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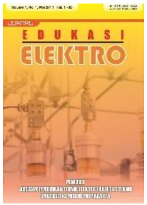

Enhancing Electric Motor Control of Electric Motor Installation in Indonesian Vocational Schools Using PLC and VSD Technology with HMI

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Abstract— Vocational education plays a crucial role in producing skilled labor that is prepared to meet industry demands. This research aims to develop a learning medium in the form of an Automated Sorting Conveyor System based on PLC, VSD, and HMI technology to enhance the competencies of vocational high school students in the subject of Electric Motor Installation. This study employs a Research and Development approach with the ADDIE development model (Analysis, Design, Development, Implementation, and Evaluation). Feasibility testing was conducted by subject matter experts and media experts, while effectiveness testing was performed through pre-tests and post-tests with 33 eleventh-grade students at State Vocational High School 1 South Kuta. The validation results indicate that the media was rated highly feasible by experts (media: 84.17%, material: 95.17%). The use of Automated Sorting Conveyor System has proven effective in improving student learning outcomes, with an average gain score of 0.333 for theoretical aspects and 0.335 for practical aspects. This study recommends the use of Automated Sorting Conveyor System media in the practical learning of electric motor control in vocational schools, as well as training for teachers to optimize its use.

Keywords: electric motor control, learning media, vocational education, plc, hmi, vsd.

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1 Introduction

The increasing need for skilled labor in Indonesia stems from the expansion of industries that necessitate workers to fulfill organizational requirements. By promoting vocational education and training, internships, and competency certification for learners within the scope of national education, quality educational and skills training initiatives based on Information and Communication

Technology (ICT) can cultivate and produce a workforce equipped with the work capability, work skills, and work capacity to enhance a more effective and efficient work system in boosting work productivity [1], [2]. Vocational education, particularly at Vocational High Schools of Kuta, plays a crucial role in supplying workers for diverse industries, especially those requiring technical and practical skills. As these industries continue to expand, there is an increasing demand for advanced educational resources that can equip students for the workforce. In this context, it is crucial to create effective educational tools for technical training. Specifically, the incorporation of technological solutions in vocational training will greatly enhance educational quality. The Automated Sorting Conveyor System is among the advanced solutions aimed at enhancing the practical learning experience for students studying motor control systems at Vocational High School. Due to the swift advancement of technology, the industry requires workers who are not only skilled but also capable of adapting to new tools and techniques.

The World Economic Forum indicates that by 2025, 50% of all workers will need retraining because of the advent of new technologies. In five years, over two-thirds of the skills required in today's workforce will have evolved. A third of the most essential skills in 2025 will be technical skills that are not yet deemed significant to the current job market [3], [4]. The Automated Sorting Conveyor System seeks to close the gap between conventional learning methods and the demands of contemporary industries by providing a comprehensive and practical learning experience [18], [19], [20]. This research examines the creation, execution, and assessment of the Automated Sorting Conveyor System as a learning resource in technical schools. This research adheres to research and development processes within the ADDIE model framework and highlights a methodical approach to the creation and evaluation of the Automated Sorting Conveyor System. Incorporating expert validation and student responses, this research assesses the effectiveness and efficiency of the Automated Sorting Conveyor System in enhancing students' comprehension and abilities in motion control systems. As the need for proficient workers continues to rise, particularly in technical sectors, the significance of effective vocational training is undeniable. By improving practical learning opportunities through innovative resources like the Automated Sorting Conveyor System, vocational education can equip students to tackle the challenges of the evolving workforce. This study will aid ongoing initiatives to enhance vocational education in Indonesia and guarantee that students acquire the skills and knowledge necessary for success in their future professions.

1.1 Collaboration Between Vocational Schools and Industry in Competency Development

Competency criteria are influenced by industrial growth and must correspond with the competencies provided in vocational institutions. For vocational schools and the industry to effectively cultivate and develop skills, they must achieve three essential objectives: process, strategic management, and roles and responsibilities [5]. The collaboration between Vocational High School and Industry-Business Sector has a common goal, which is to improve quality in accordance with market needs, synchronize curricula and enhance school programs, and boost the integration and employment of graduates into the job market. The quality of Vocational High School graduates is enhanced through the partnership between Vocational High School and Industry-Business Sector regarding input, process, output, and outcome [6]. Furthermore, continual feedback from business partners ensures that the skills taught are relevant and practical, preparing students for the dynamic workforce [19], [21].

