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Effects of Simulation on Students Achievement, Retention, and Skill Performance in Motor Vehicle Mechanic in Niger State, Nigeria

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Abstract

Traditional teaching methods, such as lectures, have long been criticized for their lack of innovation and passive learning approach, particularly in technical disciplines like Motor Vehicle Mechanics (MVM). This study explores the impact of simulation-based instruction, using the Motor Vehicle Mechanic Computer Animation Instructional Package (MVMCAIP), compared to conventional methods in enhancing students' achievement, retention, and skill performance. Employing a quasi-experimental and descriptive multi-method design, the research was conducted across technical colleges in Niger State, involving 118 Technical College II students. Of these, 58 students were taught using MVMCAIP, while 60 received traditional instruction. Data collection tools included the Motor Vehicle Mechanic Achievement Retention Test (MVMART), the Motor Vehicle Mechanic Skill Performance Test (MVMSPT), and lesson plans. Findings reveal that simulation-based instruction significantly enhances student performance across all metrics, with gender influencing achievement scores but showing no significant interaction effect with instructional methods. These results highlight the potential of simulation tools to revolutionize technical education by providing interactive, engaging, and effective learning experiences. The study recommends integrating simulation technologies like MVMCAIP into MVM curricula and prioritizing professional development programs to enhance educators' proficiency with these tools, paving the way for more impactful and future-ready technical education.

Keywords: Student achievement and retention; Motor Vehicle Mechanic (MVM); Simulation-based instruction; Technical education innovation; Skill performance

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Introduction

Educators express significant concern about effective teaching and learning methods, recognising their substantial influence on students' skills such as innovation, collaboration and critical thinking (Isaac et al., 2021). Though widely used, traditional teaching approaches, such as lectures, role-playing, and demonstrations, have faced criticism for their lack of innovation and tendency to promote passive learning (Dietrich & Evans, 2022). The adverse outcomes of the lecture method, including reduced student motivation and achievement, have been noted (Ramadhani, 2021).

Several studies have explored instructional strategies' influence on academic outcomes, revealing that teaching methods significantly affect students' achievement, retention, and skill performance (ARS). One noteworthy investigation by (Markard, 2020) focused on applying task instruction sheets (TIS) in metalwork technology education, demonstrating the effectiveness of TIS in enhancing students' psychomotor achievement and retention compared to conventional methods. The study recommended the adoption of TIS in teaching metalwork, emphasising the need for sufficient instructional materials. The current research landscape strongly emphasises examining different instructional approaches concerning students' ARS across various educational domains. Yet, Chernikova et al., (2020) observed that a distinct void is apparent in exploring the effects of simulation in vocational and technical education, specifically in MVM trades, leading to a global shortage of literature on this topic.s

MVM, a specialized subset of mechanical engineering, is experiencing a growing demand for professional expertise, which requires targeted educational objectives (Mustapha et al., 2022). The intricacies of the automobile industry

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require identifying instructional techniques that enhance academic and technical competency, encompassing occupational and employability skills (Kanife et al., 2022). The integration of simulation in education has transformed learning, enabling teachers to guide students collectively in problem-solving (Chernikova et al., 2020). Despite the growing recognition of simulation as an effective tool for enhancing achievement, retention, and skill performance (ARS) in various educational fields (Chen, 2021), there is limited research on its specific impact in the context of vocational education, particularly in the MVM field in Niger State, Nigeria. This study aims to fill this gap by examining how simulation can improve the ARS outcomes for students in this discipline, addressing the need for more evidence-based strategies to enhance technical education in the region. The shift from instructor-centered to learner-centered instruction is essential for acquiring 21st-century workplace skills (Atibuni et al., 2022; Wulandari, 2021).

