JURNAL EDUSCIENCE (JES)
p-ISSN : 2303 - 355X | e-ISSN : 2685 - 2217
PUBLISHED BY : LPPM of UNIVERSITAS LABUHANBATU

The Effectiveness of Virtual Reality in Vocational Education for Fashion Design and Production

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ARTICLE INFO

Keywords:
Virtual Reality
Vocational Education
Fashion Design
Learning Outcomes
Usability

ABSTRACT

Purpose – The fashion industry must master the practical skills needed today to employ immersive technology like VR in Vocational Education and Training. Due to the cost and hazard of hands-on instruction, Indonesian vocational high schools have a skill gap. In order to deal with this problem, this study talks about the real-life outcomes of "Fashion Tech Edu-VR," an immersive learning tool that fits perfectly with the Indonesian national curriculum.

Methodology – This study employs a quasi-experimental research approach with a pre-test and post-test Control Group Design. The research subjects consist of 90 grade XI (Phase F) students from the Fashion Design and Production expertise program at a Vocational High School (SMK) in Semarang City. The data collection techniques used were threefold: tests, observation, and questionnaires. To test the hypotheses in this study, a t-test (paired sample t-test) was utilized with the assistance of IBM SPSS Statistics 26, comparing the post-test scores between the control group and the experimental group.

Findings – The findings show a statistically significant difference in learning outcomes between the control and experimental classes (t = -27.935). Student engagement in the control group was 3.31, compared to 4.62 in the experimental class after the Fashion Tech Edu-VR intervention. This study found that students who used 'Fashion Tech Edu-VR' achieved significantly higher learning gains compared to the control group. The platform also received excellent usability ratings and fostered much higher levels of student engagement, confirming its effectiveness as an educational tool.

Contribution – The study concludes that "Fashion Tech Edu-VR" is a useful educational tool that solves real-world training problems and is a very effective teaching example.

Received 11 November 2025; Received in revised form 22 November 2025; Accepted 10 April 2026
Jurnal Eduscience (JES) Volume 13 No. 2 (2026)
Available online 30 April 2025

INTRODUCTION

Fashion Vocational Education plays a crucial role in preparing a competent workforce for the Industry 4.0 era. In line with rapid technological advancement, Vocational Education and Training (TVET) programs in the fashion field are required to produce graduates with digital-based work skills, data literacy, and mastery of instrumented tools such as PLM and IoT (UNESCO, 2023). Digitalization, which is reconstructing the fashion industry—as a labor-intensive sector—makes process-based problem-solving competencies increasingly vital for prospective workers (Ahmad et al., 2020; Glogar et al., 2025). This need is particularly pronounced in Indonesia, where the textile and apparel industry serves as the backbone of manufacturing and a major export contributor, making the availability of practitioners with technological literacy in fashion vocational education a necessity (Indonesia, 2024).

However, this practical education system has not been implemented in the best possible way. Vocational High School (SMK) graduates have the highest unemployment rate among people with different levels of schooling. In 2024, that rate reached 9.01%. In 2025, data from the Central Statistics Agency (BPS) showed that this rate was higher than the national average jobless rate. SMK grads lack the skills the Indonesian job market needs right now (Ariansyah et al., 2024; OECD, 2020). This is the main cause of the problem. This shows that teaching models that focus on schools do not always meet the needs of businesses . Several operational constraints make this gap even bigger: letting students use machines before they are fully ready for them poses safety risks, limited access to standard industrial equipment makes it harder to master skills, and the high cost of practice materials makes it harder to learn by doing. In the end, these fundamental problems make it impossible to have a great blended learning experience at SMK (OECD, 2020).

This problem gets worse with the new Merdeka Curriculum (Phase F for SMK), which emphasizes project-based learning, learning from real life, and school-wide project events (P5). Implementing these methods can be difficult as they require substantial resources (UNESCO, 2023). Implementing the Merdeka Curriculum (KuMer) in Phase F for Fashion Design and Production requires students to have advanced skills and to align with how the business operates (K. P. D. dan M. R. Indonesia, 2025). To improve imagination and reduce mistakes, the best way to learn is to use 3D virtual reality to mimic real-world practices (Kiliç & Ceylan, 2023; Wang, 2024).

