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DEVELOPMENT AND VALIDATION OF E-TOOLSIM CAKRA AS AN INTERACTIVE SIMULATOR FOR LEARNING AUTOMOTIVE EQUIPMENT

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ABSTRACT
This study aims to develop and test the feasibility of e-ToolSim Cakra as an interactive learning media in the automotive equipment course at the Automotive Engineering Education Study Program, Universitas Negeri Malang. This study uses a Research and Development (R&D) approach with the ADDIE model which includes the stages of analysis, design, development, implementation, and evaluation. The research subjects consist of 3 material experts, 2 media experts, and 25 students as users. The instruments used are expert validation sheets and student response questionnaires. Validity data analysis uses Aiken's V, while practicality is analyzed using descriptive percentages. The results of the study show that the developed media obtains validity values on the material aspect of 0.85 and the media aspect of 0.86, which are included in the valid category because they are above 0.80. The practicality test on students shows a feasibility level of 83.5% in the very practical category. Based on these results, e-ToolSim Cakra is declared feasible and practical to use as a learning media in supporting theoretical and practical learning through interactive simulation. The main contribution of this study lies in the development of a digital simulation-based learning model that integrates learning stages in the form of theorization, simulation, practice, and reflection in one interactive learning system for vocational education in the automotive field.

INTRODUCTION

The automotive industry is currently developing rapidly with the integration of sensor technology, actuators, and digital diagnostic systems in modern vehicles (Ahmadian et al., 2023; Putra et al., 2025; Varriale et al., 2023; Q.

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Wang et al., 2025). This development demands that vocational education students possess accurate practical competencies, particularly in the use of measuring tools and vehicle service equipment, because the accuracy of measurement results and work procedures greatly determines the quality of diagnosis and repair (Bahyaoui et al., 2026; Hastindra Na Ayudhaya et al., 2026).

However, practical learning in the field of automotive equipment still faces various obstacles. The results of initial observations at the Automotive Engineering Education Study Program of Universitas Negeri Malang show a limited number of practical tools with a ratio of approximately 1:4 to 1:6 students per unit of tool. This condition causes not all students to obtain adequate practical experience in one session, because some must wait their turn or only observe (Yusuf, 2024). In addition, the limited practice time, which is approximately 100 to 150 minutes per meeting covering explanation, demonstration, and practice, is not sufficient to provide optimal training experience, especially for students in the early stages of learning (Nguyen (Ruby) & Barbieri, 2026; Rose, 2026).

Another factor that also becomes an obstacle is the difference in students' initial abilities. Variation in experience and readiness in understanding tool usage causes differences in learning speed among students. Under conditions of limited time and facilities, these differences are difficult to accommodate optimally, potentially causing competency gaps (Putra, Heong, et al., 2022; Suswanto et al., 2018).

On the other hand, the utilization of digital technology in learning has developed rapidly. More than 80% of students are already accustomed to using online learning platforms. In addition, SIPEJAR has been adopted at Universitas Negeri Malang as a Learning Management System. However, its utilization is still dominated by material distribution, discussion forums, and assignments, while the use of interactive simulation media is still limited. Yet, simulation-based learning approaches have the potential to improve student engagement and procedural understanding in a more systematic manner (Putra et al., 2020; Putra, Ulfatin, et al., 2022). Several studies also show that simulations can increase learning engagement by 30 to 50% and strengthen understanding of work procedures (Valencia-Forrester, 2026; Wall et al., 2026; Y. Wang et al., 2026). In addition, students can repeat practice without the risk of tool damage, making it more effective in technical skills learning.

Nevertheless, existing simulation media currently still has limitations. Most are generic in nature and have not been specifically designed to meet the learning needs of automotive equipment in vocational education. Many simulations only display visualization without interactive experience based on real work procedures. In addition, integration with learning systems such as SIPEJAR is also still very limited. This shows a gap between the needs of practical learning in the automotive field and the characteristics of the simulation media currently available (Deniz, 2026; Jeong, 2026; Luu et al., 2026).

Based on these conditions, the development of learning media that is more contextual, interactive, and appropriate to practical learning needs is required. Therefore, e-ToolSim Cakra was developed as an interactive automotive equipment simulator designed to provide a more flexible and systematic learning experience. This media is expected to help students understand tool usage, work procedures, and potential errors in practice. Thus, this study aims to develop and validate the interactive learning media e-ToolSim Cakra in automotive equipment learning at the Automotive Engineering Education Study Program of Universitas Negeri Malang, with a focus on content validity, competency validity, and ease of use.

