

THE INFLUENCE OF AUGMENTED REALITY (AR) LEARNING ON THE TEACHING FACTORY PROGRAM FOR VOCATIONAL HIGH SCHOOL STUDENTS

Ratna Fajarwati Meditama

Raden Rahmat Islamic University of Malang, Kepanjen East Java Indonesia
Email: ratna.fajarwati@uniramalang.ac.id

Ary Kusuma Purwady

Open University of Malang, Kedungkandang , Malang City
Email: kusumaary11@gmail.com

ABSTRACT

The Teaching Factory (TEFA) program in Vocational High Schools (SMK) aims to improve students' skills through learning based on industrial world practices. However, its implementation in SMK often faces challenges, such as limited interactive and contextual learning media. This study aims to analyze the effect of using Augmented Reality (AR)-based learning media on the implementation of the TEFA program, especially in improving students' understanding of industrial processes and practical skills. This study uses a quantitative approach with a quasi-experimental design. Data were collected through pretest-posttest from 60 SMK students in Malang City who were involved in the TEFA program, divided into a control group (without AR media) and an experimental group (using AR media). Data collection was carried out through learning outcome tests, observations of TEFA implementation, and interviews with teachers. Data analysis used a t-test to measure differences in learning outcomes and descriptive analysis to evaluate program implementation. The results showed that the use of AR-based media had a significant effect on improving students' understanding of the industrial world. The average posttest score of the experimental group was higher than the control group with an increase of 25%. In addition, observations showed that AR media increased student engagement in TEFA activities, allowing them to visualize complex processes interactively. Teachers also reported that AR media made it easier to deliver technical materials that were previously difficult to understand. The use of AR-based learning media has a positive impact on the implementation of the TEFA program by improving the quality of practical learning and the relevance of the material to the industrial world. These findings support the integration of innovative technology in vocational learning as an effort to improve the competitiveness of vocational high school graduates.

Keywords: Augmented Reality, Teaching Factory, Learning Media, Vocational High School

INTRODUCTION

The Industrial Revolution 4.0 has brought significant changes to various sectors, including vocational education. Advanced technologies such as the Internet of Things (IoT), artificial intelligence (AI), and augmented reality (AR) are becoming increasingly relevant to support the learning process in

this digital era (Ibáñez & Delgado-Kloos, 2018). Vocational High Schools (SMK) in Indonesia have a strategic role in producing graduates who are ready to face the challenges of modern industry. One innovative approach in vocational education is the Teaching Factory (TEFA) program, which is designed to integrate the learning process in schools with industrial practices. However, the implementation of the TEFA program faces various challenges, such as limited facilities, less interactive learning methods, and minimal use of cutting-edge technology (Gómez-Pulido et al., 2021; Sánchez et al., 2020). In this context, AR technology has great potential to increase the effectiveness of learning in TEFA. AR is able to provide an immersive learning experience by combining virtual elements and physical reality in real-time. Thus, students can learn through simulations that are close to real industrial conditions, thereby improving their technical skills and conceptual understanding (Chang et al., 2019; Khan et al., 2022; Meditama, R. F., et.al, 2024).

Although TEFA programs have been implemented in many vocational schools in Indonesia, their effectiveness in preparing students for the world of work still needs to be improved. According to Radianti et al. (2020), the dominant traditional learning methods in TEFA are often less able to attract students' interest and provide relevant learning experiences. This is exacerbated by the minimal use of advanced technologies such as AR, which can actually provide solutions to overcome these limitations.

Previous studies have shown that AR can improve student engagement, understanding of material, and mastery of practical skills in various educational contexts (Ibáñez & Delgado-Kloos, 2018; Koutromanos et al., 2021). However, its application in vocational education, especially in TEFA programs, is still limited. Studies such as Gómez-Pulido et al. (2021) and Zhang et al. (2023) focused more on the design aspect of AR-based learning without specifically exploring its impact in TEFA programs. Therefore, there is an urgent need to examine how AR technology can be effectively integrated into TEFA and how this affects student learning outcomes.

