Effect of Virtual Reality in Developing Entrepreneurial Skills of At-Risk Secondary School Students in Sokoto State

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Abstract

In an era where economic challenges require innovative solutions, integrating technology with education is essential for fostering an entrepreneurial mindset. The research is grounded in Kolb's Experiential Learning Theory (ELT), to explore the potential of Virtual Reality (VR) technology in developing entrepreneurial skills among at-risk secondary school students in Sokoto State, Nigeria by emphasizing the importance of hands-on experiences in learning. The study employed a quasi-experimental design with a sample of 50 students, divided into experimental and control groups. The experimental group was exposed to VR simulations designed to enhance entrepreneurial skills, while the control group continued with traditional curriculum methods. Data analysis revealed that the experimental group showed significant improvements in entrepreneurial mindset, self-awareness, integration of concepts, and active experimentation abilities, with p-values less than 0.001 and large effect sizes (Cohen's d > 0.8). These results showed that VR is an effective tool for fostering entrepreneurial skills, offering an engaging and immersive learning experience that can better prepare students for real-world challenges. The study highlighted the potential of VR in transforming educational practices, particularly for at-risk students, and calls for its integration into educational policies and curricula. The findings underscore the importance of utilising technology to equip students with the necessary skills to navigate an increasingly complex and interconnected world.

Keywords: Virtual Reality, Entrepreneurial Mindset, Experiential Learning, At-Risk Students, Skill Development

Introduction

In the 21st century, addressing communal challenges, particularly economic concerns, requires knowledge that integrates technology and creativity (UNESCO, 2023). This equips

individuals with skills to navigate contemporary anxieties in an interconnected world. An entrepreneurial mindset encompassing attitudes, behaviours, and competencies such as strategic thinking, financial literacy, leadership, and communication is critical for success, driving economic growth and development both in business creation and within existing organizations (Daniel & Ganiyu, 2021).

McGrath and MacMillan (2020) describe the entrepreneurial mindset as involving cognitive processes that enable individuals to identify opportunities, embrace innovation, and adapt to environmental changes, characterized by a high tolerance for ambiguity and risk. Studies by Ayala and Manzano (2018) and Corner, Singh, and Pavlovich (2017) emphasize resilience and adaptability as crucial for navigating setbacks and adjusting strategies effectively.

Moreover, recent studies have highlighted the role of resilience and adaptability in entrepreneurial success. Ayala and Manzano (2014) found that resilient entrepreneurs are better equipped to handle setbacks and persist in the face of challenges, thereby increasing their chances of success. Similarly, Corner, Singh, and Pavlovich (2017) suggest that adaptability enables entrepreneurs to pivot and adjust their strategies in response to changing market conditions, which is essential for long-term sustainability.

At-risk students are those who are enrolled in schools located in areas affected by banditry, terrorist attacks, kidnappings for ransom, and retaliatory violence stemming from tribal conflicts. These volatile circumstances have significantly disrupted the educational environment, prompting government interventions such as relocating some schools to safer areas, merging others, and closing down certain institutions. For at-risk students, developing creative and innovative skills is crucial. These skills empower students to overcome challenges and thrive in diverse environments (Adamu, Samaila, Murtala, & Ibrahim, 2023). Creative skills like idea generation and problem-solving encourage fresh perspectives, while innovation skills foster an entrepreneurial mindset essential for adapting to a dynamic world. Activities such as brainstorming, artistic expression, design thinking, and collaborative projects enhance these skills, enabling students to leverage diverse perspectives and turn ideas into action (Samuel, Onasanya, & Yusuf, 2019).

Developing creative and innovation skills in at-risk secondary school students holds immense potential for their personal growth and future success. These skills not only empower students to overcome challenges but also equip them with tools to thrive in diverse environments. Creative skills, such as idea generation and problem-solving, enable students to approach

situations with a fresh perspective and devise innovative solutions. Through activities like brainstorming sessions and visual artistic expression in entrepreneurship, students can unleash their creativity and explore new avenues of self-expression.

Moreover, fostering innovation skills among at-risk students cultivates an entrepreneurial mind-set essential for adapting to an ever-changing world. By instilling design thinking principles, students learn to empathize with others, identify needs, and develop solutions that address real-world problems (S. S. Danmali et al., 2024). Collaborative projects and networking opportunities further enhance students' ability to work effectively in teams, leverage diverse perspectives, and turn ideas into action (Hossein Shokri, 2024). Embracing technology as a tool for innovation, students gain digital literacy and coding skills, enabling them to create tech-based solutions and navigate the digital landscape with confidence.