METHOD

The method used in this study is Research and Development (R&D) adopting the ADDIE model which consists of five stages, namely Analysis, Design, Development, Implementation, and Evaluation. The ADDIE model was chosen because it provides a systematic framework in the development of technology-based learning media. At the analysis stage, identification of learning needs was conducted through observation of the learning process in the

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Automotive Equipment course at the Automotive Engineering Education Study Program of Universitas Negeri Malang. This stage also includes identification of available practical tools, analysis of learning time allocation, and identification of problems experienced by students in the use of measuring tools and automotive service tools.

At the design stage, planning of the learning system and media was conducted by compiling a flowchart for using e-ToolSim Cakra, designing the User Interface (UI) display, determining simulation materials covering measuring tools and vehicle service tools, and compiling research instruments. Research instruments consist of expert validation sheets and student response questionnaires. The validation instrument is divided into material aspects and media aspects. Assessment indicators on the material aspect include suitability of material with learning outcomes, accuracy of concepts, clarity of material delivery, depth of material, and relevance to automotive practice. Meanwhile, indicators on the media aspect include interface display, readability, navigation, interactivity, ease of use, feedback features, and technical functions of the media. The student response questionnaire covers indicators of ease of use, clarity of simulation, media attractiveness, usefulness of media in understanding material, and student learning motivation.

The development stage was focused on creating the e-ToolSim Cakra product in accordance with the design that had been planned. The main features developed include interactive simulation of measuring tool usage, procedures for using service tools, and provision of automatic feedback on tool usage errors. After the product was completed, validation was conducted by experts consisting of two material expert validators from the automotive field and two media expert validators who have competence in the field of learning technology. Subsequently, at the implementation stage, the product was tested on a limited basis to 30 students of the Automotive Engineering Education Study Program of Universitas Negeri Malang. Students were asked to use the e-ToolSim Cakra media, then provide assessments through response questionnaires to determine the level of practicality and ease of use of the media.

The evaluation stage was conducted to determine the level of validity and feasibility of the developed media. Data from expert validation results were analyzed using the Aiken's V formula to measure the level of agreement among validators for each assessment indicator. The formula used is as follows:

$$\mathbf{V} = \frac{\Sigma s}{n(c-1)} \quad \text{.....(1)}$$

where $s = r - l_o$, r is the score given by the validator, lo is the lowest score on the rating scale, c is the highest score on the rating scale, and n is the number of validators. The validity interpretation criteria used are V > 0.80 categorized as very valid, 0.60 < V <= 0.80 categorized as valid, 0.40 < V <= 0.60 categorized as sufficiently valid, and V <= 0.40 categorized as less valid. Furthermore, student response data were analyzed using descriptive percentages to determine the level of media feasibility with criteria of 81 to 100% = very feasible, 61 to 80% = feasible, 41 to 60% = sufficiently feasible, and below 40% = not feasible. The results of this analysis were used as the basis for determining the validity, practicality, and overall feasibility of the e-ToolSim Cakra learning media.

RESULT AND DISCUSSION

Result

Development and Validation of e-ToolSim Cakra

The analysis was conducted through observation and preliminary analysis of the subject matter of this study, namely at the Automotive Engineering Practicum Unit of the Automotive Engineering Study Program at the State University of Malang. The observation results indicate that the use of practicum tools has not been as optimal as expected, due to limited availability of practicum tools. The ratio of tools to students is 1:4 to 1:6; meaning that not all students can interact directly with the tools in one practicum session. Furthermore, the lab time (approximately

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100-150 minutes per session) is insufficient to cover more than one exercise. Some students are unfamiliar with using measuring instruments, especially during the first few sessions. Therefore, flexible learning materials need to be developed that allow students to learn independently.

During the design process, e-ToolSim Cakra was developed as an interactive simulator connected to SIPEJAR. The system comprises a series of key features, including a dashboard, tool selection menu, tool usage simulation, and feedback features. Emphasis was placed on basic vehicle measurement and service tools. Furthermore, at this stage, research instruments were created, namely an expert validation sheet and a student feedback questionnaire, which will be implemented in subsequent research stages.

