JIPS 6 (3) (2025)
Jurnal Inovasi Pendidikan dan Sains
E-ISSN 2721-9119
https://ejournal.unwmataram.id/JIPS

Improvement of Panel Assembly Competence through Learning Using FluidSIM Simulation Software Integrated with Student Video-Based Presentations

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Accepted: October 20th 2025. Approved: December 24th 2025. Published: December 31th 2025

ABSTRACT

The rapid advancement of information and communication technology has changed learning strategies in vocational education, particularly in engineering, which requires mastery of practical competencies. This study aims to evaluate the effectiveness of learning using FluidSIM simulation software integrated with student video-based presentations in improving learning outcomes in the Panel Motor Assembly subject at SMKN 1 Blitar. This study used a quantitative experimental design with two groups: the experimental group that received learning assisted by FluidSIM software simulation and video-based presentations, and the control group that used conventional instruction. Data were collected through practical tests, observation, and questionnaires, and then analyzed using descriptive and inferential statistics. The results of the study showed that the experimental group achieved a higher average score (87.5) than the control group (70), indicating improved students' conceptual understanding and technical skills. The integration of video-based presentations and simulations also promotes problem-solving skills, reflective learning, and communication. Therefore, it can be concluded that technology-based learning, by integrating FluidSIM simulation software with students video-based presentations, is effective in improving vocational students' performance and supporting the development of 21st-century competencies.

Keywords: FluidSIM simulation, video-based presentation, vocational education

INTRODUCTION

The rapid advancement of information and communication technology (ICT) has significantly influenced various sectors, particularly education. This transformation has redefined the way teachers deliver instruction and how students interact with learning materials. The integration of ICT not only modernizes administrative functions but also revolutionizes teaching and learning strategies. In the context of vocational education, this change plays an important role in preparing students to face the demands of Industry 4.0. Therefore, the implementation of technology in learning practices has become a fundamental aspect of effective and relevant learning [1], [2], [3].

Vocational education emphasizes practical learning, in which students are expected to apply theoretical knowledge to real-world situations. In the field of Industrial Electronics, one of the essential competencies is the ability to assemble and operate motor control panels accurately [4], [5], [6]. However, conventional learning methods often focus on memorization and theoretical explanations, which limit students' opportunities to practice and internalize technical skills. This pedagogical gap leads to low student learning outcomes, particularly in practical examinations. Therefore, innovative learning strategies are required to improve both conceptual understanding and students' practical performance [7], [8].

Simulation-based learning has emerged as an effective pedagogical innovation in vocational education. Tools such as FluidSIM allow students to visualize electrical, pneumatic, and hydraulic systems before performing actual assembly [9]. This virtual learning environment minimizes errors during practice and enhances understanding of complex technical processes. By experimenting with circuits in a safe digital environment, students gain a deeper understanding of system operations and inter-component relationships. This approach aligns with constructivist learning theory, which emphasizes knowledge construction through active engagement [10], [11], [12]

In addition to simulation, video-based presentation learning has gained recognition as a reflective and communicative learning tool. Through video-based presentations, students can document the learning process, evaluate their performance, and receive constructive feedback. This method promotes self-assessment, critical thinking, and communication skills, which are highly valued in the modern workplace [13], [14]. Furthermore, video-based reflection fosters metacognitive awareness, enabling students to monitor their learning progress and identify areas for improvement. Therefore, video-based presentations become an effective medium for strengthening both technical skills and soft skills [15], [16], [17].

Although various studies have shown that the use of digital technology, such as simulation and video media, can improve the quality of vocational learning, its implementation in Vocational High Schools (SMK) still faces several challenges. In the Panel Motor Assembly subject, the learning process is still dominated by conventional methods that rely on teacher explanations and limited workshop practice. This condition leads to low students' conceptual understanding, a high rate of errors during practice, and underdeveloped students' reflective and technical communication skills. In addition, the limitation of practice time and the risk of assembly errors also become major constraints in achieving the expected competencies [18], [19], [20].