Discussions on student retention focus on the fundamental function of teaching methods in shaping learning outcomes across education levels. Ineffective approaches hinder knowledge retention, impede learning objective recognition, and impact skill execution. Traditional teaching structures, criticised for falling behind the rapid changes in the automobile industry, are deemed insufficient in producing professionals adaptable to modern society. Aligning simulation with student preferences emerges as crucial for achieving higher success in MVM education in Niger State technical colleges. Past attempts to address issues in the automobile trade have lacked concerted efforts, negatively impacting students' performance. Recognising the need for a shift in instructional methods, particularly in technical colleges (TC), to incorporate technology and support teachers becomes imperative in addressing the persistent problem of poor student performance in the MVM trade. The research aims to address issues related to student retention and performance by investigating how simulation impacts ARS in MVM within TC in Niger State, as outlined in Figure 1 (objectives) and Figure 2 (Hypotheses).

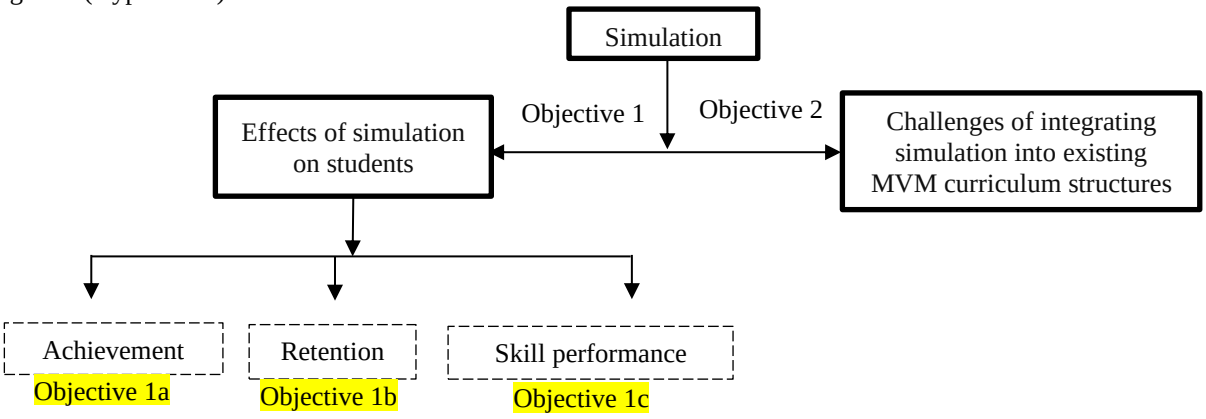

Figure 1. Research Objectives

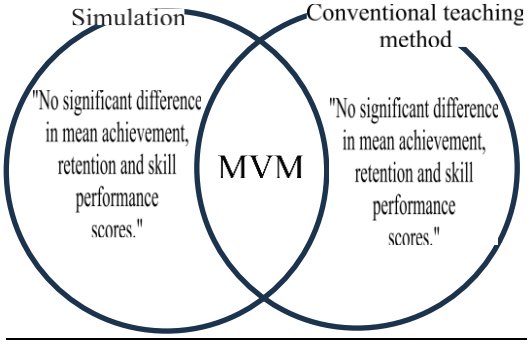

Figure 2: Hypotheses of the study ($p < .05$)

Figure 2 illustrates the hypotheses of the study, comparing the effectiveness of the Simulation teaching method and the Conventional teaching method. The overlapping section of the Venn diagram highlights the primary finding: there is no significant difference in terms of mean achievement, retention, and skill performance scores between the two

methods, as indicated by a significance level of $p < .05$. This result suggests that both teaching approaches yield comparable outcomes, providing evidence that either method can be effectively implemented without a notable advantage over the other. The findings emphasize that educators can choose the most suitable method based on contextual needs or preferences without compromising the overall learning outcomes.

Method

This study adopted a multi-method research design that combined quasi-experimental and descriptive approaches. The descriptive aspect involved administering a questionnaire, while the quasi-experimental design used a pre-test and post-test non-equivalent control group structure (John & Timothy, 2021). Quasi-experimental methods were chosen to minimize disruptions to academic schedules by avoiding random sampling and group assignments. Intact classes of students were assigned to experimental and control groups to assess the impact of simulation-based instruction on students' Achievement, Retention, and Skill performance (ARS) in Motor Vehicle Mechanics (MVM).