1.2 Integration of PLC, VSD, and HMI in Electric Motor Control

Electric motor control is an essential aspect of electrical installations, particularly in vocational schools preparing learners for the workforce. Different technologies, including Programmable Logic Controller (PLC), Variable Speed Drive (VSD), and Human-Machine Interface (HMI), have been utilized to improve the efficiency and effectiveness of electric motor control. In summary, industrial automation boosts efficiency, conserves time, and enhances the adaptability of various businesses. It improves system accuracy, provides enhanced protection for equipment safety, which is why it is gradually becoming essential. Therefore, automation acts as a significant driver of economic productivity and is likely to become more widespread in Indian industries [7]. To upgrade an outdated steel plate cutter, a remote monitoring and automation control system utilizing PLCs and HMIs was developed. The HMI allows the operator to input the panel length, and the quantity needed. Coupled with remote monitoring through VPN technology, this provides an additional advantage. Consequently, the system has amplified production capacity, ensured better safety, reduced operating labor costs, and streamlined processes [8]. After prolonged service, some outdated machines in factories were operated manually, which hampered productivity and jeopardized operator safety. Replacing these obsolete machines is, in fact, a more economically viable solution. This paper presents a steel plate cutting machine fitted with automatic control system, which significantly enhances productivity, safety, and reduces labor while diminishing labor input and production expenses [9]. The study of interface design, development, and evaluation between humans and machines is referred to as human–machine interaction, or HMI [10]. The combination of these three technologies will enable the creation of an electric motor control system that is more efficient and better aligned with the educational requirements of Indonesian technical and vocational schools.

The creation of specialized training resources, such as the Automated Sorting Conveyor System, exemplifies the wider movement towards enhancing vocational education through technological means. The Automated Sorting Conveyor System aims to elevate hands-on learning in motor control systems, which is an essential aspect of various technical education curricula. Research indicates that by employing adaptive learning platforms, gamified education, virtual labs, online collaboration tools, and emerging technologies like VR and AR, educators can construct engaging, customized, and supportive educational environments that enable students to excel in their STEM (Science, Technology, Engineering, and Mathematics) disciplines [12]. Additionally, this study employs the ADDIE model to develop well-organized instructional materials, particularly digital educational games for Arabic language learning, increasing students' achievements and motivation while providing a foundation for future researchers in e-learning course design [13]. The structural framework of the ADDIE model—which includes analysis, design, development, implementation, and evaluation—guarantees that educational initiatives are meticulously planned and executed systematically. Investigations in vocational education have demonstrated that even in workplace settings, AI has progressed, incorporating generative AI tools into classrooms and facilitating student learning. Responsible and constructive application can also gear students to succeed in AI-driven jobs in after-school settings. Educators can leverage generative AI models such as ChatGPT to enhance their students' educational experiences [14]. The analysis results indicate that conventional educational settings have greater capacity to address higher needs, whereas innovative—or digital—educational settings emphasize fulfilling students' basic needs more. Consequently, there is presently a necessity to enhance the quality of digital technology in education [15].

In the context of vocational education in Indonesia, the demand for effective teaching instruments is quite significant. Given that many workers emerge from vocational schools, it is essential for students to be equipped for the industry's requirements. The research conducted has revealed various challenges and issues within Indonesian education, such as uneven educational outcomes, inadequate facilities and infrastructure, poor quality and conduct of teachers, students' moral behavior, and tolerance regarding racial intolerance [16]. The caliber of Indonesian graduates from the Technical Vocational Education and Training (TVET) program is substandard and falls short of industry benchmarks and required competencies. This occurs because the skills or talents demanded by this sector differ from those readily accessible. Thus, developing nations require a pragmatic VET framework and a dual system. Recently, Indonesia has sought to investigate the Dual Vocational Education and Training system in greater detail [17]. The Automated Sorting Conveyor System signifies progress in tackling these challenges by providing an extensive, technology-driven solution that caters to the requirements of students and businesses. Overall, the literature underlines the significance of integrating innovative technologies into vocational education to enhance learning results and better equip students for the job market. The advancement and execution of instruments such as the Automated Sorting Conveyor System, inspired by established instructional design models, present an excellent opportunity for the advancement of vocational education in Indonesia and beyond.

2 Method

2.1 Research Design

This study employs the research and development approach, which is commonly utilized in scholarly research to develop, evaluate, and enhance new tools and materials. This study adheres to the ADDIE model [11], a well-known instructional design framework that comprises five stages: analysis, design, development, implementation, and evaluation, as shown in Figure 1. The ADDIE model offers a methodical strategy for the creation of the Automated Sorting Conveyor System as an educational tool in vocational training.

