



Examining the Effectiveness of Augmented Reality-Based Practical Models in Electropneumatic Education in Vocational High Schools

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ABSTRAK

Masalah yang dihadapi dalam pembelajaran elektro pneumatik di SMK adalah terbatasnya media pembelajaran yang dapat memfasilitasi praktik yang efektif dan menarik. Penelitian ini bertujuan untuk menguji keefektifan penerapan model praktikum berbasis augmented reality dengan melihat dampaknya terhadap motivasi belajar siswa, hasil belajar siswa, dan kepuasan siswa. Penelitian ini menggunakan metode kuantitatif dengan pengumpulan data melalui tes, checklist, dan kuesioner. Sebelum dan setelah penerapan model, data dikumpulkan melalui pre-test, post-test, lembar checklist motivasi belajar, dan kuesioner kepuasan pengguna. Hasil penelitian menunjukkan bahwa penerapan model praktikum berbasis augmented reality efektif meningkatkan motivasi belajar siswa yang semula berada di kategori sedang (58,5) menjadi tinggi (76,0). Selain itu, hasil belajar siswa mengalami peningkatan signifikan, dengan nilai rata-rata pre-test sebesar 54,2 dan post-test 77,6. Untuk mengukur peningkatan pemahaman siswa, digunakan N-Gain Score yang menunjukkan kenaikan pemahaman sebesar 31,48%, yang tergolong dalam kategori sedang. Kepuasan siswa terhadap aplikasi ini juga dinilai positif, meskipun masih ada ruang untuk perbaikan. Analisis deskriptif menunjukkan bahwa penerapan model ini secara signifikan meningkatkan pemahaman siswa terhadap materi elektro pneumatik dan memberikan dampak positif terhadap kepuasan penggunaan. Kesimpulannya, model praktikum berbasis augmented reality terbukti efektif dalam meningkatkan motivasi belajar, hasil belajar, dan kepuasan siswa.

ABSTRAK

The challenges in teaching electropneumatics in vocational high schools (SMK) lie in the limited availability of learning media that can facilitate effective and engaging practical activities. This study aims to examine the effectiveness of implementing an augmented reality-based practical model by assessing its impact on: student learning motivation, student learning outcomes, and student satisfaction. The research employed a quantitative method with data collection through tests, checklists, and questionnaires. Data were collected before and after the implementation of the model using pre-tests, post-tests, motivation checklists, and user satisfaction questionnaires. The results indicate that the application of the augmented reality-based practical model effectively increased student learning motivation from the moderate category (58.5) to the high category (76.0). Additionally, students' learning outcomes showed significant improvement, with average pre-test scores of 54.2 and post-test scores of 77.6. To measure the improvement in student understanding, the N-Gain Score was used, showing a 31.48% increase in understanding, categorized as moderate. Student satisfaction with the application was also rated positively, though there is room for improvement. Descriptive analysis demonstrated that this model significantly enhanced students' understanding of electropneumatic material and had a positive impact on user satisfaction. In conclusion, the augmented reality-based practical model has been proven effective in improving student motivation, learning outcomes, and satisfaction.

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1. INTRODUCTION

Various related parties always improve the quality of learning at the secondary level of vocational pathways (Vocational High School/SMK). The availability of adequate facilities and the formation of a strong vocational identity in students, including teacher support and the industrial world, are important aspects of the continued involvement of SMK students in learning (Keijzer et al., 2022; Suharno et al., 2020). It is well known that learning in SMK has characteristics that distinguish it from secondary schools in general. The characteristic in question is that learning in SMK focuses on technical and practical skills and cultured human competencies in various dimensions of life to directly enter the world of work (Grolleau et al., 2022; Inderanata & Sukardi, 2023; Mulianti et al., 2023). The learning process significantly impacts the acquisition of competencies of SMK graduates (Cholik et al., 2021; Hasyim et al., 2021). Technical and practical skills of SMK students are obtained through practical activities in each subject taken in addition to the internship program in the world of work later. The assessment and priority of vocational students toward practical knowledge is a form of active alignment with the world of work and a rational response to labor market requirements (Ferm, 2021; Juliantari et al., 2017). Therefore, practical activities must be adequately facilitated. Facilitation provides various practical learning activities, including valid learning content and media. One of the subjects offered at SMK, especially in the Department of Electronics, is Electro-pneumatic lessons. Limited learning media facilities, especially in vocational schools in Jakarta and Bekasi, are considered to have not met the needs of students to carry out practices at school, and limited facilities and equipment cause learning not to follow practical learning standards in SMK (Suartini, 2019). The impact of limited learning media facilities is increasingly evident during the COVID-19 pandemic. During the COVID-19 pandemic, there were various challenges in learning vocational students through practice caused by the lack of direct physical interaction with practical tools available at school (Jaya et al., 2020).

