Research Paper

Role of Innovative Entrepreneurship Education on Entrepreneurial Intention among STEM Students at a Rural University

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Abstract

This study examines the effect of entrepreneurship education on the entrepreneurial intentions of STEM students at a historically disadvantaged university in South Africa, addressing a critical research gap: limited evidence on how targeted interventions influence entrepreneurial aspirations in emerging economies. A mixed-methods design was employed, with 285 students completing a customized Entrepreneurial Intention Questionnaire (EIQ) before and after two interventions: a traditional classroom module and a work-integrated learning (WIL) component. Quantitative data were analyzed using descriptive statistics and repeated-measures ANOVA, while qualitative insights were derived from semi-structured interviews and thematic analysis using NVivo software. The results revealed significant positive shifts across the six constructs of entrepreneurial intention, with WIL having the most potent effect on perceived feasibility and self-efficacy. Qualitative findings highlighted mindset transformation, enhanced confidence, peer collaboration, real-world application, and mentorship as key factors. Based on these insights, this study recommends integrating experiential learning, mentorship, and tailored curricula to strengthen STEM students' entrepreneurial competence. These findings offer actionable guidance for educators and policymakers seeking to design entrepreneurship education programs that foster innovation and economic resilience in marginalized contexts.

Keywords *Historically Disadvantaged Institutions; Mindset Transformation; Self-Efficacy; Mixed-Methods Research; Work-Integrated Learning; STEM; Entrepreneurial Intentio; South Africa*

INTRODUCTION

Entrepreneurship is a crucial catalyst for global economic development and innovation, especially in developing regions such as sub-Saharan Africa, where there is a pressing need for adaptable and innovative solutions (Endris & Kassegn, 2022; Leger et al., 2025). The dynamism generated by entrepreneurial endeavours stimulates job creation and facilitates the emergence of novel goods and services, enhancing productivity across diverse industries. However, despite the growing body of research on entrepreneurship education, a critical gap remains due to limited evidence on how STEM students in historically disadvantaged universities (HDUs) develop entrepreneurial intentions in emerging economies. This gap is significant because HDUs are public institutions established to serve previously marginalized communities and play a vital role in addressing systemic inequities and fostering inclusive economic growth.

Existing research often lacks specificity regarding the unique challenges that STEM students encounter in developing countries (Tennakoon et al., 2020; Ferreira et al., 2021; De Waal & Maritz, 2022). These challenges include limited access to resources, diverse cultural attitudes towards entrepreneurship, and an urgent need for innovative solutions to local economic problems (Bruton et al., 2021). While prior studies have broadly examined entrepreneurship education, few have explored its impact within STEM disciplines at HDUs, where students face compounded barriers, such as inadequate business training and risk aversion (Cohen et al., 2021; Ewim, 2023). A one-size-fits-all approach to entrepreneurship education fails to effectively nurture entrepreneurial intentions among these students, as it overlooks their contextual realities and discourages engagement (Liu et al., 2022; Malawu & Waghid, 2024).

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This study addresses these gaps by investigating how innovative entrepreneurship education interventions, specifically a combination of classroom-based modules and work-integrated learning (WIL), influence the entrepreneurial aspirations of STEM students at rural HDU in South Africa. By integrating the Theory of Planned Behaviour (TPB) and the Entrepreneurial Event Model (EEM), this study provides a nuanced understanding of how attitudes, perceived behavioural control, and feasibility perceptions evolve through targeted educational experiences. Unlike previous studies, this study presents an evidence-based analysis of the role of experiential learning in shaping entrepreneurial intentions among STEM students in resource-constrained environments, providing actionable insights into curriculum design and policy development for STEM entrepreneurship education in developing countries.

LITERATURE REVIEW

Entrepreneurship education is widely recognised as a catalyst for innovation and economic resilience. This review synthesises theoretical and empirical perspectives to explain how entrepreneurship education influences intention formation among STEM students in resource-constrained contexts. It introduces the conceptual foundations provided by the Theory of Planned Behaviour (TPB) and the Entrepreneurial Event Model (EEM). It then examines psychological and social factors, followed by barriers that hinder entrepreneurial engagement.

Importance of Entrepreneurship Education

Entrepreneurship education plays a pivotal role in shaping the aspirations and ambitions of STEM students and equipping them with the business acumen necessary for success in the field. It fosters essential skills and a proactive mindset, addressing socioeconomic challenges such as poverty and unemployment (Zacharias et al., 2021; Sahut et al., 2023). Empirical research consistently demonstrates a strong correlation between entrepreneurship education and entrepreneurial intention (EI), aligning with policy trends that position entrepreneurship as a catalyst for productivity and job creation (Ajayi-Nifise et al., 2024; Leiva-Lugo et al., 2024). Studies have further linked EI to TPB constructs, attitudes, subjective norms, perceived behavioural control, and EEM dimensions of desirability and feasibility (Hattab & Fahmy, 2022; Passaro et al., 2023; Rauch & Hulsink, 2023; Vedula et al., 2022). Individuals who perceive entrepreneurship as desirable and feasible are more likely to engage in entrepreneurial activity. However, barriers such as limited financial support and a lack of tailored interventions for STEM students reduce perceived behavioural control and feasibility (Ferreira et al., 2021; Ozyazici et al., 2025; Kaya-Capocci et al., 2025), reinforcing the need for integrated educational strategies.

