INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY: APPLIED BUSINESS AND EDUCATION RESEARCH
2025, Vol. 6, No. 12, 6199 – 6218
http://dx.doi.org/10.11594/ijmaber.06.12.26

Research Article

Advancing Electrical Technology Education: Investigating the Impact of Immersive Simulation Tools on Hands-On Learning Outcomes

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Article history:
Submission 17 September 2025
Revised 31 November 2025
Accepted 23 December 2025

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ABSTRACT

This study investigates the effectiveness of immersive simulation tools in enhancing hands-on learning, engagement, and practical skills among Bachelor of Technical Vocational Teacher Education (BTVTEd) Electrical Technology students. Recognizing the challenges of traditional laboratory-based training, such as safety risks, limited resources, and restricted practice opportunities, the study explores how immersive technologies can address these limitations. Utilizing a mixed-methods research design, the study combines quantitative approaches, including pre-test and post-test assessments and surveys, with qualitative methods, such as focus group discussions and semi-structured interviews, to comprehensively evaluate the tools' impact. Conducted in a teacher education institution in Ilocos Norte, the study involves third-year electrical technology students and their instructors. Results indicate that immersive simulation tools significantly improve students' practical skills, as evidenced by a statistically significant increase in post-test scores. Both students and instructors perceive these tools as highly effective and user-friendly, emphasizing their ability to simplify complex concepts, enhance skill acquisition, and foster confidence. The tools also provide realistic and safe environments for practicing high-risk tasks, such as working with high-voltage equipment, reducing safety concerns while promoting deeper learning. However, challenges such as technical issues, limited access to equipment, high costs, and the need for training are identified as barriers to broader adoption. The study concludes that immersive simulation tools are a transformative innovation in technical education, offering safer, more engaging, and effective learning experiences. It recommends future research to include longitudinal studies tracking the long-term impact of these tools on career readiness and

How to cite:
Borromeo, C. G. G., Fabro, R. B. B., Juan, S. M. G., Daquioag, D. J. V., Ladran, P. J. P., Blanco, J. M. A., & Balintec, C. J. G. (2025). Advancing Electrical Technology Education: Investigating the Impact of Immersive Simulation Tools on Hands-On Learning Outcomes. *International Journal of Multidisciplinary: Applied Business and Education Research*. *6*(12), 6199 – 6218. doi: 10.11594/ijmaber.06.12.26

professional success, as well as strategies to address implementation challenges and ensure wider accessibility.

Keywords: *Immersive Simulation Tools, Hands-on Learning, Technical Vocational Education, Electrical Technology, Learning Outcomes, Student Engagement*

Background

Hands-on learning has long been recognized as a crucial component of technical vocational education, particularly in the field of electrical technology. Students not only need to acquire theoretical knowledge but also develop the practical skills necessary to safely and effectively perform electrical tasks. However, traditional laboratory-based training often faces challenges such as limited resources, safety concerns, and restricted opportunities for repeated practice. For many students, these barriers hinder the full development of competence and confidence in applying classroom concepts to real-world scenarios. These challenges highlight the need for innovative solutions that can enhance learning experiences while addressing resource and safety constraints.

Recent advancements in digital learning have introduced immersive simulation tools as innovative solutions to these challenges. Immersive technologies, including virtual reality (VR), augmented reality (AR), and metaverse-based platforms, provide learners with interactive and realistic environments that replicate hands-on experiences. According to Bower and Jong (2020), immersive VR allows students to explore complex concepts in a safe and engaging manner, while Petersen et al. (2023) highlight its effectiveness in promoting collaboration and deeper cognitive processing. Similarly, Albarracin-Acero et al. (2024) demonstrated how VR can transform the teaching of electrical circuits, allowing students to apply theoretical concepts in practical scenarios without the immediate risks of electrical hazards. These findings suggest that immersive simulations can complement traditional methods by offering safe, cost-effective, and flexible avenues for practice, making them particularly relevant for technical education where precision, safety, and hands-on competence are paramount.

Immersive technologies have also been shown to enhance motivation and learning outcomes. Sviridova et al. (2023) found that the integration of immersive tools increased academic success and motivation in higher education, while James, Oates, and Schonfeldt (2024) observed that gamified immersive experiences improved student engagement and retention. Similarly, Susilana, Dewi, and Rullyana (2024) emphasized the positive perceptions of students toward the use of metaverse platforms, underscoring their role in creating more engaging and collaborative learning environments. Furthermore, Lee and Ji (2024) found that visual realism in avatars and virtual spaces influences students' engagement and sense of presence, while Oyserman and Dawson (2024) emphasized that effective learning environments must align with students' motivations and identities. Taken together, these studies affirm that immersive simulations do more than transmit knowledge—they build learner confidence, motivation, and readiness to perform real-world tasks.

In the context of technical education, immersive simulation tools enable learners to engage in simulations that closely mirror real-world applications. These tools address not only cognitive aspects but also affective aspects of learning, creating environments that are both realistic and engaging. For instance, Makransky and Petersen (2021) noted that immersive VR facilitates deeper cognitive benefits and learning outcomes, while Parong and Mayer (2021) highlighted its effectiveness in teaching complex scientific concepts. Merchant, Goetz, and Cifuentes (2020) observed that immersive learning environments bridge the gap between theory and practice by offering students opportunities to repeatedly practice skills in safe and controlled settings. Zhao and Liao (2023) further reinforced the value of

gamification in immersive learning environments, noting its positive effects on student engagement and skill acquisition.

Given the increasing demand for skilled technical-vocational graduates and the growing integration of digital technologies in education, it is timely and necessary to explore how immersive simulation tools can enhance the hands-on learning experiences of Bachelor of Technical Vocational Teacher Education (BTVTEd) Electrical Technology students. By bridging the gap between theory and practice, these tools hold the potential to improve student engagement, ensure safety in learning, and prepare future educators and instructors with the competencies required in the electrical field (Fabro et al., 2023). This study seeks to investigate the role of immersive simulation tools in enhancing hands-on learning for BTVTEd Electrical Technology students, particularly in developing their engagement, motivation, and preparedness for practical application.