Creating an environment conducive to creativity and innovation is paramount in supporting at-risk secondary students on their journey of skill development. Mentorship programme offer guidance and inspiration, helping students navigate challenges and realize their potential, this by providing them access to resources, such as art supplies and technology, that facilitates hands-on learning experiences and encourages experimentation (Prafulla, 2023). Additionally, using modern technologies that offer extracurricular activities fosters experiential learning, where students can apply their creative and innovative skills to real-world scenarios. Virtual Reality (VR) technology has emerged as a transformative tool in education, offering immersive and interactive experiences that can enhance learning and assessment processes. In this context it focuses on the application of VR in assessing the creative skills of at-risk secondary school students in Sokoto State. As these students often facing numerous socio-economic challenges, they benefit significantly from innovative educational tools that provide engaging and supportive learning environments that require them to showcase their experiences. Kolb's Experiential Learning Theory (ELT) (1984) emphasised the importance of experience in learning, highlighting hands-on experiences like simulations and internships as crucial for developing entrepreneurial abilities. VR can provide these immersive, interactive, and anxiety-reducing learning environments, particularly beneficial for at-risk secondary students (Kolb, 2008).

Experiential Learning Theory (ELT) of Kolb (1984) asserts that "learning is the process whereby knowledge is created through the transformation of experience". Research by Neck and Greene (2011) discusses the importance of experiential learning in developing an entrepreneurial

mind-set. They argue that hands-on experiences, such as simulations, internships, and project-based learning, are crucial for cultivating the skills and attitudes necessary for entrepreneurship. This approach allows individuals to practice and refine their entrepreneurial abilities and soft skills development (Yeni Erita et al., 2024)

Statement of the problem

Creating employment opportunities for all individuals to achieve self-reliance is a strategic objective recognised by authorities as a critical pathway to fostering sustainable development and ensuring lasting peace within the volatile regions. As noted by UNESCO (2023), the ability to integrate these elements into education is crucial for equipping individuals with the skills necessary to navigate an increasingly interconnected and complex world. A key component of these skills is an entrepreneurial mindset, which includes strategic thinking, financial literacy, leadership, and communication—competencies that are essential for driving economic growth and development, both in creating new businesses and within established organizations (Daniel & Ganiyu, 2021). However, developing such a mindset is particularly challenging for at-risk students in volatile regions like Sokoto State, where violence and instability further exacerbate educational disadvantages. These students often lack access to the resources and opportunities needed to cultivate creativity, innovation, and resilience skills that are critical for overcoming the adversities they face and for thriving in diverse and dynamic environments (Adamu, Samaila, Murtala, & Ibrahim, 2023). For these students, traditional educational methods may not be sufficient to foster the entrepreneurial mindset needed to adapt to the demands of the modern world.

Research by McGrath and MacMillan (2020) highlights the importance of cognitive processes in entrepreneurship, including the ability to identify opportunities, embrace innovation, and tolerate ambiguity and risk. Furthermore, studies by Ayala and Manzano (2018) and Corner, Singh, and Pavlovich (2017) emphasize that resilience and adaptability are crucial for navigating setbacks and adjusting strategies effectively traits that are particularly important for at-risk students who face unique challenges in their educational and personal lives.

Virtual Reality (VR) technology offers a promising solution by providing immersive, interactive, and anxiety-reducing learning environments that can enhance the development of entrepreneurial skills. Grounded in Kolb's Experiential Learning Theory (ELT) (1984), VR can simulate real-world experiences that allow students to engage in concrete experiences, reflective observation, abstract conceptualization, and active experimentation. These experiences are

especially valuable for at-risk secondary students, who may benefit from the hands-on, engaging nature of VR to build critical entrepreneurial abilities.

Despite the potential benefits, the use of technology, particularly VR, in educational settings in Sokoto State remains limited. This gap therefore intrigues the need for innovative approaches that can bridge the divide and provide at-risk students with the tools they need to succeed. The study aims to apply experiential learning principles through VR to harness the entrepreneurial talents of at-risk students in Sokoto State. By using immersive technology, it seeks to facilitate skill enhancement and empower students to engage in business ventures, contributing to economic growth and social development. this research explores VR's potential in transform hands-on learning and skill acquisition, preparing students for professional success.

This research aims to develop a simpler and faster method for identifying technologies that can make students self-reliant, ultimately benefiting the community. The study holds significant potential for various stakeholders including Government At-risk students and general society. As the government seeks solutions to support at-risk students in overcoming their life experiences and becoming self-sufficient, this research provides valuable insights and recommendations for effective interventions in a short period. For At-risk Students facing challenging circumstances and perceiving themselves as lacking value, this research uncovers their hidden skills and empowers them to use these abilities to create art, benefiting both themselves and the community. The broader community will benefit from this research by gaining strategies to identify and support individuals in distress, thereby contributing to collective well-being and societal improvement.

Purpose of the Study

The main purpose of the study is to explore how virtual reality could be used to extract and develop Entrepreneurial Skills of At-Risk Secondary School Students in Sokoto State. Specifically, the study tends to:

i. Evaluate the effectiveness of virtual reality simulations in offering concrete experiences that foster entrepreneurial mindset and skills.
ii. Explore how virtual reality-facilitated reflective observation enhances critical reflection leading to self-awareness in entrepreneurial challenges.
iii. Investigate how abstract conceptualization via virtual reality platforms enhances the integration of entrepreneurial concepts and theories.

iv. Evaluate how virtual reality applications facilitate active experimentation for entrepreneurial principles in practical scenarios.

