JPPIPA 11(10) (2025)

Jurnal Penelitian Pendidikan IPA

http://jppipa.unram.ac.id/index.php/jppipa/index

Innovation of Learning Media: Developing a Car Air Conditioning Trainer to Improve Student Performance in Vocational Physics and Engineering

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Received: August 05, 2025
Revised: September 29, 2025
Accepted: October 25, 2025
Published: October 31, 2025

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DOI: 10.29303/jppipa.v11i10.12423

Abstract: This study aims to develop a mobile air conditioning (AC) trainer as an innovative learning medium to enhance students' understanding, interest, and performance in automotive AC systems. The research adopted the Research and Development (R&D) approach using the 4D model, which consists of the Define, Design, Develop, and Disseminate stages. Validation was conducted by media and material experts, yielding Aiken's V coefficients of 0.93 and 0.96, respectively, categorized as "Valid." The practicality test involving teachers and students obtained mean scores of 94.20% and 96.24%, categorized as "Highly Practical." The effectiveness of the developed trainer was evaluated through pretest and posttest data, resulting in an N-Gain score of 0.69, which indicates a "High" level of improvement. These findings demonstrate that the developed AC trainer is valid, practical, and effective as instructional media in vocational education, particularly in enhancing students' academic achievement in automotive air conditioning systems.

Keywords: Learning media; Mobile air conditioning trainer; Vocational education; Student Performance

Introduction

One of the primary factors contributing to the low level of student learning achievement in certain vocational subjects is the lack of appropriate instructional media (Desmiarni et al., 2025). In particular, the topic of automotive air conditioning (AC) systems presents considerable challenges due to its integration of complex electrical circuits and thermodynamic principles (Vasta, 2023). These technical aspects often make it difficult for students to fully comprehend how the system operates (Fitrianto & Saif, 2024). As a result, students' understanding of the maintenance and servicing of automotive AC systems remains inadequate. This issue is reflected in school performance data, which shows that nearly 50% of students have not met the minimum competency standards, as presented in Table 1.

Table 1. Student Pass Rate in Automotive AC Subject, Academic Year 2023/2024

Class	Total Students	Passed	Not Passed
XI TKR	15	8	7

External factors, especially the learning environment and availability of instructional media, significantly influence student achievement (Hardiyansyah et al., 2019). In the context of automotive AC maintenance, students are expected to grasp how the cooling circulation system and its associated electrical components function in an integrated manner (Tonellato et al., 2025). Delivering such knowledge solely through lectures or rhetorical explanations often proves insufficient (Hontarenko & Kovalenko, 2024). In vocational education, where practice is a core component, students must be exposed to realistic

How to Cite:
Afriwandi, Maksum, H., Rifdarmon, & Indrawan, E. (2025). Innovation of Learning Media: Developing a Car Air Conditioning Trainer to Improve Student Performance in Vocational Physics and Engineering. *Jurnal Penelitian Pendidikan IPA*, *11*(10), 553–558. https://doi.org/10.29303/jppipa.v11i10.12423

simulations or physical demonstrations to develop technical and analytical skills (Long et al., 2024).

However, the use of real vehicles in the learning process presents several practical limitations (Zhao et al., 2024). The components of an automotive AC system are often located beneath the engine compartment or concealed within the dashboard, making them difficult to access or observe directly (Ahmad et al., 2024). As a result, students often face difficulties when asked to analyze or trace the system's operation on an actual car (Cummings & Bauchwitz, 2024). This leads to ineffective learning and low engagement (Zhiqiao et al., 2025).

To overcome these obstacles, the development of a trainer for the car air conditioning system becomes a necessary solution (Poyyamozhi et al., 2024; Sinha & Lee, 2024). This trainer functions as an instructional medium that simplifies the complexity of the AC system by making each component visible, accessible, and easier to understand (Larasati et al., 2024). It enables students to observe the entire working process in a more interactive and structured way (Sun et al., 2024). With such media, the teaching and learning process can run more effectively, allowing students to achieve better learning outcomes (Makhrus et al., 2020). In addition, the trainer provides a safer, more controlled environment for practical learning (Isaeva et al., 2025). Enhancing both the cognitive and psychomotor aspects of student competence (Nasrudin et al., 2025).

From a theoretical perspective, this study is grounded in Constructivist Learning Theory, which emphasizes that students build knowledge through direct experiences and active engagement with learning materials (Vygotsky, 1978). Supporting this, Dale's Cone of Experience also highlights that learners retain more information when they participate in hands-on or simulated experiences compared to verbal instruction alone (Praja & Andriani, 2025). Therefore, developing a car air conditioning trainer aligns with these educational principles by providing students with concrete learning experiences that strengthen conceptual understanding and technical mastery (Indiwara, 2025; Xuan et al., 2025).