Theoretical Frameworks

To understand how entrepreneurship education influences intention formation, this study draws on two widely applied theoretical frameworks: the Theory of Planned Behaviour (TPB) and the Entrepreneurial Event Model (EEM). The TPB posits that entrepreneurial intentions are shaped by attitudes towards behaviour, subjective norms, and perceived behavioural control (Ajzen, 1991), while the EEM emphasises perceptions of desirability and feasibility as primary drivers of entrepreneurial aspirations (Tan et al., 2021). These frameworks are particularly relevant for STEM students because their entrepreneurial decisions often hinge on their confidence in applying technical knowledge to business contexts and their perception of feasibility in resource-constrained environments. For instance, perceived behavioural control in TPB aligns with STEM students' need to feel capable of transforming scientific ideas into viable ventures. Simultaneously, EEM's focus on desirability and feasibility underscores the importance of demonstrating that entrepreneurship is both attractive and practical for technically oriented learners. By linking these

constructs to STEM learners' realities, TPB and EEM provide a robust conceptual lens for examining how educational interventions, such as experiential learning and mentorship, can strengthen attitudes, enhance perceived behavioural control, and increase the desirability and feasibility of entrepreneurship.

This study examines a rural South African university where students strive to develop innovative solutions for their communities despite significant socioeconomic challenges (Omodan et al., 2024). It explores how entrepreneurship education influences STEM students' intentions and behaviours through the application of TPB and EEM frameworks, focusing on the transformation of entrepreneurial intentions into actions (Aadland & Aaboen, 2020; Bell & Bell, 2020; Joshi et al., 2020; Abdullahi et al., 2021; Hanage et al., 2024). These insights are essential for advancing academic discourse on entrepreneurship education in developing regions and informing strategies that foster innovation and economic resilience in similar contexts (Dyantyi et al., 2024).

Psychological and Social Drivers of Entrepreneurial Intention

These factors influence attitudes, perceived behavioural control, and perceptions of desirability and feasibility, which are key constructs in the TPB and EEM, and therefore play a pivotal role in shaping entrepreneurial outcomes among STEM students. Emotional intelligence (EI), beliefs, subjective norms, and self-efficacy are key factors in this interaction, as they influence how students perceive entrepreneurship and their ability to act on entrepreneurial opportunities.

Role of Emotional Intelligence in Entrepreneurial Education

Integrating emotional intelligence (EI) into entrepreneurship curricula is increasingly recognised as essential for fostering entrepreneurial readiness. EI development, encompassing self-awareness, emotional regulation, empathy, and interpersonal skills, strengthens resilience and confidence, enabling students to navigate the uncertainty and complex decision-making inherent in entrepreneurial contexts (Nguyen et al., 2023). For STEM students, who often prioritise technical problem-solving, EI training complements cognitive skills and enhances perceived behavioural control and self-efficacy within the TPB framework (Xanthopoulou & Alexandros, 2022), while reinforcing the desirability of entrepreneurship, as emphasised in EEM (Ajzen, 1991). By embedding EI into entrepreneurship education, institutions can equip learners with both technical and emotional competencies, thereby creating a holistic foundation for entrepreneurial success.

Beliefs, Subjective Norms, and Self-Efficacy

Beyond emotional intelligence, individuals' beliefs about entrepreneurship shape their intentions. Positive perceptions of entrepreneurship significantly increase the likelihood of pursuing entrepreneurial objectives (Batz Liñeiro et al., 2024). Subjective norms, such as social pressures from family, peers, and mentors, also exert a strong influence, underscoring the need for educational environments that promote supportive networks and entrepreneurial role models. Therefore, institutions must move beyond technical skill development to actively cultivate ecosystems that normalise entrepreneurship and empower students to confidently engage in entrepreneurial pursuits.

Finally, perceived behavioural control and self-efficacy remain central to intention formation. These constructs reflect an individual's evaluation of the feasibility of launching a venture and their confidence in successfully managing it (Xanthopoulou & Alexandros, 2022). Ajzen's (1991) Theory of Planned Behaviour provides a comprehensive lens for understanding how attitudes, subjective norms, and perceived behavioural control interact to shape entrepreneurial intention, while EEM emphasises the importance of perceived desirability and feasibility. Together, these frameworks underscore the need for entrepreneurship education that integrates technical,

emotional, and experiential dimensions to transform intention into action.

Barriers Faced by STEM Students

Although STEM students often possess strong technical competencies, they encounter significant challenges that can impede entrepreneurial engagement. The most notable barriers include a lack of foundational business skills, limited access to financial resources, and a tendency towards risk aversion (Cohen et al., 2021). Empirical evidence supports these observations. Ferreira et al. (2021) documented structural barriers, such as high patent costs and limited financial support, which undermine perceived behavioural control within the TPB and perceived feasibility under the EEM. Similarly, Ozyazici et al. (2025) highlighted the scarcity of tailored entrepreneurship interventions for STEM learners, which reduces positive attitudes and subjective norms (TPB) and lowers desirability (EEM). Kaya-Capocci et al. (2025) further demonstrated that even targeted experiential programmes improved qualitative outcomes but yielded no significant quantitative gains in entrepreneurial skills, indicating that interventions did not sufficiently enhance perceived behavioural control or feasibility—both critical for intention formation under TPB and EEM frameworks. These limitations underscore the need for integrated programmes that combine technical training with business acumen and experiential learning opportunities to foster entrepreneurial readiness among STEM students (Ewim, 2023; Hynes et al., 2023).

