of vocational education graduates is not only to meet the needs of the national workforce but also to drive the nation's economy through productive contributions in the industrial and service sectors (Kaviyarasu, E., 2024). To realize these expectations, vocational education institutions, especially vocational high schools, bear a great responsibility in producing graduates who are competent, adaptable to technological developments, and relevant to the needs of the business world and the industrial sector (Magagula, M. M., & Awodiji, O. A., 2024).

However, the challenges in realizing quality vocational education are still very complex (de Vries, N., Meeter, M., & Huizinga, M., 2024). One of the significant challenges is the limited facilities and infrastructure in schools, particularly in private Vocational Schools, which often have limited funding (Tareke, T. G., et al., 2024). In the context of learning how to maintain a car's air conditioning system, this challenge is increasingly real. The rapid development of vehicle technology, particularly the shift from analog to digital control systems for air conditioning, is also evident in foreign-assembled vehicles (Completely Built-Up/CBU), which have traditionally utilized automatic heating and cooling systems. This evolution demands adaptive learning and technology advancements based on the latest developments. However, not all schools can keep up with the acceleration due to the limitations of practical tools and adequate teaching materials.

Learning in vocational education is ideally carried out in two forms, namely theoretical learning and practicum (Nyström, S., & Ahn, S. E., 2024). However, limitations in the fulfillment of practical tools often cause practicum learning to run suboptimally (Altakhaineh, A. R. M., AlTalafeeh, A., & Al-Ziadat, M., 2025). In this condition, teachers strive to optimize learning through alternative learning resources, such as presentation media, learning videos, and other representative teaching materials (Kleftodimos, A., 2024).

However, this effort is still not fully able to replace students' hands-on experience in handling real vehicle components. Hands-on practical experience is essential for shaping job skills that align with industry standards.

Evaluation of students' learning outcomes shows results that are not yet encouraging. Based on the data collected from the test results of grade XI students on the competence of the car air conditioning system, out of 29 students, only 4 students achieved a score above the Minimum Completeness Criterion of 75. This means that only 13.79% of students have been declared complete, while the other 86.20% have not reached completion. The average score of the test results also indicates that the achievement remains below the Minimum Completeness Criteria. This finding indicates that the learning material has not been delivered optimally, and students' competence in maintaining the car's air conditioning system remains low.

Several factors also contribute to the low achievement. Car air conditioning materials that are very complex require sufficient learning time to be delivered in depth. However, the time allocation available in the curriculum is relatively limited. In practice, teachers often have only the opportunity to convey general information about the working principles of the air conditioning system, without being able to explain in detail the functions and maintenance of each component, let alone provide direct practical experience in improving the system. The lack of systematic, structured, and contextual learning modules is another obstacle to an effective learning process.

Students' learning motivation is greatly influenced by the availability of practical facilities and supportive learning media. When students do not have the opportunity to practice the material they have learned directly, their confidence in mastering the competencies decreases. Therefore, innovation is needed in the preparation of teaching tools that can bridge these limitations, especially through the development of competency-based practicum learning modules and by following the latest developments in vehicle technology.

Student competency tests as part of the skills certification process also require the existence of teaching instruments and materials that can facilitate the achievement of minimum competency standards. In this case, practicum learning modules play a crucial role as guides for student learning, both individually and in groups. Modules designed with a systematic approach, per the Indonesian National Work Competency Standards, will provide clear direction for students in achieving the competency indicators that have been set.

By considering the above problems and challenges, this study focuses on developing a car air conditioning maintenance practicum learning module that can be used by students, especially at Al Asror School in Semarang. This module aims to address the issue of limited practical media, provide structured and applicable learning, and enhance students' competencies in the field of HVACR. Through the development of the ADDIE model-based module, it is hoped that the result will not only be academically valid but also practical, effective, and relevant to the current needs of the automotive industry.

METHOD

This study employs a descriptive qualitative approach, focusing on the development of practicum learning modules to enhance students' competence in analyzing car air conditioning system damage within the subject of Light Vehicle Electrical Maintenance. A qualitative approach is used to describe the module development process in depth, from the needs analysis stage to the final evaluation. Meanwhile, a descriptive approach is used to explain the application of the module and its impact on improving student competence. The results of this process are systematically displayed in the form of findings and conclusions.