Various efforts were made by relevant parties to explore various relevant alternative solutions during the developing situation. Exploring these alternative solutions is important not only to deal with practical learning barriers in various situations post-majeur such as the Covid-19 pandemic, but also for the potential development of online learning in SMK, which causes SMK students to have limited access to carry out physical learning practices directly at school. Previous research findings confirmed that online learning in vocational schools emphasizes using student-centred learning pedagogy (Cox & Prestridge, 2020), so the solution in question leads to the independent use of student learning facilities. The solution to using learning facilities for students independently can be by utilizing media in learning. Previous studies have shown that the use of appropriate media, such as e-learning media, audiovisual media, and also virtual labs, affects student learning outcomes and motivation (Bima et al., 2021; Hoerunnisa et al., 2019; Indrawati et al., 2022).

In addition to media facilitation, as already stated, one of the potential forms of media to facilitate student practicum is media-augmented reality. It gives students greater control over managing their learning and provides opportunities for collaborative learning (Lester & Hofmann, 2020). Studies Augmented Reality the preceding indicates increased learning outcomes using Augmented Reality (Amores-Valencia et al., 2023; Sirakaya & Cakmak, 2018). Besides improving learning outcomes, Augmented Reality can also improve self-efficacy and reduce students' cognitive load (Lee & Hsu, 2021). The existence of media-augmented reality is believed will positively impact students by stimulating competencies from within students along with the development of science. Given how important practicum activities are in the learning process, valid Augmented Reality media has been designed and developed to facilitate electro-pneumatic practice activities for vocational students in 2022 (Sukardjo et al., 2023) so that students are expected to be motivated and obtain the expected learning outcomes. However, the effectiveness of using augmented reality media in electro-pneumatic practicum on student learning outcomes and motivation is still untested. Therefore, this study tested the effectiveness of applying the Augmented Reality-based electro-pneumatic practicum model in Vocational High Schools to increase learning motivation, learning outcomes, and user satisfaction.

2. METHOD

Effectiveness of application Electro Pneumatic-Based Practicum Model Augmented Reality on Vocational High School tested with a single subject plan (single subject design). Considering the advantages of single-subject design, this design has the potential to assist researchers and practitioners in better understanding which interventions work and under what circumstances (Baker et al., 2018). The target of the study was 70 students in 2 vocational schools, namely 35 students of SMK Negeri 69 Jakarta and 35 students of SMK Negeri 5 Bekasi. The research procedures that have been taken are as follows. The first stage is the preparation stage, including preparing research instruments, orientation for model teachers in both vocational schools, preparation of students as participants, and installation of Augmented Reality media for electro-pneumatic practice activities for vocational students. The second stage is the

implementation stage: giving pretests, filling out motivational checklist sheets, implementing learning by applying Augmented Reality-based electro-pneumatic practicum, giving post-tests, filling out motivational checklist sheets, and giving questionnaires. The third stage is the reporting stage, including tabulation of research data, analysis of research data, preparation of results, and discussion.

Several instruments can be used to test the effectiveness of the application of Augmented Reality in learning, such as checklists, tests, interviews, and other instruments (Guntur & Setyaningrum, 2021; Khan et al., 2023). The research instruments used are sheet checklists to collect student motivation data, tests to collect student comprehension learning outcomes, and questionnaires to collect student satisfaction data. Researchers provide pretests and sheets of checklist motivation to learn before implementation and provide post-tests, sheets of checklist learning motivation, and user satisfaction questionnaires after implementation. Sheet checklist used to measure learning motivation consists of 23 statement items, the comprehension test for electropneumatic material to measure student learning outcomes consists of 15 multiple-choice questions, and the questionnaire sheet used to measure usage satisfaction consists of 10 questions. The collected data is then analyzed by using quantitative descriptive analysis techniques. The classification of motivation categories and overall student learning outcomes is presented in Table 1 below.