Overall, the extant literature highlights the critical role of entrepreneurship education in shaping entrepreneurial intentions and demonstrates the relevance of the TPB and EEM frameworks in explaining intention formation. Despite these insights, most studies have concentrated on general student populations or business disciplines, with limited attention to STEM students in historically disadvantaged universities (HDUs) in South Africa. These contexts present unique challenges, including resource constraints and a lack of tailored interventions, which significantly influence attitudes, perceived behavioural control, and perceptions of desirability and feasibility. Addressing these gaps is crucial for promoting entrepreneurial readiness among STEM learners in emerging economies such as South Africa. This study examines how integrated entrepreneurship education—combining theoretical foundations with experiential learning—can strengthen entrepreneurial intentions and inform curriculum design and policy development aimed at promoting innovation and economic resilience in marginalized settings.

RESEARCH METHOD

This study adopted a sequential explanatory mixed-methods design, integrating quantitative and qualitative approaches to provide a comprehensive understanding of how entrepreneurship education influences entrepreneurial intention. This design was chosen because TPB and EEM constructs, such as attitudes, subjective norms, perceived behavioural control, desirability, and feasibility, require both numerical measurement and contextual interpretation. Quantitative data established patterns of change, while qualitative insights explained the underlying mechanisms, ensuring theoretical alignment and a depth of understanding.

We conducted this study over two academic years to assess the immediate and long-term effects of entrepreneurship education on students' entrepreneurial intentions. The target population for this study was STEM students enrolled at a historically disadvantaged university in South Africa during the 2022–2024 academic years. To ensure representativeness and capture a broad range of STEM fields within the HDU context, we enrolled participants from all STEM disciplines, including engineering, computer science, and natural sciences. Initially, we had a sample of 300 students who volunteered to participate in the study. While this potentially introduced a self-selection bias, voluntary participation was deemed necessary to respect student autonomy and minimise coercion. The attrition rates remained low throughout the study, with less

than 5% of respondents withdrawing. We attribute this low attrition rate to our effective participant engagement and flexible data collection schedules that accommodate students' academic commitments.

Instrument Development and Validation

A bespoke Entrepreneurial Intention Questionnaire (EIQ) was developed to measure six constructs derived from the TPB and EEM: attitudes towards behaviour, subjective norms, perceived behavioural control, perceived desirability, perceived feasibility, and propensity to act. Attitudes towards behaviour refer to the degree to which students view entrepreneurship positively, subjective norms capture perceived social pressures from peers and mentors, perceived behavioural control reflects confidence in managing entrepreneurial tasks, perceived desirability indicates the attractiveness of entrepreneurship as a career, perceived feasibility assesses the practicality of starting a venture, and propensity to act measures readiness to translate intentions into entrepreneurial action (Ajzen, 1991; Tan et al., 2021). The development process followed a multi-step approach, beginning with item generation, which was informed by an extensive literature review of TPB, EEM, and existing entrepreneurial intention measures (Broder et al., 2007; Shahsavari et al., 2020; Leon et al., 2022). A panel of five specialists in entrepreneurship education and psychometrics evaluated the items for content validity, clarity, and relevance to the study's target population. Based on expert feedback, the questionnaire was refined for precision and improved readability. A pilot study involving 35 STEM students was conducted to assess the psychometric properties. Exploratory Factor Analysis (EFA) confirmed a six-factor structure aligned with TPB and EEM, while Confirmatory Factor Analysis (CFA) demonstrated a strong model fit (χ^2/df = 1.5, CFI = 0.93, TLI = 0.91, RMSEA = 0.03) (Finch, 2020). Reliability was established through Cronbach's alpha values ranging from 0.72 to 0.85 (Crouch et al., 2017) and test-retest stability, with correlation coefficients ranging from 0.68 to 0.84 (Levante et al., 2021). These results confirm the instrument's validity and reliability in assessing entrepreneurial intentions among STEM students.

Data Collection

Data were collected in three phases: pre-intervention, post-classroom module, and post-work-integrated learning. At each stage, the participants completed the Entrepreneurial Intention Questionnaire (EIQ), which measured six constructs derived from the TPB and EEM. This allowed for tracking changes in attitudes, subjective norms, perceived behavioural control, desirability, feasibility, and propensity to act over time. To complement the quantitative data, semi-structured interviews were conducted with a purposive subsample of participants after each intervention stage. These interviews were used to explore experiential insights, perceptions of feasibility, and factors influencing behavioural control, providing depth to statistical trends. Triangulation of survey responses and qualitative narratives enriched the interpretation, validated emerging patterns, and ensured alignment with the TPB and EEM constructs.

Data Analysis

Quantitative data were analysed using descriptive statistics to summarise the participants' characteristics and construct scores. To assess changes across time points, repeated-measures ANOVA was employed because it accounts for within-subject variability and the correlation between repeated measurements. Post-hoc tests using Bonferroni correction were applied to identify significant pairwise differences, and effect sizes (η) were calculated to determine the magnitude of the intervention effects. Qualitative data from open-ended EIQ responses and semi-structured interviews were analysed using Braun and Clarke's six-step thematic analysis

framework. Coding progressed from open to axial coding, culminating in the development of themes aligned with TPB and EEM constructs. To ensure reliability, two independent coders analysed the data, and inter-coder agreement was established (Cohen's $\kappa = 0.82$), confirming consistency in theme identification. This integrated approach allowed for a systematic interpretation of patterns related to entrepreneurial intentions, skill development, and mindset shifts.

