IJECA
International Journal of Education & Curriculum Application
http://journal.ummat.ac.id/index.php/IJECA
ISSN 2614-3380 | Vol. 7, No. 3, December 2024

Development of Learning Modules for Electric Power Plant Machinery for Class XI Phase F of Electric Power Plant Engineering Expertise Program in Vocational Schools

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Keywords:
Research and Development;
Learning Module;
Teaching Materials;
Power Plant;
Electrical Machinery;
Generator.

ABSTRACT

The Power Plant Engineering program at SMK aims to equip students with technical skills in operating machinery, diagnosing faults, and installing control equipment. However, observations at SMK Brantas Karangkates showed that the materials taught were not in accordance with the Merdeka Curriculum and the existing learning modules were not comprehensive enough. To address this problem, a new learning module was developed through Sugiyono's Research and Development model approach with an additional product development phase. The validity of the module was evaluated by two experts, a lecturer from State University of Malang who specializes in Learning Media and Power Plant Engineering, and a senior teacher from SMK Brantas Karangkates. The experts assessed the module from the aspects of content, language, presentation, and graphics, with excellent validation results: content 93.7%, language 87.3%, presentation 100%, and graphics 96.1%, with an average score of 94.3%. The limited trial with 10 grade XI students resulted in a score of 76%, indicating the need for revision. After revisions were made, the final trial with 64 students yielded a score of 93.6%, indicating that the module was highly valid and effective in improving the learning process.

Article History:
Received: 18-08-2024
Revised : 19-09-2024
Accepted: 28-09-2024
Online : 03-12-2024

Crossref
https://doi.org/10.31764/ijeca.v7i3.26218

A. INTRODUCTION

Vocational education is very important in producing skilled human resources who are able to meet the needs of the industry, especially in technical fields such as Power Plant Engineering. One of the significant challenges faced by vocational education institutions today is bridging the gap between the curriculum and the evolving needs of the industry. This gap is especially evident in the Power Generation Engineering skill program, where students need not only theoretical knowledge but also practical and hands-on experience to thrive in the workforce. In many vocational institutions, including SMK Brantas Karangkates, outdated teaching materials do not match industry standards, resulting in suboptimal outcomes for students. McGrath & Yamada (2023) emphasize that vocational education must be continuously updated to reflect technological advances and industry demands to ensure that students are equipped with the skills they need in the workplace.

As highlighted by Suharno et al. (2020), vocational education should focus on the acquisition of practical skills, not just theoretical knowledge. The demand for electricity continues to increase due to technological development and industrialization, making Power Generation Engineering one of the most important fields in the vocational education landscape. It is crucial to ensure that vocational graduates can meet this growing industry demand. Effective teaching materials play an important role in facilitating this, as they provide a structured pathway for students to apply theoretical concepts in real-world settings. Esmail & Khan (2024) argue that learning modules need to be continuously adapted to technological advances to maintain relevance in the industry, thus ensuring that students acquire the skills needed for the world of work. Effective alignment of curriculum and learning materials with industry needs is essential for student readiness.

However, at SMK Brantas Karangkates, several issues have been identified with the learning process for the Power Plant Engineering program. Existing materials, such as the Electronic School Book (BSE), are outdated and not synchronized with the modern Merdeka Curriculum. This lack of alignment creates a significant gap between what is taught and what is required by the industry. In addition, there are no specialized learning modules to support the practical application of knowledge, particularly regarding the Power Plant Machinery element, which is a core component of the Power Plant Engineering curriculum. Zhao (2024) highlighted the importance of updating teaching materials and ensuring that they reflect current standards and industry needs to better prepare students for real-world challenges.

Developing teaching materials aligned with industry needs has been shown to significantly improve learning outcomes. Niittylahti et al. (2023) emphasize that students retain information more effectively when educational materials reflect curriculum standards and industry expectations. This alignment helps bridge the gap between theoretical knowledge and practical application. In addition, Diao & Qu (2024) noted that well-structured modules enhance students' cognitive engagement and ensure that practical skills are retained, which is crucial in engineering education. For engineering fields such as Power Generation Engineering, practical skills are as important as theoretical knowledge, and the curriculum should reflect this balance.