The development model used in this study is the ADDIE (Analysis, Design, Development, Implementation, Evaluation) model developed by Dick and Carey (1996) and popularized by Reiser and Mollenda in the early 1990s. The ADDIE model was chosen because of its generic and flexible nature in supporting the development of effective and sustainable learning tools. According to Benny A. (2009: 128–132), the ADDIE framework functions as a framework for building a systematic and controlled training and learning system. The five main stages in the ADDIE model used in this study are as follows:

1. Analysis

This stage is conducted to identify learning needs, analyze student characteristics, and review the curriculum in conjunction with the Indonesian National Work Competency Standards. The results of the analysis showed that the low learning outcomes of students in the competence of the car air conditioning system were caused by the limitations of practicum learning media and the lack of direct practical experience.

2. Design

At this stage, a learning module is designed that includes the content structure, presentation format, and determination of competency achievement indicators. The modules are compiled based on the procedures for maintaining and overhauling the car air conditioning system, as well as referring to Standard

Operating Procedures (SOPs), the use of Personal Protective Equipment (PPE), and occupational safety provisions.

3. Development**:**

The modules that have been designed are then developed into a complete product, ready for use in the learning process. This process involves validation by subject matter experts and media experts to ensure the feasibility of the content and display quality of the module. Revisions are carried out based on input from validators to ensure the final product aligns with learning needs.

4. Implementation**:**

The modules that have been developed are piloted in practical learning activities with students at SMK Al Asror Semarang. The implementation is carried out comprehensively, encompassing both theoretical and practical learning activities, as well as observation of students' learning processes.

5. Evaluation**:**

Evaluation is carried out in two forms, namely formative and summative. Formative evaluations are conducted during the development and implementation process to address the weaknesses identified. Meanwhile, summative evaluation is conducted at the end of the learning process to assess the effectiveness of the module in enhancing student competence, which is measured through the results of practical tests and observations of student performance in carrying out car air conditioning maintenance.

This study also employs quantitative descriptive data analysis to evaluate the impact of module use on enhancing student competence. Data were obtained from the results of the initial test (pretest) and the final test (posttest), which were carried out before and after the use of the module, as well as from the practical skills observation sheet. The test result data was analyzed to determine the increase in the percentage of student learning completeness after the implementation of the learning module. This approach is used to objectively assess the extent to which the developed modules are able to have a positive impact on the achievement of student competencies in the field of HVACR, especially the maintenance of the car air conditioning system.

Overall, the methods used in this study aim to develop learning products that are not only theoretically valid but also effective and practical in their implementation. By combining a qualitative approach in the development process with a quantitative approach in the analysis of learning outcomes, it is hoped that the results of this research will make a significant contribution to improving the quality of practical learning in vocational schools.

Research Code of Conduct Statement

This research is conducted in accordance with the ethical principles of research. The entire process of data collection, instrument development, learning implementation, and evaluation is carried out professionally and responsibly, without causing physical or psychological harm to the participants. Participants in this study are grade 11 students in the Light Vehicle Engineering program at SMK Al Asror Semarang. All participants were involved voluntarily after receiving a comprehensive explanation of the study's objectives, benefits, procedures, and potential risks. The researcher also obtained approval from the school as an educational institution to implement this research activity.

The identities of participants are kept confidential and not included in publications to protect their privacy rights. The data obtained is used solely for academic and scientific development purposes and is not misused for other purposes outside of research interests. This study does not involve interventions that endanger the health or safety of students, while still paying attention to the aspect of occupational safety, especially in learning activities related to car air conditioning system maintenance practices. Each learning activity is conducted with attention to work safety procedures and the use of personal protective equipment by established standards.

Thus, this research has been conducted by the ethical principles of educational research and the guidelines of Good Research Practice (GRP) as established by national and international research institutions.

RESULT AND DISCUSSION

Results

Research and development is an effort to find or develop existing products. Of course, due to development, some previous products may require further development to improve them later. Therefore, in this study, relevant previous research serves as a source of reference for developing a product. Many terms related to vocational education include vocational education, technical education, professional education, and occupational education. According to Hughes, Suharto (1988: 1) stated that vocational education is a special education whose programs or subject matter are chosen for anyone interested in preparing

themselves to work on their own, or to work as part of a work group system. Vocational education is a part of the education system that prepares a person to be better able to work in a job group or one field of work than in other fields of work

In the study, Syarifuddin & Nurmi (2022) investigated 29 students, achieving a classical completeness rate of 62.07% in the first cycle. This indicated that 18 students achieved scores above 75, while 11 students did not meet the standards of completeness. Then, in the second cycle, with a completeness rate of 89.66%, it is evident that 26 students met the completeness standards, while only 3 students did not meet the minimum completeness requirement. The application of practicum learning to mathematics subjects can improve student learning outcomes by cultivating students' abilities, developing materials tailored to individual students' needs, and adopting an individualized approach. Faiz et al. (2022) also explained that the results of conceptual research revealed that the purpose of differentiated learning is to coordinate learning by paying attention to learning interests, learning readiness, and learning preferences. Helping all students learn so that they can achieve their learning goals, increase student motivation and learning outcomes, and establish a harmonious relationship between teachers and students, thereby fostering a more enthusiastic learning environment. Helping students become independent learners who are accustomed to being individuals and have an appreciative attitude towards diversity. Increasing teacher satisfaction because there is a sense of challenge to want to develop their teaching skills, so that teachers will be more creative. It can be concluded that differentiated learning provides opportunities for students to learn naturally and efficiently with teachers who can collaborate on the methods and approaches needed