The study population comprised Technical College II (TC II) students specializing in MVM from Government Technical Colleges in Eyagi-Bida, Minna, and Kontagora. A total of 216 students were selected through simple random sampling, with intact classes allocated to experimental and control groups based on zoning considerations. The study employed the Motor Vehicle Mechanic Computer Animation Instructional Package (MVMCAIP), the Motor Vehicle Mechanic Achievement Retention Test (MVMART), and the Motor Vehicle Mechanic Skill Performance Test (MVMSPT) for data collection. The MVMCAIP, developed by the researcher using HTML5, served as the instructional tool, while the MVMART and MVMSPT measured students' achievement, retention, and skill performance in topics such as onboard diagnostics, troubleshooting automotive electronic ignition systems, engine performance evaluation, and the operational principles of two-stroke and four-stroke Spark Ignition Engines (SIE).

The MVMART included 20 multiple-choice questions (MCQs) with four answer options, using a rating system to assess performance levels. The MVMSPT employed a scoring rubric aligned with the National Business and Technical Examinations Board (NABTEB) framework (Mohammed, 2022). A retention test was administered two weeks after the post-test to measure long-term retention. The experimental group received simulation-based instructional lesson plans, while the control group was taught using traditional methods. Both groups participated in pre-tests, post-tests, and retention assessments. To ensure consistency, the researcher developed six tailored lesson plans aligned with the study's objectives. Each plan included clear learning goals, activities for recall enhancement, and motor skill performance assessments. Regular subject teachers from participating schools conducted the lessons to maintain uniformity and minimize experimental bias, while the researcher refrained from directly administering the research instruments.

Instrument validation encompassed face and content validation, alongside test-retest reliability and inter-rater reliability evaluations. Reliability testing at GTC Eyagi-Bida yielded a test-retest reliability score of 0.83, determined using the Pearson Product Moment Correlation Coefficient (PPMC) over two weeks. Inter-rater reliability for MVMART, assessed by three raters using a scoring guide on 25 pilot students, achieved a Kendall's Coefficient of Concordance of 0.76, indicating strong agreement. The MVMSPT's internal consistency, measured using Cronbach's Alpha, demonstrated a reliability coefficient of 0.87, suitable for non-dichotomously scored items. Data analysis involved descriptive statistics (mean and standard deviation) and Analysis of Covariance (ANCOVA) to determine the impact of simulation-based instruction on ARS, adjusting for initial group differences. This robust methodology ensured the reliability and validity of findings, providing meaningful insights into the role of simulation in technical education.

Results and Discussion

Result

The integration of innovative teaching methods, such as simulation-based learning, has gained attention in recent years for its potential to enhance student outcomes in technical education. This study aimed to investigate the effectiveness of simulation-based instruction compared to traditional teaching methods in the context of Motor Vehicle Mechanic (MVM) education in Niger State technical colleges. The focus was on three key areas: students' academic achievement, retention of learning, and skill performance. The following sections present the findings of this research, highlighting the differences observed between the experimental group (taught using simulation) and the control group (taught using

traditional methods). The results are analyzed to provide insights into the impact of simulation-based learning on student performance and to identify challenges associated with its integration into the existing curriculum.

Research Objective 1a: Effect of simulation on students' achievement in MVM trade in Niger State technical colleges.

This objective sought to compare the impact of simulation-based learning and traditional teaching methods on students' academic performance in technical colleges in Niger State as shown in Figure 3.