Given these challenges, this research aims to develop a learning module specifically for vocational students enrolled in the Power Generation Engineering program, focusing on the Power Generation Machine element. The module will address the gap between outdated teaching materials and the practical demands of the industry. Yoto et al. (2022) highlighted that comprehensive modules incorporating case-based learning and real-world applications significantly improve technical competence and student engagement, especially in the field of engineering education. The development of this module will also be guided by the need to ensure students gain hands-on experience in operating and maintaining generators, which are critical components in the power generation process.

Hands-on practice and interactive media are important components in the learning process, especially in vocational education. Research by Chernikova et al. (2020) shows that the use of simulation and case-based learning improves students' understanding of complex concepts and allows them to experiment and learn from mistakes in a controlled environment. This interactive learning approach is particularly important for the Power Generation Engineering program, where students must understand both the theoretical and practical aspects of power generation. Practical demonstrations and hands-on practice will allow students to engage deeply with the material, ensuring they can apply theoretical knowledge in a real-world context.

This research will adopt a Research and Development (R&D) approach, which incorporates various stages such as needs analysis, module design, development, and evaluation. A needs analysis is essential to identify the specific needs of the Power Plant Engineering program and align the module with the curriculum and industry needs. According to Yang & Huang (2023), involving industry professionals in the development process ensures that learning materials remain up-to-date and aligned with industry practices, thus improving students' readiness to enter the workforce. The module design and development will focus on creating engaging and practical learning activities, while the evaluation phase will involve a limited pilot test in SMK to gather feedback from students and experts in the field of Power Plant Engineering.

Incorporating real-world applications into the learning process is key to ensuring the success of the module. Ahmad et al. (2023) emphasize that experiential learning, where students are actively involved in solving real-world problems, increases engagement and ensures that the knowledge gained can be applied directly in the workplace. By incorporating case studies and practical projects in the module, students will develop the necessary skills to address real-world challenges in the power generation industry. This is in line with the current trend of vocational education, which prioritizes the development of practical skills alongside theoretical knowledge. Ultimately, the development of learning modules for the Power Plant Machinery element at SMK Brantas Karangkates will improve the quality of education in the Power Plant Engineering program. By aligning the module with industry standards and ensuring that students receive both theoretical and practical training, graduates will be better prepared to face the challenges of the power generation industry. Okolie et al. (2019) suggest that educational modules developed in close collaboration with industry professionals can improve graduate outcomes by ensuring that the skills learned are directly transferable to the workplace.

The impact of this module will extend beyond SMK Brantas Karangkates, and serve as a model for other vocational schools looking to improve their curriculum and teaching materials to match industry needs. In conclusion, vocational education in fields such as Power Plant Engineering should focus on bridging the gap between theory and practice. By developing teaching materials that are relevant to the industry and aligned with the curriculum, this research will contribute to improving student learning outcomes and enhancing graduate employability. Ogur (2023) highlighted that the education system must be adaptive to technological changes and industry shifts to remain relevant in the rapidly evolving technical sector. The modules developed through this research will address these challenges, providing students with the skills and knowledge they need to succeed in the power generation industry while ensuring that vocational education remains relevant in a changing world.

B. METHODS

1. Development Model

This research adopts Sugiyono (2021) Research and Development (R&D) model, which includes 11 stages with an additional stage for the product manufacturing process. The stages involve identifying potential and problems, gathering information, designing the product, validating it with experts, making improvements, producing the module, conducting limited and broader trials, and refining the module based on feedback. The learning module is specifically designed for the Power Plant Engineering Expertise Program at SMK Brantas Karangkates. Validation was carried out by two experts in Power Plant Engineering and Learning Media, using instruments to assess content, language, and presentation. Following validation, necessary revisions were made, and trials were conducted with students to evaluate usability, clarity, and effectiveness. Feedback was collected through qualitative and quantitative methods using a 4-point Likert scale, and improvements were implemented based on this data. The final module was

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then prepared for mass production, ensuring it meets industry and curriculum standards. Figure 1 shows the development research method.