Research Questions

To achieve the above specific objectives, the study sought to answer the following questions:

i. How effective are virtual reality simulations in offering concrete experiences that foster entrepreneurial mindset and skills?
ii. In what ways does virtual reality-facilitated reflective observation enhance critical reflection leading to self-awareness in entrepreneurial challenges?
iii. How does abstract conceptualization through virtual reality platforms enhance the integration of entrepreneurial concepts and theories?
iv. How do virtual reality applications facilitate active experimentation with entrepreneurial principles in practical scenarios?

Research Hypothesis

The study sought to test the following null hypotheses:

Ho_1: Virtual reality simulations do not significantly offer concrete experiences that foster an entrepreneurial mindset and skills among at-risk secondary school students.

Ho_2: Virtual reality-facilitated reflective observation does not significantly enhance critical reflection leading to self-awareness in entrepreneurial challenges among at-risk secondary school students.

Ho_3: Virtual reality platforms for abstract conceptualization do not significantly enhance the integration of entrepreneurial concepts and theories among at-risk secondary school students.

Ho_4: Virtual reality applications do not significantly facilitate active experimentation for entrepreneurial principles in practical scenarios among at-risk secondary school students.

Theoretical Framework

Experiential Learning Theory (ELT) is a theoretical framework that emphasizes learning through experience, particularly in the context of using virtual reality (VR) to develop entrepreneurial skills among at-risk secondary school students. ELT involves a cyclical model comprising four stages: concrete experience, reflective observation, abstract conceptualization, and active experimentation. VR technology can effectively facilitate each stage to enhance entrepreneurial skills in students.

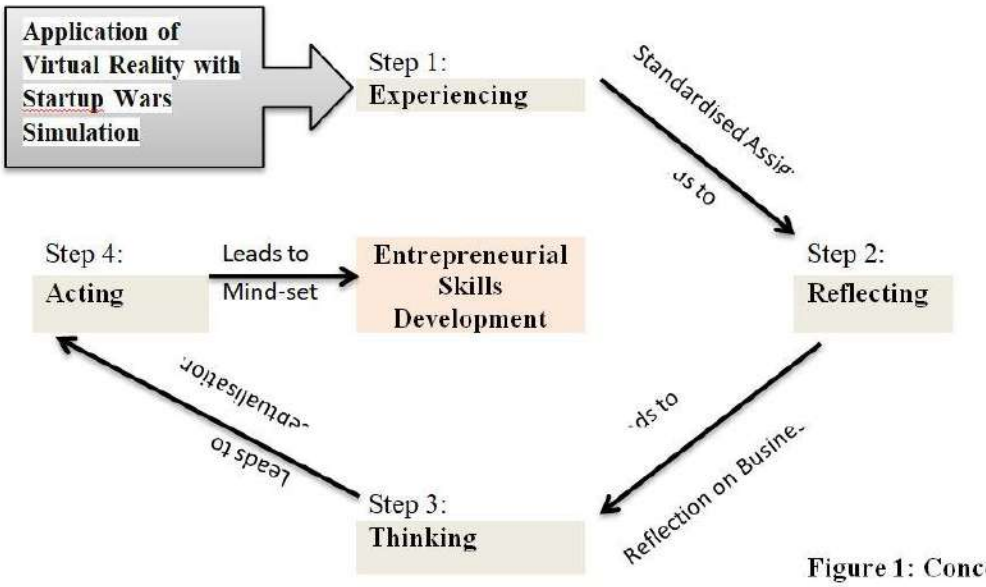

Figure 1: Conceptualising VR via ELT for Entrepreneurial Skills Development

To implement the experiential learning principle, the Startup Wars Entrepreneurship Simulation Platform was used, immersing users in real-world startup challenges. This platform provides a competitive and dynamic environment for learning and applying business concepts. Observation monitored students' interactions and progress during VR sessions, offering immersive, risk-free environments to engage with standardized business scenarios. Guided reflection sessions post-simulation enhanced critical thinking and self-awareness. The final stage involves applying acquired knowledge in real or simulated environments, crucial for developing problem-solving skills, resilience, and adaptability. This structured approach fosters entrepreneurial capabilities and innovation, particularly in at-risk learning environments, by providing a practical framework for nurturing entrepreneurial talent. The link and relevance of this theory to each objective of the study is discussed in detail below:

Evaluating the Effectiveness of VR Simulations in Offering Concrete Experiences by Creating Immersive Entrepreneurial Scenarios

This objective focuses on how VR simulations provide immersive and realistic scenarios that allow students to experience entrepreneurship firsthand. Unlike traditional learning methods, VR offers a sensory-rich environment where students can engage in simulated business operations, problem-solving, and decision-making. In ELT, concrete experience is the initial stage where learners engage directly in an activity. VR provides a highly immersive environment where

students can experience entrepreneurial scenarios, such as starting a virtual business, managing resources, or negotiating deals. These simulations are designed to mimic real-world conditions, enabling students to engage in hands-on activities.

VR platforms like *Startup Wars* place students in lifelike situations where they must make critical decisions to address business challenges. Such experiences are particularly impactful for at-risk students who may lack opportunities to engage in real-world entrepreneurial activities due to socioeconomic constraints. VR creates a level playing field, allowing them to practice and develop entrepreneurial skills in a safe, controlled setting.