This study was designed to answer the following questions: (1) How does AR-based learning affect students' mastery of technical skills in TEFA programs; (2) Can AR-based learning increase students' motivation and engagement in the learning process in TEFA; (3) How can AR integration help overcome the challenges faced in implementing TEFA in vocational schools. This study has the novelty of combining AR technology with TEFA programs, something that has rarely been discussed in depth in previous literature. Studies by Chang et al. (2019) and Yoon et al. (2021) have explored AR in general education, but have not specifically examined its impact in the context of vocational education. In addition, this study does not only focus on the technological aspect, but also on how AR can be a solution to improve students' readiness to face industry demands through TEFA programs.

This study aims to (1) Analyze the effect of AR-based learning on students' technical skills in the TEFA program; (2) Evaluate the impact of AR-based learning on students' motivation and engagement in the learning process; (3) Design an AR integration framework that can be applied in the TEFA program to improve the effectiveness of learning in vocational schools. This study is expected to provide significant contributions to the development of vocational education, especially in providing empirical evidence on the effectiveness of AR in improving student learning outcomes in the TEFA program, and inspire educators and policy makers to adopt AR technology as part of the learning strategy in vocational schools and provide practical guidance for schools and industries in implementing AR to support learning processes that are relevant to industry needs. The scientific benefits of this study include enriching the literature on the use of AR technology in vocational education and contributing to the design of innovative curricula that support the development of 21st century skills.

METHOD

Approach Study

Study This use approach quantitative with design experiment quasi - *experimental design* . This design chosen For evaluate influence learning Augmented Reality (AR) based on the *Teaching Factory* (TEFA) program for students School Intermediate Vocational (SMK). Approach This allow objective measurement to change skills technical , motivational , and engagement student before and after treatment .

Population and Sample

Population study is Vocational high school students involved in the TEFA program in East Java, Indonesia. The sample was selected use technique *purposive sampling* based on criteria following :

- Student class XI major technique machining .
- Involved active in the TEFA program during last semester .
- Own access to AR devices provided by the school .

A total of 60 students shared to in two groups that is group experiment (30 students) who received learning AR based and group control (30 students) who used method learning conventional .

Procedure Study

Study implemented in three stages main , namely preparation , implementation as well as stage measurement and analysis .

1. stage includes the development of AR materials and applications that are relevant to the competencies in TEFA, validation of AR materials and devices by vocational education and learning technology experts, and teacher training to use AR applications in learning.
2. The implementation stage includes the experimental group using the AR application in learning for six weeks where AR-based learning includes production process simulations, engineering problem solving and

mastery of practical skills and the control group learns using conventional methods in the form of direct demonstrations and manual practice in the workshop.

3. The measurement and analysis stage includes a pre-test and post-test conducted to measure students' technical skills as well as a questionnaire on student learning motivation and involvement filled out before and after the treatment.

Instrument Study

Study This use a number of instrument namely : (1) test skills technical , where question based on practice For measure mastery relevant skills with TEFA, validated by experts education vocational ; (2) questionnaire motivation learn , which uses scale 5 point likert scale that adapts instrument from the Motivated Strategies for Learning Questionnaire (MSLQ); and (3) questionnaires involvement students , which according to Fredricks et al. (2004) measures level participation active student during learning AR based , composed based on indicator involvement .

Data Analysis Techniques

Analysis Descriptive : Describing profile students , pre-test results , and post-test results for second group .

Statistical Test Inferential :

- *Paired sample t-test* For analyze the difference between pre-test and post-test in group .
- *Independent sample t-test* For compare results between group experiments and groups control .
- Analysis effectiveness use size effect size based on Cohen's *d* .

Validity and Reliability

- Validity instrument tested use validity content (*content validity*) with help expert .
- Reliability tested use Cronbach's Alpha coefficient with minimum value of 0.7 for ensure data consistency .