Table 1. Student Motivation and Learning Outcomes Categories

Interval	Score (X)	Category
$\bar{X}+1.5SDi < X \leq \bar{X}+3SDi$	$74.75 < X \leq 92$	Very High
$\bar{X}+0.5SDi < X \leq \bar{X}+1.5SDi$	$63.25 < X \leq 74.75$	High
$\bar{X}-0.5SDi < X \leq \bar{X}+0.5SDi$	$51.75 < X \leq 63.25$	Moderate
$\bar{X}-1.5SDi < X \leq \bar{X}-0.5SDi$	$40.25 < X \leq 51.75$	Low
$\bar{X}-3SDi \leq X \leq \bar{X}-1.5SDi$	$23 \leq X \leq 40.25$	Very Low

3. RESULT AND DISCUSSION

Results

Student learning motivation can be known by how students fill out learning motivation questionnaires before and after applying the Augmented Reality-based practicum model. Based on data recapping from 23 learning motivation questionnaire statements of SMK Negeri 69 Jakarta students and SMK Negeri 5 Bekasi City, student learning motivation data were obtained as presented in Tables 2 and Table 3.

Table 2 Description of Student Motivation Questionnaire Results of SMK Negeri 69 Jakarta

	Initial conditions	Post-condition
Average	77.8	83.04
Variants	116.23	89.78
Standard deviation	10.58	9.33
The score is ideal	100	100
Score maximum	93.3	93.3
Score minimum	46.7	53.3
Stretch	46.7	40

Based on the results of descriptive statistical analysis as presented in Table 2 above, the measurement results show that the average result of measuring the learning motivation of SMK Negeri 69 Jakarta students before applying the Augmented Reality-based practicum model is 77.8. Based on the category of student learning motivation contained in Table 1, the initial condition of student learning motivation is in the Very High category. After learning with the application of the Augmented Reality-based practicum model, it is 83.04 with Very High learning motivation category.

Table 3. Description of Student Motivation Questionnaire Results of SMK Negeri 5 Bekasi

	Initial conditions	Post-condition
Average	58.5	76.0
Variants	217.218	183.529
Standard deviation	14.526	13.352
The score is ideal	100	100.0

	Initial conditions	Post-condition
Score maximum	86.7	86.7
Score minimum	33.3	26.7
Stretch	53.3	60.0

Based on the results of descriptive statistical analysis as presented in Table 3 above, the measurement results show that the average measurement of learning motivation of SMK Negeri 5 Kota students before applying the Augmented Reality-based practicum model is 58.5. Based on the category of student learning motivation contained in Table 1, the initial condition of student learning motivation is in the Moderate category. Meanwhile, after applying the Augmented Reality-based practicum model, it is 76.0 with High learning motivation category. The results of learning electro pneumatics students in both schools were obtained based on the pretest and post-test. The results of learning electro-pneumatic at SMKN 69 Jakarta and at SMKN 5 Bekasi are presented in Tables 4 and Table 5.

Table 4 Average Learning Outcomes of Students of SMKN 69 Jakarta

	Pretest (Average Score)	Post-Test (Average Score)
Number of Students	35	35
Average Pretest	75.2	84.1

Based on the results of measuring pretest and post-test knowledge scores in the application of Augmented Reality-based electro-pneumatic practicum models at SMKN 69 Jakarta, it can be seen that there is a significant increase in student understanding. Before joining this program, students' pretest average score was around 75.2. After applying the Augmented Reality-based electro-pneumatic practicum model, the average student's post-test score increased to around 84.1.