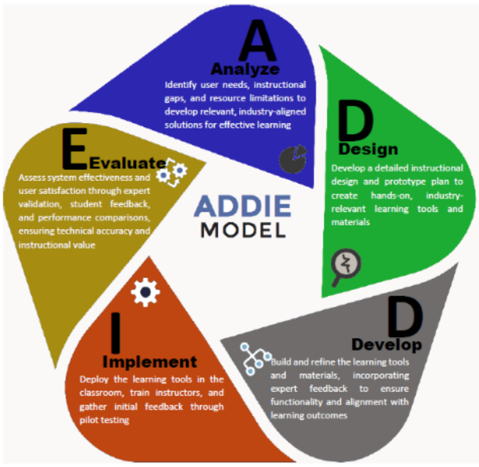

Figure 1. Model ADDIE

The individuals involved in this study consist of two main categories, namely experts and students. The expert category consists of two subject matter experts and two media experts who assess the instructional materials based on accuracy, purpose, and instructional design. In contrast, the student category was made up of 33 grade XI students from State Vocational High School 1 South Kuta who participated in the trial during the implementation phase to evaluate the effectiveness and usefulness of the created learning media. A range of research instruments were employed in this study. Interviews were conducted to collect qualitative insights, especially from experts and educators, regarding the instructional materials. Questionnaires using the Likert scale were distributed to assess media, content, and user experience, with an emphasis on relevance, usability, and their effect on learning results. Furthermore, pre-tests and post-tests were given to students to evaluate their knowledge before and after using the developed learning media. The information gathered was analyzed using both qualitative and quantitative techniques. Descriptive statistics were utilized to summarize the answers from questionnaires and participant input. A t-test was performed to identify significant differences between students’ pre-test and post-test scores. In addition, the gain score was calculated to assess the effectiveness of the learning media in improving students' comprehension of the electric motor control system. This comprehensive methodology ensures a complete assessment of the impacts and practical applications of the learning media.

The study utilized a quantitative method that included pretest-posttest assessments, with statistical evaluations performed using software for analysis to guarantee strong validation of results. The selection of Levene’s Test for evaluating homogeneity was made due to its appropriateness for small sample sizes. This method ensured that the data examination reliably represented the dependability and uniformity of the results, offering a firm basis for understanding the effectiveness of the Automated Sorting Conveyor System.

2.2 Analyze Phase

In the analysis phase, the requirements of the intended users - professional students studying motion control systems - were determined. This involves performing a needs assessment to pinpoint the primary obstacles students encounter while learning motion control systems, particularly due to restricted access to practical equipment. Feedback was also collected from faculty and industry specialists to confirm the relevance and appropriateness of the Automated Sorting Conveyor System to contemporary industry standards and training needs.

In the Analyze phase, preliminary assessments pinpointed a deficiency in instructional resources and engagement for both educators and learners in the Electrical Motor Installation subject at State Vocational High School 1 South Kuta. Educators have fundamental abilities but require training in advanced, industry-relevant technologies, whereas students demonstrate minimal engagement owing to the theoretical nature of lessons, exacerbated by scarce practical resources. The current infrastructure and tools (e. g., basic PLC, pneumatic controls) require enhancement to satisfy industry benchmarks. The suggested solution is an economical, industry-oriented automatic sorting tool employing PLC, HMI, and SCADA, aimed at improving hands-on learning and aligning with the student-centered approach of the 2013 curriculum.

Data analysis was performed utilizing software for analysis to confirm the findings through strong statistical techniques. The Levene's Test was used to evaluate homogeneity, as it is especially appropriate for small sample sizes. This guaranteed that the following analyses, including comparisons between pretest and posttest scores, were statistically dependable.

2.3 Design Phase

The design phase concentrated on developing comprehensive designs for the Automated Sorting Conveyor System and associated training resources, including manuals and worksheets. This strategy was executed with the insights gained from the analysis phase with the objective of addressing the specified requirements. The Automated Sorting Conveyor System model is intended to replicate actual motorcycle control systems in a practical environment that enables students to practice and refine their skills safely.

A prototype for automatic sorting is proposed as a teaching aid, organized to categorize metal and non-metal objects using sensors. The initial sensor, an inductive proximity sensor, identifies metal, causing Electric Linear Actuator (ELA) 1 to separate the item. The subsequent sensor, a fiber optic sensor, recognizes colors, activating ELA 2 for additional sorting. The wiring plan in Table 1 permits students to perform secure electrical setups, while labeled wires and a manual guide facilitate the procedure. The OMRON PLC programming utilizes SYSWIN software for ladder diagram logic, with HMI developed through NB-Designer for visualizing and managing input and output signals. Furthermore, a manual book and job sheets assist students in programming assignments, such as sorting metal objects using proximity sensors and dual sorting utilizing both proximity and fiber-optic sensors. The layout of the automated goods sorting conveyor system is illustrated in the Figure 2. Meanwhile, the schematic representation of the automated sorting conveyor system can be observed in the Figure 3. The setup of the PLC CX-Supervisor, encompassing its input and output signals, is essential for enhancing the system's performance, as outlined in Table 2.