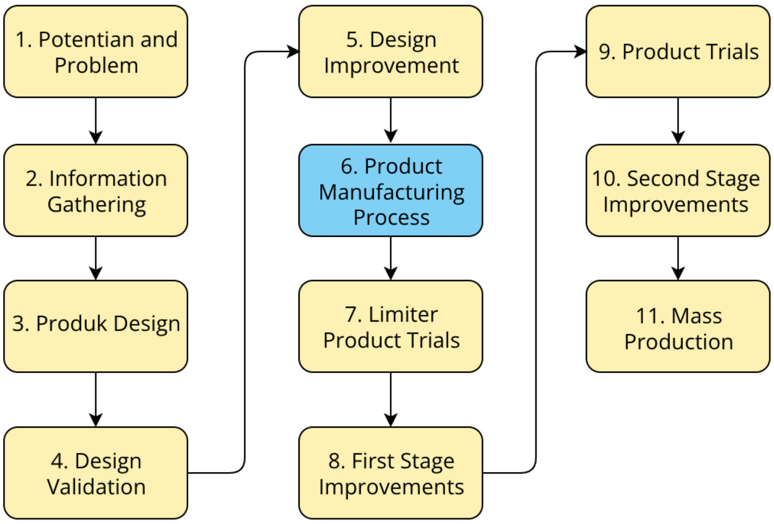

Figure 1. (Sugiyono, 2021) method with the addition of 1 stage at stage 6

2. Development Procedure

This research adopts Sugiyono (2021) development model, consisting of 11 stages, with the addition of one stage specifically for the product manufacturing process. The stages are designed to ensure a comprehensive process in developing the learning module for Power Plant Engineering, which is aligned with industry needs and curriculum requirements.

a. Potential and Problems

The first stage focuses on identifying potential and problems in the existing learning process. At SMK Brantas Karangkates, the main issue is the lack of a dedicated learning resource for the Electrical Power Plant Machinery subject. Current materials, such as BSE and internet resources, are outdated and not aligned with the Merdeka Curriculum, creating a gap between student competency and industry expectations. This indicates the need for a targeted learning module to improve student understanding and skills.

b. Information Gathering

The second stage involves gathering information from various sources, including teachers, industry professionals, and curriculum standards. The purpose is to define the core learning outcomes for the module. These learning outcomes are detailed in Table 1.

Table 1. Flow of Learning Objectives

Elements	Learning Outcomes	Learning Objectives	Learning Objective Flow
Power Generation Machine	By the end of Phase F, learners are able to maintain power plant machinery, including basic concepts (mechanical and electrical), operation and	1. Understand the operation of electric motors, generators, transformers, sweatchgear. 2. Understand the operation of mechanical equipment:	1. Understand the operation of electric motors, generators, transformers, sweatchgear. 2. Understand the operation of mechanical equipment: pumps,

Elements	Learning Outcomes	Learning Objectives	Learning Objective Flow
	maintenance of electrical equipment (electric motors, generators, transformers, sweatchgear), and mechanical equipment (pumps, turbines, compressors, valves).	pumps, turbines, compressors, valves. 3. Understand the maintenance of electric motors, generators, transformers, sweatchgear. 4. Understand mechanical equipment maintenance: pumps, turbines, compressors, valves.	turbines, compressors, valves. 3. Understand the maintenance of electric motors, generators, transformers, sweatchgear. 4. Understand mechanical equipment maintenance: pumps, turbines, compressors, valves.

c. Product Design

Product design is the core stage in this development process. The design involves integrating theoretical and practical content related to Power Plant Engineering. The module includes visual aids, practical exercises, case studies, and assessments to provide a comprehensive learning experience. The design focuses on promoting active learning and is aligned with both the curriculum and the demands of the power plant industry.

d. Design Validation

After the module design was completed, the module was validated by 2 experts in the field of Power Plant Engineering and Learning Media. The two experts are a lecturer from the State University of Malang who is an expert in the field of Learning Media and Power Plant Engineering, and a senior teacher from SMK Brantas Karangkates who has been certified in the field of power plant engineering. The validation process used specific instruments to evaluate the module based on content, language, and presentation. The validation criteria are outlined in Table 2.