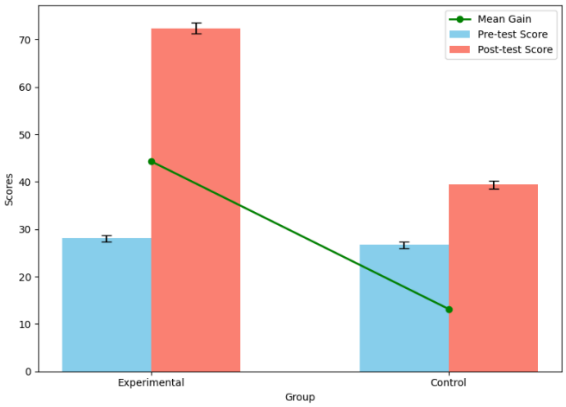

Figure 3. Effect of simulation on students' achievement

Figure 3 illustrates the impact of simulation-based learning on students' achievement in Motor Vehicle Mechanic (MVM) education. The experimental group, which underwent simulation-based learning, exhibited a significant improvement in academic performance. The pre-test mean score for this group was 28.10 (SD = 0.70), while the post-test mean score increased to 72.41 (SD = 1.12), resulting in a mean gain of 44.31. This substantial increase indicates the positive influence of simulation on student achievement. In contrast, the control group, which received traditional teaching methods, demonstrated a smaller improvement. The pre-test mean score for the control group was 26.67 (SD = 0.67), and the post-test mean score was 39.38 (SD = 0.81), reflecting a mean gain of 13.16. The error bars in the graph show that the experimental group exhibited more consistent performance, with less variability in their post-test scores. On the other hand, the control group showed greater variability, suggesting that while both groups improved, the simulation-based approach led to more stable and reliable learning outcomes. These results indicate that simulation-based learning not only enhances academic achievement but also fosters more consistent and reliable performance in technical education. This suggests that incorporating simulations into the curriculum can be an effective strategy to improve student learning and achievement in the MVM trade.

Research Objective 1b: Effect of simulation on students' retention in MVM trade in Niger State technical colleges

This objective sought to compare the impact of simulation-based learning and traditional teaching methods on students' retention of learning in technical colleges in Niger State as shown in Figure 4.

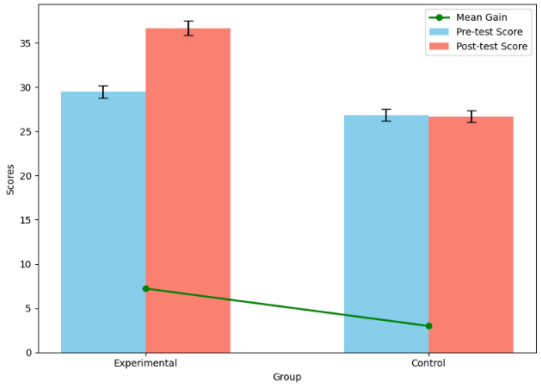

Figure 4. Effect of simulation on students' retention

Figure 4 illustrates the effect of simulation-based learning on students' retention in Motor Vehicle Mechanic (MVM) education. The experimental group, which was exposed to simulation-based learning, showed a notable improvement in retention. The pre-test mean score for this group was 29.46 (SD = 0.71), while the post-test mean score increased to 36.68 (SD = 0.80), resulting in a mean gain of 7.22. This gain indicates a significant enhancement in the ability of the experimental group to retain the learned material.

In contrast, the control group, which received traditional teaching methods, demonstrated a smaller improvement in retention. The pre-test mean score for the control group was 26.83 (SD = 0.67), and the post-test mean score was 26.67 (SD = 0.67), showing a mean gain of only 2.99. The error bars in the graph reveal that the experimental group exhibited more consistent retention, with less variability in their post-test scores, whereas the control group displayed greater variability. This suggests that simulation-based learning not only improves retention but also leads to more stable and reliable learning outcomes. These results highlight the effectiveness of simulation-based instruction in enhancing students' retention of knowledge in technical education. By engaging students in realistic scenarios and hands-on experiences, simulations help strengthen their ability to retain and apply the learned content over time.

Research Objective 1c: Effect of Simulation on Students' Skill Performance in MVM Trade in Niger State Technical Colleges

This objective aimed to compare the impact of simulation-based learning and traditional teaching methods on students' skill performance in Motor Vehicle Mechanic (MVM) education at technical colleges in Niger State, as illustrated in Figure 5.