Methods

Research Design

The study utilized a mixed-methods research design, combining both quantitative and qualitative approaches to comprehensively investigate the effectiveness of immersive simulation tools in enhancing hands-on learning for electrical technology students.

Quantitative methods were employed to measure the impact of the tools on students' practical skills through pre-test and post-test assessments, as well as surveys to gather numerical data on student and instructor perceptions. Qualitative methods were used to explore deeper insights into the challenges and limitations associated with the implementation of these tools through semi-structured interviews and focus group discussions.

The comparative analysis of learning outcomes and engagement levels between students using immersive simulation tools and those relying on traditional teaching methods provided additional quantitative data. This mixed-methods approach allowed the researchers to triangulate findings, ensuring a robust and holistic understanding of the phenomenon under investigation.

Locale of the Study

The research was conducted in a teacher education institution (TEI) located in the province of Ilocos Norte, recognized as a Center of Teaching Excellence by the Commission on Higher Education (CHED) for its exemplary commitment to providing quality education and producing highly skilled professionals.

Among the degree programs offered by this institution, it offers two-degree programs under Technical-Vocational and Livelihood Education (TVL) with eight specializations, catering to the growing demand for industry-ready graduates in technical fields. Notably, one of its programs has attained Level IV accreditation, the highest level of quality assurance and sustained excellence as recognized by accrediting agencies. Despite the growing number of students taking technical courses and the insufficient resources, the institution continues to uphold its dedication to innovative teaching practices and hands-on learning, making it an ideal environment for integrating and evaluating immersive simulation tools in electrical technology education. Its recognition as a Center of Teaching Excellence further underscores its leadership in advancing educational methodologies, solidifying its role as a fitting locale for this study.

Population and Sampling Procedure

This study consisted of third year electrical technology students and instructors from the sole teacher education institution in Ilocos Norte offering electrical technology degree programs in Technical-Vocational and Livelihood Education (TVL). The students were enrolled in major courses that required electrical hands-on practice, while the instructors included those teaching electrical major courses and those familiar with immersive simulation tools or traditional teaching methods.

The study employed total enumeration, wherein thirty (30) students actively enrolled in electrical technology courses during the second semester of SY 2024-2025, as well as three instructors teaching electrical technology course in the technical-vocational department within the same period, were included as participants. This approach ensured that the entire

population relevant to the study was represented, providing comprehensive data on the use and implementation of immersive simulation tools.

By involving all eligible students and instructors, the study was able to gather a complete set of insights and experiences to address the research objectives effectively.

Research Instruments

The study employed a variety of research instruments specifically designed to address the research objectives. These instruments included pre-test and post-test assessments, surveys, focus group discussions, semi-structured interviews, and comparative analysis tools. Each instrument was carefully developed based on an extensive review of related literature and aligned with the research questions to ensure their relevance and effectiveness in gathering meaningful data.

For the first research objective, which aimed to evaluate the effectiveness of immersive simulation tools in improving the practical skills of electrical technology students, pre-test and post-test assessments were utilized. These assessments measured students' practical skills before and after using immersive simulation tools, with data analyzed using paired t-tests to determine statistical significance.

To address the second research objective, which sought to identify the perceptions of students and instructors regarding the usability and effectiveness of immersive simulation tools, surveys and focus group discussions were conducted. The surveys gathered quantitative data, while the focus group discussions provided qualitative insights into the experiences of both students and instructors. Survey responses were analyzed through descriptive statistics, and qualitative data from focus groups were examined using thematic analysis following the Braun and Clarke's model to identify recurring themes.

For the third research objective, which aimed to determine the challenges and limitations associated with implementing immersive simulation tools, semi-structured interviews were employed. These interviews provided in-depth qualitative data regarding the obstacles faced by students and instructors. The data collected were analyzed using content analysis to categorize and interpret recurring themes.

Finally, for the fourth research objective, which focused on assessing the overall learning outcomes and engagement levels of students using immersive simulation tools compared to traditional teaching methods, a comparative analysis was conducted. This analysis utilized student performance records, engagement surveys, and observation checklists to evaluate the learning outcomes and engagement levels of a single group of 3rd-year electrical technology students. The study compared the students' experiences and performance when using immersive simulation tools versus traditional teaching methods. Data were analyzed using paired t-tests to identify differences in learning outcomes and engagement levels within the same group under the two different teaching approaches.

In addition, these instruments underwent content validation, which was conducted by a panel of experts selected through purposive sampling to ensure their validity and reliability. The panel consisted of three educators, three research specialists, and three instructional designers who were chosen based on their expertise in educational research, instructional design, and technology integration. A pilot test was also carried out with 30 participants who were not part of the actual study sample, yielding a Cronbach's alpha coefficient of 0.89, which indicated high reliability. The finalized instruments were made available in both printed and digital formats to ensure accessibility for all respondents.

Statistical Treatment of Data

The data gathered through various research instruments underwent systematic statistical treatment to ensure accurate and reliable analysis in addressing the research questions.

Initially, data cleansing was performed to remove incomplete responses and invalid entries, ensuring a clean dataset for analysis. The organized data were processed using Microsoft Excel for initial preparation and then transferred to Statistical Package for Social Sciences

(SPSS) version 26 for advanced statistical computations.

Paired t-tests were used to analyze pre-test and post-test assessments, measuring the significance of differences in students' practical skills before and after using immersive simulation tools. This statistical method provided insights into the effectiveness of the tools in enhancing hands-on learning outcomes.

Descriptive statistics particularly mean scores were utilized to analyze survey data, quantifying students' and instructors' perceptions of the usability and effectiveness of immersive simulation tools based on a Likert scale. Additionally, thematic analysis was applied to qualitative data from focus group discussions to identify recurring themes and patterns, offering deeper insights into participants' experiences.

Content analysis was employed to examine data from semi-structured interviews, categorizing recurring themes related to challenges and limitations associated with implementing immersive simulation tools. This approach provided detailed perspectives on obstacles faced during the implementation process.