The development stage produced an interactive learning media called e-ToolSim Cakra, which was designed to help students learn the use of measuring and vehicle service tools. The media provides tool visualization, procedural simulations, and an interactive feedback system to identify user errors during the simulation process. The application interface is presented in Figure 1.

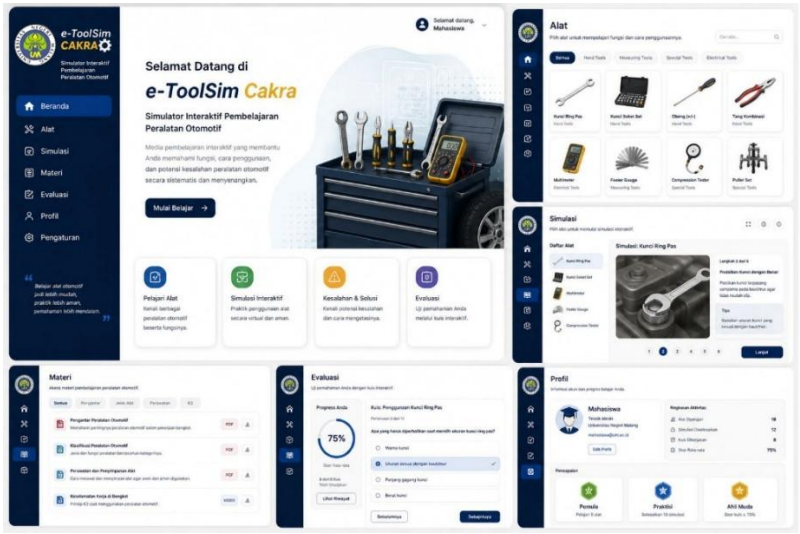

Figure 1. Cakra e-ToolSim Application as an Interactive Simulator for Learning Automotive Equipment
Source: Researcher documentation / results of e-ToolSim Cakra application development

Based on Figure 1, the design of the e-ToolSim Cakra interface is designed based on a modern minimalist concept that is simple, professional, and attractive as shown in Figure 1. The dark blue and white color scheme was chosen because it will give an academic, technological, and ergonomic impression and is comfortable for long-term learning. The main part of this system is the graphic part, namely the logo of the State University of Malang and the logo of the e-ToolSim product, namely the Cakra graphic. The purpose of the Home page is to provide a navigation point to the platform (and some descriptions of each platform's functions) along with direct links to learning menus and automotive equipment visuals. The system's main menu consists of Home, Tools, Simulation, Materials, Assessment, and User Profile. All menus have several interrelated functions, forming a systematic and interactive learning process.

In the Equipment menu, students can obtain details about various automotive equipment, such as their functions, equipment names, and usage characteristics. In addition, students can learn to use equipment virtually, step by step, with animations and step-by-step instructions through the Simulation menu. Simulations also identify

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potential equipment errors and how to fix them, providing students with practical experience before entering the workshop for practical work. Digital learning materials are stored by topic in the "Materials" menu, and student knowledge is assessed in the "Assessment" menu through interactive quizzes and case study assessments. Additionally, the "Profile" menu provides students' learning progress, learning activities, and learning outcomes while using the platform.

E-ToolSim Cakra was developed as an information and learning simulation tool that can increase student engagement in the learning process. The interactive and contextually relevant visual approach is expected to improve students' conceptual understanding, procedural skills, and practical readiness on automotive equipment topics. The developed media was subsequently evaluated through expert validation to determine its content and media feasibility. The assessment involved three material experts and two media experts using a rating-scale instrument analyzed with Aiken's V. The results of the material expert validation are presented in Table 1.

Table 1. Results of Material Expert Validation

Aspect	Aiken's V	Category
Material suitability	0.86	Very valid
Depth of material	0.83	Very valid
Clarity of presentation	0.85	Very valid
Average	**0.85**	**Very valid**

Source: Processed by the researcher, 2026

Based on Table 1, all aspects of the material assessment have a value greater than 0.80 Aiken's V. This means that the material used in the e-ToolSim Cakra is in accordance with the expected competencies and has a high level of clarity. An average score of 0.85 points indicates a "very high" level of content validity. Furthermore, the validation results from media experts can be seen in the table 2 below.