However, SMKs do not always have the best facilities, tools, or access to cutting-edge technology, such as CAD software for digital pattern-making, 3D design, and modern sewing machines. This means that the level of training is not as good as at vocational schools (Fadhilah et al., 2023; Kolosnichenko et al., 2021; Tanjung et al., 2023; Widiyawati et al., 2024). The high cost of training materials also makes students less likely to participate, be engaged, and be motivated (Rolling & Martindale, 2024; Swain & Pathak, 2024), and teachers who are not properly trained cannot use current technology effectively (Du et al., 2022; Hrytsenko et al., n.d.). All of these problems make it much harder to have the real, engaging, and safe learning experiences that are so important in Phase F of Fashion Design and Production.

Immersive virtual reality (VR) looks like a good idea. Reviews and meta-analyses of VR for vocational and safety training show that it provides a repeatable, low-risk, and materials-free environment for learning procedures while simulating the real-world production pace and profit dynamics (Conrad et al., 2024; Scorgie et al., 2024). However, there remains a significant evidence gap specific to the Indonesian vocational context: few published studies detail the planning, development, and empirical validation of VR platforms that are methodically aligned with the Merdeka Curriculum and the practical resource constraints of schools. This is a commonly cited shortcoming in broader VR-in-education research, which advocates for more theory-grounded design and assessment to ensure effective integration into actual curricula (Radianti et al., 2020).

To solve this multifaceted problem, we need radical technological solutions to help us develop new ways to teach. For many reasons, including design, prototyping, and retail, the fashion industry is increasingly using virtual reality (VR). VR lets fashion designers create and view 3D models in a virtual world, reducing the need for physical prototypes and speeding up the design process (Liu et al., 2025; Widiyawati et al., 2024). It also helps students learn useful skills such as pattern-making, material selection, and production (Irmayanti, 2017).

It is very helpful for fashion students to practice and improve their skills in a controlled setting (Long et al., 2025), as this combination of theory and practice enhances student learning outcomes (Maulana & Purnomo, 2021). Project-Based Learning (PjBL) with VR has been shown to get students more involved by making learning more fun, lowering resistance to traditional methods, and creating an immersive environment that gets students more interested and motivated in vocational education (Huang & Sheng, 2019; Maulana & Purnomo, 2021; Ravichandran & Mahapatra, 2023).

Researchers have found that using Virtual Reality (VR) in fashion education lets students see how patterns are turned into clothes, study how fabrics drape, and try out different designs without using real materials (Choi, 2022; Meng et al., 2010; Moritz & Youn, 2022). These results show that VR has significant promise and is useful for vocational education in fashion. However, more research is still needed, especially in Indonesia. Specifically, there needs to be a study on how VR-based learning tools can help vocational high school (SMK) students in the fashion field learn more effectively and become more interested in their work. Also, no study has yet developed VR learning materials specifically designed to fit the Merdeka Curriculum model and the needs of Indonesian Fashion Design Vocational Schools.

This study's goal is to fill this gap by creating Fashion Tech Edu-VR. The goal of the study is to determine the extent to which Fashion Tech Edu-VR improves learning outcomes and student engagement in vocational fashion education.

METHODOLOGY

Research Design

With a pre-test and post-test Control Group Design, this study uses a method similar to an experiment. This plan shows how an intervention affected two groups side by side, without changing the way the classes are set up. Participants are split into two groups for the study: a control group that uses traditional learning methods and an experimental group that uses Fashion Tech Edu-VR. The variables in this study consist of independent, dependent, and control variables. The independent variable is the learning method: the experimental group uses Fashion Tech Edu-VR media, and the control group uses the conventional method. The dependent variables are student learning outcomes (cognitive and psychomotor) and student engagement in the learning process. The control variables in this study include the lesson material, instruction duration, and student education level (11th-grade SMK students), which are kept equivalent between both groups to minimize bias.