Inferential statistics particularly, independent t-tests were used for comparative analysis of overall learning outcomes and engagement levels between immersive simulation tools and traditional teaching methods. Student performance records, engagement surveys, and observation checklists were analyzed to evaluate differences in effectiveness, highlighting the impact of immersive tools on student engagement and learning outcomes.

The systematic application of both descriptive and inferential statistics ensured the reliability and comprehensiveness of the findings. The use of SPSS for advanced statistical computations further enhanced the accuracy and validity of the results, while qualitative analyses complemented the quantitative data by providing deeper insights into the experiences of the participants.

Data Gathering Procedures

The researchers implemented a systematic approach to data collection, combining quantitative and qualitative methods to address the study's objectives and research questions comprehensively. The process began with a formal request letter addressed to the Dean of the Teacher Education Institution in Ilocos Norte, seeking approval to conduct the study among third-year electrical technology students and their instructors. Once approval was granted, the researchers developed the research instruments, which included pre-test and post-test assessments, surveys, semi-structured interview guides, and observation checklists. These instruments were prepared in both printed and digital formats to ensure accessibility for all participants.

To evaluate the effectiveness of immersive simulation tools in improving practical skills, pre-test and post-test assessments were administered to electrical technology students enrolled in hands-on learning courses. Instructors teaching these courses were informed about the study and trained to integrate immersive simulation tools into their lessons, particularly in topics requiring hands-on activities. The pre-test was conducted at the beginning of the intervention period to assess students' baseline practical skills using traditional teaching methods. Over a four-month period, immersive simulation tools were actively incorporated into the lessons, providing students with opportunities to apply simulations in practical scenarios. At the end of the intervention, a post-test was administered to measure improvements in students' practical skills. During this period, observation checklists were also used to assess student engagement levels, and surveys were distributed to gather their perceptions of the tools' usability and effectiveness.

After the intervention period, participants were scheduled to complete surveys, participate in focus group discussions, and undergo semi-structured interviews to provide insights into their experiences and perceptions. Regular follow-ups were conducted to ensure maximum participation and completeness of the data. Once the data collection phase concluded, quantitative data from pre-tests, post-tests, surveys, and observation checklists were encoded into spreadsheets for statistical analysis. Since the study involved only one group of students, a paired t-test was used to compare pre-test and post-test scores for both practical

skills and engagement levels, as this design measured changes within the same group under different conditions. Descriptive statistics were applied to analyze survey responses, providing insights into participants' perceptions. Qualitative data from focus group discussions and interviews were transcribed and subjected to content analysis to identify recurring themes related to challenges and limitations.

To gather data on the perceptions of students and instructors regarding immersive simulation tools, surveys were distributed using online and face-to-face methods. For online distribution, Google Forms links were shared via Facebook Messenger, accompanied by a cover letter explaining the study's purpose, voluntary participation, and confidentiality of responses. For face-to-face distribution, printed copies of the survey were handed out during scheduled laboratory classes to ensure that participants had sufficient time to complete the questionnaires. Additionally, focus group discussions and semi-structured interviews were conducted to explore the challenges and limitations associated with implementing immersive simulation tools. These sessions were scheduled during laboratory periods to ensure participant availability and meaningful engagement.

This systematic approach ensured that each research question was addressed effectively, with appropriate instruments, participants, and analysis methods. The combination of quantitative and qualitative techniques provided a comprehensive understanding of the effectiveness, perceptions, challenges, and comparative outcomes of using immersive simulation tools in electrical technology education.

Ethical Considerations

The ethical considerations in this study were carefully addressed to ensure the protection of the rights, privacy, and well-being of all participants.

Prior to the conduct of the study, formal approval was obtained from the Dean of the Teacher Education Institution in Ilocos Norte, demonstrating respect for institutional protocols and ensuring that the research adhered to ethical standards. Participants were provided with a cover letter that clearly explained the purpose of the study, the voluntary nature of their participation, and the assurance of confidentiality and anonymity of their responses. This transparency ensured that participants were fully informed and provided their consent willingly. The instructors teaching electrical courses were also informed about the study and actively participated by integrating immersive tools into their lessons, ensuring the activities aligned with the curriculum and did not interfere with the students' regular learning experiences. Furthermore, the researchers ensured that data collection methods—whether through online surveys shared via official classroom Facebook Messenger or printed questionnaires distributed during scheduled laboratory classes—did not disrupt the participants' schedules or impose undue burden. Regular follow-ups were conducted respectfully, avoiding any form of coercion, to encourage participation while maintaining the voluntary nature of the study. All data collected, both online and manually encoded, were handled with strict confidentiality and used solely for the purposes of the research. By adhering to these ethical principles, the study ensured the integrity of the research process and the protection of all individuals involved.

Results and Discussion

Effectiveness of Immersive Simulation Tools in Improving the Practical Skills of Electrical Technology Students

Table 1 highlights the impact of immersive simulation tools on the acquisition of practical skills among electrical technology students. The paired t-test analysis reveals a statistically significant improvement in students' performance, as indicated by the increased mean score from the pre-test to the post-test.

Table 1. Pre-Test and Post-Test Scores of Electrical Technology Students Using Immersive Simulation Tools

Assessment	M	SD	t-value	p-value	Interpretation
Pre-Test	72.45	5.32	8.52	<0.001	Significant
Post-Test	85.67	4.89			

Note: m-mean, SD- Standard Deviation

This significant difference ($t = 8.52$, $p < 0.001$) underscores the effectiveness of immersive simulation tools in enhancing technical proficiency and practical skills. These findings align with prior research emphasizing the benefits of immersive technologies in fostering hands-on learning and engagement in vocational education (Agbo et al., 2023; Barrett et al., 2021).

The significant improvement in students' practical skills observed in this study demonstrates the effectiveness of immersive simulation tools in technical education. The tools provided a realistic and interactive environment where students could apply theoretical concepts to practical scenarios, enhancing their understanding and proficiency. The increase in mean scores from 72.45 (pre-test) to 85.67 (post-test) reflects the positive impact of these tools, which allowed students to engage deeply with the learning material and refine their skills in a controlled yet realistic setting.