Given these theoretical and practical considerations, this research was conducted to design and develop a car air conditioning trainer that can serve as an innovative (Sotiropoulos et al., 2025), valid, practical, and effective learning medium to improve students' performance in vocational subjects (Agyemang et al., 2025).

Method

This research employed the Research and Development (R&D) method using the 4D model (Hidayat & Rahmi, 2025). The study focused on creating an innovative learning media tailored for vocational education (Diana & Putri, 2025). The developed product was designed to support the teaching and learning process in the Automotive Air Conditioner System Maintenance subject. The target users of this media were Class XI students of the Light Vehicle Engineering (TKR) program at SMKN 4 Pariaman. Through this development, the study aimed to enhance students' understanding and engagement in learning activities (Zahroh, 2025). The development process followed the four stages of the 4D model: Define, Design, Develop, and Disseminate (Setiawati et al., 2024).

The data analysis technique used in this study was descriptive analysis, which aimed to provide a comprehensive description of the research findings (Rahmawati et al., 2023). The focus of the data analysis was to determine the validity, practicality, and effectiveness of the developed car AC trainer as a learning media. Validity was assessed through expert judgment (Muslikatin et al., 2025). Practicality was evaluated based on responses from teachers and students (Aiman, 2025). Effectiveness was measured through pretest and posttest results to determine student learning outcomes (Yeni, 2025).

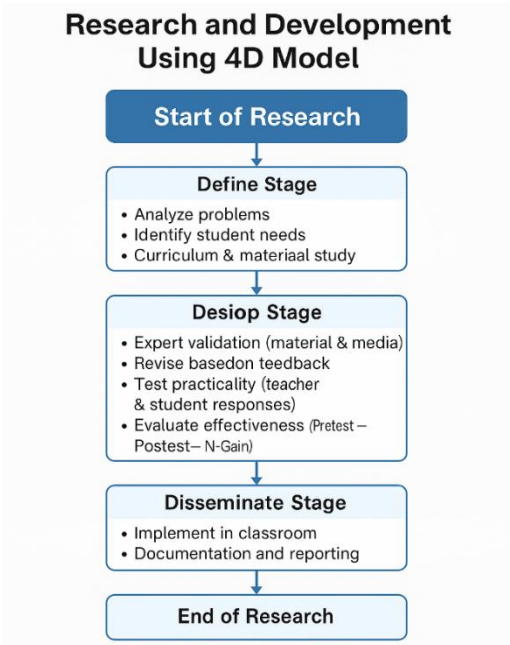

Figure 1. Flowchart

To provide a clearer overview of the research procedure, the following flowchart illustrates each stage of the development process based on the 4D model (Wulandari et al., 2025). This diagram helps visualize how the research was conducted systematically—from the initial identification of problems to the final dissemination of the developed product (Wulandari et al., 2025). The flowchart serves as a comprehensive representation of the steps taken to design, validate, and

implement the instructional media in the classroom setting.

Result and Discussion

The research and development of a trainer for the automotive air conditioner (AC) system at SMKN 4 Pariaman has resulted in an instructional medium that is not only valid and practical but also highly effective in improving student learning outcomes. This section presents a comprehensive analysis of the data obtained from the validation, practicality, and effectiveness testing stages (Komalasari et al., 2019).

Validity Analysis

To ensure the quality of the developed media, expert validation was carried out focusing on three primary components: design, technical functionality, and usability (Makhrus et al., 2019). The results showed high average scores of 91.11% for design, 92.00% for technical aspects, and 89.33% for usability. When averaged, the overall validity score reached 90.94%, which is within the "Valid" category. These results indicate that the trainer has met the expected standards in terms of appearance, construction, and user relevance.

Moreover, further statistical validation using Aiken's V formula produced strong coefficients: 0.93 for the media and 0.96 for the instructional content. An Aiken's V value above 0.60 is considered indicative of a high level of agreement among expert validators. Therefore, both the media and content aspects of the trainer meet the criteria for high validity. These findings affirm that the trainer is appropriate for classroom implementation and aligns well with learning objectives, curriculum demands, and technical accuracy.

Practicality Analysis

Practicality testing involved both teachers and students as end-users of the developed trainer. The goal was to evaluate how easily the trainer could be implemented in actual learning settings (Anas & Hartono, 2024). The teacher response showed an overall average score of 94.20%, which falls under the "Highly Practical" category. The components measured included ease of use, clarity of instructions, accessibility of trainer components, and efficiency of use in the learning process.

Similarly, student responses were extremely positive. The trainer was rated 97.18% in terms of ease of use, 95.38% for time efficiency, and 97.14% for overall appeal or attractiveness. The average total practicality score from students reached 96.57%, reinforcing the conclusion that the trainer is highly suitable for practical learning environments. These ratings demonstrate that the trainer can be easily operated by both teachers and students, even those with limited prior knowledge of automotive AC systems.