Table 2. Media Expert Validation Results

Aspect	Aiken's V	Category
Appearance	0.88	Very valid
Interactivity	0.84	Very valid
Navigation	0.86	Very valid
Average	**0.86**	**Very valid**

Source: Processed by the researcher, 2026

Based on Table 2, the display, interactivity, and navigation aspects scored above 0.80. This indicates that e-ToolSim Cakra has good display quality, is easy to use, and supports optimal user interaction. The average score was 0.86, indicating that the instrument can be considered "very valid." Even so, there are several recommendations, such as providing instructions at the start of the application and a better color scheme. Students have tested the product based on these recommendations.

After the expert validation process, e-ToolSim Cakra was tested on 25 students from the Automotive Engineering Education Study Program at Universitas Negeri Malang. Students used the simulator and subsequently completed a response questionnaire to evaluate the practicality and usability of the media. The results of student responses are presented in Table 3.

Table 3. Student Response Results

Aspect	Percentage	Category
Ease of use	84%	Very worthy
Clarity of simulation	82%	Very worthy
Appearance	85%	Very worthy

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Interest	83%	Very worthy
Average	**83.5%**	**Very worthy**

Source: Processed by the researcher, 2026

Based on Table 3, it can be seen that all aspects scored above 80%, indicating that Cakra e-ToolSim falls into the "very appropriate" category. The maximum score (85%) was given for the interface aspect and the minimum score (82%) was given for the clarity of the simulation. However, all aspects still fall into the "very appropriate" category. Along with the quantitative data, several students reported that the simulation was useful in helping them understand how to operate the equipment before the laboratory practicum. Furthermore, students stated that the feedback function was useful in identifying some errors during the simulation.

Overall, the validation and implementation results indicate that e-ToolSim Cakra is highly feasible for vocational learning applications. The media achieved high validity scores from both material and media experts (Aiken's V = 0.85–0.86), while student responses showed a high practicality level with an average score of 83.5%. These findings suggest that e-ToolSim Cakra can support interactive and simulation-based learning in automotive equipment education.

Discussion

Interactive Simulation-Based Learning in Vocational Education

The results of the study show that e-ToolSim Cakra has a high level of validity with Aiken's V scores ranging from 0.83 to 0.88. These findings indicate that the developed media is in accordance with the competency needs of vocational learning and supports procedural learning in automotive education. High agreement among experts is reflected in the variation of V scores ranging from 0.83 to 0.88 by Aiken experts. This indicates that the content presented meets competency expectations. Thus, it can be concluded that the resulting media is one of the learning media that can be relied upon in the student learning process.

The validity of educational media is not only determined by the accuracy of the media content, but also by the presentation structure according to the learning characteristics. In vocational education, what is needed is not only declarative knowledge, but also a systematic understanding of the procedures (Bezuidenhout et al., 2025; Jiao et al., 2026; Zhu et al., 2026). e-ToolSim Cakra aims to combine the two by presenting the work steps systematically. This will help students understand the sequential steps of the tool. This systematic presentation helps students understand the sequence of work procedures in a more structured manner. (Fauzan et al., 2025; Martel, 2025).

Empirical validation results indicate that the content suitability aspect received a high score. This indicates that the material is relevant to the learning needs of the Automotive Engineering Education Program. Furthermore, the clarity of presentation aspect also received a good score, indicating that the information presented is easy for users to understand (Chaerunnisa et al., 2025; Hashim et al., 2025; Martella et al., 2025). This finding is significant because clear information is crucial for successful media-based learning. Learning objectives will not be easily achieved if the media cannot present information clearly.

The results of media validation show that the aspects of display, navigation, and interactivity have been well designed and are easy to use. Interactive features allow students to be actively engaged in the simulation process, which is important in procedural-based vocational learning (Almazroui, 2022; Tzortzoglou et al., 2023). Interactive learning media does not only function as a means of information delivery, but also as part of the learning process itself (Irfandi et al., 2024). Nevertheless, validators still provided some input regarding usage instructions and visual contrast so that media development still needs to be continuously refined.

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The high practicality score (83.5%) shows that e-ToolSim Cakra was well received by students and is easy to use in independent learning activities. Ease of use is an important factor because learning media can only be utilized optimally when it has good accessibility and usability (Neophytou et al., 2025; Vrana, 2025).