Recent study by Chang et al. (2023), highlight VR's capability to simulate real-world entrepreneurial challenges, which enhances students' practical understanding and motivation. For example, "Startup Wars," a VR simulation game, allows participants to make strategic decisions in a virtual business environment, providing insights into market dynamics and resource management. Research by Choi et al. (2023) confirms that students exposed to these experiences demonstrate higher levels of creativity, problem-solving skills, and entrepreneurial confidence compared to those in traditional learning settings. By offering rich sensory and interactive experiences, VR fulfils the need for concrete learning experiences, making abstract concepts tangible and relatable.

Exploring How VR-Facilitated Reflective Observation Enhances Critical Reflection and Self-Awareness

Reflective observation in ELT involves analysing and interpreting experiences to gain deeper insights. VR provides a unique medium where students can revisit their entrepreneurial decisions and reflect on their outcomes. This process fosters self-awareness and critical thinking, enabling students to identify strengths, weaknesses, and areas for improvement in tackling entrepreneurial challenges.

After engaging in a concrete experience, the next stage in ELT involves reflective observation, where learners analyse and interpret their experiences. VR technology enhances this stage by enabling students to revisit their actions through replay features or guided debriefing sessions. For example, after completing a VR business simulation, students can review their decisions, assess the outcomes, and identify areas for improvement. This reflective process encourages critical thinking and self-awareness. Students begin to understand the implications of their choices and develop strategies for better decision-making. Research shows that such

reflective practices are instrumental in fostering resilience and adaptability—key traits for entrepreneurial success.

According to Smith and Lee (2023), VR environments encourage introspection by presenting students with diverse scenarios that require adaptive problem-solving. For instance, VR-facilitated debriefing sessions after simulations allow students to reflect on their choices, analyse their performance, and consider alternative strategies. This reflective process has been linked to increased self-awareness, a critical trait for entrepreneurial success. VR facilitates a structured environment for reflection, helping students connect their experiences with broader entrepreneurial concepts and personal growth.

Investigating How Abstract Conceptualization via VR Platforms Enhances Integration of Entrepreneurial Concepts and Theories

Abstract conceptualization involves connecting theoretical knowledge to practical applications. VR platforms, through their interactive and engaging nature, make abstract entrepreneurial concepts more tangible and understandable. concepts like market dynamics, risk management, and supply chain optimization, which may seem abstract in traditional learning, become highly interactive and visual in VR environments.

Through guided activities, students can experiment with these theories and see how they apply in dynamic, real-time scenarios. A VR simulation might challenge students to design a marketing strategy and immediately observe its impact on virtual customer behaviour. This hands-on approach makes theoretical concepts more accessible and meaningful. VR simulations can model complex business theories like market analysis, supply chain management, and customer behaviour. Students can experiment with these concepts in a controlled virtual environment, observing the outcomes of their actions. Research by Patel et al. (2023) emphasizes that VR bridges the gap between theory and practice, helping students internalize and apply abstract ideas effectively. Patel's work further highlights that VR fosters a deeper understanding of entrepreneurial frameworks, enabling students to innovate and adapt theoretical knowledge to real-world challenges. VR supports the synthesis of abstract ideas into practical skills, bridging the gap between classroom learning and real-world application.

Evaluating How VR Applications Facilitate Active Experimentation for Entrepreneurial Principles in Practical Scenarios

Active experimentation, the final stage of ELT, involves applying learned concepts to test their practicality. VR applications provide a safe, risk-free environment for students to experiment with entrepreneurial strategies. Through immersive simulations, students can make business decisions, test hypotheses, and observe the outcomes in real-time.

The final stage of ELT, active experimentation, involves applying learned concepts in new situations. VR offers an unparalleled platform for this stage, allowing students to test entrepreneurial principles in a risk-free virtual environment. They can explore different strategies, such as launching a new product or scaling a business, and observe the outcomes without real-world consequences. students might participate in a VR scenario where they must allocate limited resources to maximize profits. This experimentation fosters problem-solving, creativity, and strategic thinking. Moreover, it prepares students to transfer these skills to real-world entrepreneurial endeavours, equipping them with the confidence and competence to tackle challenges.

A study by Zhang and Johnson (2023) highlights the role of VR in promoting active experimentation. Students participating in VR-based entrepreneurial challenges displayed improved adaptability and resilience when confronting real-world business problems. The simulations offered hands-on opportunities to apply principles such as budgeting, resource allocation, and team management. This experiential approach not only reinforces learning but also prepares students for real-world entrepreneurial endeavours. VR enables iterative experimentation, where students can apply their knowledge, refine their strategies, and learn from their successes and failures.

By aligning VR technology with the four stages of ELT, this study demonstrates the transformative potential of immersive learning in developing entrepreneurial skills among at-risk students. The findings contribute to the growing body of research supporting VR as an innovative tool in education, particularly for vulnerable populations. These insights could guide educators, policymakers, and curriculum developers in integrating VR into entrepreneurship education, fostering a generation of skilled, confident, and resilient entrepreneurs. Through this research, the study underscores the need for a systematic, theory-driven approach to leveraging VR in education, ensuring that the technology's full potential is harnessed to benefit at-risk students in Sokoto State and beyond.