The findings support the growing body of literature on the role of immersive technologies in education. Agbo et al. (2023) and Albarracín-Acero et al. (2024) emphasize that virtual reality and simulation tools foster cognitive engagement and skill development by enabling learners to interact with complex systems in a safe and immersive manner. Similarly, Barrett et al. (2021) highlight the acceptance and effectiveness of high-immersion systems in improving student performance and engagement.

In this study, the integration of immersive tools into laboratory classes by instructors further contributed to the positive outcomes. This approach ensured that students could practice their skills within the context of their curriculum, making the learning experience both relevant and impactful. Additionally, the statistically significant results ($p < 0.001$) confirm that the observed improvement is not due to chance but rather a direct result of the intervention.

These findings have important implications for vocational education and training. Immersive simulation tools can be a powerful resource for enhancing technical skills, particularly in fields like electrical technology, where hands-on proficiency is critical. Future research may explore the long-term effects of using these tools and their applicability to other technical disciplines. Moreover, integrating immersive technologies with collaborative and gamified learning strategies could further enhance their effectiveness, as suggested by studies such as Petersen et al. (2023) and Radianti et al. (2020).

In conclusion, immersive simulation tools significantly impact the acquisition of practical skills among electrical technology students. By providing an engaging and interactive learning environment, these tools contribute to improved performance and confidence, making them an invaluable addition to technical education.

Perceptions Toward the Usability and Effectiveness of Immersive Simulation Tools

Students' Perceptions Toward the Usability and Effectiveness of Immersive Simulation Tools

Table 2 provides insight into students' perceptions of the usability and effectiveness of immersive simulation tools, with an overall mean score of 4.54, indicating strong agreement on their positive impact in learning.

Students strongly agree that immersive simulation tools are easy to navigate and

use (4.70), suggesting that these technologies are user-friendly and accessible for learners. Additionally, they strongly agree that these tools enhance understanding of complex concepts through interactive features (4.75) and improve hands-on skills and practical application (4.80). These findings highlight the tools' ability to simplify difficult topics and bridge the gap between theoretical knowledge and practical skills, making them effective for fostering deeper learning.

Table 2. Perceptions of Students toward the Usability and Effectiveness of Immersive Simulation Tools

Statements	Mean	DI
Immersive simulation tools are easy to navigate and use.	4.70	Strongly Agree
These tools enhance understanding of complex concepts through interactive features.	4.75	Strongly Agree
Immersive simulations improve hands-on skills and practical application.	4.80	Strongly Agree
The tools provide realistic experiences that reflect real-world scenarios.	4.65	Strongly Agree
Technical issues occasionally disrupt the learning process.	4.05	Agree
Immersive tools boost confidence in applying knowledge to real-world tasks.	4.70	Strongly Agree
The cost of acquiring and maintaining immersive tools is a concern.	4.00	Agree
Using these tools encourages active participation and sustained focus during lessons.	4.68	Strongly Agree
Overall Mean	**4.54**	**Agree**

Note: 4.50 – 5.00- Strongly Agree, 4.00 – 4.49- Agree, 3.50 – 3.99- Neutral, 3.00 – 3.49- Disagree, 1.00 – 2.99- Strongly Disagree, DI-Descriptive Interpretation

Students also strongly agree that immersive tools provide realistic experiences that reflect real-world scenarios (4.65), indicating that these tools create authentic environments that prepare learners for challenges they may encounter outside the classroom. Moreover, students perceive immersive simulation tools as effective in boosting their confidence in applying knowledge to real-world tasks (4.70). The tools encourage active participation and sustained focus during lessons, as reflected in the high mean score of 4.68, which emphasizes their ability to engage learners and improve overall academic performance.

Despite the overwhelmingly positive feedback, students acknowledged occasional technical issues (4.05) as a challenge that can disrupt the learning process. While technical disruptions are not frequent, they can interrupt lessons and cause frustration among learners. One student shared, "Sometimes the software freezes or crashes, which interrupts my learning and requires time to fix." This finding aligns with Radianti et al. (2020), who emphasized the importance of addressing technical challenges to optimize immersive technologies in education.

Another limitation noted by students is the cost of acquiring and maintaining immersive tools (4.00), which reflects financial barriers that may limit accessibility for some learners. One student remarked, "These tools are great for learning, but not everyone has access to them because of the cost." This corroborates findings by Ravichandran and Mahapatra (2023), who reported that the high cost of immersive technologies can hinder their widespread adoption, particularly in resource-constrained educational settings.

The strong agreement among students highlights the transformative potential of immersive simulation tools in education. Their

user-friendly design, interactive features, and ability to simulate real-world scenarios make them effective for simplifying complex concepts, developing practical skills, and fostering confidence. These findings are supported by Albarracín-Acero et al. (2024), who demonstrated the effectiveness of virtual reality in enhancing conceptual understanding in technical fields such as engineering and science. Similarly, Petersen et al. (2023) emphasized the role of immersive tools in promoting collaborative and generative learning activities, aligning with students' perceptions of their ability to improve engagement and learning outcomes.

In conclusion, students perceive immersive simulation tools as highly effective for enhancing their understanding, engagement, and practical skills. These tools are recognized for their ability to provide realistic experiences, foster confidence, and encourage active participation. However, addressing technical issues and financial barriers is essential to maximize their potential and ensure wider accessibility. By leveraging the strengths of immersive simulation tools while addressing implementation challenges, educational institutions can empower students to achieve deeper learning and improved academic outcomes.

Instructors' Perceptions Toward the Usability and Effectiveness of Immersive Simulation Tools

Table 3 provides insight into instructors' perceptions of the usability and effectiveness of immersive simulation tools, with an overall mean score of 4.49, indicating strong agreement on their positive impact in teaching and learning.

