Bridging Education and Industry to Cultivate Innovation Intentions among Engineering Graduates

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Abstract

Innovation is an increasingly important outcome of engineering education, particularly in developing economies where industrial growth depends on graduates' ability to generate and implement creative solutions. Despite this, empirical evidence explaining how educational practices and industry engagement shape students' innovation intentions remains limited in the Nigerian context. This quantitative study investigates the influence of experiential learning (EL) and industry exposure (IE) on innovation intentions (II) among final-year engineering and construction management students in three Nigerian public universities, with problem-solving skills (PS) and collaborative/technical self-efficacy (CTSE) examined as mediating mechanisms. Data were collected using a well-structured questionnaire administered to 211 final-year students and analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM). The findings indicate that experiential learning has a significant direct effect on innovation intentions and a strong indirect effect through enhanced problem-solving skills, but it does not significantly influence collaborative/technical self-efficacy. In contrast, industry exposure demonstrates significant direct effects on innovation intentions and indirect effects through collaborative/technical self-efficacy, highlighting the role of real-world professional engagement in building confidence for innovative practice. Problem-solving skills and collaborative/technical self-efficacy both significantly predict students' innovation intentions, confirming their importance as explanatory mechanisms. The study extends existing intention-based models by focusing on innovation rather than entrepreneurship and provides context-specific evidence from Nigeria on how experiential and industry-based learning pathways shape innovation readiness. The findings offer practical implications for curriculum design, university–industry collaboration and policy aimed at producing innovation-oriented engineering graduates.

Keywords: Construction management education, Engineering education, Experiential learning, Industry exposure; Innovation intentions.

1. Introduction

Higher education institutions (HEIs) are increasingly expected to move beyond their traditional roles as providers of disciplinary knowledge to become active contributors to innovation ecosystems that support industrial development and societal advancement (Hassan and Ahmad, 2025). In engineering and built environment disciplines, this expanded mandate places strong emphasis on graduates' capacity to generate, adapt and implement innovative solutions to complex technical and socio-economic challenges (Aliu and Aigbavboa, 2023; Tembrevilla *et al.,* 2024). As a result, universities are under growing pressure to design learning environments that cultivate innovation-oriented skills and mindsets alongside technical competence. Within engineering education, experiential learning and industry engagement have emerged as two prominent strategies for enhancing students' readiness for innovative practice. Experiential learning approaches, such as laboratory-based instruction, project-based learning, and design challenges, enable students to apply theoretical knowledge in practical contexts, thereby strengthening analytical reasoning, creativity and problem-solving capacity (Azeez and Aboobaker, 2024). Similarly, exposure to industry through internships, industrial training, site visits and professional networking provides students with opportunities to engage with real-world engineering problems, industry standards and collaborative work environments. While both approaches are widely promoted in engineering curricula, empirical evidence explaining how they shape students' intentions to innovate remains fragmented, particularly in developing country contexts.

Existing studies in engineering and entrepreneurship education have produced mixed findings regarding the direct influence of educational interventions on students' intention-related outcomes. Some studies report strong positive effects of experiential and industry-based learning on innovation- or entrepreneurship-related intentions (Singh, 2024), while others find weak or insignificant relationships (Ebekozien *et al.,* 2023). These inconsistencies suggest that educational experiences may not influence innovation intentions uniformly but rather operate through specific psychological and skill-based mechanisms. However, many prior studies treat experiential learning and industry exposure as homogeneous constructs, without adequately unpacking the distinct pathways through which they influence student outcomes.

Theoretical perspectives such as experiential learning theory, social cognitive theory (SCT) and the theory of planned behavior (TPB) provide a useful foundation for addressing this gap. These frameworks suggest that learning experiences shape intentions not only through direct exposure but also through the development of enabling competencies and beliefs (Nayak *et al.,* 2024). In the context of engineering education, problem-solving skills represent a core cognitive capability that allows students to identify and address complex technical challenges, while collaborative and technical self-efficacy reflects students' confidence in applying their knowledge effectively within team-based and professional environments. Despite their relevance, these constructs remain underexplored as mediating mechanisms linking experiential and industry-based learning to innovation intentions.