Interface design is crucial for user experience. Research findings show that visual aspects are rated higher than other aspects. This means that engaging visual design can increase students' learning motivation (Varriale et al., 2023; Vrana, 2025). Furthermore, the user-friendly interface allows students to understand the media workflow. Thus, the visual display does not only function aesthetically but also supports the effectiveness of learning. That said, there is a slight decrease in the clarity of the simulation in other aspects. Consequently, improving the quality of procedural representation in the media is still possible. The working steps of a good simulation should be easy to understand and modeled in detail. Students may not understand how to perform a procedure if the simulation is unclear. For this reason, further work would be beneficial to improve the quality of the simulation.

Moreover, student feedback indicates that this tool can help students understand the material before the practicum session. Therefore, e-ToolSim Cakra can be used as pre-learning for practicum sessions. Students can now learn independently using this tool to learn procedural steps. Especially in vocational education, there is a need for practical readiness. Accordingly, this tool can improve learning efficiency (Khasanah et al., 2024; Marsono et al., 2024). Overall, it can be seen that this media is very practical and can be applied in real-world situations. This media is not only theoretically valid but has also been proven to be applicable in educational contexts. This reflects the success of media development to meet user needs. Thus, it can be concluded that e-ToolSim Cakra can be implemented as an alternative in effective learning.

In recent years, an increasingly widely adopted method for vocational training is Interactive Simulation (IS). This provides students with the opportunity to learn through experiences similar to those they would encounter in real life. In this study, the simulation medium used was e-ToolSim Cakra, which was used to assist the procedural learning process. Students can use the tools without having to be in a laboratory. This provides flexibility in the learning process. From a pedagogical perspective, interactive simulation can be linked to experiential learning theory (Armanto et al., 2025; Handayani et al., 2025). This theory argues that learning occurs as a result of direct experience. Simulations won't replace hands-on practice, but they can help provide practical experience. Students will have the opportunity to learn the steps first and practice them. First, simulations are part of the learning process.

The research results show that simulation is a more systematic approach to student learning. This is reflected in student responses, which stated that using simulations helped them understand the steps. Using simulations allows processes to be tried as many times as desired. This is important because procedures require extensive practice to learn. Therefore, simulations can be used to enhance learning. Furthermore, due to the varying abilities of students, simulations can also reflect this situation. Students have the opportunity to engage in learning at their own pace. This learning is not uniform like traditional learning. Interactive simulation also supports independent learning and self-paced learning in accordance with the individual learning needs of each student (Putra, Sumarli, et al., 2024; Putra, Ulfatin, et al., 2024; Rosyid & Prasetyo, 2025). Interactive simulation does not only function as a supporting medium, but also becomes an important part of the practice-based learning process in vocational education. Vocational education simulations can serve as a bridge between theory and practice, further enhancing the importance of simulations in today's learning environment.

Contribution of e-ToolSim Cakra to Digital Vocational Learning

The research results can be presented in the form of a conceptual model that serves as a representation of the research formulation, namely the Cakra e-ToolSim-based learning conceptual model. This model consists of a combination of theoretical learning, simulation, and practical learning. This integration is crucial for providing a comprehensive learning experience to students. This model also depicts learning as a holistic process.

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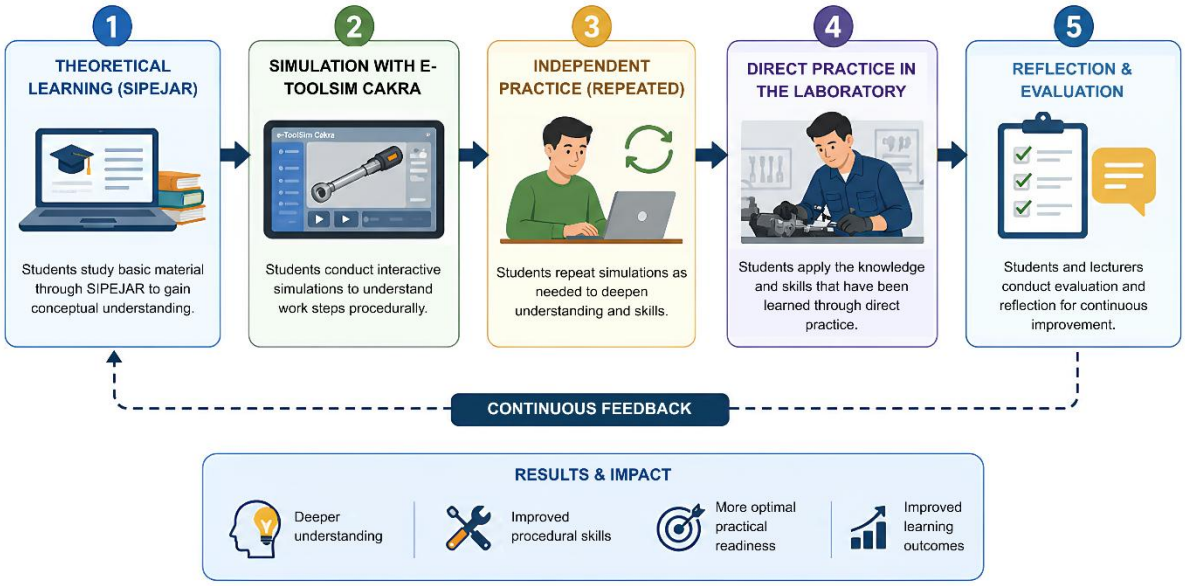