Instructors strongly agree that immersive simulation tools are intuitive and user-friendly for teaching purposes (4.60), suggesting that these technologies are accessible and easy to integrate into instructional practices. Additionally, instructors strongly agree that these tools help students grasp difficult concepts through interactive learning (4.70) and enhance their ability to perform practical tasks effectively (4.70). These findings highlight the tools' capacity to bridge the gap between theoretical knowledge and practical application, fostering deeper understanding and skill acquisition.

Moreover, immersive tools are perceived as effective in simulating real-world environments that support experiential learning (4.60). This indicates that instructors recognize their value in creating realistic scenarios that prepare students for real-world challenges. Similarly, instructors strongly agree that these tools help students develop confidence in applying theoretical knowledge to practical situations (4.60), further emphasizing their role in building both competence and confidence. The highest-rated statement, "These tools promote student engagement and improve learning outcomes" (4.72), underscores the tools' ability to captivate students' attention and enhance their academic performance through active participation and sustained focus.

Despite the overwhelmingly positive perceptions, instructors acknowledged occasional software glitches (4.00) as a challenge that can disrupt the smooth delivery of lessons. This suggests that while technical issues are not frequent, they can still pose a barrier to effective implementation. One instructor commented, "Although the tools are generally reliable, technical problems can interrupt lessons and require time to resolve." This finding aligns with Radianti et al. (2020), who emphasized the importance of addressing technical issues to optimize the use of immersive technologies in education. Additionally, the cost of implementing immersive tools (4.00) was also identified as a limitation, reflecting financial barriers that may hinder accessibility, particularly in resource-constrained educational institutions. Ravichandran and Mahapatra (2023) similarly noted that the high cost of immersive technologies can limit their adoption in vocational education.

The strong agreement among instructors highlights the transformative potential of immersive simulation tools in education. Their intuitive design, interactive features, and ability to simulate real-world scenarios make them effective for simplifying complex concepts and fostering practical application. These findings are corroborated by Albarracín-Acero et al. (2024), who demonstrated how virtual reality enhances conceptual understanding in technical fields such as electrical circuits. Similarly, Petersen et al. (2023) emphasized the role of

immersive tools in promoting collaborative and generative learning activities, aligning with instructors' perceptions of their ability to improve student engagement and learning outcomes.

In conclusion, instructors perceive immersive simulation tools as highly effective for enhancing student understanding, engagement, and practical skills. These tools are recognized for their ability to simulate real-world environments, foster experiential learning, and promote confidence in applying theoretical knowledge. However, addressing technical glitches and financial barriers is essential to maximize their potential and ensure wider adoption. By leveraging the strengths of immersive simulation tools while addressing implementation challenges, institutions can empower instructors to deliver innovative and impactful learning experiences that benefit students.

Table 3. Perceptions of Instructors on the Usability and Effectiveness of Immersive Simulation Tools

Statements	Mean	DI
1. Immersive simulation tools are intuitive and user-friendly for teaching purposes.	4.60	Strongly Agree
2. These tools help students grasp difficult concepts through interactive learning.	4.70	Strongly Agree
3. Immersive simulations enhance students' ability to perform practical tasks effectively.	4.70	Strongly Agree
4. The tools simulate real-world environments that support experiential learning.	4.60	Strongly Agree
5. Occasional software glitches affect the smooth delivery of lessons.	4.00	Agree
6. Immersive tools help students develop confidence in applying theoretical knowledge.	4.60	Strongly Agree
7. The cost of implementing immersive tools limits their accessibility.	4.00	Agree
8. These tools promote student engagement and improve learning outcomes.	4.72	Strongly Agree
Overall Mean	**4.49**	**Agree**

Note: 4.50 – 5.00- Strongly Agree, 4.00 – 4.49- Agree, 3.50 – 3.99- Neutral, 3.00 – 3.49- Disagree, 1.00 – 2.99- Strongly Disagree, DI-Descriptive Interpretation

Challenges and Limitations in Using Immersive Simulation Tools

Challenges and Limitations Experienced by Students in Using Immersive Simulation Tools

Table 4 outlines the challenges and limitations faced by students when using immersive simulation tools. The most frequently cited challenge is technical issues, reported by 30% of students and ranked first. This aligns with the perceptions in Table 2, where students rated the statement "Technical issues occasionally disrupt the learning process" with a mean of 4.05 ("Agree"). While students strongly agreed (mean = 4.70) that immersive simulation tools are easy to navigate and use, technical disruptions remain a concern that can impact the learning experience. One student shared, "Sometimes the software freezes or crashes during lessons, which interrupts my learning process." This finding highlights the need for improved technical reliability to ensure smoother and uninterrupted learning experiences. Radianti et al. (2020) similarly emphasized the importance of addressing technical challenges to optimize the use of immersive technologies in education.

The second most reported challenge is limited access to equipment, cited by 25% of students. This suggests that not all students have equal opportunities to utilize immersive simulation tools, which may hinder their ability to fully benefit from their features. In Table 2, students strongly agreed (mean = 4.80) that immersive simulations improve hands-on skills and practical application, but limited access to

equipment may restrict the time students can spend practicing these skills. One student remarked, "We often have to wait for our turn to use the tools, which reduces the time we get to practice." This aligns with findings by Abeygunawardena and Jathunga (2024), who noted that access to immersive tools can pose challenges in resource-constrained educational settings, ultimately impacting equitable learning opportunities.

Ranked third, with 20% of students reporting it, is the learning curve associated with using immersive simulation tools. While students strongly agreed (mean = 4.70) that the tools are easy to navigate, some students still face initial difficulties adapting to the technology. One student commented, "It took me some time to understand how to use the tools effectively, and I had to ask for help multiple times." This reflects findings by Cao et al. (2023), which emphasize the importance of providing adequate training and support to ensure students can fully utilize immersive tools. Although most students find the tools user-friendly, the learning curve highlights the need for introductory guidance and structured onboarding to ease the transition to using these tools effectively.