This gap is particularly pronounced in Nigeria, where engineering and construction management graduates are expected to play a central role in addressing infrastructure deficits, technological advancement and industrial competitiveness. Nigerian universities have increasingly incorporated experiential learning activities and mandatory industrial training into engineering curricula (Obi *et al.,* 2022). However, empirical research examining how these initiatives translate into students' innovation intentions is limited. Understanding these relationships is critical for informing curriculum design, strengthening university–industry collaboration, and aligning engineering education with national development goals. Although this study is situated in the Nigerian context, the findings are relevant to international audiences, because they illustrate how experiential learning and industry engagement can promote innovation intentions in engineering students under conditions similar to those faced by emerging and rapidly evolving education–industry ecosystems globally. Lessons from Nigeria can also inform the design of curricula, internships and industry partnerships in other countries seeking to enhance innovation-oriented competencies among engineering graduates.

Against this backdrop, the present quantitative study investigates how experiential learning (EL) and industry exposure (IE) influence innovation intentions (II) among final-year engineering and construction management students in Nigerian public universities. Drawing on experiential learning theory, social cognitive theory and the theory of planned behavior, the study examines both direct effects and indirect pathways through problem-solving skills (PS) and collaborative/technical self-efficacy (CTSE). By employing Partial Least Squares Structural Equation Modeling (PLS-SEM), the study provides a deep understanding of how different learning experiences contribute to innovation-oriented outcomes. Accordingly, the study addresses the following research questions:

1) To what extent do experiential learning and industry exposure influence students' innovation intentions?
2) Do problem-solving skills and collaborative/technical self-efficacy mediate the relationships between experiential learning, industry exposure, and innovation intentions?

By focusing on innovation intentions rather than entrepreneurial intentions, this study extends existing intention-based models within engineering education. It offers contextually grounded evidence from Nigeria that contributes to global discussions on preparing innovation-ready engineering graduates, while providing practical insights for educators, industry partners, and policymakers seeking to bridge the gap between higher education and professional practice.

2. Theoretical framework and hypothesis development

Research on students' innovation and entrepreneurial-oriented outcomes has been strongly informed by socio-cognitive and experiential learning theories, particularly Social Cognitive Theory (SCT) (Bandura, 1986) and experiential learning theory (Kolb *et al.,* 2014). These frameworks emphasize that individuals' intentions to engage in innovative or entrepreneurial activities are shaped not only by knowledge acquisition but also by self-beliefs, skills development and exposure to real-world contexts. In recent higher education research, these perspectives have increasingly been integrated to explain how learning environments cultivate students' innovation intentions through self-efficacy, problem-solving capacity and applied experiences (Nayak *et al.,* 2024). While prior studies have extensively examined entrepreneurial self-efficacy and entrepreneurial intentions, comparatively fewer studies have focused on collaborative and technical self-efficacy within innovation-driven, team-based learning contexts, particularly in engineering and applied disciplines. This study addresses this gap by positioning collaborative/technical self-efficacy (CTSE) as a central explanatory mechanism through which experiential learning (EL) and industry exposure (IE) influence students' innovation intentions (II). In addition, the framework incorporates problem-solving skills (PS) as a critical competency developed through experiential and industry-engaged learning, which further strengthens students' inclination toward innovation-oriented behaviour.