Table 2. Grid of Questionnaires for Experts

No.	Aspects		Criteria	Source	Number of items
1.	Content eligibility	a.	Suitability of material with learning outcomes	(Laksana, 2024)	1
		b.	Accuracy of Material	(Anzures, 2022)	2
		c.	Supporting Learning Materials	(Ramdani et al., 2021)	5
2.	Language feasibility	a.	Communicative	(Chinga-Zambrano & Muñoz-Ponce, 2022)	1
		b.	Readability	(Kamarudin & Sugianto, 2020)	2
		c.	Appropriateness of rules in the use of language	(Wildeman et al., 2023)	1
		d.	Systematic and coherent	(Spatioti et al., 2023)	1
		e.	Spelling usage	(Ratnaningsih & Azizah, 2019)	1
3.	Presentation Feasibility	a.	Presentation Technique	(Ismawati, 2019)	2
		b.	Support and completeness of presentation	(Hasanah Lubis et al., 2023)	5
4.	Graphics feasibility	a.	Book cover design	(Pulatovna & Pavlovna, 2022)	4
		b.	Book content design	(Indrawan et al., 2023)	9

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e. Design Improvement
After validation, improvements are made based on feedback from the experts. The qualitative feedback is categorized into themes such as content, language, and presentation. Necessary revisions are incorporated to ensure that the module is both educationally effective and aligned with industry practices.

f. Product Manufacturing Process
Following validation and revision, the next step is the product manufacturing process. In this stage, the module is finalized for use in the classroom. It is printed and prepared for distribution, with attention to quality in terms of both content and physical presentation.

g. Limited Product Trial
The limited product trial was conducted on a small group of students in class XI of the Power Plant Engineering Expertise Program with a total of 10 students. The purpose of this stage is to test the usability, clarity, and effectiveness of the module. Students provided feedback through questionnaires, and qualitative and quantitative data were collected for analysis. Details of the questionnaire are shown in Table 3.

Table 3. Questionnaire Lattice for Learners

No.	Aspects	Source	Number of items
1.	Interest	(Morris et al., 2022)	5
2.	Material	(Zhou, 2023)	5
3.	Language	(Shahidzade et al., 2021)	3

h. First Stage Improvement
Based on the results of the limited product trial, first stage improvements are made to the module. Student feedback and questionnaire results are analyzed to identify any areas that need further refinement.

i. Product Trial
After the initial improvements, the module undergoes a broader product trial with 64 students from two classes. The goal is to ensure that the module effectively supports the learning objectives and enhances student skills in power plant machinery. Student feedback is gathered once again through questionnaires to assess the module's overall performance.

j. Second Stage Improvement
Based on the data collected from the broader product trial, second stage improvements are made to finalize the module. These revisions address any remaining issues and ensure that the module is optimized for student use.

k. Mass Production
Once the module has been validated and refined through the earlier stages, the final step is mass production. The module is printed and made available in both physical and digital formats for use by students at SMK Brantas Karangkates. The product is also uploaded on the school’s website for easy access and distribution.

3. Data Analysis

a. Quantitative Data

The data from the questionnaires are analyzed using a 4-point Likert scale (Table 4). Scores are calculated based on the percentage of validity using the following formula:

$$Va = \frac{TSe}{TSh} \times 100\% \tag{1}$$

Description: Va is Validity; TSe is Total Score obtained; TSh is Total expected score; and 100% is Constant. The validity of the learning module was measured using a 4-point Likert scale, which allows a quantitative assessment of the relevance, appropriateness, and effectiveness of the module by comparing the total score obtained with the expected score. This method, as emphasized by Gopalan et al. (2020) and Siripipatthanakul et al. (2023), is essential for ensuring the reliability of educational tools, especially in vocational education. Sürücü & Maslakci (2020) emphasized the importance of validity formulas in creating learning materials that can be applied in real-world environments, while Gerdts-Andresen et al. (2022) highlighted the need for proper instruments to rigorously evaluate educational interventions. The Likert scale, as used in this study, evaluates the clarity, usability, and relevance of the module, with Opuni & Alhassan (2023) noting its effectiveness in measuring subjective opinions. Alkharusi (2022) emphasize its role in simplifying data interpretation, and Flake et al. (2022) support its adaptability in assessing various educational outcomes such as student motivation. Ultimately, Likert scales provide a structured, data-driven approach to refining learning modules based on feedback. The Likert scale used in this study can be seen in Table 4.

Table 4. Likert Scale

Score	Description
4	Very Interesting / Very Clear / Very Easy / Very Suitable
3	Interesting / Clear / Easy / Appropriate
2	Not Interesting / Not Clear / Not Easy / Not Suitable
1	Very Uninteresting/Very Unclear/Very Uneasy/Very Unsuitable

The results are categorized based on validity levels shown in Table 5.