Previous studies generally examined simulation or learning using video-based presentation separately. Research on simulation has primarily emphasized improving technical understanding, whereas learning using video-based presentation has generally focused on cognitive or communication aspects. However, empirical studies that integrate FluidSIM-based technical simulation with student-produced video-based presentations within a single integrated learning model, particularly in the context of Panel Motor Assembly learning in Vocational High Schools (SMK), remain very limited. This gap indicates the need for a learning approach that not only improves technical skills but also promotes reflection, communication, and students' work readiness holistically.

As a solution to these problems, this study offers an innovative learning approach by integrating the FluidSIM simulation software with student video presentation tasks. The novelty of this study lies in the combination of digital simulation as a medium for initial technical understanding with video-based presentations as a reflective and communicative medium, so that students are not only able to assemble panels accurately but also explain the process, technical reasoning, and the results of their work systematically. This approach is expected to bridge the gap between conceptual mastery, practical skills, and the soft skills required in the industrial world.

Based on the above description, the purpose of this study is to comprehensively analyze the influence of integrating the FluidSIM simulation software with student video-based presentations on improving learning quality in the Panel Motor Assembly subject. Specifically, this study aims to examine the effectiveness of using FluidSIM simulations in improving students' conceptual understanding of circuit logic and component relationships, and to evaluate the role of learning using video-based presentation in developing students' reflective and technical communication skills. In addition, this study aims to identify the contribution of integrating these two approaches to improving students' technical skills, including assembly accuracy, problem-solving ability, and practical performance. Furthermore, this study analyzes the level of student activity and engagement during the technology-based learning process and examines the synergistic effects of integrating simulation and video in developing vocational competencies holistically, encompassing cognitive, psychomotor, and affective aspects. Ultimately, this study also aims to identify the key factors that influence improvements in students' learning outcomes, particularly those related to learning visualization, interactive experiences, and technology-based reflective processes.

RESEARCH METHOD

1. Research Design

This study used a quantitative, quasi-experimental design, namely the non-equivalent control group design. This design was chosen because the researcher was unable to conduct full randomization of subjects, but was still able to compare learning outcomes between the experimental and control groups by providing different treatments.

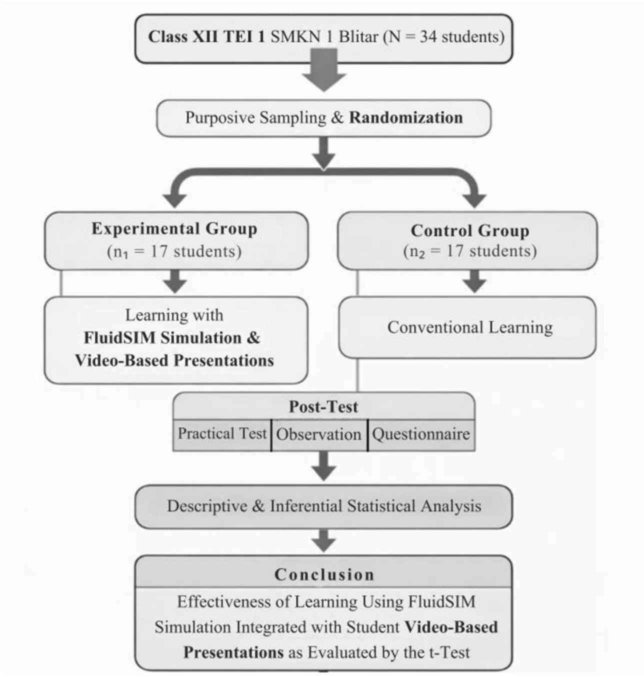

Figure 2. Research Design and Flow

2. Population and Sample

The population in this study was all twelfth-grade students of the Industrial Electronics Expertise Program at SMKN 1 Blitar in the 2023/2024 academic year. The research sample was drawn from one class, namely class XII TEI 1, comprising 34 students. The sampling technique used was purposive sampling, with consideration of material suitability, the readiness of practical facilities, and the similarity of students' academic characteristics. The sample was then divided into two groups, namely the experimental group and the control group.