FINDINGS AND DISCUSSION

This study examined the impact of entrepreneurship education on STEM students at a disadvantaged university in South Africa, employing an integrative mixed-methods approach. A tailored EIQ combining quantitative metrics with open-ended questions based on the established TPB and EEM constructs was employed to allow structured responses and rich qualitative data to emerge from participants' experiences. The quantitative data were analysed to identify trends and patterns, and the responses to the open-ended questions enriched our understanding of the context and nuances of these findings. Additionally, follow-up semi-structured interviews were conducted after each intervention to provide further qualitative insights, allowing participants to elaborate on their experiences. This comprehensive analysis illustrates how quantitative results are informed by qualitative narratives, culminating in a multifaceted view of the impact of entrepreneurship education on the entrepreneurial intentions of STEM students at a historically disadvantaged university (HDU) in South Africa. The findings are organised thematically, beginning with an overview of the quantitative results, followed by qualitative insights that deepen our understanding of the observed numerical trends.

Quantitative Data Analysis

A quantitative analysis of the tailored Entrepreneurial Intention Questionnaire (EIQ) was conducted to assess participants' levels across six constructs derived from the TPB and EEM: attitudes towards behaviour, subjective norms, perceived behavioural control, perceived desirability, perceived feasibility, and propensity to act. Two hundred ninety-two students completed the EIQ, enabling an examination of changes across three phases: pre-intervention, post-classroom module, and post-WIL. Descriptive statistics were calculated for each construct, including the means, standard deviations, and percentiles (25%, 50%, and 75%) for all phases (Table 1).

Table 1. Descriptive statistics of engagement constructs pre- and post-intervention

Variable	Mean	Standard Deviation	25%	50%	75%
Pre ATB	2.07	0.92	1.00	2.00	3.00
Post ATB	5.57	1.07	5.00	6.00	6.00
PostWILATB	5.74	1.08	5.00	6.00	7.00
Pre SN	2.20	0.98	2.00	2.00	3.00
Post SN	5.77	1.10	5.00	6.00	7.00
Post SN WIL	6.05	1.02	6.00	6.00	7.00
PrePBC	2.00	0.89	1.00	2.00	3.00
Post PBC	5.75	1.14	5.00	6.00	7.00
Post WILPBC	6.32	0.93	6.00	7.00	7.00
PrePD	2.54	0.75	2.00	3.00	3.00
Post PD	5.49	1.07	5.00	6.00	6.00
Post WIL PD	6.27	1.04	6.00	7.00	7.00
PrePF	1.99	0.79	2.00	2.00	2.00
Post PF	5.63	1.13	5.00	6.00	6.00

Variable	Mean	Standard Deviation	25%	50%	75%
PostWILPF	6.45	0.84	6.00	7.00	7.00
Pre PA	2.10	0.76	2.00	2.00	2.00
Post PA	5.52	1.16	5.00	6.00	6.00
PostWILPA	5.99	0.15	6.00	6.00	6.00

Source: Effect of entrepreneurship education Survey data

Table 1 provides an overview of the descriptive statistics for entrepreneurial intention (EI) constructs, attitudes towards behaviour (ATB), subjective norms (SN), perceived behavioural control (PBC), perceived desirability (PD), perceived feasibility (PF), and propensity to act (PA) across three phases: pre-intervention, post-classroom module, and post-WIL phase. The notable increase in the mean scores across all constructs indicates a substantial positive shift in the participants' attitudes and perceptions following both educational interventions. These findings align with prior research emphasising the role of structured entrepreneurship education in fostering entrepreneurial intentions (Autio et al., 2001; Porfírio et al., 2022; Cekule et al., 2023).

The pre-intervention means ranged from 1.99 to 2.54, reflecting a low baseline entrepreneurial intention among STEM students, consistent with prior studies (Barrero et al., 2024; Bozward et al., 2023). The interquartile ranges further confirmed clustering at the lower end of the scale. After the interventions, the mean scores rose sharply, ranging from 5.49 to 6.45, with narrower standard deviations, indicating both improvement and greater consistency. These results corroborate the evidence that conventional and experiential learning significantly enhance entrepreneurial intention (Bell & Bell, 2020; Nazneen et al., 2024).

Comparing the two phases, WIL yielded marginally higher means across all constructs, particularly for PBC (6.32 vs. 5.75), PD (6.27 vs. 5.49), PF (6.45 vs. 5.63), and PA (5.99 vs. 5.52) than the other group. This pattern aligns with the existing literature, which highlights the role of experiential learning in enhancing self-efficacy and perceived feasibility (Fayolle et al., 2014). The very small SD for post-WIL PA (0.15) suggests remarkable homogeneity, warranting further exploration of the factors driving this consistency.

While these descriptive trends are compelling, statistical significance and practical relevance were confirmed using repeated-measures ANOVA and post-hoc tests (Tables 2 and 3). All pre- to post-intervention and pre- to post-WIL differences were highly significant ($p < .001$) with large effect sizes (Cohen's $d \approx 3.10–5.58$), reinforcing the transformative impact of entrepreneurship education on STEM students' entrepreneurial intentions.

Repeated Measures ANOVA results

A repeated-measures ANOVA was conducted to examine the effect of entrepreneurship education interventions, specifically the traditional classroom module and the work-integrated learning (WIL) component, on six entrepreneurial intention constructs: Attitude Towards Behaviour (ATB), Perceived Behavioural Control (PBC), Perceived Desirability (PD), Perceived Feasibility (PF), Propensity to Act (PA), and Subjective Norms (SN). The results of the ANOVA are presented in Table 2.