Suharto (1988:3) presented four theoretical arguments in support of the need for spiritual education. First, human beings exist because of the need for activity, freedom, power, social recognition, and pleasure. Second, humans are driven to work due to three aspects: material, cooperation, and identity (ego). The third motivation to work is driven by psychological factors, including security, a sense of belonging and love, interests, respect, self-esteem, and freedom. Additionally, it encompasses a desire for information, understanding, love, and beauty, as well as personal self-actualization. Fourth, it is crucial for human beings to have work, which can also be interpreted as urging them to pursue vocational education for work preparation.

First of all, a customer's journey and interactions with a café, from their first impression to their post-visit reflection, are all included in the term "customer experience" (CX).

1. The experience of special training to form proper habits of action and thought is repeated over and over again until the habits developed become the whole set of habits necessary for real work.
2. The value of vocational Education depends on the individual's ability to apply their training in their job. If they are unable to stay in their job, this can be mitigated when the graduate reaches a point where they have acquired assets in skills and knowledge that can be sold to employers. Thus, for every job, there is a minimum standard of employment that requires a person to possess productive abilities to survive and continue working in that job. If vocational Education cannot carry out this, vocational Education is either personal or social.
3. The formation of effective process habits in every student will be successful when training is applied to actual work, rather than work practice or pretend work. Job training can be defined as training in an operation where the whole goal is to develop skills and provide opportunities to apply technical knowledge. Pretend work is production work that is performed insofar as it involves knowledge and skills. However, the product is not in use, and the working conditions do not match the actual working conditions.

The above opinions imply that Education and vocational training are educational processes that prepare individuals to develop skills, understanding, behaviors, attitudes, work habits, and appreciation for jobs needed by the community, government, or institutions, and are productivity-based.

Discussion

The development process of this practicum learning module uses the ADDIE (Analysis, Design, Development, Implementation, Evaluation) model. The development of this learning module utilizes the ADDIE model because it is rational, systematic, easy to learn, and comprehensive. The ADDIE model is systematically arranged so that, in its implementation, each stage that is passed always refers to the previous stage that has been completed, allowing the next stage to produce an effective learning product.