3. Data Sources

The data sources in this study included both primary and secondary data. Primary data were obtained directly from students through the results of practical tests, observation sheets of learning activities, and student response questionnaires. Secondary data were obtained from school documents, such as the syllabus, Lesson Plan (*Rencana Pelaksanaan Pembelajaran; RPP*), and students' initial scores, which were used as supporting data.

4. Data Collection Techniques

Data collection was conducted through several techniques, namely:

a. Practical tests were used to measure students' conceptual understanding and technical skills in assembling motor control panels;
b. Observation was conducted to observe student engagement, learning activeness, as well as the conformity of the learning implementation with the planned design;
c. Questionnaires were used to identify students' responses to the use of FluidSIM simulation and learning using video-based presentation, covering aspects of motivation, interest, and perceptions of learning.

5. Data Analysis Techniques

The data obtained were analyzed using descriptive and inferential statistics. Descriptive analysis was used to calculate mean scores, percentages, and trends in students' learning outcomes. Inferential analysis used a t-test to assess significant differences in learning outcomes between the experimental and control groups. All analyses were conducted at a significance level of 0.05. The results of the analysis were then interpreted to assess the effectiveness of integrating FluidSIM simulation software with video-based presentation in improving learning outcomes.

RESULT AND DISCUSSION

This study aimed to evaluate the effectiveness of integrating student video-based presentations and FluidSIM simulations to improve learning outcomes in the Panel Motor Assembly subject. The results of the data analysis showed a significant difference between the experimental and control groups. The experimental group that received learning assisted by student video-based presentations and FluidSIM simulation achieved an average posttest score of 87.5, whereas the control group that used only conventional learning achieved an average score of **70**. These findings indicate that the integrated technology-based learning approach significantly improved students' learning outcomes.

In addition to improvements in practical test scores, learning observations showed that students in the experimental group were more active, engaged in technical discussions, and able to explain the panel assembly process systematically. Students not only completed practical tasks more accurately but also demonstrated a better understanding of the functions and logic of motor control circuits. Therefore, the main finding of this study is that integrating simulation and video-based presentations can simultaneously improve students' conceptual understanding, technical skills, and communication skills.

1. Learning Process Using Video-based presentations

Several factors caused the significant improvement observed. First, the use of FluidSIM facilitated interactive simulations that improved students' visual and practical understanding of circuit operations and component interactions. This visual reinforcement strengthened conceptual retention and supported more meaningful learning.

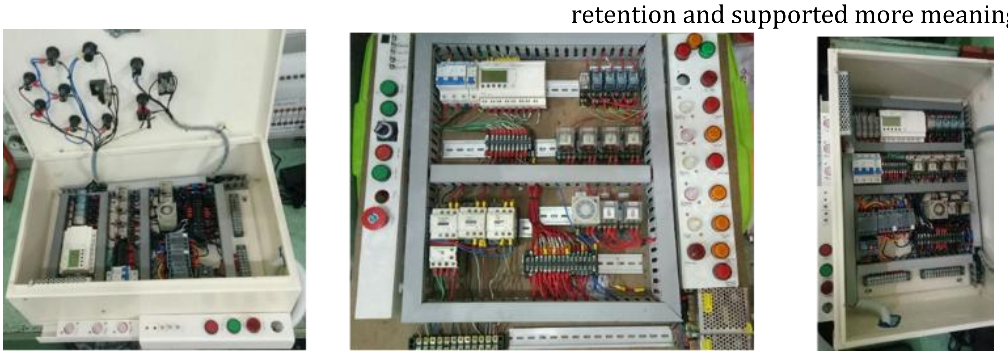

Figure 3. Panel Assembly Practice Test Media

Second, the activity of recording video-based presentations enabled students to reflect on their learning process. By reviewing their presentation recordings, students were able to evaluate their strengths and weaknesses in communication and presentation skills. Anisa (2021) found that students who were involved in video-based presentations tended to be more prepared and confident when participating in practical assessments.