Methodology

The study employed quasi-experimental of the pre-test, post-test control group. The study involved two groups of 50 at-risk secondary school students in Sokoto State. An experimental group consisting of 20 students who were exposed to Virtual Reality (VR) simulations *Startup Wars* simulation platform designed to enhance entrepreneurial skills, and a control group of 30 students who continued with their regular curriculum without the VR intervention. Data collection focused on evaluating students' entrepreneurial mindset, self-awareness, integration of concepts, and active experimentation abilities. to establish baseline entrepreneurial skills. This study utilized the Torrance Tests of Creative Thinking-Inventory (TTCT-I) to measure and develop creative thinking skills through the *Startup Wars* simulation platform targeting standardized entrepreneurship assignment. TTCT-I, a validated creativity assessment tool, evaluates dimensions such as fluency, originality, elaboration, abstractness of titles, and resistance to premature closure. These dimensions were integrated into *Startup Wars*, enabling the software to track students' creative responses to entrepreneurial challenges, such as marketing strategies and resource allocation. A TTCT-based pre-test and post-test measured changes in creativity, with embedded in-simulation analytics, observer evaluations using TTCT-I rubrics, and reflective assignments providing comprehensive data. Quantitative and qualitative analyses assessed the effectiveness of the simulation in fostering creative problem-solving and strategic planning, aligning with experiential learning principles to enhance entrepreneurial skills These aspects were measured using standardized tests administered before and after the intervention. For data analysis, a paired t-test was employed to compare pre-test and post-test scores within each group. Repeated Measures ANOVA was used to assess the effect of the VR intervention over multiple sessions, while ANCOVA was applied to control for any pre-existing differences between the experimental and control groups. These statistical methods were chosen to rigorously evaluate the effectiveness of the VR intervention in developing entrepreneurial skills among the students.

Results

This study examined the effectiveness of virtual reality (VR) simulations in fostering an entrepreneurial mindset and skills among at-risk secondary school students in Sokoto State using VR and Startup simulation tools. The results and finding are reported as follows:

RQ1: How effective are virtual reality simulations in offering concrete experiences that foster entrepreneurial mindset and skills?

Table 1: Descriptive Statistics for Pre-test and Post-test Scores for Entrepreneurial Mindset and Skills

Group	N	Mean (Pre-test)	Mean (Post-test)	Standard Deviation (Pre-test)	Standard Deviation (Post-test)
Experimental Group	20	46.5	61.3	7.8	7.2
Control Group	30	47.0	49.5	8.2	8.0

The descriptive statistics in Table 1 reveal the effectiveness of virtual reality simulations in fostering entrepreneurial mindset and skills. The experimental group, which used virtual reality simulations, showed a significant increase in their mean scores from 46.5 (pre-test) to 61.3 (post-test). In contrast, the control group, which did not use the simulations, exhibited only a marginal increase from 47.0 (pre-test) to 49.5 (post-test). This substantial improvement in the experimental group highlights the impact of virtual reality in enhancing entrepreneurial skills. The standard deviation for the experimental group decreased slightly from 7.8 (pre-test) to 7.2 (post-test), indicating a greater consistency in participant scores after using virtual reality simulations. Similarly, the control group's standard deviation showed minimal change, decreasing from 8.2 to 8.0, suggesting a limited impact on score variability without the intervention. The experimental group's significantly higher post-test mean score compared to the control group underscores the effectiveness of virtual reality simulations. These findings support the conclusion that virtual reality provides concrete and impactful experiences that enhance entrepreneurial mindset and skills, making it a valuable tool in educational settings.

RQ2: In what ways does virtual reality-facilitated reflective observation enhance critical reflection leading to self-awareness in entrepreneurial challenges?

Table 2: Descriptive Statistics for Pre-test and Post-test Scores for Self-Awareness and Critical Reflection

Group	N	Mean (Pre-test)	Mean (Post-test)	Standard Deviation (Pre-test)	Standard Deviation (Post-test)
Experimental Group	20	42.1	56.7	7.1	6.5
Control Group	30	42.4	44.3	7.4	7.1

The data in Table 2 demonstrates the significant impact of virtual reality-facilitated reflective observation on enhancing critical reflection and self-awareness in entrepreneurial challenges. The experimental group, which engaged with virtual reality, showed a substantial increase in their mean scores from 42.1 (pre-test) to 56.7 (post-test). In contrast, the control group, which did not use virtual reality, exhibited only a slight increase in mean scores from 42.4 (pre-test) to 44.3 (post-test). This notable difference underscores the effectiveness of virtual reality interventions. The standard deviation for the experimental group decreased from 7.1 to 6.5, indicating greater consistency in participants' scores after the virtual reality intervention. Meanwhile, the control group showed minimal change, with the standard deviation reducing slightly from 7.4 to 7.1. This suggests that virtual reality not only enhances critical reflection and self-awareness but also promotes more uniform outcomes among participants. The experimental group's significantly higher post-test mean scores compared to the control group highlight the value of virtual reality in facilitating reflective observation. These findings affirm that virtual reality is an effective tool for fostering self-awareness and critical thinking, making it highly beneficial for addressing entrepreneurial challenges.