Table 5. Validity Criteria

No.	Eligibility Criteria	Feasibility Level
1	85,01% - 100,00%	Very Valid, or can be used without revision.
2	70,01% - 85,00%	Moderately Valid, or can be used but needs minor improvements.
3	50,01% - 70,00%	Less Valid, recommended not to be used as it needs major revisions.
4	01,00% - 50,00%	Invalid, should not be used

The practicum module is used if the results of the trial get a score from the expert of at least 70.01% or more so that the module can be used at SMK Electric Power Plant Engineering Expertise Program.

b. Qualitative Data

The qualitative data collected through student and expert feedback were analyzed using thematic analysis, which helped identify patterns related to content relevance, language clarity, and presentation. Tomaszewski et al. (2020) highlight that qualitative methods offer deep insights into participant experiences, while Busetto et al. (2020) emphasize the effectiveness of thematic analysis in processing qualitative feedback. This analysis was crucial for refining the module based on user needs and ensuring alignment with learning outcomes. Braun & Clarke (2021) underscore the value of this method in understanding student engagement with the material, while Liang (2019) emphasizes the importance of incorporating participant feedback to enhance the relevance and practicality of educational tools.

C. RESULT AND DISCUSSION

1. Product Development Planning

The learning module for Power Plant Machinery was designed to meet the specific needs of students in the Power Plant Engineering Expertise Program. The module includes structured learning materials, example questions, and practical exercises, all complemented by visual aids that enhance comprehension. The reflection section, which encourages students to solve problems creatively and collaborate, follows the best practices identified in previous studies (e.g., Pulatovna & Pavlovna, 2022). This approach to learning supports both theoretical and practical knowledge acquisition, consistent with findings from Ghafar (2024), who emphasize the importance of integrating practical applications in vocational education.

2. Product Development Results

The learning module is organized into several key sections: the cover, foreword, table of contents, learning objectives, content, assessments, and appendices. These components were designed based on student feedback and expert validation, ensuring that the module is both comprehensive and user-friendly. A concept map (Figure 3 in the module) outlines the relationships between various topics, aiding in learner comprehension by visually organizing the information.

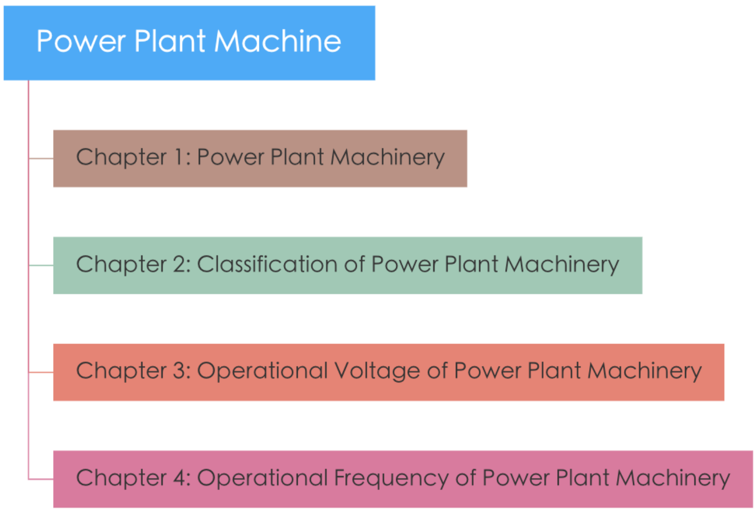

Figure 3. Module Concept Map

This structure supports the learning process by making complex information more accessible, similar to the findings of (Katona et al., 2023), which emphasize the effectiveness of visual aids in enhancing student understanding. Additionally, feedback during the early stages of development influenced design improvements, including simplifying technical explanations and incorporating real-world case studies, which are consistent with the findings from Acosta et al. (2019) on the importance of making learning content relevant and accessible.

3. Validation

The module underwent validation by two experts: one from a university specializing in learning media and power plant engineering, and a certified senior teacher from SMK Brantas Karangkates. The validation focused on four aspects: content feasibility, language feasibility, presentation, and graphics. As shown in Table 6, both experts rated the module highly, although there was a slight variation in scores, particularly in language feasibility, where Expert 2 gave a slightly lower score. The difference in scores can be attributed to the distinct focus of each expert. The senior teacher (Expert 2) noted that the language used in the module was sometimes too technical for students, which could impact comprehension. Meanwhile, Expert 1, who is more accustomed to academic standards, found the language appropriate for vocational students. This discrepancy highlights the challenge of balancing academic rigor with accessibility, a challenge also noted by Blazar & Kraft (2019) in similar studies. As a result, revisions were made to simplify certain technical terms while maintaining the integrity of the content. This balance is critical in ensuring the module remains both educationally rigorous and accessible, as emphasized by Saefudin & Sumardi (2019).