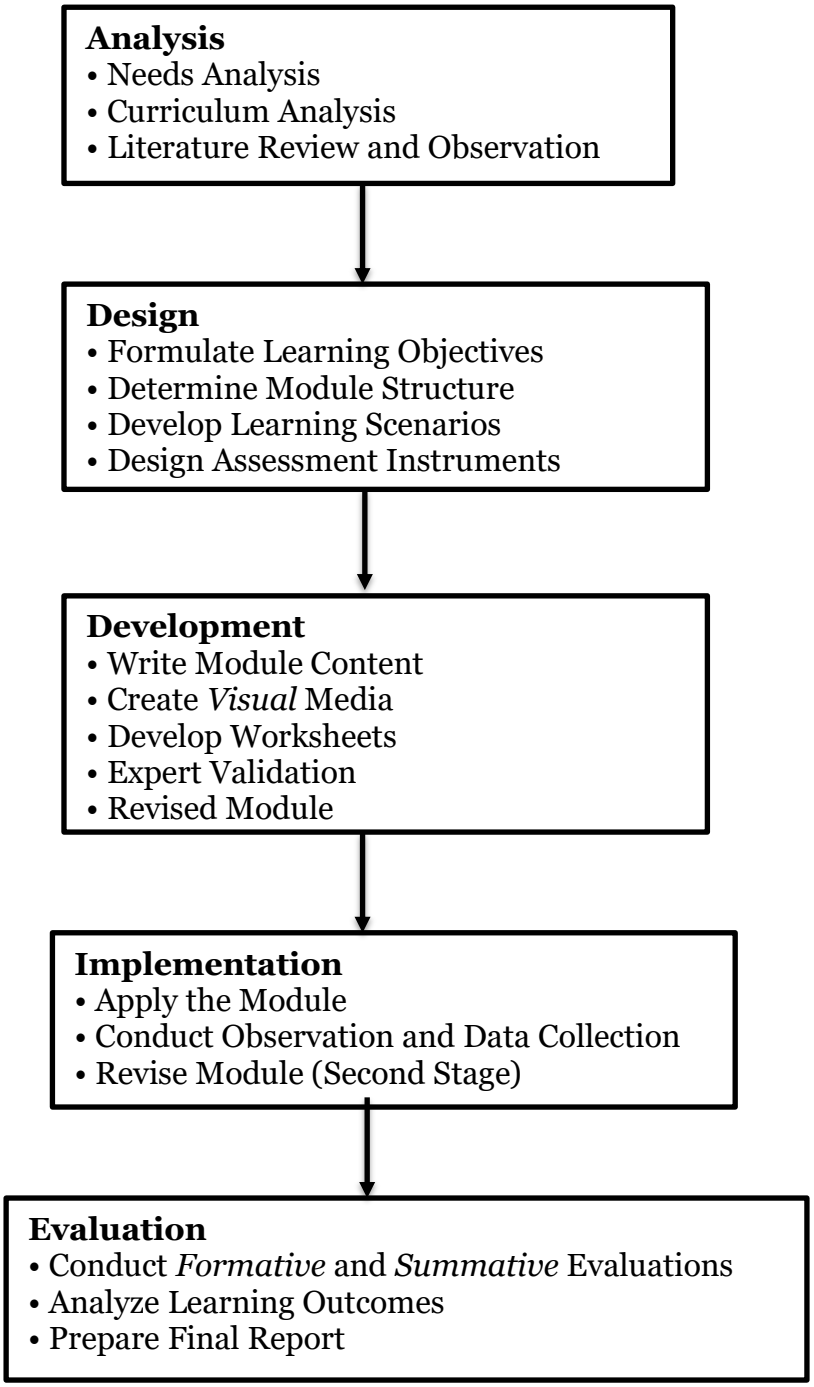

Figure 1. Learning Model Development Process

At the analyst stage, the problem to be solved is the lack of student competence in maintaining car air conditioners. This shortage is due to the lack of infrastructure to support practicum. Meanwhile, Car Air Conditioners are local content that is not included in the Air Conditioning Engineering curriculum. Based on the problems found after analysis, the module design was made as the required teaching medium. Learning objectives, learning structures, video tutorials, and assessment instruments are also designed to support learning and development.

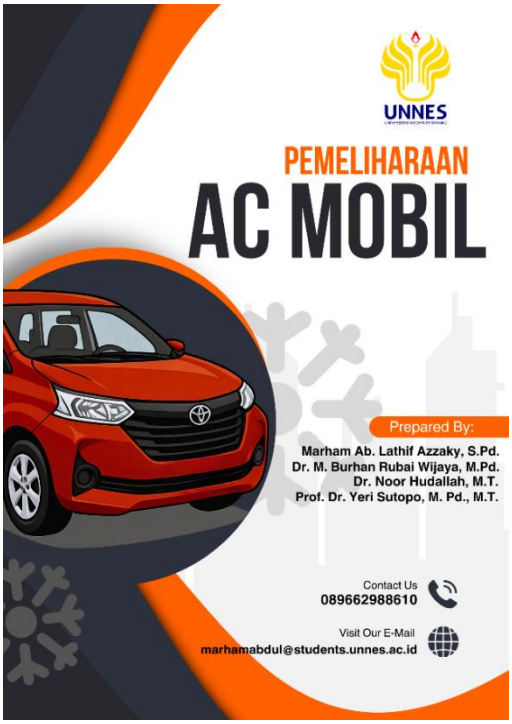

Figure 2. Cover Module

The development of the module, based on the design results, was then written and assessed by experts. According to the assessment of 10 material experts, a score of 94.52% was obtained, indicating that it is highly feasible in terms of material expertise.

Table 1. Assessment Criteria Interval

Interval	Criteria
81.25% < Score ≤ 100%	Highly Feasible
62.50% < Score ≤ 81.25%	Feasible
43.75% < Score ≤ 62.50%	Moderately Feasible
25% ≤ Score ≤ 43.75%	Less Feasible

According to media experts, a score of 72.26% was obtained, which also indicated feasible criteria. Then, when errors or suggestions from experts are found, the writing is revised. Furthermore, the modules deemed suitable are applied in learning implementations. Implementation is carried out as a benchmark for initial conditions, which will be analyzed, and the results will be presented at the end. Treatment is carried out in the classroom as opposed to class hours. Data collection is carried out if a revision is found, and a second correction is made. The practicality of the module was also analyzed using questionnaire data from students, assessing aspects such as convenience, clarity, appearance, benefits, and suitability of the module. From the results of the practicality test, an average score of 91.21% was obtained, indicating that the module met the criteria for being very practical in learning.