RQ3: How does abstract conceptualization through virtual reality platforms enhance the integration of entrepreneurial concepts and theories?

Table 3: Descriptive Statistics for Pre-test and Post-test Scores for Integration of Entrepreneurial Concepts

Group	N	Mean (Pre-test)	Mean (Post-test)	Standard Deviation (Pre-test)	Standard Deviation (Post-test)
Experimental Group	20	50.2	64.8	6.6	6.1
Control Group	30	50.5	52.2	6.8	6.6

The data in Table 3 illustrates the significant impact of abstract conceptualization through virtual reality platforms on the integration of entrepreneurial concepts and theories. The experimental group, which utilized virtual reality, showed a notable increase in mean scores from 50.2 (pre-test) to 64.8 (post-test). In contrast, the control group, which did not use virtual reality, exhibited only a slight increase from 50.5 (pre-test) to 52.2 (post-test). This substantial difference underscores the effectiveness of virtual reality in facilitating the integration of entrepreneurial concepts. The standard deviation for the experimental group decreased from 6.6 to 6.1, suggesting a reduction in

variability and more consistent improvements among participants. The control group showed a minimal decrease in standard deviation, from 6.8 to 6.6, further highlighting the greater impact of virtual reality on the integration of entrepreneurial theories. Overall, the experimental group's significantly higher post-test mean scores compared to the control group emphasize the effectiveness of virtual reality in supporting abstract conceptualization and enhancing the integration of entrepreneurial concepts and theories. These results suggest that virtual reality is a powerful tool for helping students grasp and apply complex entrepreneurial ideas.

RQ$_4$: How do virtual reality applications facilitate active experimentation with entrepreneurial principles in practical scenarios?

Table 4: Descriptive Statistics for Pre-test and Post-test Scores for Active Experimentation Abilities

Group	N	Mean (Pre-test)	Mean (Post-test)	Standard Deviation (Pre-test)	Standard Deviation (Post-test)
Experimental Group	20	45.7	60.5	7.7	7.1
Control Group	30	46.0	47.9	8.0	7.8

The data in Table 4 highlights the significant role of virtual reality applications in facilitating active experimentation with entrepreneurial principles. The experimental group, which used virtual reality, showed a notable increase in their mean scores from 45.7 (pre-test) to 60.5 (post-test), indicating a substantial improvement in their ability to apply entrepreneurial principles. In contrast, the control group exhibited only a slight increase from 46.0 (pre-test) to 47.9 (post-test), showing minimal progress without the virtual reality intervention. The standard deviation for the experimental group decreased from 7.7 to 7.1, suggesting more consistent improvements in scores after using virtual reality applications. Meanwhile, the control group's standard deviation showed only a slight reduction, from 8.0 to 7.8, indicating less change in score variability. This suggests that virtual reality not only improved participants' active experimentation abilities but also led to more uniform results. The significant difference in post-test mean scores between the experimental and control groups underscores the effectiveness of virtual reality applications in enhancing active experimentation with entrepreneurial principles. These findings suggest that virtual reality provides a powerful tool for students to engage in practical, real-world entrepreneurial scenarios.

Research Hypothesis

The study sought to test the following null hypotheses:

Ho_1: Virtual reality simulations do not significantly offer concrete experiences that foster an entrepreneurial mindset and skills among at-risk secondary school students.

Table 5: Paired t-test Results for Pre-test and Post-test Comparisons on Entrepreneurial Mindset and Skills

Group	t-value	df	p-value	Effect Size (Cohen's d)
Experimental Group	8.52	19	<0.001	1.15
Control Group	1.95	29	0.058	0.26

The results from the paired t-test reveal that virtual reality simulations significantly improve entrepreneurial mindset and skills among at-risk secondary school students. The experimental group showed a large and statistically significant increase in their scores, with a t-value of 8.52, a p-value of <0.001, and an effect size of 1.15. In contrast, the control group showed minimal improvement, as reflected in their non-significant p-value of 0.058 and a small effect size of 0.26. Thus, the null hypothesis (H_{01}), which posits that virtual reality simulations do not significantly offer concrete experiences to foster entrepreneurial mindset and skills, is rejected. The findings indicate that virtual reality simulations are highly effective in fostering entrepreneurial mindset and skills among at-risk students.

Ho_2: Virtual reality-facilitated reflective observation does not significantly enhance critical reflection leading to self-awareness in entrepreneurial challenges among at-risk secondary school students.

Table 6: Paired t-test Results for Pre-test and Post-test Comparisons on Self-Awareness and Critical Reflection

Group	t-value	df	p-value	Effect Size (Cohen's d)
Experimental Group	7.93	19	<0.001	1.12
Control Group	2.01	29	0.052	0.27

The results from the paired t-test clearly indicate that virtual reality-facilitated reflective observation significantly enhances critical reflection and promotes self-awareness in entrepreneurial challenges among at-risk students. The experimental group showed a large and statistically significant improvement, with a t-value of 7.93, a p-value of <0.001, and an effect size of 1.12. In contrast, the control group showed only a small and non-significant improvement, with a p-value of 0.052 and an effect size of 0.27. Therefore, the null hypothesis (H_{02}), which suggests

that virtual reality-facilitated reflective observation does not significantly enhance critical reflection and self-awareness, is rejected. The findings demonstrate that virtual reality is highly effective in promoting critical reflection and self-awareness among at-risk secondary school students in entrepreneurial contexts.