The effectiveness of the intervention is measured by comparing the gain score (the difference in scores) between the pre-test (O1) and post-test (O2) in both groups. An overview of this research design is shown in Figure 1.

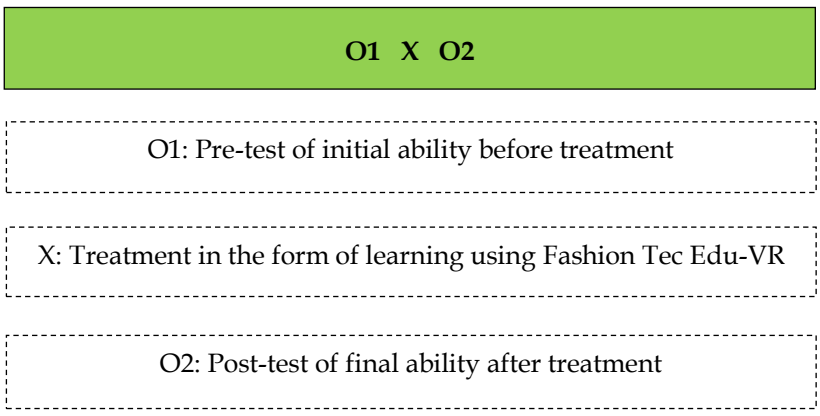

Figure 1. Research Design of Quasi Eksperimental Pre-test Post-test Design

Participant

The subjects of this study consisted of 90 grade XI (Phase F) students from the Fashion Design and Production expertise program at a Vocational High School (SMK) in Semarang City. The sample was selected using a simple random sampling technique and then divided into two equivalent groups: an experimental group (n=45) and a control group (n=45). To reduce selection bias, this study had strict inclusion criteria. To be included, students had to meet two requirements: (1) Be active second-years who had already taken and passed the basic pattern construction course; and (2) Have a similar level of academic ability based on their exam scores from the previous term, so that both groups started from the same point. At the same time, students who could not fix their vision (for safety reasons) or who had already done VR-based training were not allowed to join.

Data Collection

The study took four weeks to complete. First, a pre-test was given to all 90 people to see how much they already knew. The subsequent use of the Fashion Tech Edu-VR platform to help the experimental group learn how to create men's shirts followed. The tool was meant to help people see 3D models that showed the steps and process of making a men's shirt. The control group, on the other hand, learned the same information through traditional methods like lectures, live demonstrations, and textbook exercises. Both groups received the same amount of instruction. After the intervention, students in both groups were given a post-test to assess their learning. Tests, observations, and surveys were the three methods used to gather data. There were tests to assess how much the students learned, direct observation to assess how well the men's shirt products the students made turned out, and a questionnaire to assess how involved the students were.

Instrument

The instruments used in this research were a test and an observation sheet for assessing the men's shirt product. However, prior to their use in the study, the developed instruments were first tested for their validity and reliability. Testing was conducted both before the use of Fashion Tech Edu-VR (pre-test) to determine students' initial ability and after its implementation in the learning process (post-test).

The first tool was a mental test about the information on how to make a man's shirt. It had twenty-five (25) multiple-choice questions and five (5) essay questions. The questions covered important topics like analysis, inference, explanation, and review. Great (A), Above Good (AB), Good (B), Above Satisfactory (BC), Satisfactory (C), Below Satisfactory (CD), Poor (D), and Fail (E) were the nine levels of scoring. The discrimination index and the difficulty index were used to test the correctness of the items. The discrimination score was greater than 0.25, and the difficulty level ranged from 0.30 to 0.60 across all items. This test had a reliability coefficient of 0.85, indicating that the test equipment was reliable.