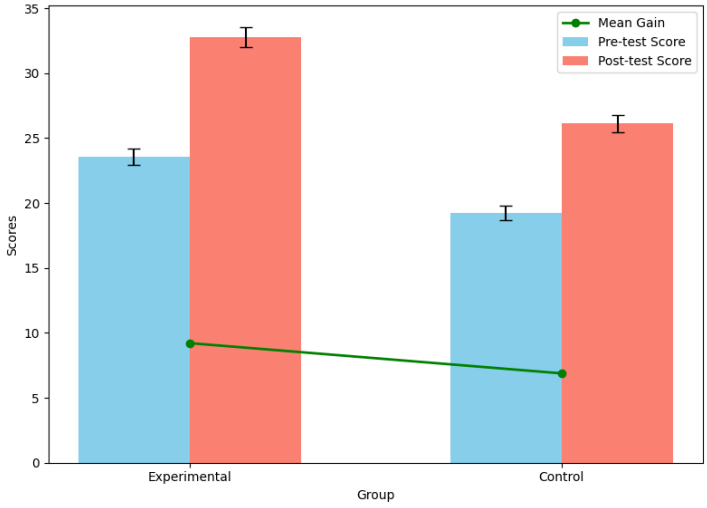

Figure 5. Effect of simulation on students' skill performance test

Figure 5 illustrates the impact of simulation-based learning on students' skill performance. The experimental group, which initially had a pre-test mean score of 23.55 (SD = 0.64), achieved a post-test mean score of 32.76 (SD = 0.75), resulting in a significant mean gain of 9.21. This improvement reflects a substantial enhancement in skill performance. In contrast, the control group, starting with a pre-test mean score of 19.23 (SD = 0.57) and a post-test mean score of 26.11 (SD = 0.66), demonstrated a smaller mean gain of 6.88. The error bars for the experimental group suggest a more consistent performance, highlighting the effectiveness of simulation-based learning in fostering reliable and meaningful improvements in skill development.

Research Objective 2: Challenges of integrating simulation into existing MVM curriculum structures

This objective aimed to identify and assess the challenges associated with integrating simulation-based learning into the existing Motor Vehicle Mechanic (MVM) curriculum structures, as presented in Table 1.

Table 1. Challenges of integrating simulation into existing MVM curriculum structures.

S/N	Item	Mean		Standard Deviation
		Statistics	Std. Error	
1	Technological infrastructure	4.6396	.05694	.59989
2	Training and familiarity	4.7928	.04267	.44959
3	Cost	4.4685	.07443	.78416
4	Resources	3.7297	.13662	1.43936
5	Curricular adaptation	4.2703	.04779	.50355
6	Resistance to change	4.5405	.06866	.72342
7	Limited access for students	4.3153	.05862	.61765
8	Maintenance and technical issues	4.7387	.04189	.44131
9	Student readiness	4.4505	.07651	.80610
10	Limited customisation	3.9820	.12275	1.29321
11	Assessment methods	4.6667	.05012	.52800

Analysis: Table 1 outlines the challenges faced in integrating simulation-based learning into the MVM curriculum. The highest mean score, 4.7928 (SD = 0.44959), was recorded for "Training and familiarity," suggesting that a lack of adequate training and familiarity with simulation tools is a significant barrier. This challenge is followed closely by "Technological infrastructure," with a mean of 4.6396 (SD = 0.59989), indicating concerns about the availability and adequacy of technological resources necessary for simulation-based learning.

Other notable challenges include "Maintenance and technical issues" (mean = 4.7387, SD = 0.44131), which highlights the need for consistent upkeep and technical support for simulation tools, and "Resistance to change" (mean = 4.5405, SD = 0.72342), reflecting the reluctance among some stakeholders to adopt new teaching methods. "Cost" (mean = 4.4685, SD = 0.78416) and "Student readiness" (mean = 4.4505, SD = 0.80610) were also identified as significant obstacles to the successful implementation of simulation in the curriculum, emphasizing financial constraints and the necessity of preparing students for new learning approaches.