Finally, the cost of access was identified as a challenge by 15% of students, ranking fourth. This aligns with the perceptions in Table 2, where students rated the statement "The cost of acquiring and maintaining immersive tools is a concern" with a mean of 4.00 ("Agree"). While students strongly agreed (mean = 4.68) that these tools encourage active participation and sustained focus during lessons, financial constraints may limit accessibility for some learners. One student commented, "These tools are great for learning, but they're expensive, and not everyone can afford them." This finding corroborates Ravichandran and Mahapatra (2023), who identified cost as a significant barrier to the adoption of immersive technologies in education, particularly in resource-limited contexts.

The results from Table 4, supported by the perceptions in Table 2, demonstrate that while students recognize the usability and effectiveness of immersive simulation tools, addressing these challenges is essential to maximize their potential. Improving technical reliability, ensuring equitable access to equipment, providing introductory training, and exploring cost-effective solutions can help overcome these barriers. As noted by Agbo et al. (2023) and Albarracín-Acero et al. (2024), addressing these challenges can enhance the usability and accessibility of immersive tools, ultimately improving student engagement and learning outcomes. By mitigating these challenges, institutions can ensure that immersive simulation tools reach their full potential in transforming the educational experience for all students.

Table 4. Challenges and Limitations Faced by Students in Using Immersive Simulation Tools

Challenges/ Limitations	f	%	Rank
Technical issues	12	30%	1
Limited access to equipment	10	25%	2
Learning curve	8	20%	3
Cost of access	6	15%	4

Note: f-frequency, %-percentage

Challenges and Limitations Experienced by Instructors in Using Immersive Simulation Tools

Table 5 outlines the challenges and limitations instructors face when utilizing immersive simulation tools. The most frequently cited challenge is technical issues, reported by 28% of instructors and ranked first. This aligns with the perceptions in Table 3, where instructors rated the statement "Occasional software glitches affect the smooth delivery of lessons" with a mean of 4.00 ("Agree"). While instructors strongly agreed that immersive simulation tools are intuitive and user-friendly for teaching purposes (mean = 4.60), technical disruptions remain a concern that can interrupt lesson flow and reduce instructional time. One instructor shared, "The tools are effective, but

when glitches occur, they interrupt the flow of teaching and waste valuable time." This finding highlights the need for improved technical reliability to ensure seamless lesson delivery, as supported by Radianti et al. (2020), who emphasized that technical challenges can hinder the effective adoption of immersive technologies in education.

The second most reported challenge is limited training and support, cited by 22% of instructors. Despite the tools being perceived as intuitive and user-friendly, instructors require adequate preparation and guidance to maximize their potential. In Table 3, instructors strongly agreed (mean = 4.70) that immersive simulations enhance students' ability to perform practical tasks effectively, but limited training can hinder instructors' ability to fully integrate these tools into their teaching practices. One instructor remarked, "We need more workshops and support to fully understand how to use these tools in teaching." This finding aligns with research by Cao et al. (2023), which highlights the importance of providing educators with comprehensive training programs to build confidence and competence in using immersive technologies effectively.

Ranked third, with 19% of instructors reporting it, is the challenge of time constraints. Preparing lessons with immersive simulation tools often requires significant time and effort, which can be difficult for instructors managing multiple responsibilities. While instructors strongly agreed (mean = 4.60) that these tools simulate real-world environments that support experiential learning, the time investment required to plan and implement such lessons can be a barrier. One instructor noted, "Planning lessons with these tools takes too much time, which adds to my workload." This finding is consistent with Abeygunawardena and Jathunga (2024), who observed that time constraints can limit the effective integration of innovative teaching technologies, especially for educators with demanding schedules.

The cost of implementation, cited by 17% of instructors and ranked fourth, is another significant challenge. This aligns with the perceptions in Table 3, where instructors rated the statement "The cost of implementing immersive tools limits their accessibility" with a mean of 4.00 ("Agree"). While instructors recognize the benefits of immersive tools, financial constraints remain a barrier to widespread adoption, particularly in institutions with limited budgets. One instructor commented, "The tools are excellent, but their high cost makes it difficult for schools with limited budgets to adopt them." This finding corroborates Ravichandran and Mahapatra (2023), who highlighted that the high costs of immersive tools can limit their accessibility in educational institutions, especially in underfunded schools.

Finally, student engagement variability was identified as a challenge by 14% of instructors, ranking fifth. This reflects the perception that while immersive tools generally promote engagement (mean = 4.72 in Table 3), not all students respond equally to these technologies. One instructor shared, "Some students are highly engaged, while others seem distracted or uninterested, even with these tools." This finding aligns with Agbo et al. (2023), who emphasized the importance of tailoring teaching strategies to accommodate diverse learning preferences and ensure all students benefit from immersive technologies. This suggests that while immersive tools are generally effective, they may need to be supplemented with differentiated instructional strategies to engage all learners effectively.

The results from Table 5, supported by the perceptions in Table 3, demonstrate that while instructors recognize the effectiveness and usability of immersive simulation tools, addressing these challenges is critical to their successful implementation. Providing technical support, comprehensive training, and sufficient preparation time, as well as exploring cost-effective solutions, can help instructors overcome these barriers. As noted by Azzam et al. (2024) and Albarracín-Acero et al. (2024), addressing these challenges can enhance the usability and effectiveness of immersive tools, ultimately improving teaching outcomes and student learning experiences. By mitigating these challenges, institutions can ensure that immersive simulation tools reach their full potential in transforming education and empowering instructors to deliver innovative and impactful lessons.

Table 5. Challenges and Limitations Faced by Instructors in Using Immersive Simulation Tools

Challenges/ Limitations	f	%	Rank
Technical issues	10	28%	1
Limited training and support	8	22%	2
Time constraints	7	19%	3
Cost of implementation	6	17%	4
Student engagement variability	5	14%	5

Note: f-frequency, %-percentage

Comparison of Learning Outcomes and Engagement Levels Between Immersive Simulation Tools and Traditional Methods

Comparison of Learning Outcomes Between Immersive Simulation Tools and Traditional Methods

Table 6 shows the paired t-test results comparing the learning outcomes of electrical technology students under two different teaching approaches: traditional teaching methods and immersive simulation tools.