Table 1. Input components

Component Name	Component Code	Description
Emergency Button	EMG	Emergency button
Proximity Inductive Sensor	S1	Object Reading Sensor Metal
Fiber Optic Sensor	S2	Item Reader Sensor Based on Color
Power Supply	PSU	Power Source 24 and 12 VDC
Electric Linier Actuator 1	ELA1	S1 Actuator
Electric Linier Actuator 2	ELA2	S2 Actuator

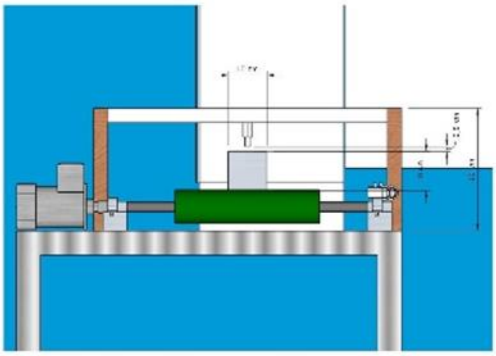

Figure 2. The automated sorting conveyor system design

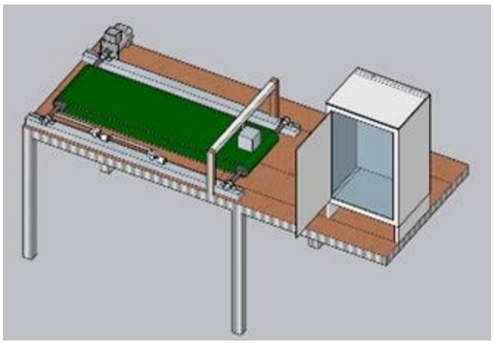

Figure 3. Layout diagram the automated sorting conveyor system

Table 2. Input and output alocationlist

Signal Symbol		Address	Description
Machine	On	W0.00	Push Button to activate the system
	Off	W0.01	Push Button to deactivate the system
ELA1		100.01	ELA 1 Indicator
ELA2		100.02	ELA 2 Indicator
CONV		0.02	Motor CONV Indicator

2.4 Development Phase

In the development stage, the Automated Sorting Conveyor System was established based on the design specifications. This section encompasses the creation of a physical model and related training resources. Testing and refinement were conducted to guarantee that the Automated Sorting Conveyor System functioned as designed and achieved the learning objectives. Contributions from subject matter experts and instructional designers were integrated to enhance the efficacy and usability of the system. Figure 4 shows the installation process of the Conveyor System. The Automated Sorting Conveyor System, aimed at enhancing the efficiency of automatic sorting processes, integrates cutting-edge hardware and software components to deliver optimal performance. As shown in Figure 5, the Automated Sorting Conveyor System includes essential components such as a conveyor, sensors, and a PLC control panel, all of which are seamlessly interconnected to facilitate automated sorting.

Figure 4. Conveyor installation

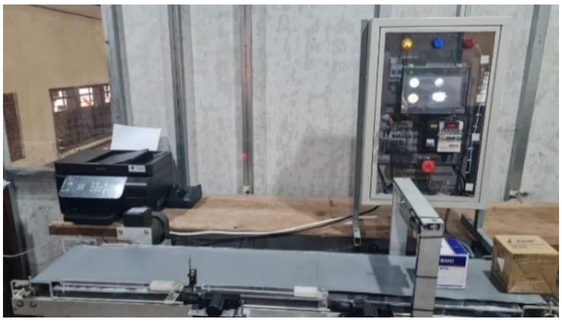

Figure 5. The automated sorting conveyor system

2.5 Implementation Phase

In the execution stage, the Automated Sorting Conveyor System was integrated into the educational setting at State Vocational High School 1 South Kuta. In this research, 33 students from the 11th grade took part in training sessions that utilized the Automated Sorting Conveyor System. Sufficient training was given to the teachers to enable them to use the system efficiently in their instruction. The execution stage also consists of a trial run to collect preliminary feedback from both students and teachers. Figure 6 shows the Implementation in the learning process.