For judging the men's shirts that the students made, the second tool was an observation sheet for judging student work. It was graded on several factors, such as getting the tools and materials ready, taking measurements, the process, sewing methods, form balance, and the result. Five levels were used to rate each aspect: Excellent, Good, Fair, Poor, and Very Poor. The instrument was then put to the test by seven validators to assess its validity and reliability. The Aiken's V formula validity test showed that all items met the acceptance standards, with a value of 0.926, indicating validity. Using Cronbach's Alpha, the assessment tool's reliability was 0.942, indicating it is reliable.

Student Engagement Instrument (SEI) (Appleton et al., 2006) was the third tool. It was a questionnaire used to gauge students' involvement in school. The test has 50 questions that measure students' engagement in school across cognitive, behavioral, and emotional domains. After running a validity test, we found that all the questions on the form meet the requirements, with a score of 0.712, indicating they are all valid. Using Cronbach's Alpha, the assessment tool's reliability was 0.92, indicating it is reliable.

Data Analysis

The data analysis in this study employs both descriptive and inferential statistical methods. Descriptive statistical analysis is used to outline students' learning outcomes before and after the intervention using Fashion Tech Edu-VR. Subsequently, inferential statistical analysis techniques are applied to test the research hypotheses. This is done using a t-test (paired sample t-test) facilitated by IBM SPSS Statistics 26, comparing the post-test scores between the control and experimental groups. However, before conducting the data analysis, prerequisite tests are performed: the normality test (Kolmogorov-Smirnov) and the homogeneity test (Bartlett's). The results of the data analysis are then used to determine the effectiveness of Fashion Tech Edu-VR in improving learning outcomes and student engagement in Fashion Design vocational education. This is achieved by comparing the post-test results and questionnaire responses of the experimental and control classes.

FINDINGS

The Effectiveness of Fashion Tech Edu-VR in Improving Learning Outcomes

This research begins by presenting a description of the pre-test and post-test data on students' outcomes in making a men's shirt. The control class received instruction without using Fashion Tech Edu-VR, while the experimental class received instruction using Fashion Tech Edu-VR after the pre-test was administered. Student learning outcomes were assessed both before and after the instruction. The learning outcomes were evaluated using a test instrument and direct observation, with the assessment criteria being the students' ability to: apply worksheets according to design specifications; implement production steps, measurement, pattern making, and fabric cutting; apply sewing techniques following procedures, including trimming and pressing; conduct quality control of the garment; handle garment packaging; and complete final finishing of the garment. Based on the results of the pre-test and post-test administered to 90 students, the obtained data are presented in Table 1 and Figure 2.

Table 1. Statistic Descriptif of Students' Learning Outcomes in Men's Shirt Design and Production

	Control Class			Experimental Class		
	N	Mean	Std. Deviation	N	Mean	Std. Deviation
Pre-test Score	45	64.13	1.492	45	64.58	1.557
Post-test Score	45	66.01	2.148	45	85.07	4.043
Valid N (listwise)	45			45		