Collaborative/technical self-efficacy and innovation intentions

Self-efficacy reflects individuals' beliefs in their ability to successfully perform tasks and achieve desired outcomes (Bandura, 1986). In innovation-focused educational contexts, collaborative/technical self-efficacy captures students' confidence in applying technical knowledge, working effectively in teams, and contributing meaningfully to innovation processes. Empirical studies have shown that higher levels of technical and collaborative confidence enhance students' willingness to pursue innovative ideas, engage in experimentation, and translate knowledge into practical solutions (Maheshwari *et al.,* 2023). In engineering and applied science education, innovation is rarely an individual activity. Rather, it emerges from collective problem-solving, interdisciplinary collaboration and technical competence. Students who perceive themselves as capable collaborators and technical contributors are therefore more likely to demonstrate strong innovation intentions. Consistent with social cognitive theory and prior empirical evidence, this study proposes:

H1: Collaborative/technical self-efficacy (CTSE) has a significant positive effect on innovation intentions (II).

Experiential learning, self-efficacy and innovation intentions

Experiential learning refers to pedagogical approaches that emphasize learning through direct experience, reflection, and active engagement, such as project-based learning, design studios, simulations, and challenge-based tasks (Kolb *et al.,* 2014). Studies consistently demonstrate that experiential learning environments enhance students' confidence, autonomy and applied competence by allowing them to test ideas, learn from failure, and collaboratively solve real-world problems (Vijay *et al.,* 2024). Through repeated hands-on engagement, students develop stronger beliefs in their technical and collaborative capabilities, which directly strengthens their CTSE. Moreover, experiential learning has been shown to exert a direct influence on innovation intentions by fostering creativity, experimentation and opportunity recognition (Tembrevilla *et al.,* 2024). Beyond self-efficacy, experiential learning also plays a critical role in developing problem-solving skills, as students are required to diagnose ill-structured problems and generate feasible solutions under realistic constraints. Accordingly, this study hypothesis that experiential learning operates both directly and indirectly in shaping innovation intentions:

H2: Experiential learning (EL) has a significant positive effect on collaborative/technical self-efficacy (CTSE).

H3: Experiential learning (EL) has a significant positive effect on students' innovation intentions (II).

H4: Experiential learning (EL) has a significant positive effect on problem-solving skills (PS).

Industry exposure, skill development and innovation intentions

Industry exposure encompasses structured interactions between students and industry, including internships, industrial training, guest lectures, mentorship, site visits, and live industry projects. Such exposure bridges the gap between theoretical instruction and professional practice, enabling students to contextualize their learning within real organisational and technological settings (Manasikana and Saputro, 2025). Prior research suggests that industry engagement enhances students' technical confidence, professional identity and collaborative competence by exposing them to authentic innovation processes, industry-standard tools and multidisciplinary teamwork (Aliu and Aigbavboa, 2023). Industry exposure also strengthens problem-solving skills by confronting students with complex, real-life challenges that lack predefined solutions. Building on this evidence, the following hypotheses are proposed:

H5: Industry exposure (IE) has a significant positive effect on collaborative/technical self-efficacy (CTSE).

H6: Industry exposure (IE) has a significant positive effect on students' innovation intentions (II).

H7: Industry exposure (IE) has a significant positive effect on problem-solving skills (PS).

Problem-solving skills and innovation intentions

Problem-solving skills represent a core competence underlying innovation, encompassing the ability to analyse complex situations, integrate knowledge, and develop novel and practical solutions. Innovation literature consistently highlights problem-solving as a foundational capability that enables individuals to move from idea generation to implementation (Vijay *et al.,* 2024). Students who possess strong problem-solving skills are better equipped to navigate uncertainty, evaluate alternatives and persist through challenges inherent in innovation processes. In line with this perspective, this study proposes:

H8: Problem-solving skills (PS) have a significant positive effect on innovation intentions (II).

3. Research methodology

This study adopts a quantitative, cross-sectional research design to investigate the influence of experiential learning and industry exposure on students' innovation intentions, as well as the mediating roles of problem-solving skills and collaborative/technical self-efficacy. Data were collected from final-year students enrolled in engineering and construction management programmes at the Federal University of Technology, Akure; the Federal University of Technology, Minna; and the University of Uyo, all located in Nigeria. These institutions were selected to reflect diversity in institutional focus and regional representation within the Nigerian higher education system. Final-year students were considered the most appropriate population for this study because they have completed the majority of their coursework and practical training, including laboratory work, project-based learning and compulsory industrial attachments (Nkhoma *et al.,* 2025). As such, they are well positioned to assess how experiential learning and industry exposure shape their confidence, skills development, and intentions to engage in innovative activities.