Figure 2. Conceptual Model of e-ToolSim Cakra-Based Learning
Source: Processed by the researcher, 2026

The conceptual model developed in this study integrates theoretical learning through SIPEJAR, simulation using e-ToolSim Cakra, independent practice, and laboratory experience. This integration forms a continuous learning cycle that connects students' conceptual understanding with practical skills. The final stage in this model is reflection and evaluation, where students assess their learning outcomes and lecturers provide feedback for improvement. This process shows that learning takes place in a continuous and systematic manner. This model is one of the important contributions of this study.

The novelty of this study lies not only in the resulting product, but also in the ideas for product development and learning system integration. Based on the research results and discussion, several forms of novelty can be clearly identified. The novelty of this study lies not only in the product produced, but also in the integration of the learning system and procedural simulation approach. e-ToolSim Cakra was developed as an automotive equipment learning simulator that not only displays tool visualization, but also simulates work steps procedurally. In addition, the system is equipped with interactive feedback that allows students to correct errors directly, thereby supporting more adaptive independent learning compared to conventional media (Ooi et al., 2023; Putra et al., 2025).

This research has several aspects related to its contribution to science, which can be seen from the conceptual, methodological, and practical aspects. Scientifically, this study contributes to the development of simulation-based learning in vocational education. Conceptually, this study strengthens the view that simulation is not merely a learning aid, but a part of the learning process itself. Methodologically, the use of the ADDIE model integrated with digital systems shows that media development can be conducted systematically and can be replicated. Practically, e-ToolSim Cakra provides a solution to the limitations of practical tools in the laboratory by providing a simulation-based learning alternative.

The implications of this study cover theoretical, practical, and institutional aspects. Theoretically, the results of this study strengthen the concept of vocational learning that integrates theory, simulation, and practice as a unified

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learning process. Practically, e-ToolSim Cakra can be utilized as supporting learning media to improve student readiness before laboratory practice. Institutionally, this media has the potential to support the development of digital learning and reduce dependence on physical practical equipment in vocational higher education institutions.

CONCLUSION

Based on the research results, it can be concluded that E-ToolSim Cakra was successfully developed as a learning medium in the automotive equipment course at the Automotive Engineering Education Study Program, Universitas Negeri Malang through the ADDIE development model. This media is feasible to use as a simulation-based learning tool that supports procedural learning in the vocational field. Validation results by subject matter experts and media experts show that E-ToolSim Cakra is in the very valid category, both in terms of content suitability with competencies and in terms of learning media feasibility. In addition, the results of the practicality test show a very positive student response, particularly in terms of ease of use, attractiveness, and the ability of the media to assist in understanding automotive equipment usage procedures. Thus, E-ToolSim Cakra is not only theoretically and practically feasible, but also serves as a bridge between theoretical and practical learning through a simulation approach. This media helps improve student readiness before conducting laboratory practice and supports independent learning outside the classroom.

Nevertheless, this study has limitations, namely the number of trial subjects that is still limited and the direct effectiveness testing on improving student learning outcomes has not yet been conducted. Therefore, future research is advised to involve a wider sample and test the effect of using E-ToolSim Cakra on learning outcomes experimentally. In addition, further research can also develop the integration of simulation with other technologies or expand learning materials so that this media becomes increasingly comprehensive in supporting digital-based vocational learning.

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