Figure 6. Implementation in the learning process

2.6 Evaluation Phase

The evaluation phase assessed the usefulness and effectiveness of the Automated Sorting Conveyor System as an educational resource. Evaluations were carried out through both summative and formative assessments, which included expert validation, student feedback, and performance metrics. Essentially, the Automated Sorting Conveyor System was appraised based on its performance, user-friendliness, and educational impact. Information was gathered from surveys, observations, and assessments of student performance prior to and following the use of the system. Figure 7 shows data collection from students in classes IML1 and IML2.

Figure 7. Data collection from students in classes IML1 and IML2

Data collection, two primary groups of participants took part in the evaluation process, subject matter experts (two subject experts and two media specialists) and students (33 students from State Vocational High School 1 South Kuta). Expert validation concentrated on assessing the technical accuracy, functionality, and instructional design of the Automated Sorting Conveyor System, while student feedback offered perspectives on usability and its effects on learning outcomes. Data Analysis, quantitative data derived from assessments and expert evaluations were examined using descriptive statistics to ascertain the effectiveness and efficiency of the Automated Sorting Conveyor System. The proportion of correct answers, average scores, and student feedback were computed to assess the system's performance. Furthermore, qualitative data derived from open-ended survey responses and observations were utilized to pinpoint areas needing enhancement and refinement of the Automated Sorting Conveyor System. Measuring effectiveness: The effectiveness of the Automated Sorting Conveyor System was gauged by contrasting the pre-test and post-test scores of the students’ Performance scores were calculated to assess students' improved understanding of motor control systems after using the Automated Sorting Conveyor System. The evaluation also included assessments of user satisfaction and feedback on the effectiveness and relevance of the system to real-world applications. Ethical considerations: During the research, ethical guidelines were strictly followed. Participation in the study was voluntary, and all participants gave informed consent. The anonymity and confidentiality of the participants was maintained, and the data was carefully guarded and used for research purposes only. Figure 8 shows the Evaluation after students received training on the automatic sorting conveyor system.

Figure 8. Evaluation after students receive the automated sorting conveyor system training

3 Results and Discussion

3.1 Development of the Automated Sorting Conveyor System

The primary aim of this research is to create a basic trainer in the form of the Automated Sorting Conveyor System that serves as an educational program in technical and Vocational High School. The Automated Sorting Conveyor System has been successfully designed with features that emulate machine control systems. This system consists of a conveyor mechanism, sensors, and control units that facilitate the automatic sorting of items. In addition to the equipment, a variety of educational materials, such as textbooks and charts, have been created to assist students in their learning journey.

3.2 Performance Evaluation of the Automated Sorting Conveyor System

The second aim was to assess the performance of the Automated Sorting Conveyor System as a training instrument for functional training in motion control systems. The evaluation of the Automated Sorting Conveyor System performance was based on both component assessments and functional evaluations. The findings indicated that all components employed in the Automated Sorting Conveyor System operated exceptionally well, achieving an average score of 100% in 19 evaluation instances. Similarly, the performance assessment, which measured the Automated Sorting Conveyor System ability to fulfill its intended functions, obtained a performance rating of 100% across 14 assessment criteria. These findings demonstrate that the Automated Sorting Conveyor System is very dependable and effective in comparison to global engineering practices. Figure 9 shows the results of media and material validation by experts, while Figure 10 shows a comparison of student responses: experimental vs. control.