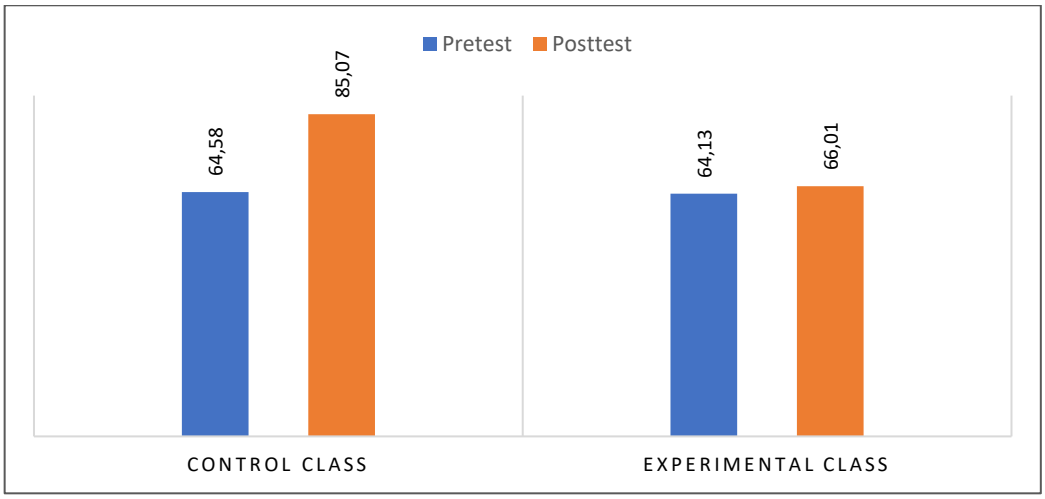

Figure 2. The Average of Learning Outcomes in the Experimental and Control Class

Based on Table 1 and Figure 2, the average pre-test score for the experimental class was 64.58, while the average pre-test score for the control class was 64.13. Subsequently, the experimental class's average post-test score was 85.07, while the control class' was 66.01. Based on these results, it can be concluded that student learning outcomes improved, as evidenced by the increase in average scores. However, the class that showed a substantial improvement in learning outcomes was the experimental class, with an average pre-test score of 64.58 and an average post-test score of 85.07.

Following this, a hypothesis test was conducted to determine the effectiveness of Fashion Tech Edu-VR in improving student learning outcomes. However, prior to testing the hypothesis, prerequisite analyses—namely, normality and homogeneity tests—were performed. A summary of the results from the normality and homogeneity tests is shown in Tables 3 and 4.

Table 3. Normality Test Results

	Control Class			Experiment Class		
	Statistic	df	Sig.	Statistic	df	Sig.
Pre-test Score	0.114	45	0.173	0.084	45	0.200*
Post-test Score	0.102	45	0.200*	0.121	45	0.099

Based on the normality and homogeneity tests (Table 3 and 4), all data were found to be normally distributed and homogeneous. Subsequently, hypothesis testing was performed to examine the proposed hypothesis. This test used a Paired Sample t-test. The results of the data analysis can be seen in Table 5.

Table 4. Results of Homogeneity Test

		Levene Statistic	df1	df2	Sig.
Learning outcomes	Based on the mean	0.004	1	88	0.947
	Based on Median	0.046	1	88	0.831
	Based on Median and with adjusted df	0.46	1	79.193	0.831
	Based on the trimmed mean	0.006	1	88	0.940

Based on Table 5, the calculated t-value is -27.935, with Sig. value of 0.000. This test indicates a significant difference in learning outcome scores between the control and experimental classes. From these results, it can be concluded that Fashion Tech Edu-VR effectively improves student learning outcomes in the production of men's shirts. This is evidenced by the increase in student scores from the pre-test to the post-test, with all assessment indicators achieving a high category.

Table 5. Paired Sample t-test Result

Comparison	Mean	Std. Deviation	Std. Error Mean	t	df	Sig. (2-tailed)
Pre-test and post-test	-19.062	4.577	0.682	-27.935	44	0.000

Improving Student Engagement through the Use of Fashion Tech Edu-VR

Based on the student engagement questionnaire, there is a significant difference between the experimental and control groups. Students in the experimental group demonstrated higher engagement than those in the control group. The average engagement score for students in the experimental group was M=4.62 with a standard deviation (SD) of 0.49. In contrast, the control group had an average engagement score of M=3.3 with an SD of 0.46. This difference is evident in Table 6.

Table 6. Average Student Engagement Scores

Group	Average Student Engagement Score	Standard Deviation
Experimental	4.62	0.490
Control	3.31	0.468

This difference indicates that Fashion Tech Edu-VR effectively enhances student engagement in the learning process. Fashion Tech Edu-VR helps students more easily understand the process of making a men's shirt by providing a detailed 3D simulation of the entire process, from pattern-making to finishing. This demonstrates that the Fashion Tech Edu-VR technology can improve student interaction and engagement. When students actively think and analyze information, it reflects a high level of cognitive engagement. Similarly, when students exhibit strong interest and high motivation towards a topic, it signifies a high level of affective engagement as well (Depita, 2024).