Table 2. ANOVA: Entrepreneurship education effects on entrepreneurial intention

Source	Sum of Squares	df	F-value	p-value
Condition	16656.62	17	1055.79	< 0.001
Residual	4861.02	5238	-	-
Total	21517.64	5255	-	-

Source: Effect of entrepreneurship education Survey data

The results in Table 2 indicate a highly significant effect of the intervention condition on entrepreneurial intention, as evidenced by the large F-value ($F(17, 5238) = 1{,}055.79$, $p < .001$). The effect size was substantial, with $\eta^2 = 0.774$, meaning that approximately 77.4% of the variance in entrepreneurial intention scores was explained by the intervention type. This magnitude far exceeds the conventional benchmarks for significant effects, underscoring the transformative impact of entrepreneurship education on STEM students' attitudes, perceived behavioural control, and feasibility perceptions.

The residual sum of squares (4,861.02) represents unexplained variability, whereas the total sum of squares (21,517.64) reflects the overall variance across conditions. These findings corroborate prior research, highlighting the strong influence of structured and experiential entrepreneurship education on intention formation (Astiana et al., 2022; Porfírio et al., 2022; Motta & Galina, 2023). However, ANOVA did not reveal which specific phases differed significantly. Therefore, Bonferroni-adjusted post-hoc comparisons were conducted to identify pairwise differences (Table 3).

Post-hoc Analysis of Significant Findings

Following the significant results from the repeated-measures ANOVA, Bonferroni-adjusted post-hoc tests were conducted to identify the specific differences between the intervention phases for each entrepreneurial intention construct. The outcomes of these comparisons are presented in Table 3.

Table 3. Post-hoc analysis of entrepreneurship education on entrepreneurial intention

Variable	Group 1	Group 2	Mean Difference	p-value	Reject Null Hypothesis
ATB	PostWILATB	Post ATB	0.1644	0.1309	False
	Pre ATB	Post ATB	3.5034	0.0000	True
	Pre ATB	PostWILATB	3.6678	0.0000	True
PBC	Post WILPBC	Post PBC	0.5705	0.0000	True
	PrePBC	Post PBC	3.7500	0.0000	True
	PrePBC	Post WILPBC	4.3205	0.0000	True
PD	Post WIL PD	Post PD	0.7808	0.0000	True
	PrePD	Post PD	2.9507	0.0000	True
	PrePD	Post WIL PD	3.7315	0.0000	True
PF	PostWILPF	Post PF	0.8205	0.0000	True
	PrePF	Post PF	3.6400	0.0000	True
	PrePF	PostWILPF	4.4605	0.0000	True
PA	PostWILPA	Post PA	0.4692	0.0000	True
	Pre PA	Post PA	3.4178	0.0000	True
	Pre PA	PostWILPA	3.8870	0.0000	True
SN	Post SN WIL	Post SN	0.2800	0.0000	True
	Pre SN	Post SN	3.5700	0.0000	True
	Pre SN	Post SN WIL	3.8500	0.0000	True

Source: Effect of entrepreneurship education Survey data

The results in Table 3 reveal several important patterns. First, all pre- to post-intervention and pre- to post-WIL comparisons were highly significant ($p < .001$), confirming that both interventions substantially improved entrepreneurial intention constructs. For example, ATB increased by 3.50 points from pre- to post-intervention and by 3.67 points from pre- to post-WIL ($p < .001$ for both cases). However, the difference between the post-intervention and post-WIL ATB scores was not significant ($p = .131$). This suggests a possible ceiling effect, where attitudes towards entrepreneurship were already maximised after the classroom module, leaving little room for

further improvement through WIL. This interpretation aligns with research indicating that attitudinal constructs often shift early in structured interventions and stabilise thereafter (Autio et al., 2001; Schlaegel & Koenig, 2014). The implication that can be drawn from these results is that WIL may not add substantial value for attitude change but remains critical for skill-based and experiential learning.

In contrast, WIL provided statistically significant incremental gains for PBC, PD, PF, PA, and SN, with mean differences ranging from 0.28 to 0.82 ($p < .001$). Although these improvements were smaller than the initial intervention effects, they indicate that experiential learning offers supplementary benefits, particularly for constructs linked to confidence, feasibility, and social norms. For instance, perceived feasibility increased by 0.82 points between the post-classroom and post-WIL phases, reinforcing the role of real-world application in strengthening entrepreneurial readiness (Fayolle et al., 2014; Dobrin, 2020). Similarly, the pronounced gains in PBC and PA suggest that hands-on experience enhances entrepreneurial self-efficacy and action orientation (Nguyen et al., 2023; Vijayan et al., 2024).

The significant difference in SN scores further indicates that WIL programs may cultivate stronger peer networks and social support for entrepreneurial endeavours, consistent with the literature on the influence of subjective norms on intention formation (Barrero et al., 2024; Rus-Casas et al., 2020). However, the additional improvements were generally modest, suggesting that while WIL deepens the practical and social dimensions, its incremental effect on attitudes may be limited when foundational exposure has occurred. Future research should explore how WIL components can be optimised to maximise these benefits (Aadland & Aaboen, 2020; Motta & Galina, 2023).

Qualitative Findings of Entrepreneurial Intentions in STEM Students

To complement the quantitative results, qualitative data were analysed using NVivo to capture the students' experiences and perceptions of entrepreneurship education. Table 4 summarises the groundedness and density of emergent themes, which include *Mindset Transformation*, *Confidence and Self-Efficacy*, *Peer Interaction*, *Real-World Application*, *Mentorship and Guidance*, and *Desirability of Entrepreneurship*.