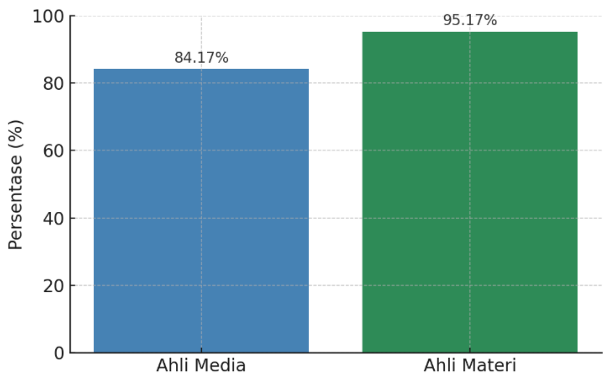

Figure 9. Results of media and material validation by experts

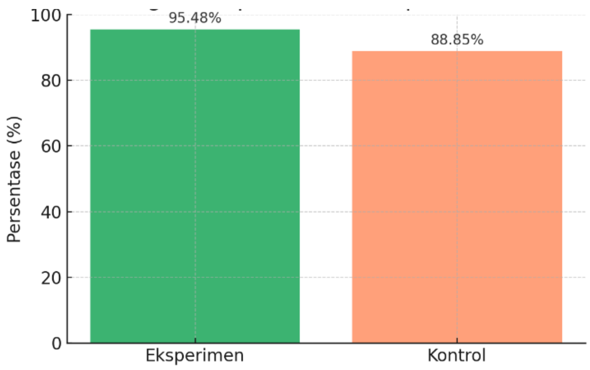

Figure 10. Comparison of student responses between experiment vs control

3.3 Feasibility of the Automated Sorting Conveyor System as a Learning Medium

The third project concentrated on evaluating the effectiveness of the Automated Sorting Conveyor System as a vocational education program in vocational institutions. Its applicability was examined by experts in media and materials. Table 3 shows the results of media evaluation, which encompassed 24 criteria, recorded an average score of 84.17%, categorizing the Automated Sorting Conveyor System as "very feasible". The evaluation of the materials, which included 23 criteria, yielded a higher score of 95.17% and was classified as "highly feasible". Figure 11 shows the Evaluation after students received training on the automatic sorting conveyor system. These outcomes affirm that the Automated Sorting Conveyor System is an effective and practical resource for instruction in motor control systems in Vocational High School.

Table 3. Graph of respondent's evaluation vs assessment content

Category	Media Expert (%)		Material Expert (%)		Respondent Classes (%)		Average
	E1	*E2*	*E3*	*E4*	*IML1*	*IML2*	
Content and Objectives	97.22	97.22	79.17	83.33	95.22	90.23	90.40
Learning	92.86	96.43	85.71	85.71	95.38	90.18	91.05
Technical	96.88	87.50	83.33	85.42	95.74	87.50	89.40

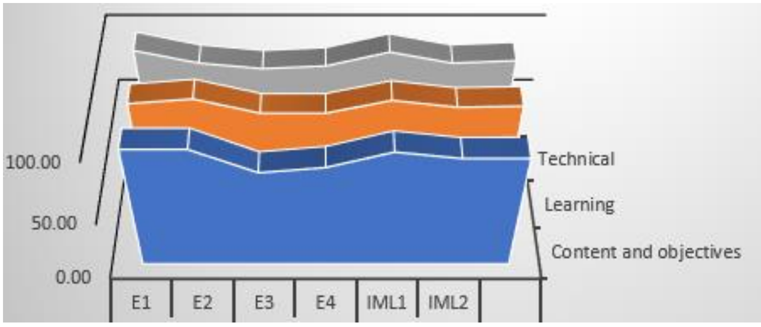

Figure 11. Evaluation after students receive the automated sorting conveyor system training

3.4 User Response to the Automated Sorting Conveyor System

The fourth aim is to assess user reaction to the Automated Sorting Conveyor System. This was accomplished through feedback gathered from students in the experimental and control groups. The evaluation of the Automated Sorting Conveyor System-based learning materials included a variety of statistical assessments, such as homogeneity, normality, and T-tests, to establish its efficacy in enhancing learning outcomes. The homogeneity evaluation, conducted using Levene's test using software analysis, showed that the theoretical learning outcomes achieved a significance value of 0.083, whereas the practical learning outcomes revealed 0.301. Both values indicated that the data were homogeneous. The normality evaluation, utilizing the Kolmogorov-Smirnov test, confirmed that the residual values of the theoretical and practical learning outcomes for both classes L1 and L2 displayed a normal distribution, with significance values of 0.200 across all assessments. In addition, the independent sample T-test indicated a significant difference in learning outcomes between pretest and posttest scores. The theoretical learning outcomes yielded a significance value (2-tailed) of 0.000, and the same value was observed for practical learning outcomes, indicating a statistically significant enhancement in both cases. These findings strengthen the validity and effectiveness of the Automated Sorting Conveyor System-based learning materials in facilitating notable improvements in both theoretical and practical learning achievements [22], [23], [27].

The test group that utilized the Automated Sorting Conveyor System provided the students with an average score of 95.48%, indicating that the students deemed this system highly beneficial and effective for learning. The control group, which did not implement the Automated Sorting Conveyor System, obtained an average score of 88.85%. The combined score for both groups is 92.16%, categorizing the Automated Sorting Conveyor System as "best" based on user feedback. This favorable response suggests that students perceive the Automated Sorting Conveyor System as appealing and advantageous for their educational experience. Table 4 and Figure 12 show how students' evaluation scores changed across five learning levels (P1–P5) after the Automated Sorting Conveyor System was introduced. The graph shows a consistent rise from an average grade of 61 in phase P1 to 75 in phase P5. The rising trend shows that as students interacted with the Automated Sorting Conveyor System-based learning materials, their understanding and skill grew. The steady expansion also shows how effectively the Automated Sorting Conveyor System interactive and procedural elements help to boost pupils' cognitive and practical learning outcomes. The results provide evidence for the function of the system in advancing long-term learning gains.