Figure 4. Panel Assembly Practice Exercise

Feedback from students also showed a preference for interactive and innovative learning methods, in line with constructivist learning theory, which emphasizes students' active engagement in constructing knowledge [21], [22], [23]. This finding strengthens the role of technology integration in improving students' learning outcomes.

2. The Effectiveness of FluidSIM Simulation in Improving Learning Outcomes

The results of this study showed that the use of FluidSIM simulation software provided a significant positive impact on students' learning performance. Students who used the simulation were able to visualize electrical circuits more effectively and understand the logic of motor control systems before direct practice was conducted [24], [25], [26]. This visual and interactive learning experience made it easier for students to connect theoretical concepts with practical application in the field. The results of the practical test showed a fairly large increase in scores in the experimental group compared to the control group. This improvement proves that the integration of simulation-based learning can bridge the gap between abstract theory and real practice in vocational education [27], [28].

In addition, FluidSIM encourages students to engage in problem-solving and critical thinking during the learning process. By allowing students to manipulate and experiment with circuit configurations, they can obtain immediate feedback on the accuracy of their designed configurations. This process develops analytical skills and technical creativity that are highly important in the industrial work environment [29], [30]. The interactive nature of simulation-based learning is also aligned with constructivist principles, in which knowledge is actively constructed by learners rather than passively received. Therefore, simulation-based learning not only improves cognitive understanding but also develops students' higher-order thinking skills [31], [32].

The improvement in practical test results reinforces findings from previous studies that simulation-based learning significantly improves students' technical performance. The ability to experiment in a virtual environment allows learners to make mistakes without real consequences, thereby reducing anxiety and creating a positive learning atmosphere [33], [34]. Students become more confident when transferring their simulation experiences to real laboratory tasks [35], [36]. This confidence, in turn, improves mastery of practical competencies. Therefore, it can be concluded that FluidSIM simulation plays an important role in developing conceptual understanding, technical accuracy, and students' confidence in performing practical tasks.

3. The Role of Video-based Presentations in Enhancing Reflection and Communication Skills

Video-based presentation activities provided opportunities for students to reflect on their learning experiences and express their understanding of technical concepts more deeply. Through the video recording process, students were able to review their performance and identify areas for improvement, both in content mastery and in presentation delivery. This reflective process strengthened students' metacognitive awareness, helping them independently monitor and evaluate their learning progress. In addition, presenting technical concepts through video also improved students' communication skills and professionalism, two attributes important in the industrial world. Therefore, learning through a video-based presentation not only developed technical skills but also enhanced soft skills.

The results of this study confirmed findings that state that learning through a video-based presentation improves students' readiness and confidence during the assessment process [37], [38]. Students in the experimental group showed better verbal explanation ability, clearer visual demonstrations, and more organized presentation structures. The presence of self-review activities and teacher feedback contributed to deeper engagement in learning. In addition, video tasks also encouraged collaboration among students because they often worked in teams to write scripts, record, and edit presentations. This collaborative interaction is aligned with Social Learning Theory, which emphasizes that learning is most effective when it occurs through interaction and shared experience [39], [40].

From a pedagogical perspective, the use of video-based presentations also supports differentiated learning. Students with different learning styles, whether visual, auditory, or kinesthetic, can benefit from the multimodal representations provided through video production. This inclusive learning environment enables each learner to access and demonstrate their understanding in ways that align with their strengths. In addition, video-based presentation reflection strengthens long-term retention because students actively process and reconstruct information as they present it. Therefore, integrating video-based presentations into vocational education can yield more holistic learning outcomes, encompassing technical competencies, communication skills, and self-regulation [41], [42].