Table 4. Groundedness and density of emergent themes and codes

Theme	Code	Groundedness (Gr)	Density (DS)
Transformation of Mindset	Mindset Shift	15	4
	Motivation	12	4
	Self-Identified Entrepreneur	10	4
	Growth Mindset	9	4
Increased Confidence and Self-Efficacy	Increased Confidence	14	4
	Skills Recognition	11	4
	Self-Efficacy	13	4
	Empowerment	10	4
Influence of Peer Interaction	Peer Support	13	3
	Collaborative Spirit	10	3
	Peer Learning	11	3
Real-World Application	Practical Application	14	4
	Tangible Learning	12	4
	Industry Exposure	13	4
	Skill Development	11	4
Desirability of Entrepreneurship	Career Path Perception	12	3
	Excitement about	11	3

Theme	Code	Groundedness (Gr)	Density (DS)
	Entrepreneurship		
	Entrepreneurial Aspirations	13	3
Value of Mentorship and Guidance	Mentorship Impact	10	4
	Inspirational Stories	9	4
	Guidance and Support	12	4
	Role Models	11	4

Source: Effect of entrepreneurship education research data

Table 4 presents the groundedness and density scores for the themes and codes derived from the NVivo analysis. Groundedness (Gr) represents the frequency of references coded for each concept, indicating how often participants mentioned it. For example, *Mindset Shift* recorded 15 references, highlighting its prominence in shaping the entrepreneurial orientation. Density (DS) reflects the number of codes grouped under each theme, signifying its conceptual richness. For instance, *mindset* transformation has four codes (density = 4), illustrating its multidimensional nature.

Mindset Transformation

Qualitative analysis revealed a significant transformation in the students' mindsets regarding entrepreneurship. Codes under this theme, such as *Mindset Shift* (Gr = 15; DS = 4), *Motivation* (Gr = 12), and *Self-Identified Entrepreneur* (Gr = 10), indicate that students began to view themselves as active participants in the entrepreneurial landscape. The high groundedness values suggest that this was one of the most frequently mentioned themes, while the density score (4) reflects its conceptual richness. This evolution resonates with the growth mindset theory, which posits that belief in one's ability to improve through effort is fundamental to success (Chen et al., 2023; Dweck, 2006; Yeager & Dweck, 2020).

Increased confidence and self-efficacy

Students consistently reported heightened confidence and self-belief, as supported by codes such as "Increased Confidence" (Gr = 14; DS = 4) and "Self-Efficacy" (Gr = 13). These findings underscore the significance of entrepreneurship education in cultivating psychological readiness for entrepreneurial actions. High groundedness values confirm the prevalence of this theme, whereas its density reflects multiple dimensions of confidence development. This aligns with the literature linking self-efficacy to entrepreneurial intention (Deliana, 2018; Renko et al., 2021).

Influence of Peer Interaction

Peer interaction is a critical enabler of entrepreneurial learning. Codes such as *Peer Support* (Gr = 13; DS = 3) and *Collaborative Spirit* (Gr = 10) highlight the importance of social learning environments. The moderate density score indicates fewer subcodes but strong thematic relevance. These findings are consistent with research emphasising the role of social networks in sustaining entrepreneurial motivation (Aldrich et al., 1986; Rus-Casas et al., 2020).

Real-World Application

Students valued opportunities to apply theoretical knowledge in practical contexts, as reflected in codes such as *Practical Application* (Gr = 14; DS = 4) and *Industry Exposure* (Gr = 13). High groundedness and density scores confirm that experiential learning is a dominant theme, reinforcing its role in enhancing entrepreneurial readiness. This supports the experiential learning

theory, which emphasises hands-on engagement for a more profound understanding (Anwar & Abdullah, 2021; Motta & Galina, 2023).

Value of Mentorship and Guidance

Mentorship emerged as a vital factor, with codes such as *Guidance and Support* (Gr = 12; DS = 4) and *Role Models* (Gr = 11) indicating its influence on entrepreneurial intention. The density score reflects multiple dimensions of mentorship, reinforcing its importance in shaping entrepreneurial mindsets (Mouammer & Bazan, 2021; Al-Issa, 2024).

Desirability of Entrepreneurship

The theme of desirability was evident through codes such as *Entrepreneurial Aspirations* (Gr = 13; DS = 3) and *Career Path Perception* (Gr = 12). These findings suggest that entrepreneurship education increases students' enthusiasm for entrepreneurship as a viable career option, complementing the quantitative evidence of increased perceived desirability (Astiana et al., 2022).

Overall, the qualitative findings highlight significant themes in students' learning experiences related to entrepreneurship education, demonstrating profound shifts in their mindsets, confidence, and aspirations. Engaging in peer interactions, practical applications, and valuable mentorship further enriches these experiences, fostering a stronger inclination towards entrepreneurship as a viable career path. These insights, grounded in the established literature, provide an essential context for understanding the transformative impact of entrepreneurship education on students, emphasising the interconnected roles of mindset, self-efficacy, peer support, real-world application, mentorship, and the desirability of entrepreneurship.