While challenges such as "Limited customization" (mean = 3.9820, SD = 1.29321) and "Resources" (mean = 3.7297, SD = 1.43936) were found to be less critical, they still represent barriers that need attention. Additionally, "Curricular adaptation" (mean = 4.2703, SD = 0.50355) and "Assessment methods" (mean = 4.6667, SD = 0.52800) highlight the need for curriculum adjustments and the development of appropriate evaluation strategies to effectively incorporate simulation-based learning into the existing educational framework. These findings suggest that while there are several challenges to overcome, addressing issues related to training, technology, and curriculum adaptation could significantly improve the integration of simulation into the MVM curriculum.

Hypotheses Testing

The Analysis of Covariance (ANCOVA) results were conducted on students' achievement, retention, and skill performance in Motor Vehicle Mechanics, examining the effects of teaching methods, gender, and their interaction as shown in Table 2.

Table 2. Summary of Analysis of Covariance (ANCOVA) of Students' Achievement, Retention and Skill Performance in Motor Vehicle Mechanics

Source	Sum of Squares	df	Mean of Square	F	Sig.
Factor A (Methods)	0.71	1	0.71	0.67	0.77
Factor B (Gender)	21.81	38	7.27	0.10	0.04
Interaction (Method x Gender)	19.97	1	19.97	21.65	0.00
Error	21.81	3	6.92		
Total	64.30	43			

Table 2 summarizes the Analysis of Covariance (ANCOVA) for students' ARS in MVM. The analysis shows that Factor A (Methods), with a sum of squares of 0.71 (Mean Square = 0.71), has an F-value of 0.67 and a significance value of 0.77, indicating no significant effect of teaching methods on students' performance. Factor B (Gender), with a sum of squares of 21.81 (Mean Square = 7.27), has an F-value of 0.10 and a significance value of 0.04, suggesting a significant gender effect on performance. The Interaction (Methods × Gender) term, with a sum of squares of 19.97 (Mean Square

= 19.97), shows an F-value of 21.65 and a significance value of 0.00, indicating a significant interaction effect between teaching methods and gender. The error term has a sum of squares of 21.81 (Mean Square = 6.92), and the total sum of squares is 64.30, with 43 degrees of freedom.

Discussions

The impact of simulation on students' achievement in MVM is evident from the significant improvement observed in the simulation-based instruction group. This finding supports the work of (Kralikova & Lumnitzer, 2022), who emphasise the crucial role of technology, particularly simulations, in boosting academic performance in technical education. Moreover, the experimental group's post-test mean score exceeded that of the control group, further confirming the effectiveness of the simulation approach. This finding is consistent with (Mustapha, 2016) that the positive influence of technology on achievement, especially in technical disciplines paves the way for further investigation into how simulation can impact other educational outcomes, such as retention.

Regarding retention, the experimental group showed a greater mean gain than the control group. It demonstrated the significant role of simulation-based technology in supporting long-term learning retention. This result echoes the findings of (Liu & Pei, 2023), who argue that technology-enhanced learning contributes to sustained comprehension over time. Additionally, the experimental group's higher post-test mean score further reinforces the idea that technology-driven methods promote the retention of learning outcomes. This suggests that the advantages of simulation-based instruction extend beyond immediate achievement and have a lasting impact on students' ability to retain knowledge (Abubakar et al., 2019).

Skill performance was another area where the experimental group outpaced the control group. The higher mean gain in the experimental group supports (Lee et al., 2023) that underscores the efficacy of simulation in enhancing practical skills within technical education. Furthermore, the post-test mean score for the experimental group exceeded that of the control group, consistent with (Bracco et al., 2022), who found that simulation plays a vital role in improving practical skills in technical fields. These findings collectively suggest that simulation enhances academic achievement and retention and significantly contributes to developing essential skills in technical subjects.