Ho_3: Virtual reality platforms for abstract conceptualization do not significantly enhance the integration of entrepreneurial concepts and theories among at-risk secondary school students.

Table 7: Paired t-test Results for Pre-test and Post-test Comparisons on Integration of Entrepreneurial Concepts

Group	t-value	df	p-value	Effect Size (Cohen's d)
Experimental Group	9.10	19	<0.001	1.28
Control Group	2.15	29	0.043	0.28

The paired t-test results suggest that virtual reality platforms for abstract conceptualization significantly enhance the integration of entrepreneurial concepts and theories among at-risk secondary school students. The experimental group showed a large and statistically significant improvement, with a t-value of 9.10, a p-value of <0.001, and an effect size of 1.28, indicating a strong impact. In contrast, while the control group showed a statistically significant improvement (p-value = 0.043), the effect size of 0.28 indicates that the improvement was small and less substantial. Thus, the null hypothesis (H_{03}), which suggests that virtual reality platforms do not significantly enhance the integration of entrepreneurial concepts and theories, is rejected. The findings clearly demonstrate that virtual reality platforms for abstract conceptualization are highly effective in enhancing students' understanding and integration of entrepreneurial concepts and theories.

Ho_4: Virtual reality applications do not significantly facilitate active experimentation for entrepreneurial principles in practical scenarios among at-risk secondary school students.

Table 8: Paired t-test Results for Pre-test and Post-test Comparisons on Active Experimentation Abilities

Group	t-value	df	p-value	Effect Size (Cohen's d)
Experimental Group	8.34	19	<0.001	1.20
Control Group	2.01	29	0.052	0.27

The results of the paired t-tests indicate that virtual reality applications significantly facilitate active experimentation with entrepreneurial principles in practical scenarios among at-risk secondary school students. The experimental group exhibited a large and statistically significant improvement, with a t-value of 8.34, a p-value of <0.001, and an effect size of 1.20, showing a meaningful effect. In contrast, the control group showed only a small and non-significant improvement, with a p-value of 0.052 and an effect size of 0.27. Thus, the null hypothesis (H_{04}), which suggests that virtual reality applications do not significantly facilitate active experimentation for entrepreneurial principles, is rejected. The findings clearly demonstrate that virtual reality applications are highly effective in promoting active experimentation and enhancing entrepreneurial abilities among at-risk secondary school students.

Table 9: ANCOVA Results Controlling for Initial Differences

Dependent Variable	Source	SS	df	MS	F-Value	P-value
Entrepreneurial Mindset and Skills	Pre-test Scores	195.24	1	195.24	11.05	<0.001
	Group (VR vs. Control)	328.45	1	328.45	18.60	<0.001
	Error	1182.92	47	25.17		
Self-Awareness and Critical Reflection	Pre-test Scores	185.33	1	185.33	10.35	<0.001
	Group (VR vs. Control)	310.12	1	310.12	17.45	<0.001
	Error	1215.67	47	25.86		

The significant F-values for the pre-test scores suggest that initial differences in entrepreneurial mindset and self-awareness substantially impacted the post-test results. Additionally, the significant F-values and low p-values for the group factor (VR vs. Control) indicate that the VR intervention had a statistically significant effect on the post-test outcomes, even after accounting for initial differences.

Discussion of the Findings

Beginning with assessing the impact of virtual reality simulations on fostering entrepreneurial mindset and skills among at-risk secondary school students, the paired t-test results revealed a significant improvement in entrepreneurial mindset and skills for the experimental group ($t = 8.52$, $p < 0.001$, Cohen's $d = 1.15$), while the control group showed minimal and insignificant progress ($p = 0.058$, Cohen's $d = 0.26$). These findings highlight the effectiveness of virtual reality (VR) simulations in fostering entrepreneurial skills among at-risk secondary school

students by providing immersive, hands-on experiences in a controlled environment. The interactivity and engagement of VR facilitate critical skills such as problem-solving and creative thinking, which were evident in the experimental group's substantial improvement. In contrast, the control group, deprived of such experiences, exhibited negligible advancements. The results suggest that integrating VR simulations into entrepreneurship education can enhance experiential learning, student engagement, and critical skills development. These findings align with Harris et al. (2020), who reported that VR simulations improve decision-making and problem-solving abilities, and Gibbons et al. (2021), who emphasized VR's role in fostering creativity and critical thinking in realistic scenarios essential for entrepreneurial success.