Table 4. Average progress of student assessments

Assessment progress	**P1**	**P2**	**P3**	**P4**	**P5**
Average	61	68	70	73	75

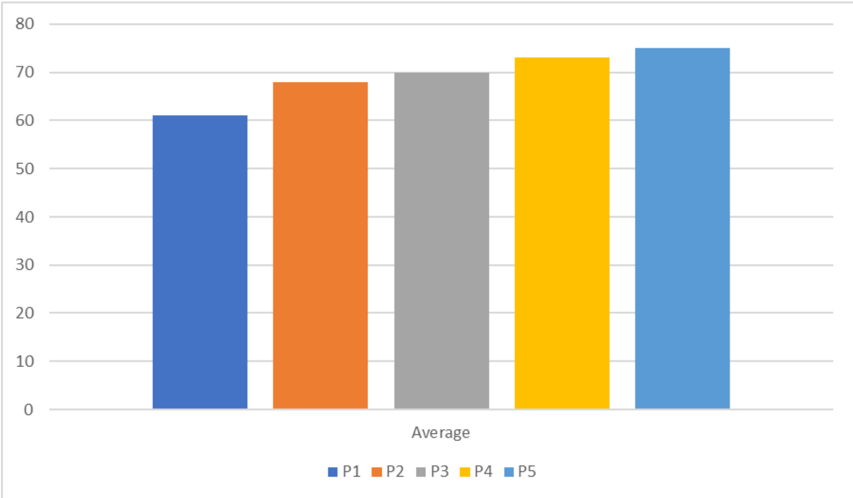

Figure 12. Student progress assessment chart

3.5 Effectiveness of the Automated Sorting Conveyor System in Enhancing Learning Outcomes

The main objective is to evaluate the effectiveness of the Automated Sorting Conveyor Systemin increasing student learning outcomes. Effectiveness was measured through pre- and post-test assessments, and performance scores were calculated for theoretical and practical learning.

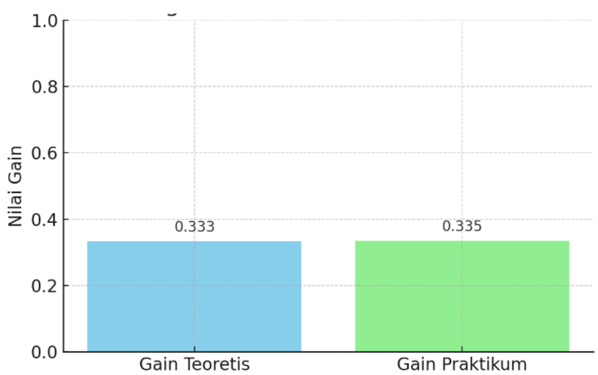

Figure 13. Comparison of gain score theories and practicum

Figure 13 shows the comparison of gain score theory and practice. The score for theoretical learning is 0.333, and the score for practical learning is 0.335, indicating a significant improvement in students' understanding and skills after using the Automated Sorting Conveyor System. This shows that the Automated Sorting Conveyor System is not just a learning tool, but an effective way to improve students' proficiency in motion control systems [25], [27]. The criteria for the Gain Index can be seen in the Table 5 [24], [26].

Table 5. The criteria for the gain index

Indeks Gain	Description
$g \geq 0,7$	High
$0,3 \leq g < 0,7$	Medium
$g < 0,3$	Low

The effectiveness of the Automated Sorting Conveyor System in improving learning outcomes was thoroughly assessed using various analytical methods, including Trainer Kit Performance Analysis, Media Eligibility Analysis, Material Feasibility Analysis, User Test Analysis, and Media Effectiveness Test. The results are presented in Figure 14, which clearly shows the Automated Sorting Conveyor System consistent performance across all evaluated parameters. These findings highlight the system's reliability and its practical application as a comprehensive learning tool.