In practical classroom situations, especially in vocational schools, time efficiency and hands-on accessibility are crucial (Danmali et al., 2025). Real vehicle-based systems often present physical barriers—components hidden within engine bays or dashboards make observation and analysis difficult. This trainer resolves such challenges by presenting all components clearly and externally, allowing students to observe the function and interconnection of each part with minimal obstruction.

Effectiveness Analysis

Effectiveness was measured through a quasi-experimental design using pretest and posttest assessments administered to students before and after the use of the trainer (Gabr et al., 2025). Each test consisted of 40 multiple-choice questions measuring student understanding of automotive AC systems. The average pretest score was 45.52, while the average posttest score increased significantly to 86.10. The N-Gain score was calculated to be 0.69, which is categorized as "High" and interpreted as "Effective."

The substantial improvement in posttest scores indicates that the use of the trainer significantly enhanced students' conceptual understanding of the material. The structured, visible, and interactive design of the trainer likely contributed to this improvement by enabling more intuitive learning and retention of complex concepts—especially those related to AC system circuitry, airflow, and component functions.

When compared to previous studies, such as the one conducted by Handoko (2020), which reported a gain score improvement of 0.65 in similar vocational settings, the findings of this study are consistent. This supports the generalizability of the results, suggesting that trainer-based media development is an effective strategy in technical-vocational education.

Furthermore, Makhrus et al. (2019) also found that the application of project-based learning integrated with instructional media increased students' conceptual understanding and engagement in physics-related vocational subjects. Similarly, Komalasari et al. (2019) demonstrated that interactive learning media significantly improved both the cognitive and psychomotor domains of vocational students.

The effectiveness of the developed AC trainer is also in line with the study by Pramudita et al. (2023) which emphasized that learning aids designed for automotive systems enhance students' motivation and facilitate deeper comprehension of technical processes. Likewise, Zhao et al. (2024) noted that visualization-based tools help students grasp complex engineering

mechanisms more effectively compared to conventional demonstrations.

Taken together, these findings reinforce that the developed car air conditioning trainer aligns with the conclusions of previous research—valid, practical, and highly effective in improving student achievement, especially in learning environments that require a balance between theory and practice.

Educational Implications

The results of this study hold important implications for vocational education. The automotive AC trainer serves not only as a substitute for hard-to-access real systems but also as a pedagogical tool that enhances visualization, interaction, and learning outcomes. The integration of this media into the classroom can foster higher student engagement, reduce dependence on real vehicle availability, and provide safer environments for exploration and error (Pramudita et al., 2023).

Furthermore, the media can serve as a platform for formative assessment. Teachers can more easily observe student understanding in real-time as students interact with the trainer, enabling timely feedback and scaffolding. This approach aligns with competency-based education models widely adopted in vocational schools.

Future Development Potential

While the developed media has proven valid, practical, and effective, it also opens opportunities for further innovation. Future research may involve digital integration (e.g., sensors, simulation software) to enhance interactivity or connect the physical trainer to virtual learning environments. Expanding the scope to cover diagnostic procedures or fault simulation could also increase the media's realism and instructional value.

Moreover, additional testing with larger and more diverse student populations could help refine the trainer and further validate its effectiveness across various vocational schools. Collaborations with industry experts or practitioners could also enrich the content and technical design, ensuring the trainer remains aligned with current automotive technologies.

Conclusion

Based on the development research conducted, it can be concluded that a car air conditioning (AC) trainer has been successfully developed for use as instructional media in the AC maintenance subject at SMK Negeri 4 Pariaman. The development of a car air conditioning (AC) trainer for the AC maintenance subject at SMK Negeri 4 Pariaman has proven valid, practical, and effective. Expert validation reached 90.94% (Aiken's V = 0.93 for media and 0.96 for material), indicating high validity. Practicality scores from teachers (94.20%) and students (96.57%) were categorized as "Highly Practical." Effectiveness testing showed an N-Gain score of 0.69, indicating a high level of learning improvement. Overall, the developed trainer effectively enhances students' understanding and performance in AC maintenance learning.

Acknowledgments

The author would like to express sincere gratitude to the supervisors and validators who have provided guidance and suggestions throughout the research and development process. Appreciation is also extended to the teachers and students of SMK Negeri 4 Pariaman for their cooperation and participation during the implementation and testing of this learning media.

Author Contributions

All research activities, including design, data collection, analysis, and manuscript preparation, were fully carried out by the author.

Funding

This research was carried out using the author's personal funds. No external funding was received for this work.

Conflicts of Interests

The author declares that there is no conflict of interest regarding the publication of this paper.

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