Integration of Quantitative and Qualitative Findings

Integrating quantitative and qualitative findings provides a comprehensive understanding of the impact of entrepreneurship education on students' perceptions, motivations, and aspirations. Both data streams revealed significant insights that affirmed and enriched the educational outcomes observed in this study, highlighting a multifaceted approach to evaluating the effectiveness of entrepreneurship programs. Figures 1 and 2 illustrate the overall impact of entrepreneurship education and provide a more precise breakdown of WIL's role in entrepreneurial growth and the influence of mentorship and social dynamics.

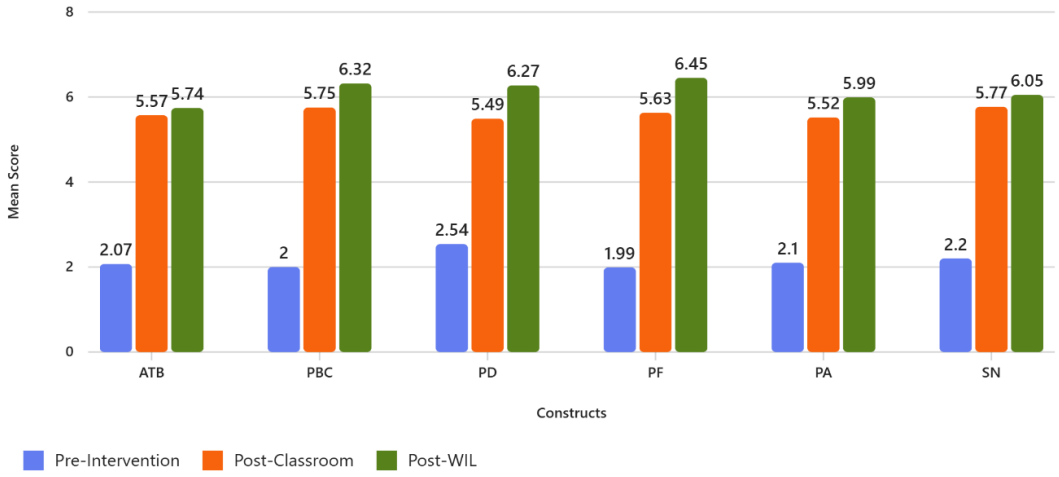

Figure 1. Impact of Entrepreneurship Education on Key Constructs Across Phases

Figure 1 illustrates how entrepreneurship education interventions, classroom-based learning and Work-Integrated Learning (WIL) shape entrepreneurial intention across six

constructs: Attitude Towards Behaviour (ATB), Perceived Behavioural Control (PBC), Perceived Desirability (PD), Perceived Feasibility (PF), Propensity to Act (PA), and Subjective Norms (SN). While both interventions produced substantial improvements, WIL stood out as a transformative component within the broader context of entrepreneurship education. The most significant gains occurred in PBC and PF during the WIL phase, signalling that experiential learning does more than reinforce theory—it builds confidence and practical readiness, which are essential for entrepreneurial action (Deliana, 2023; Nguyen et al., 2023).

WIL's contribution extends beyond incremental changes in scores. It operationalises entrepreneurship education by bridging the gap between classroom concepts and real-world applications. Codes such as *Practical Application* and *Industry Exposure* (Figure 2) confirm that WIL immerses students in authentic entrepreneurial contexts, enabling them to test ideas, solve problems, and engage with industry networks (Anwar & Abdullah, 2021; Motta & Galina, 2023). This experiential dimension transforms abstract knowledge into actionable skills, fostering entrepreneurial self-efficacy and perceptions of feasibility, which are critical drivers of venture creation.

Moreover, WIL amplifies the effects of relational learning. Themes such as mentorship, guidance, and peer interaction underscore their role in cultivating social capital, which complements technical competence. These relational experiences align with improvements in SN and PA, demonstrating that WIL not only equips students with skills but also embeds them in supportive networks that normalise entrepreneurial behaviour (Rus-Casas et al., 2020; St-Jean & Audet, 2012). In the broader framework of entrepreneurship education, WIL is not an add-on; rather, it is the mechanism that transforms intention into capability and readiness for entrepreneurial action.

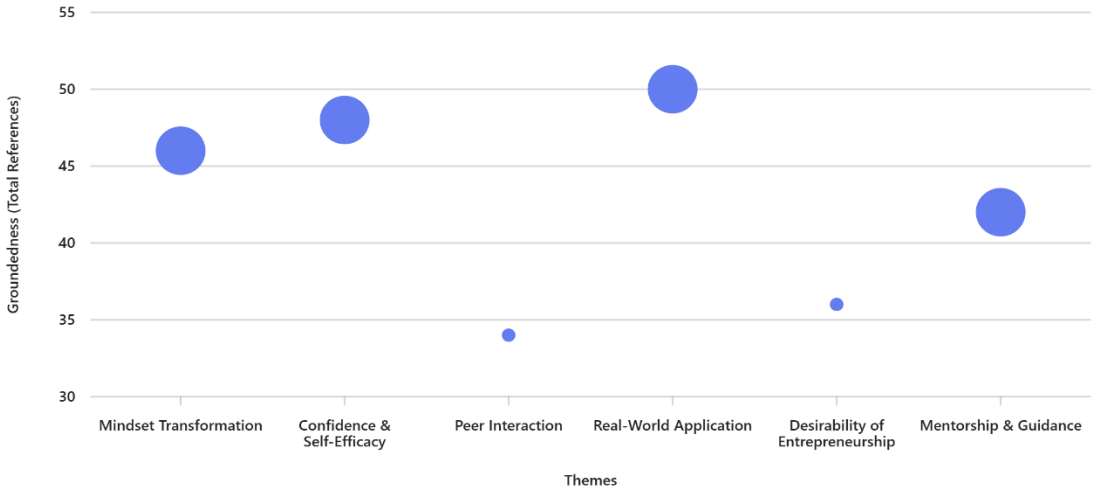

Figure 2. Qualitative Insights showing Groundedness and Density of Themes in Entrepreneurship Education