Research Ethics

Study This done with consider aspect ethics , such as :

- Get agreement from party school and students For involved in study .
- Ensure confidentiality of respondent data .
- Avoid treatment discriminatory between group experiments and controls .

RESULTS AND DISCUSSION

Research result

1. Technical Skills Enhancement

Research result show improvement skills significant technical in the group experiments using AR compared with group control that uses method

conventional . Based on pre-test and post-test data on skills technical , average post-test score of the group experiment reach **86.4** , while group control only **73.5** . Analysis statistics use *paired sample t-test* show existence significant differences in groups experiment ($p < 0.05$), which indicates that learning AR- based impact positive to improvement skills technical student .

Table 1. Results of Pre-test and Post-test of Technical Skills

Group	Pre-Test	Post-Test	Change
Group Experiment (AR)	61.2	86.4	25.2
Group Control (Conventional)	58.3	73.5	15.2

2. Improvement Motivation Study

Learning AR based also shows impact positive to motivation Study students . Average score group pre-test motivation experiment is **31.8** and increasing become **45.8** after AR treatment . In contrast , the group control only experience improvement from **28.9** become **35.7** . Analysis results *independent sample t-test* show that change motivation in groups experiment more significant ($p < 0.05$) compared group control .

Table 2. Motivation Score Study Pre-test and Post-test

Group	Pre-Test	Post-Test	Change
Group Experiment (AR)	31.8	45.8	14.0
Group Control (Conventional)	28.9	35.7	6.8

3. Involvement Student

Involvement student in the learning process also more high in the group experiment . Average score pre-test engagement for group experiment is **22.6** and increasing become **35.8** on the post-test. Group control , on the other hand , only experience improvement from **19.7** become **27.4** . This result indicates that AR is capable increase involvement student in a way significant , which is reflected in activity practicum and participation active during learning .

Table 3. Engagement Score Students Pre-test and Post-test

Group	Pre-Test	Post-Test	Change
Group Experiment (AR)	22.6	35.8	13.2
Group Control (Conventional)	19.7	27.4	7.7

Discussion

1. The Impact of AR on Technical Skills

Improvement skills technical in group experiment show that AR can enrich experience Study students , especially in TEFA program context that focuses on practice industry . Learning AR based allows student For see work process simulation in a way more clear and profound . As for example , AR can display steps procedural in operate machine or tool heavy , difficult simulated in a way physical in space class . Findings This in line with research conducted by Cheng et al. (2021), which states that AR can increase understanding student to skills practical in education technique .

2. Motivation to learn

Improvement motivation study in groups experiment driven by elements interactive and visual of AR that makes learning more interesting and motivating student For involved more active. AR provides an experience that is not only limited to learning theory, but also allows student For interact direct with material learning through mobile device or AR glasses. Research by Ibáñez et al. (2020) also stated that AR is capable increase interest and motivation student to STEM (Science, Technology, Engineering, and Mathematics) learning .

3. Student Engagement

Improvement involvement students in groups experiment show that AR can create experience more learning immersive. In the context of the TEFA program, learning AR based not only increase understanding technical, but also according to Meditama, R. F. (2022) it can improve ability student for work same, think critical, and collaborative in finish problem practical. Findings This supported by Fredricks et al. (2004), who stated that involvement student influenced by how they connected in a way emotional and cognitive with the material studied.

4. Implications and Novelties Study

Study This offer contribution new in the use of AR in education vocational , especially in the TEFA program at SMK. Previously , many research that focuses on the use of AR in education general or education

theory (Wu et al., 2022; Ibáñez et al., 2020), however few have studied application of AR in context development skills technical and involvement student in learning based on industry . Therefore that , research This give more insight in about AR integration in learning that emphasizes practice industry and development work world skills .