1. Trainer Kit Performance Analysis (TPA)
2. Media Eligibility Analysis (MEA)
3. Material Feasibility Analysis (MFA)
4. User Test Analysis (UTA)
5. Media Effectiveness Test (MET)

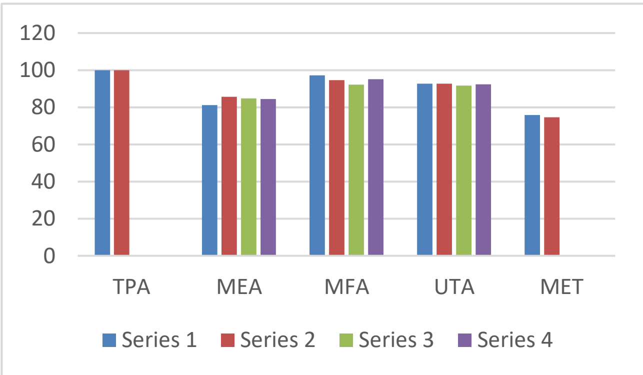

Figure 14. Evaluation parameters of the automated sorting conveyor system

4 Discussion

The results of this study provide strong evidence for the effectiveness and feasibility of the Automated Sorting Conveyor System as a learning tool in vocational education. The High-Performance ratings and positive feedback from both experts and students suggest that the Automated Sorting Conveyor System can significantly enhance practical learning experiences in Vocational High School. The ability of the system to simulate real-world conditions allows students to practice and develop their skills in a safe and controlled environment, which is particularly important in technical fields like motor control systems. Furthermore, this aligns not only with the educational theory of experiential learning, which emphasizes the importance of engaging students in active, practical experiences [28], [29].

It also aligns with Ausubel's theory of meaningful learning within the cognitive learning theory framework [39]. Ausubel emphasized that meaningful learning occurs when students can relate new information to their existing cognitive structures [39]. In the context of this study, the Automated Sorting Conveyor System media enables students to build meaningful connections between theoretical knowledge and practical experience gained during procedural tasks such as PLC programming and HMI operations. The Automated Sorting Conveyor System media provides clear guidance for students to follow procedural content, which is essential for developing technical skills in electric motor control. The Automated Sorting Conveyor System media enables the visual and interactive display of procedural information through the integration of PLC, sensors, and HMI, which demonstrate automated workflows to help students grasp the sequence of processes. Supported by procedural modules and job sheets, this approach facilitates the step-by-step execution of complex tasks, simplifies learning, and enhances students' skills in handling electric motor control systems. This didactic transposition—transforming sophisticated industrial concepts like PLC logic, HMI configuration, and sensor integration into more digestible learning materials—ensures that students at the vocational level can comprehend and master the skills required. Additionally, by structuring content in a way that promotes meaningful connections, the Automated Sorting Conveyor System not only improves skill proficiency but also nurtures cognitive development [37], [38]. It bridges the gap between theoretical and practical learning, helping students internalize the procedural steps and apply them confidently in real-world scenarios.

Therefore, the Automated Sorting Conveyor System is an important addition to vocational education in Indonesia. It is a practical and effective solution to improve the skills and knowledge of students in car control systems, thus contributing to the development of skilled and safe workers. Future research could explore improvements to the system and its application to other technological aspects of vocational education. This study successfully developed and evaluated the Automated Sorting Conveyor System as a learning tool for motor control systems in Vocational High School. The research findings indicate that the Automated Sorting Conveyor System is highly effective in enhancing students' practical skills and knowledge, as evidenced by significant improvements in learning outcomes. The system's components and functionalities performed excellently, receiving high ratings from both experts and users, and proving its reliability in simulating real-world motor control operations. This aligns with prior studies that highlight the importance of integrating innovative and technology-based learning tools to improve vocational education outcomes [30], [31]. The feasibility assessments from media and material experts further confirmed that the Automated Sorting Conveyor System is a suitable and practical educational tool, with strong positive responses from students indicating its effectiveness and engagement in the learning process. Comparable results were likewise documented by [32] and [33] who discovered that interactive and simulated learning resources greatly improve student involvement and skill development in technical education. The system's ability to provide a safe and controlled environment for practical learning makes it a valuable addition to vocational education, helping to better prepare students for the technical demands of the workforce. This supports previous research by [34], [35], [36] who noted that controlled environments enhance both the safety and effectiveness of hands-on learning in technical disciplines.

5 Conclusion

The Automated Sorting Conveyor System is a powerful solution to improve the quality of vocational training in Indonesia, especially in engineering management systems. By incorporating these new learning tools into the curriculum, technical and vocational schools can improve students' skills and ultimately provide access to a skilled and knowledgeable workforce. Future research may focus on expanding the applicability of the Automated Sorting Conveyor System to other technical disciplines and further developing its features to increase its educational impact. It is advised that vocational institutions give instructors thorough training to optimize the Automated Sorting Conveyor System potential for wider adoption. Furthermore, the Automated Sorting Conveyor System can guarantee conformity with national competency criteria by being incorporated into a standardized vocational program.

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