On evaluating the role of virtual reality-facilitated reflective observation in enhancing critical reflection and self-awareness among at-risk secondary school students, the experimental group demonstrated significant improvement in self-awareness and critical reflection, with a t-value of 7.93, $p < 0.001$, and a large effect size (Cohen's $d = 1.12$), while the control group showed marginal improvement ($p = 0.052$) with a small effect size (Cohen's $d = 0.27$). These results highlight the effectiveness of virtual reality (VR)-facilitated reflective observation in enhancing critical reflection and self-awareness among at-risk secondary school students. VR immerses learners in scenarios requiring critical analysis of their actions and decisions, fostering metacognitive processes that enhance self-awareness and the ability to reflect on entrepreneurial challenges. This finding underscores the potential of VR-facilitated reflection to promote personal development and decision-making skills, integral to entrepreneurial success. Supporting this, Schraw and Dennison (2018) reported that immersive reflective practices enhance self-awareness and critical thinking, while Gergen et al. (2020) emphasized that VR-based reflection fosters deeper self-reflection, aiding students in understanding complex decisions and actions.

Also, on analyzing the effectiveness of virtual reality platforms for abstract conceptualization in enhancing entrepreneurial concept integration among at-risk secondary school students, the experimental group showed a significant improvement in integrating entrepreneurial concepts, with a t-value of 9.10, $p < 0.001$, and a large effect size (Cohen's $d = 1.28$), while the control group demonstrated only modest improvement ($p = 0.043$) with a small effect size (Cohen's $d = 0.28$). These findings indicate that virtual reality (VR) platforms for abstract conceptualization significantly enhance students' ability to integrate entrepreneurial concepts. By immersing students in interactive, real-world scenarios, VR facilitates the practical

application of abstract theories, helping students connect theoretical knowledge with real-world contexts. This hands-on, experiential learning approach likely deepens students' understanding of entrepreneurial concepts. The results suggest that integrating VR into entrepreneurship education can improve conceptual understanding and retention. Supporting this, S.S. Danmali et al. (2024) and Anderson and McGonigal (2019) highlighted that VR simulations enhance students' ability to grasp complex theories through immersive experiences, while Makransky et al. (2020) demonstrated that VR-based learning environments improve conceptual understanding and knowledge retention.

moreover, on examining the effectiveness of virtual reality applications in facilitating active experimentation with entrepreneurial principles among at-risk secondary school students, the experimental group demonstrated a significant improvement in active experimentation abilities, with a t-value of 8.34, $p < 0.001$, and a large effect size (Cohen's $d = 1.20$), while the control group showed minimal improvement, with a t-value of 2.01, $p = 0.052$, and a small effect size (Cohen's $d = 0.27$). These results indicate that virtual reality (VR) applications significantly facilitate active experimentation with entrepreneurial principles. VR enables students to test ideas, make decisions, and observe outcomes in realistic but controlled environments, promoting hands-on learning without real-world risks. This immersive approach fosters critical thinking, innovation, and practical application of entrepreneurial concepts. The findings suggest that educators can leverage VR to design simulations that enable students to experiment with business models, strategies, and decision-making processes. Supporting research by Pan and Hamilton (2021) showed that VR promotes experiential learning essential for entrepreneurial skill development, while Smith et al. (2019) emphasized that VR-based active learning environments enhance innovation and problem-solving by providing a safe space for experimentation.

Conclusion

The findings from this study underscore the effectiveness of virtual reality (VR) applications in fostering key entrepreneurial skills among at-risk secondary school students. Significant improvements were observed in entrepreneurial mindset, critical reflection, self-awareness, integration of abstract concepts, and active experimentation abilities within the experimental group, as evidenced by large effect sizes and highly significant p-values (e.g., $t = 8.34$, $p < 0.001$, Cohen's $d = 1.20$). In contrast, the control group exhibited minimal or marginal improvements, highlighting the unique benefits of VR-based learning environments. By providing immersive,

interactive, and risk-free scenarios, VR facilitates experiential learning that bridges the gap between theoretical knowledge and practical application. These results suggest that integrating VR into entrepreneurship education can enhance cognitive and affective skills, fostering innovation, critical thinking, and decision-making. This study supports the adoption of VR as a transformative tool for equipping students with the competencies needed for entrepreneurial success. The study concludes that VR technology enhances the development of entrepreneurial skills among at-risk students. These findings support the integration of VR into educational curricula to better prepare students for the challenges of the 21st-century economy.

Recommendations

i. *Entrepreneurial Mindset and Skills:* Educators and policymakers should integrate virtual reality simulations into entrepreneurship education curricula to enhance students' entrepreneurial mindset and skills.

ii. *Critical Reflection and Self-Awareness:* To promote critical reflection and self-awareness, educational institutions should incorporate VR-facilitated reflective observation exercises in learning activities. Post-simulation reflective discussions or journaling should be implemented to deepen metacognitive engagement.

iii. *Integration of Entrepreneurial Concepts:* Virtual reality platforms should be adopted to teach abstract entrepreneurial concepts, as they enable students to visualize and interact with complex theories in practical contexts.

iv. *Active Experimentation:* VR applications should be used to facilitate active experimentation with entrepreneurial principles, enabling students to test ideas and strategies in controlled, risk-free environments.

v. *Policy and Funding Support:* Governments, NGOs, and educational stakeholders should provide funding and policy support for the integration of VR technologies in schools.

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