Figure 2 provides a visual representation of the qualitative themes that underpin the effectiveness of entrepreneurship education, with the bubble size indicating density (number of codes per theme) and position reflecting groundedness (frequency of references). The most prominent themes—*Real-World Application* and *Confidence & Self-Efficacy*—stand out as conceptually rich and frequently referenced, underscoring the transformative role of WIL in bridging theory and practice. These themes demonstrate that WIL does more than supplement classroom learning; it immerses students in authentic entrepreneurial contexts, enabling them to apply theoretical knowledge, develop practical skills, and build confidence in their ability to act

entrepreneurially (Anwar & Abdullah, 2021; Motta & Galina, 2023).

The bubble chart also highlights relational dimensions through themes such as *Mentorship & Guidance* and *Peer Interaction*. These themes align with quantitative improvements in Subjective Norms (SN) and Propensity to Act (PA), illustrating how WIL fosters social capital and mentorship networks that normalise entrepreneurial behaviour and encourage risk-taking (Rus-Casas et al., 2020; St-Jean & Audet, 2012). Codes such as *Mentorship, Impact, and Guidance and Support revealed that students valued personalised advice and inspirational stories from mentors, which reinforced their* confidence and clarified their career pathways. Similarly, peer collaboration fosters a sense of community, thereby amplifying the effect of WIL on entrepreneurial growth.

In the broader context of entrepreneurship education, Figure 2 confirms that WIL is not an isolated intervention but a critical mechanism for operationalising experiential learning. By combining technical knowledge with real-world exposure and relational support, WIL transforms entrepreneurial intention into capability and readiness for action, making it indispensable in curricula that foster innovation and resilience.

Figures 1 and 2 provide a visual and conceptual bridge between these two strands of evidence. The strongest quantitative improvements (PBC and PF) corresponded to the richest qualitative themes (*Real-World Application* and *Confidence & Self-Efficacy*), underscoring the pivotal role of experiential learning and mentorship (Anwar & Abdullah, 2021; Motta & Galina, 2023). Themes such as *Mindset Transformation* explain early attitudinal shifts (Dweck, 2006), while *Peer Interaction* and *Mentorship & Guidance* reinforce the social and relational dimensions that support entrepreneurial intention (Rus-Casas et al., 2020; St-Jean & Audet, 2012). This integrated perspective demonstrates that entrepreneurship education impacts students through measurable constructs and multidimensional experiential processes.

CONCLUSIONS

This study examined the impact of entrepreneurship education on STEM students at a historically disadvantaged university in South Africa, using a mixed-methods approach. The findings revealed that entrepreneurship education significantly enhanced entrepreneurial intentions, with improvements observed in attitudes, perceived behavioural control, desirability, feasibility, and propensity to act. While classroom-based instruction provides a strong theoretical foundation, Work-Integrated Learning (WIL) has emerged as a critical component that operationalizes entrepreneurship education by bridging theory and practice. WIL's experiential nature strengthened students' confidence, perceptions of feasibility, and readiness for entrepreneurial action, while mentorship and peer collaboration amplified social support and normalized entrepreneurial behaviour.

The findings show that WIL plays a pivotal role in entrepreneurship education by converting theoretical knowledge into practical skills. Through real-world engagement, mentorship, and peer collaboration, WIL equips students with the confidence and capability to pursue entrepreneurial ventures, making it indispensable for programs aimed at fostering innovation and resilience in resource-constrained environments.

Universities should embed WIL as a core element of entrepreneurship curricula to provide students with authentic hands-on experience in real-world entrepreneurial settings. Structured mentorship programs that connect students with experienced entrepreneurs are essential for reinforcing confidence and clarifying career pathways. Additionally, fostering collaborative learning environments that encourage peer interaction and networking will help sustain entrepreneurial motivation and build social capital, thereby creating a supportive ecosystem for aspiring entrepreneurs.

Policymakers should prioritize funding and policy frameworks that incentivize partnerships

between universities and industries to expand WIL opportunities. Establishing national mentorship networks can strengthen entrepreneurial ecosystems and provide role models for aspiring entrepreneurs. Additionally, integrating entrepreneurship education into STEM programs at all levels will build innovation capacity and help address unemployment challenges in emerging economies, such as South Africa.

LIMITATION & FURTHER RESEARCH

This study provides strong evidence that entrepreneurship education, particularly when combined with experiential learning, such as Work-Integrated Learning (WIL), significantly enhances the entrepreneurial intentions of STEM students at historically disadvantaged universities. The integration of quantitative and qualitative findings highlights a multifaceted impact, fostering a mindset transformation and confidence, and reinforcing entrepreneurship as a viable career path. However, this study was limited to a single institutional context, which may affect its generalizability. Future research should explore diverse settings and identify the specific characteristics of WIL programs that yield optimal results for developing entrepreneurial competencies. Longitudinal studies are recommended to examine the sustained impact of entrepreneurship education on career trajectories and ventures' success. Additionally, investigating scalable models for mentorship and industry partnerships can inform policy and curriculum design, ensuring that entrepreneurship education continues to empower students and drives innovation in resource-constrained environments.

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