Table 5. Average Learning Outcomes of SMKN 5 Bekasi Students

	Pretest (Average Score)	Post-Test (Average Score)
Number of Students	35	35
Average Pretest	54.2	77.6

Data from pretest and Post-Test measurements of student knowledge at SMKN 5 Bekasi in applying Augmented Reality-based practicum models, as presented in Table 5, show a significant increase in students' understanding of the material taught. Before implementing this Augmented Reality-based practicum model, the average pretest score of students was only around 54.2. However, after the program, the average post-test score markedly increased to around 77.6. Further, it is important to measure the impact of an intervention's effectiveness using methods that can provide a comprehensive understanding. One way to do this is to calculate the N-Gain Score, which allows us to measure students' increased understanding in the context of pretest and post-test scores. This N-Gain Score can provide a more in-depth view of increasing student understanding and the application of Augmented Reality-based practicum models.

This study focuses on increasing students' understanding of pneumatic material using Augmented Reality-based practicum models at SMKN 5 Bekasi and SMKN 69 Jakarta. Through the Gain Score formula, the application of augmented reality-based practicum models has positively impacted students' understanding of pneumatic material. Students can gain a deeper understanding by calculating the difference between starting and ending grades and correlating them to specific categories. Based on the Gain Score calculation formula above, the result of the student's understanding of the Gain Score is 0.3148 or 31.48%. This data shows an increased understanding of Pneumatics in the Moderate category after using an Augmented Reality-based practicum. It shows that the Augmented Reality-based practicum model positively influences the understanding of pneumatic material in students in both schools.

Usability testing and evaluation are part of the process of increasing user satisfaction. *Usability* can also be used to improve usability in application-user interaction. In this study, a helper tool was used to assess aspects of user satisfaction with the help of a System Usability Scale tool. Sampling was conducted at SMK Negeri 5 Bekasi and SMK Negeri 69 East Jakarta with a sample of 70 respondents. Data testing was carried out by testing the validity and reliability of the answers of 70 respondents using the SPSS program. The results for validity testing using Pearson correlations were obtained with a significance level of 5%. Reliability testing in this study uses Cronbach's Alpha. If the Cronbach's Alpha value is greater than 0.6 (> 0.6), then the questionnaire is said to be reliable. The test results show that the Cronbach's Alpha value of 10 questionnaire items is 0.672, so the questionnaire is classified as reliable. Based on the results of the

validity and reliability test, it is found that the data results are valid and reliable. After calculating the application through the SUS test, a score of 68 was obtained, referring to the SUS Score in Figure 1.

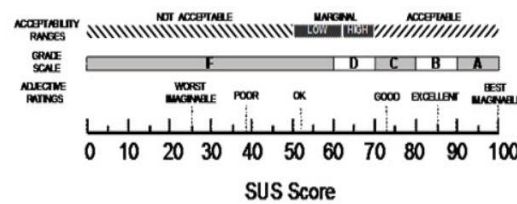


Figure 1. System Usability Scale (SUS) Score

Adjective Ratings (adjective rank) are in the OK category close to Good, Grade Scales (letter grade scale) are on the D scale, and Acceptability Ranges (Acceptance range) are at a marginal high, which indicates the application has an interface that is still acceptable to respondents. Based on the theory presented by John Brooke, a SUS score above 68 would be considered above average, and below 68 would be considered below average, but the best way to interpret the results is to "normalize" the score to produce percentile rankings (Bork et al., 2021; Hashim et al., 2018). Overall, from the results obtained, respondents rated the application as quite comfortable and easy to use but could still be improved.

Discussion

Based on data from the results of initial conditions and conditions after the application of the practicum-based model Augmented Reality For students of SMK Negeri 69 Jakarta, data was obtained that in general, 35 students of SMK Negeri 69 have learning motivation that is in the very high category, both before and after the application of practicum-based Augmented Reality. Shows that students have very high motivation. The motivation to learn is further strengthened by applying a practicum-based model augmented reality). Application of practicum-based model Augmented Reality In the 35 students of SMK Negeri 5 Bekasi, it effectively increases student motivation to learn pneumatic material. The descriptive statistical data analysis results show that student motivation was initially in the medium category to increase, namely being in the high category after applying the practicum-based model of Augmented Reality. The practicum application is based on Augmented Reality, effectively increasing student learning motivation. This finding is in line with research results showing that students who learn to use Augmented Reality show greater motivation, i.e., high interest in technology integration of Augmented Reality into the learning process (Amores-Valencia et al., 2023; Erbas & Demirer, 2019; Khan et al., 2019).