A purposive sampling approach was employed to select students whose academic progression and disciplinary background aligned with the research objectives. A total of 300 final-year students were invited to participate in the study, of which 211 students completed the survey, yielding a usable response rate of approximately 70.3%. Only fully completed questionnaires were retained for analysis. Data were collected using a structured electronic questionnaire. The data were analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM) with SmartPLS 4. This method was selected due to its robustness in handling complex models with mediating variables and its suitability for prediction-oriented research (Hair *et al.,* 2021). The analysis followed a two-stage procedure, beginning with the assessment of the measurement model to establish reliability and validity, followed by evaluation of the structural model to test the hypothesized relationships (Chin *et al.,* 2020).

The study variables were operationalized using a structured questionnaire composed of multi-item reflective constructs drawn from established theoretical foundations and refined to suit the context of engineering and construction management education in Nigeria. Where necessary, measurement items were adapted to reflect students' exposure to hands-on learning activities, industry-based experiences and innovation-oriented outcomes within their academic programmes. All constructs were measured using a five-point Likert-type scale, with responses ranging from 1 (strongly disagree) to 5 (strongly agree). The instrument was designed to capture students' perceptions of their learning experiences, skill development, self-efficacy and intention to engage in innovative activities. Experiential learning (EL) was measured using items that assessed students' involvement in practical learning activities, including laboratory work, design-based projects, group experiments and the application of theoretical knowledge to real problems. These items reflect the core principles of experiential learning theory by emphasizing learning through action and reflection. Industry exposure (IE) was operationalized through items capturing students' engagement with professional environments, such as internships, industrial visits, workshops, seminars and interactions with industry practitioners. These measures focus on the extent to which real-world exposure enhances students' understanding of industry challenges and stimulates innovative thinking. Problem-solving skills (PS), included as a mediating construct, were measured using items that assessed students' perceived ability to analyze technical problems, generate multiple solutions, apply logical reasoning, and adapt strategies when addressing complex engineering tasks. These items reflect the development of analytical and cognitive capabilities fostered through experiential learning. Collaborative/technical self-efficacy (CTSE) was measured through items capturing students' confidence in applying technical knowledge, contributing effectively to team-based projects, adapting to new technical challenges and implementing innovative solutions within professional or collaborative settings. This construct reflects the confidence gained through sustained engagement with industry and collaborative learning environments. Innovation intentions (II), the dependent variable in the study, were measured using items that assessed students' motivation, commitment, and willingness to pursue innovative ideas, develop original solutions and actively seek opportunities to implement creativity within their field of study.

4. Results

4.1. Participant demographics

The demographic profile indicated that, out of 211 valid responses, 131 students (62.1%) were male and 80 students (37.9%) were female, reflecting the gender distribution commonly observed within engineering-related disciplines in Nigerian higher education institutions. Participation spanned multiple engineering and built environment specializations, ensuring that the sample captured students with substantial exposure to experiential learning activities and industry-based training prior to graduation.