The mean score for students taught using traditional methods was 75.4, with a standard deviation (SD) of 8.2, while the mean score for students taught using immersive simulation tools was significantly higher at 85.6, with a standard deviation of 6.5. The t-value of 3.45 and a p-value of 0.002 indicate that the difference in the means is statistically significant at the 0.05 significance level. This suggests a significant improvement in learning outcomes when immersive simulation tools were used.

The results indicate that immersive simulation tools provide a measurable advantage in enhancing students' learning outcomes compared to traditional teaching methods. The higher mean score for immersive simulation tools demonstrates their effectiveness in facilitating better understanding and mastery of practical skills in electrical technology education. The lower standard deviation (6.5 compared to 8.2) also suggests that students' performance under immersive simulation tools was more consistent, indicating a more uniform learning experience.

This finding implies that immersive simulation tools can address gaps in traditional teaching methods, particularly in providing a more engaging and effective learning environment. The use of immersive simulations likely allows students to practice hands-on skills in a safe, controlled, and interactive environment, which can increase their confidence and competence. As noted by Albarracín-Acero et al. (2024), virtual reality enhances the teaching of technical subjects by offering realistic and interactive training environments, which align with the findings of this study. Similarly, Agbo et al. (2023) emphasized that immersive virtual reality tools foster deeper cognitive engagement, which may explain the improved scores observed in this study.

Furthermore, the results corroborate the findings of Brylska et al. (2024), who reported that students demonstrated higher learning efficiency in virtual reality-based lessons compared to traditional methods. This aligns with the present study's results, which show that immersive simulation tools can significantly improve learning outcomes. Additionally, Azzam et al. (2024) highlighted the role of virtual reality in enhancing students' perceived learning experience, which complements the observed improvement in learning outcomes in this study.

The implications of these findings are critical for vocational education, particularly in fields like electrical technology, where hands-on practice is essential. The ability to simulate real-world scenarios without the associated risks of traditional methods, such as working with high-voltage equipment, makes immersive simulation tools a safer and more efficient alternative. The realistic experiences provided by these tools not only enhance learning by closely mirroring real-world tasks but also allow students to practice and make mistakes in a controlled environment, reducing the likelihood of accidents and equipment damage. This is consistent with the findings of Tenzin et al. (2023), who demonstrated that simulation-

based strategies significantly enhance conceptual understanding and practical skills in technical education.

In conclusion, the results presented in Table 6 provide strong evidence that immersive simulation tools are more effective than traditional teaching methods in improving the learning outcomes of electrical technology students. These findings highlight the need for further integration of immersive technologies in vocational education to maximize student learning and skill development. Future research should explore the long-term impact of these tools on students' career readiness and performance in the workplace, as suggested by Long et al. (2024).

Table 6. Paired t-test Results for Learning Outcomes Comparison Between Teaching Methods

Assessment Period	x̄	SD	t-value	p-value	DI
Traditional Teaching Methods	75.4	8.2	3.45	0.002	Significant improvement
Immersive Simulation Teaching	85.6	6.5			

Note: x̄-mean, SD- Standard Deviation, DI-descriptive interpretation

Comparison of Engagement Levels Between Immersive Simulation Tools and Traditional Methods

Table 7 shows the paired t-test results comparing the engagement levels of electrical technology students under two teaching approaches: traditional teaching methods and immersive simulation tools.

The mean engagement score for students taught using traditional methods was 3.8, with a standard deviation (SD) of 0.9, while the mean engagement score for students taught using immersive simulation tools was significantly higher at 4.6, with a standard deviation of 0.6. The t-value of 4.12 and a p-value of 0.000 indicate that the difference in engagement levels between the two teaching methods is statistically significant at the 0.05 significance level. This result demonstrates a substantial improvement in engagement levels when immersive simulation tools were utilized.

The results suggest that immersive simulation tools are more effective in fostering student engagement compared to traditional teaching methods. The higher mean score for immersive simulation teaching indicates that students found these tools more engaging, likely due to their interactive and immersive nature. Furthermore, the lower standard deviation (0.6 compared to 0.9) implies that engagement levels were more consistent across the group, suggesting that immersive simulation tools provide a uniform and reliable platform for maintaining student interest and involvement.

This finding has significant implications for vocational education, where student engagement plays a critical role in mastering practical skills. Immersive simulation tools offer a dynamic and interactive learning environment that can replicate real-world scenarios, making the learning experience more relevant and captivating. As noted by Azzam et al. (2024), immersive virtual reality promotes higher levels of engagement by providing students with experiential learning opportunities that are both stimulating and motivating. Similarly, Agbo et al. (2023) emphasized that immersive technologies encourage active participation and enhance students' perceptions of learning, further supporting the results of this study.

Moreover, the results align with the findings of Brylska et al. (2024), who reported that virtual reality-based lessons significantly increased student attention and interest compared to traditional methods. This corroborates the idea that immersive simulation tools create a more engaging environment, which can help students remain focused and motivated throughout the learning process. Radianti et al. (2020) also highlighted that immersive virtual reality applications in higher education improve student motivation and engagement, which is consistent with the observed improvement in engagement levels in this study.

Furthermore, Petersen et al. (2023) demonstrated that collaborative generative learning activities within immersive environments enhance engagement, suggesting that

the participatory and interactive nature of immersive simulations directly impacts students' involvement in the learning process. This aligns with the findings of Rafiq et al. (2022), who noted that virtual reality improves student engagement in vocational education by offering innovative and immersive approaches to learning.

In conclusion, the results presented in Table 7 provide compelling evidence that immersive simulation tools significantly enhance student engagement levels compared to traditional teaching methods. These tools not only offer a more interactive and stimulating learning environment but also ensure consistent engagement across diverse learners. Future research should investigate how prolonged use of immersive simulation tools impacts long-term engagement and academic performance, as suggested by Cao et al. (2023). Additionally, exploring the integration of collaborative learning strategies in immersive environments could further amplify student engagement and learning outcomes.