Moreover, access to practicum-based Augmented Reality can be done using mobile equipment owned by students (Arici, F., Yildirim, P., Caliklar, S., & Yilmaz, 2019). Students benefit from exploration and hands-on experience using Augmented Reality during practicum (Ayu et al., 2021; C Erbas & Demirer, 2019). Augmented Reality stimulates complex knowledge students need to learn interactively (Chen et al 2019; Nanda et al., 2022). This is considering that Augmented Reality becomes a visualization technology that allows students to understand concepts in depth that are impossible for those unable to understand the content delivered using traditional learning methods (Diao & Shih, 2019; Kaur et al., 2020). Implementing learning that involves students using Augmented Reality directly increases their learning motivation (Y. Chen, 2019; Vargas et al., 2020).

Analysis of learning outcomes from both schools showed that students at SMKN 69 experienced an average increase in pretest to Post-Test by 8.9 points. Students at SMKN 5 Bekasi experienced a greater increase in the average pretest to Post-Test, around 23.4 points. Both schools experienced increased student understanding after implementing a practicum-based model of Augmented Reality in learning. Thus, students' electro-pneumatic learning results show that applying practicum-based models of Augmented Reality positively impacts students' knowledge. In a relatively short period, students experience a significant increase in understanding of electro-pneumatic materials.

Application of the practicum-based model of Augmented Reality proved to facilitate students to be more engaged in learning and understand difficult concepts better (Alzahrani, 2020; Dhar et al., 2021). These results demonstrate the potential of the technology Augmented Reality in improving the effectiveness of education in schools, especially in complex subjects such as electropneumatics. Augmented Reality is less cognitively demanding, contributes to long-term retention, is more rewarding, realistic, and interesting, and leads to higher performance (Buchner et al., 2022; Fidan & Tuncel, 2019). In addition, reinforced by the results of the N-Gain Score, it can be discussed that practicum-based Augmented Reality positively improved students' understanding of electro-pneumatic material in both schools, as indicated by a significant increase in final grade point average. The N-Gain Score is 0.3148, indicating that the use of practicum-based Augmented Reality Has a significant positive impact on improving students'

understanding of Mteri Electro Pneumatic. Practicum-based Augmented Reality successfully increase student understanding in a significant proportion of the maximum possible increase. These improvements have the potential to strengthen the quality of learning in both schools, with the proper application of technology. Augmented Reality combines the latest technology with real-world situations to provide engaging learning and supports real-world simulations with interactive objects (Abdullah et al., 2022). Nevertheless, it is important to still consider other factors that might affect the results, as well as the potential for further adaptation in the learning approach using practicum-based Augmented Reality. The results of this study provide a strong foundation for further exploration of the use of technology in the learning process, and have the potential to make a valuable contribution to the development of more effective and effective educational methods.

Application of practicum-based model Augmented Reality This pneumatic, electronic material provides students with convenience in using the application. The students feel satisfaction from their participation in the practicum-based Augmented Reality. These findings align with previous research showing that through learning-based Augmented Reality, Students are satisfied with their learning and desire to see similar applications offered in other subjects. In addition, students also have low learning anxiety (Bursali & Yilmaz, 2019). Student satisfaction carries out practicum-based Augmented Reality, enriching the student experience using the latest technology (Criollo-C et al., 2021). Compared to traditional learning, integrated learning Augmented Reality provides higher satisfaction service (Gäthke, 2020).

4. CONCLUSION

Based on the results and discussion, it can be concluded that the application of augmented reality-based practicum models is effective in increasing student learning motivation, improving student learning outcomes, and students as users feel satisfied. Thus, the application of augmented reality-based practicum models has been considered successful, but there needs to be a follow-up to ensure sustainability and wider application. Furthermore, it is necessary to evaluate the integration of this augmented reality-based practicum model into the curriculum and learning process in SMK. It is important to note that the results of this study apply to the two schools mentioned. To generalize these results, it is necessary to consider other factors such as student characteristics, learning environment, and learning materials.

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