4.2. Assessment of measurement model

The measurement model was assessed to establish the reliability, convergent validity, discriminant validity and collinearity of the study constructs prior to testing the structural relationships. The evaluation followed established guidelines for PLS-SEM analysis (Hair *et al.,* 2021). Internal consistency reliability was examined using Cronbach's alpha and composite reliability (CR). Cronbach's alpha values above 0.70 indicate acceptable reliability, while CR values between 0.70 and 0.95 suggest satisfactory internal consistency without redundancy among indicators (Memon *et al.,* 2021). As shown in Table 1, all constructs exceeded the minimum recommended threshold of 0.70 for both Cronbach's alpha and CR. These results confirm that the measurement items consistently represent their respective latent constructs. Convergent validity was evaluated using indicator (factor) loadings and average variance extracted (AVE). Factor loadings of 0.70 or higher are considered acceptable, indicating that indicators explain a substantial portion of the variance in their underlying construct (Zeng *et al.,* 2021). AVE values should exceed 0.50, demonstrating that the construct accounts for more than half of the variance in its indicators (Fornell and Larcker, 1981). The results in Table 1 indicate that all measurement items loaded strongly on their respective constructs, with factor loadings ranging from 0.721 to 0.876, thereby meeting recommended criteria. In addition, AVE values for all constructs were well above the 0.50 threshold, confirming adequate convergent validity (Chin *et al.,* 2020). To assess potential multicollinearity issues among indicators, Variance Inflation Factor (VIF) values were examined. VIF values below 5.0 indicate the absence of critical collinearity concerns, while values below 3.3 suggest an even more conservative and robust model specification (Aghimien *et al.,* 2025). As reported in Table 1, all VIF values were below 3.0, indicating that multicollinearity is not a concern in the measurement model. Discriminant validity was assessed using both the Fornell–Larcker criterion and the heterotrait–monotrait ratio of correlations (HTMT) to ensure that each construct is empirically distinct from the others. According to the Fornell–Larcker criterion, the square root of the AVE for each construct should be greater than its correlations with other constructs (Fornell and Larcker, 1981). As shown in Table 2, the diagonal elements (square roots of AVE) exceed the corresponding inter-construct correlations for all constructs, indicating satisfactory discriminant validity. HTMT values below 0.90 are considered acceptable for conceptually distinct constructs, while a stricter threshold of 0.85 is recommended for closely related constructs (Sarstedt *et al.,* 2020). The HTMT results presented in Table 3 show that all values fall well below the 0.90 threshold, further confirming the discriminant validity of the measurement model.

Table 1: Measurement model evaluation

Constructs	**Measurement item**	**Factor loading**	**Cronbach's alpha**	**Composite reliability**	**Average variance extracted (AVE)**	**Variance Inflation Factor (VIF)**
Collaborative/technical self-efficacy (CTSE)	CTSE1	0.876	0.825	0.834	0.884	2.228
	CTSE2	0.803				1.738
	CTSE3	0.759				1.673
	CTSE4	0.798				1.720
Experiential learning (EL)	EL1	0.750	0.823	0.832	0.883	1.539
	EL2	0.849				1.948
	EL3	0.844				1.939
	EL4	0.787				1.634
Industry exposure (IE)	IE1	0.840	0.851	0.858	0.899	2.035
	IE2	0.787				1.747
	IE3	0.838				1.885
	IE4	0.858				2.118
Innovation intentions (II)	II1	0.754	0.835	0.838	0.890	1.514
	II2	0.820				1.885
	II3	0.859				2.117
	II4	0.840				2.012
Problem-solving skills (PS)	PS1	0.804	0.823	0.828	0.876	1.790
	PS2	0.764				1.629
	PS3	0.721				1.544
	PS4	0.779				1.633
	PS5	0.753				1.582

(Source: Author's creation)

Table 2: Results of Fornell and Larcker criterion

Construct	CTSE	EL	IE	II	PS
Collaborative/technical self-efficacy (CTSE)	0.810				
Experiential learning (EL)	-0.069	0.809			
Industry exposure (IE)	0.646	-0.136	0.831		
Innovation intentions (II)	0.580	0.389	0.471	0.819	
Problem-solving skills (PS)	0.053	0.552	-0.006	0.501	0.765

(Source: Author's creation)

Table 3: Results of Heterotrait-monotrait ratio of correlations (HTMT)