4. **Integration of Simulation and Video-Based Presentation for the Development of Vocational Competencies**

The combination of FluidSIM simulation and video-based presentations produced a synergistic effect, significantly improving students' overall performance. Simulation played a role in developing technical knowledge, while video-based presentations strengthened the ability to reflect and articulate that knowledge [43], [44]. This integrated approach created a comprehensive learning cycle, including conceptual understanding through simulation, practical application in panel assembly, and reflective evaluation through video. Therefore, students not only mastered technical tasks but also developed critical thinking skills and communication skills [45], [46], [47]. These results align with the goals of modern vocational education, which emphasize technical excellence and employability skills.

The increase in the experimental group's posttest scores, from an average of 60 to 87.5, proves the effectiveness of this integrative method. Students became more independent learners, able to identify problems, test solutions, and communicate results effectively [48], [49], [50]. The research findings also showed higher levels of motivation and satisfaction among students who used this method than among those taught conventionally. These results indicate that a technology-based learning environment promotes active participation, curiosity, and sustained engagement. These factors ultimately contribute to the improvement of learning outcomes and the strengthening of vocational competencies [51], [52].

More broadly, this study highlights the importance of implementing innovative and adaptive learning models in vocational education [53], [54]. The integration of digital simulation and video-based presentation reflection aligns with global trends in Industry 4.0 and Education 5.0, which emphasize creativity, collaboration, and digital literacy. Teachers are expected to act as facilitators who guide students to explore and apply technology in a meaningful way [55], [56]. Therefore, this study provides practical implications for curriculum developers and policymakers to integrate technology-based reflective learning into vocational programs. Through such innovations, vocational education can better prepare students to meet the demands of modern industry and lifelong learning.

The improvement in learning outcomes in the experimental group did not occur by chance, but was influenced by several key factors. First, the use of FluidSIM enabled students to visualize electrical circuits and motor control systems before conducting hands-on practice. This simulation process helped students build stronger conceptual understanding, thereby reducing errors during direct panel assembly. This cause-and-effect relationship indicates that visualization and virtual experimentation act as a bridge between theory and practice [57], [58].

Second, video-based presentation tasks encouraged students to reflect on the learning process and the practical outcomes achieved. By recording and presenting the panel assembly process, students were encouraged to revisit the work procedures, technical reasoning, and the errors that occurred. This reflective process strengthened metacognitive awareness and improved students' technical communication skills. This combination of simulation and reflection forms a "new narrative" in learning, in which students not only learn to perform tasks, but also learn to explain and evaluate their own work [59], [60].

The findings of this study are aligned with the results of previous studies, which state that simulation-based learning can improve students' understanding and practical performance [61], [62]. The results of this study showed that learning through video-based presentation contributed to improvements in students' confidence and presentation skills. This study differs fundamentally from previous studies: it not only examined simulation and video separately but also integrated them into a single learning design. Therefore, this study extends previous findings by showing that the integration of technical simulation and video-based presentation reflective media produces more comprehensive learning impacts [63], [64].

CONCLUSION

This study concluded that integrating student learning through video-based presentations and FluidSIM simulations is effective in improving learning outcomes in the Panel Motor Assembly subject at SMKN 1 Blitar. The use of FluidSIM simulation helped students build stronger conceptual understanding through visualization and interactive practice, thereby improving accuracy and performance in practical tasks. Meanwhile, the video-based presentation served as a reflective medium, encouraging students to evaluate work processes, articulate technical concepts, and develop communication skills relevant to the industrial sector.

These findings indicate that technology-based integrated learning not only improves technical competencies but also supports the development of 21st-century skills, such as critical thinking, problem-solving, and professional communication. Therefore, integrating simulation and video-based presentations can be an effective learning strategy in vocational education. This study provides practical contributions for teachers and vocational education administrators in designing learning that is more contextual and adaptive to technological developments, and it also opens opportunities for further research in other vocational fields.

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