DISCUSSION

The research results presented show a difference in post-test scores between the control and experimental groups. The Paired Sample t-test gave a t-value of 27.935 and a Sig. (2-tailed) value of 0.000, which is less than the 0.05 level of significance. It was also found that the Fashion Tech Edu-VR treatment in the experimental class helped students learn more than the teaching in the control class. We can therefore say that using Fashion Tech Edu-VR makes a big difference in helping students learn and works well at doing so.

Makransky et al.'s (2019) study backs up this conclusion. They found that using VR improved people's thinking and working memory compared to traditional media alone, suggesting it should be incorporated into instructional design. Another study that supports this one is by Allcoat & von Mühlenen (2018), who said that virtual reality (VR) could be an option because it has long-lasting effects on learning, like making learning better and more fun. Chang et al. (2020) also reported that VR-based learning is highly effective; students who use VR have higher self-efficacy and a stronger tendency to think critically than those who do not use VR in a regular classroom. This shows that learning with VR technology helps people make their own products and encourages shopping experiences in the virtual world (Akram et al., 2022).

Students are involved in the learning process, which shapes their understanding and helps them reach their full potential in cognitive, affective, and psychomotor areas. This is especially important when learning how to make men's shirts as part of a course in fashion design and production, where understanding, accuracy, and care are needed at every step. The new Fashion Tech Edu-VR technology can explain ideas or things that are hard to show without teaching aids. For example, it can show how to cut fabric, sew the collar, attach pockets, make cuff plackets, sew shirt cuffs, stitch side seams, set sleeves, and finish. Fashion Tech Edu-VR can be used as a learning tool because it lets you see things in three dimensions, which can make them seem simpler and more real. (Bacca et al., 2014) agree with this point of view, arguing that learning with virtual reality (VR) improves the learning process by delivering material more accurately, effectively, and clearly, ultimately helping students reach their learning goals. The results of this study are also supported by Dede et al. (2017), who found that VR technology enables direct, engaging experiences, helping new learners remember what they have learned and apply it to real-life situations.

Fashion Tech Edu-VR technology has also been shown to encourage significant interaction and involvement, as well as provide students with hands-on experiences that can help them learn more and be more creative. This is clear because the average student engagement score in the experimental class was 4.62, which is much higher than the 3.31 in the control class. The fact that the experimental group was more involved shows that the Fashion Tech Edu-VR 3D models effectively engaged students in their learning, which, in turn, helped them better understand the material. Aripin & Suryaningsih's (2019) study backs up this conclusion. It shows that using pictures and being active while learning can help people remember and better understand what they are learning.

Students will remember the steps needed to make a men's shirt because Fashion Tech Edu-VR is an interesting medium that sticks with them. It helps them learn to simulate tools and materials, work procedures, fabric-cutting techniques, sewing collars, attaching pockets, making cuff plackets, sewing shirt cuffs, stitching sides, setting sleeves, and finishing processes. In the same way, Bodekær et al. (2016) argue that virtual reality (VR) transforms traditional learning adaptation into useful learning in a significant way. Higher-level students who use VR in one or more subjects are more motivated to learn and enjoy learning more.

CONCLUSION

Based on the t-test analysis, it can be concluded that learning with Fashion Tech Edu-VR achieves a significantly higher average score than conventional learning. The results of this study show that Fashion Tech Edu-VR not only affects cognitive processes but also positively affects students' skills and engagement in the classroom. Therefore, the implementation of Fashion Tech Edu-VR has proven effective in enhancing student learning outcomes. Consequently, Fashion Tech Edu-VR can be considered as a primary innovative learning medium and a promising pedagogical innovation to be implemented more widely in Fashion Design Vocational Education, particularly in Fashion Design Vocational High Schools.

ACKNOWLEDGMENT

This work was supported by the Directorate of Research and Community Service, Ministry of Higher Education, Science, and Technology of the Republic of Indonesia (DPPM KEMENDIKTISAINTEK), which provided financial assistance for this study under grant number 089/C3/DT.05.00/PL/2025, which the authors would like to recognize. This assistance was crucial to the study's success.

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