Table 6. Expert Validation Results

Aspects	Expert 1	Expert 2
Content eligibility	87,5%,	100%
Language Feasibility	91,6%	83%
Presentation feasibility	100%	100%
Graphics feasibility	94,2%	98%
Overall	93,3%	95,3%

The changes based on this feedback—such as simplifying technical language—had a positive impact, particularly in the broader product trial. The alignment of content with the learners' needs led to increased engagement and comprehension.

4. Trial

The module was tested in two phases: a limited trial with 10 students and a broader trial with 64 students. In the limited trial, feedback indicated a need for changes in layout and design. Specifically, students suggested more spacing between sections and additional images for clarification. The changes made after the limited trial, such as enhancing the visual layout and revising some text, had a positive impact on the final product. As shown in Table 7, there was a significant increase in student engagement and comprehension in the broader product trial, with overall satisfaction rising from 76.0% in the limited trial to 93.6% in the final trial. This increase demonstrates a clear correlation between the design improvements and the enhanced learning outcomes, supporting the findings from Xu & Zammit (2020) regarding the role of design in improving user engagement with educational materials.

Table 7. Trial Results

Aspects	Percentage of Validity	
	Limited Trial	Product Trial
Interest	76,5%	93,9%
Material	71,5%	91,4%
Language	80%	93,6%
Overall	76%	93,6%

The improvements in student feedback align with findings from Miles et al. (2019), which emphasize the importance of refining learning materials based on pilot testing to enhance learning outcomes. The changes made, such as improved spacing and clearer graphics, contributed directly to better comprehension and engagement during the product trial, demonstrating the module's effectiveness in addressing both cognitive and practical learning needs. In other words, this module has gone through a rigorous evaluation process and received positive feedback from various sources. This success indicates that this module has been well designed and effective in meeting learning needs. Therefore, this module can be immediately produced in large quantities for widespread use, thus providing significant benefits for learners in understanding the subjects taught.

5. Limitation of Study

Despite the positive outcomes, there are several limitations to this study. First, the relatively small sample size in the limited trial (10 students) may limit the generalizability of the results. Larger trials are needed to validate the findings across different vocational schools and regions. Second, the trial focused on one school and one specific expertise program, which may limit the module's applicability to other technical subjects. Finally, while the revisions improved student engagement and comprehension, further refinements, such as additional interactive elements, could enhance the module's long-term impact. Future research should explore these aspects to improve the module's effectiveness further.

D. CONCLUSION AND SUGGESTIONS

The Power Plant Machinery learning module developed for Class XI SMK Phase F in the Power Plant Engineering expertise program has been validated by experts and shown to be effective in meeting the curriculum's Learning Outcomes. This module, designed using Sugiyono's model, enhances both theoretical knowledge and practical skills through structured content and visual aids, significantly improving student engagement and comprehension. Despite these positive outcomes, the study's limitations, including the small sample size and focus on a single school, suggest that further research is needed to test the module's effectiveness in broader contexts. This research contributes to vocational education by bridging the gap between academic training and industry requirements. Future development of the module should focus on expanding it into digital formats or e-learning platforms, incorporating multimedia and interactive features to provide more adaptive and engaging learning experiences. Experimental studies should be conducted to measure the module's impact on student learning outcomes, such as competency improvement and knowledge retention. Additionally, it is recommended that the module be adapted for other vocational subjects, ensuring it meets varying curriculum and industry needs. These developments will help prepare students across different technical fields to meet workforce demands more effectively.

ACKNOWLEDGEMENT

With full gratitude and gratitude, I express my deepest gratitude to the State University of Malang for providing support and facilities in the implementation of this research. My sincere gratitude also goes to Mr. Heru Wahyu Herwanto, S.T., M.Kom. and Mr. Yoto, M.Pd. for their endless guidance and academic support. Thank you also to my friends who have provided assistance and encouragement during this research process. Hopefully all the kindness and contributions that have been given will be rewarded.

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