However, the challenges of integrating simulation into the existing MVM curriculum remain a critical concern. The study highlights barriers such as the need for technological infrastructure, adequate training, cost implications, and resistance to change—issues that align with those discussed by (Mustapha et al., 2022) regarding technology integration in education. Despite the positive attitudes towards incorporating simulations into the MVM curriculum, these challenges underscore the complexities of implementing educational technology effectively. Overcoming these obstacles is essential to fully realising the prospective gains of simulation-based lessons.

The study also revealed that instructional method alone (Factor A) did not significantly affect students' achievement, retention, or skill performance. This finding is consistent with the research of (Bellibas et al., 2022), who emphasise that multiple factors, rather than instructional methods alone, shape educational outcomes. While the gender factor (Factor B) did show a small but statistically significant effect, aligning with (Mustapha, 2016), the impact was minor, suggesting that gender differences in educational outcomes are nuanced. This finding supports (Gong, 2024), who highlight the complex nature of gender-related influences on learning. Furthermore, the significant interaction effect (MoXGender) underscores the significance of reflecting on both methods and gender when developing teaching instruction. This aligns with (Guerrero Puerta, 2023), who advocate for comprehensive approaches that account for diverse student characteristics and preferences. These insights call for a more nuanced understanding of the factors influencing educational outcomes, particularly when integrating innovative instructional methods like simulation.

Conclusions and Suggestions

Conclusions

This study provides compelling proof of the positive impact of simulation on students' ARS in MVM within technical colleges. The experimental group, exposed to the simulation-based instructional method, showed significant improvements across these key educational outcomes compared to the control group. These outcomes are coherent with

existing studies, highlighting the crucial role of technology—particularly simulations—in enhancing academic achievement, promoting long-term learning retention, and improving practical skills in technical education.

The study's implications underscore the potential for transformative changes in educational practices through the integration of simulation. The observed improvements in achievement, retention, and skill performance suggest broader implications for developing the value of technical education, thus, making it more appropriate to the evolving demands of contemporary industries. Policymakers should consider these findings when developing educational policies related to technical education. Emphasising incorporating innovative instructional methods and addressing the integration challenges can create a more skilled workforce better aligned with industry needs. Furthermore, this study opens avenues for future research in simulation-enhanced education. Subsequent studies could examine specific elements of instructional design, assess the continuing impacts of simulation-based learning, and explore the complex relationships between instructional methods, gender, and student outcomes. Such research will deepen our understanding of how simulation can improve educational practices and outcomes in technical fields.

Suggestions

Based on the positive outcomes observed, it is recommended that:

1. Educational institutions consider integrating simulation methods, such as the Motor Vehicle Mechanic Computer Animation Instructional Package (MVMCAIP), into the existing MVM curriculum. This integration should be accompanied by infrastructure development, training programs, and resources to ensure effective implementation.
2. Given the challenges identified in integrating simulation, educators should receive ongoing professional development to enhance their familiarity and proficiency with simulation technologies. Training programs should address resistance to change, adapt to curricular needs, and effectively utilise assessment methods aligned with simulation-based instruction.
3. Educational institutions should invest in the necessary technological infrastructure to overcome challenges related to technological readiness, maintenance, and accessibility. This includes ensuring reliable access to simulation tools, promptly addressing technical issues, and providing adequate support for students and educators.
4. Future interventions should adopt a comprehensive approach that accounts for instructional methods and gender differences. This inclusive strategy ensures that educational initiatives are tailored to students' diverse characteristics and preferences.

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Contribution: Aliyu Mustapha: Contributed to methodology development, formal analysis, investigation, data coding, report writing, as well as reviewing and editing the manuscript. Robert Ogbanje Okwori: Responsible for conceptualization, manuscript review, editing, and overall supervision of the study. Abdullahi Abubakar Kutiriko: Provided expertise in study design, manuscript review, and editing. Abdullahi Raji Egigogo: Facilitated resources, data curation, and contributed to reviewing and editing the manuscript.

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