Table 2. Results of Practicality Assessment

Aspect	Percentage (%)	Criteria
Ease of Use	92.67	Very Practical
Clarity	91.59	Very Practical
Appearance	89.37	Very Practical
Usefulness	90.34	Very Practical
Relevance	92.07	Very Practical
Average	**91.21**	**Very Practical**

The last stage is the evaluation of the implementation of the module by conducting an overall review. The revision is carried out as a form of improvement of the module. In the classes that are given implementation, learning outcome data is also collected at the end by conducting a competency test, which is used as an indicator of the success of the module in improving student competence. The Competency Test

is carried out in stages with 4 sessions. Examiners from Car AC practitioners were brought in as a form of assessment independence. Then the report is compiled as the final result, and then analyzed based on the results of the initial observations. The results of the N-gain test from the students' competency scores at the beginning and end got a score of 52.87, which is included in the medium category. The average student competency score increased from 52.87 points to 80.60 points.

Table 3. Results of Pre Test Posttest of the Use of Learning Media

Description	Result
Average *Pretest* Score	52.87
Average *Posttest* Score	80.60
Maximum Score	100
N-Gain	0.60
Conclusion	**Moderate**

It can be concluded that the use of the Car Air Conditioner maintenance module is quite effective in improving the competence of Car Air Conditioner maintenance. Even though it has been considered feasible and significant, the author still receives input for the improvement of this Car AC maintenance module to make it perfect. It is hoped that this Car AC maintenance module can be useful not only at SMK Al Asror, but also for all schools or competency-based learning institutions that have car air conditioning learning in Central Java, in particular, and throughout Indonesia

CONCLUSION

Based on research and development of learning media, conclusions can be drawn from the development of practicum learning modules needed by students and teachers those which can improve student competence, especially car air conditioning maintenance competencies, by paying attention to the learning style of each student and facilitating the learning media of each student to achieve learning goals. The design of the development of the Car Air Conditioner maintenance module has been adjusted to the Car Air Conditioner Maintenance Competency Standards in the Learning Objective Flow (ATP) of Light Vehicle Electrical Maintenance. The development of the Car Air Conditioner learning module goes through three stages, namely pre-production, production, and post-production. The learning module developed received a material expert score of 94.52% which showed the Very Feasible criteria, while the percentage of media expert scores was 79.69% which showed the Feasible criteria. Based on this percentage, the Car AC competency learning module is included in the category that is feasible to be applied in Car AC learning activities. The implementation of the Mobile Air Conditioning learning module on 30 students of class XI of Heating, Air and Cooling Engineering at SMK Al Asror Semarang uses a one-group pretest-posttest design, namely, in this design, there is a pretest before being given treatment or treatment and then a posttest after treatment. The practicality of the module was also analyzed with questionnaire data taken from students on the aspects of convenience, clarity, appearance, benefits, and suitability of the module. From the results of the practicality test, an average score of 91.21% was obtained, which showed that the module was in the criteria of being very practical in learning. The results of the evaluation of the use of the Car AC learning module can improve students' competence in the maintenance of Car ACs. Student competence was proven to have increased with an N-gain value of 0.60, which, if categorized in the gain factor criteria, then the score is in the medium category.

Suggestion

From the results of the research, it is hoped that based on the research and development that has been carried out, the research process and development of learning modules certainly have several obstacles in their implementation, but these obstacles do not prevent researchers from continuing to conduct research. The obstacles that arise in the research process are as follows:

1. Researchers have not mastered the specifics of the air conditioning system that the vehicles in the study.
2. The researcher had difficulty in presenting a working picture based on the practicum material for car air conditioning maintenance.

The solutions to the obstacles that arise are:

1. The researcher dug up information and collected materials for specific Toyota manuals, service manuals, and service manuals related to the Car Air Conditioner maintenance materials.
2. The researcher collected documentation during the practicum so that the modules were made from the Car Air Conditioning Maintenance material.

Through the research and development of this learning module, it is hoped that it will be useful and can provide new knowledge to students about the practicalities of Car Air Conditioning Maintenance, improve student competence, and provide learning module references that are suitable for use in learning activities for teachers and students.

The need to procure practicum facilities and infrastructure to complement the existing practicum needs, especially the 3R (*Recovery-Recycle-Recharge*) machine, to be more in line with the real world of work. It is also necessary to train and train teachers regularly to improve the competence of teachers in car air conditioning subjects, considering that automotive cooling technology, especially vehicles, is developing very quickly in this era.

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