Table 7. Paired t-test Results for Engagement Levels Comparison Between Teaching Methods

Assessment	x̄	SD	t-value	p-value	DI
Traditional Teaching Methods	3.8	0.9	4.12	0.000	Significant improvement
Immersive Simulation Teaching	4.6	0.6			

Note: x̄-mean, SD- Standard Deviation, DI-descriptive interpretation

Conclusions

Based on the findings, this study highlights the significant impact of immersive simulation tools in enhancing learning outcomes, engagement levels, and practical skills among electrical technology students. The research demonstrates that these tools provide realistic, interactive, and engaging environments that support hands-on learning, foster deeper understanding, and improve technical proficiency. Immersive simulation tools are shown to bridge the gap between theoretical knowledge and practical application, offering students opportunities to practice in safe and controlled environments that closely mirror real-world scenarios.

Both students and instructors perceive immersive simulation tools as highly effective and user-friendly, emphasizing their ability to simplify complex concepts, enhance skill acquisition, and boost confidence. These tools also promote active participation and sustained focus, making them a valuable resource in technical education. Furthermore, their ability to simulate high-risk environments, such as working with high-voltage equipment, allows students to develop practical skills without the associated dangers, ensuring a safer and more efficient learning experience.

However, the study also identifies challenges that need to be addressed for wider adoption of these tools. Technical issues, limited access to equipment, high costs, and the need for adequate training and support remain significant barriers. These limitations underscore the importance of providing reliable infrastructure, comprehensive training programs, and sustainable funding solutions to ensure equitable access and seamless integration of immersive technologies in education.

Future research should explore ways to overcome these challenges, including cost-effective implementation strategies and partnerships with technology providers. Longitudinal studies tracking the long-term effects of immersive simulation tools on students' career readiness and professional success are also recommended. Additionally, integrating collaborative and gamified learning strategies could further enhance the tools' effectiveness in fostering engagement and improving learning outcomes.

In conclusion, immersive simulation tools represent a transformative innovation in technical education. By addressing the identified challenges and refining their implementation, educational institutions can maximize their potential to prepare students for real-world challenges. These tools have the power to revolutionize technical training, providing students with the skills, confidence, and readiness needed to excel in their chosen fields.

Limitations of the Study

While this study provides valuable insights into the effectiveness of immersive simulation tools in enhancing learning outcomes and engagement among electrical technology students, several limitations must be acknowledged. First, the study was conducted within a single teacher education institution in Ilocos Norte, which may limit the generalizability of the findings to other institutions or regions with differing educational contexts, resources, and student demographics. The sample size, though comprehensive within the institution, may not fully represent the broader population of electrical technology students, particularly those in institutions with varying levels of access to immersive technologies.

Second, the study relied on total enumeration, including all enrolled students and instructors during the second semester of SY 2024-2025. While this approach ensured representation of the target population, the absence of a control group or random sampling may have introduced biases, particularly in the comparative analysis of traditional and immersive teaching methods. Additionally, the study focused solely on electrical technology courses, which limits its applicability to other technical fields or disciplines where immersive simulation tools might yield different results.

Third, the study's reliance on self-reported data through surveys, focus group discussions, and semi-structured interviews may have been influenced by subjective perceptions or social desirability bias. While qualitative methods provided rich insights, the reliance on thematic and content analysis may have introduced researcher bias during the interpretation of qualitative data. Furthermore, while the study demonstrated statistically significant improvements in learning outcomes and engagement, it did not explore the long-term effects of using immersive simulation tools or their impact on students' career readiness and industry performance.

Lastly, technical and logistical constraints posed challenges during the implementation of immersive simulation tools. The study did not account for varying levels of familiarity with technology among participants, which may have affected their ability to fully utilize the tools. Additionally, financial barriers, such as the cost of acquiring and maintaining immersive technologies, were noted but not addressed through specific interventions or solutions. These limitations highlight the need for further research to explore the scalability, sustainability, and long-term impact of immersive simulation tools across diverse educational settings and technical disciplines.

Recommendations

Based on the findings and limitations of this study, several recommendations are proposed to maximize the potential of immersive simulation tools in technical education. Future research should expand its scope to include multiple institutions across diverse regions and technical disciplines, ensuring broader applicability and generalizability of findings. Experimental designs with control groups and random sampling are recommended to minimize biases and strengthen the reliability of comparative analyses. Additionally, studies should focus on the long-term effects of immersive simulation tools, particularly their impact on students' career readiness, skill retention, and industry performance. Furthermore, future research should include longitudinal studies that track student performance and career success post-graduation, providing valuable insights into how immersive simulation tools influence professional outcomes and long-term success in technical fields.

Institutions are encouraged to provide comprehensive training programs for both students and instructors to reduce the learning curve and enhance familiarity with the tools. Regular technical support and troubleshooting mechanisms should also be established to address software glitches and ensure seamless integration into lessons. To overcome financial barriers and limited access to equipment, institutions should explore cost-effective solutions, such as shared resources, partnerships with technology providers, and government funding, while ensuring equitable distribution of tools across students and programs.

Sustainable implementation strategies should align immersive tools with course objectives and include pre-designed templates to reduce instructors' workload. Incorporating

collaborative and gamified learning approaches can further enhance student engagement and motivation. Institutions should invest in reliable infrastructure to minimize technical disruptions and explore financial support mechanisms, such as subsidies or grants, to make these tools more accessible. Personalizing learning experiences through adaptive features and tailored feedback systems can address engagement variability and ensure inclusivity.

Lastly, continuous monitoring and evaluation mechanisms should be established to assess the effectiveness of immersive simulation tools, gather feedback, and refine implementation strategies. By addressing these recommendations, institutions can foster innovative, engaging, and impactful learning experiences that prepare students for real-world challenges and careers in technical fields.

Acknowledgement

The researchers sincerely thank the Dean, faculty members, and staff of the Teacher Education Institution in Ilocos Norte for their support and permission to conduct this study. Gratitude is extended to the third-year electrical technology students and instructors who participated and shared their valuable insights. Appreciation is also given to the panel of experts for validating the research instruments and providing constructive feedback.

Lastly, the researchers acknowledge the encouragement and guidance of family, friends, and mentors, whose support made this study possible.

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