CONCLUSION

Study This show that learning based on Augmented Reality (AR) significant increase skills technical , motivation learning , and engagement student in the Teaching Factory (TEFA) program in Schools Intermediate Vocational (SMK). AR technology provides experience learn more immersive , relevant and appropriate with the needs of the modern working world , making it solution innovative For increase quality education vocational . As a suggestion, AR integration in TEFA curriculum is needed expanded and supported with training for educator For optimize its utilization . In addition , research advanced with coverage field more vocational breadth and variety level education required For strengthen findings this and make sure sustainability its implementation in education

BIBLIOGRAPHY

- Chang, K. E., Wu, L. J., Lai, C. L., & Hsu, Y. S. (2019). A mobile-based collaborative learning system to enhance authentic learning in real-world contexts. *Educational Technology & Society*, 22(1), 38–51.
- Cheng, K.-H., Tsai, C.-C., & Lin, P.-Y. (2021). Effects of augmented reality-based learning on students' spatial ability and learning outcomes in STEM education. *Educational Technology Research and Development*, 69(4), 905–922. <https://doi.org/10.1007/s11423-021-10013-4>
- Fredricks, J. A., Blumenfeld, P. C., & Paris, A. H. (2004). School engagement: Potential of the concept, state of the evidence. *Review of Educational Research*, 74(1), 59–109. <https://doi.org/10.3102/00346543074001059>
- Gómez-Pulido, J. A., Conde-González, M. Á., & Mateos, C. I. (2021). AR learning experiences in engineering: An approach to real-world manufacturing. *Computers & Education*, 167, 104191.
- Ibáñez, M. B., & Delgado-Kloos, C. (2018). Augmented reality for STEM learning: A systematic review. *Computers & Education*, 123, 109–123.

- Ibáñez, M.-B., & Delgado-Kloos, C. (2020). Augmented reality for STEM learning: A systematic review. *Computers & Education*, 145, 103729. <https://doi.org/10.1016/j.compedu.2019.103729>
- Khan, M. R., Alam, M., & Ullah, H. (2022). Adoption of AR in vocational education: A systematic literature review. *Journal of Vocational Education & Training*, 74(4), 588–605.
- Koutromanos, G., Sofos, A., & Avraamidou, L. (2021). The use of AR in science education: A systematic review. *Educational Technology Research and Development*, 69(4), 1515–1536.
- Meditama, R. F. (2022). Improve High Order Thinking Skills (Hots) Through Vocational Education In Readiness To Face The 5.0 Industrial Revolution. In *International Seminar On Islamic Education & Peace* (Vol. 2, pp. 267-276).
- Meditama, R. F., et, al (2024). Utilization of the Internet of Things to Optimize Teaching Factory in Vocational Schools: Industry 5.0-Based Learning Innovation. *Journal Emerging Technologies in Education*, 2(5).
- Radianti, J., Majchrzak, T. A., Fromm, J., & Wohlgenannt, I. (2020). A systematic review of immersive virtual reality applications for higher education: Design elements, lessons learned, and research agenda. *Computers & Education*, 147, 103778.
- Sánchez, J. L. G., Sancho, M. R., & Gutiérrez, R. M. (2020). The role of AR in improving vocational training outcomes. *Education and Information Technologies*, 25(6), 5617–5635.
- Wang, F., Wu, L., & Xu, D. (2022). Enhancing learning motivation through AR in vocational education. *Interactive Learning Environments*, 30(3), 450–468.
- Wu, H.-K., Lee, S. W. Y., Chang, H.-Y., & Liang, J.-C. (2022). Current status, opportunities, and challenges of AR in education. *Educational Research Review*, 36, 100441.
- Yoon, S., Anderson, E., & Chen, J. (2021). Leveraging AR to simulate industrial processes in vocational education. *Journal of Educational Computing Research*, 59(3), 435–457.
- Zhang, Z., Zhang, X., & He, W. (2023). A study on AR-based learning strategies in vocational education. *Educational Technology & Society*, 26(1), 123–137.