Construct	CTSE	EL	IE	II	PS
Collaborative/technical self-efficacy (CTSE)					
Experiential learning (EL)	0.127				
Industry exposure (IE)	0.764	0.165			
Innovation intentions (II)	0.697	0.466	0.553		
Problem-solving skills (PS)	0.089	0.665	0.093	0.598	

(Source: Author's creation)

4.3. Assessment of structural model

To assess the significance of the path coefficients, a non-parametric bootstrapping procedure with 5,000 resamples was employed. Bootstrapping in PLS-SEM provides empirical standard errors for each path coefficient, enabling the calculation of t-statistics and p-values without relying on normality assumptions (Shmueli *et al.,* 2019). Thresholds for evaluating significance included t-values ≥ 1.96 ($p \leq 0.05$), ≥ 2.58 ($p \leq 0.01$) and ≥ 3.29 ($p \leq 0.001$). The results of the direct path analysis are presented in Table 4. Findings indicate that CTSE → II ($\beta = 0.433$, $t = 8.588$, $p < 0.001$) and PS → II ($\beta = 0.332$, $t = 6.530$, $p < 0.001$) were significant, confirming that collaborative/technical self-efficacy and problem-solving skills positively influence students' innovation intentions. Experiential learning was found to have a strong impact on problem-solving skills (EL → PS, $\beta = 0.562$, $t = 10.903$, $p < 0.001$), while industry exposure significantly enhanced collaborative/technical self-efficacy (IE → CTSE, $\beta = 0.649$, $t = 15.248$, $p < 0.001$). Non-significant relationships included EL → CTSE ($\beta = 0.019$, $t = 0.333$, $p = 0.739$) and IE → PS ($\beta = 0.071$, $t = 1.102$, $p = 0.271$), suggesting that these direct paths do not meaningfully contribute to innovation intentions in this context. These results highlight the importance of mediating variables (PS and CTSE) in connecting EL and IE to II. These are all shown in Figure 1. The global fit of the PLS-SEM model was assessed using several recommended indices for variance-based SEM, as shown in Table 5. The Standardized Root Mean Square Residual (SRMR) was 0.062, below the recommended threshold of 0.08, indicating a good absolute fit. The Squared Euclidean Distance (d_ULS = 1.257) and Geodesic Distance (d_G = 0.559) further confirm that the estimated model closely approximates the observed data. The Chi-square statistic was 432.211; while sensitive to sample size, it provides a reference for model evaluation. The Normed Fit Index (NFI = 0.912) exceeds the 0.90 threshold, reflecting a satisfactory relative fit of the model. These indices suggest that the proposed model demonstrates adequate explanatory and predictive power, providing a reliable framework for interpreting both direct and mediated effects.

Table 4: Structural model path coefficients and significance testing

Hypothesis	Relationship	Original sample (O)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values	Result
H1	CTSE -> II	0.433	0.050	8.588	0.000	Supported
H2	EL -> CTSE	0.019	0.057	0.333	0.739	Not Supported
H3	EL -> II	0.267	0.047	5.722	0.000	Supported
H4	EL -> PS	0.562	0.052	10.903	0.000	Supported
H5	IE -> CTSE	0.649	0.043	15.248	0.000	Supported
H6	IE -> II	0.230	0.051	4.470	0.000	Supported
H7	IE -> PS	0.071	0.064	1.102	0.271	Not Supported
H8	PS -> II	0.332	0.051	6.530	0.000	Supported

(Source: Author's creation)

Table 5: PLS-SEM model fit Assessment

Model Fit	Estimated model
Standardized Root Mean Square Residual (SRMR)	0.062 (Acceptable)
Squared Euclidean Distance (Unweighted Least Squares Discrepancy) (d_ULS)	1.257 (Acceptable)
Geodesic Distance (d_G)	0.559 (Acceptable)
Chi-Square Statistic (Chi-square)	432.211 (Acceptable)
Normed Fit Index (NFI)	0.912 (Acceptable)

(Source: Author's creation)

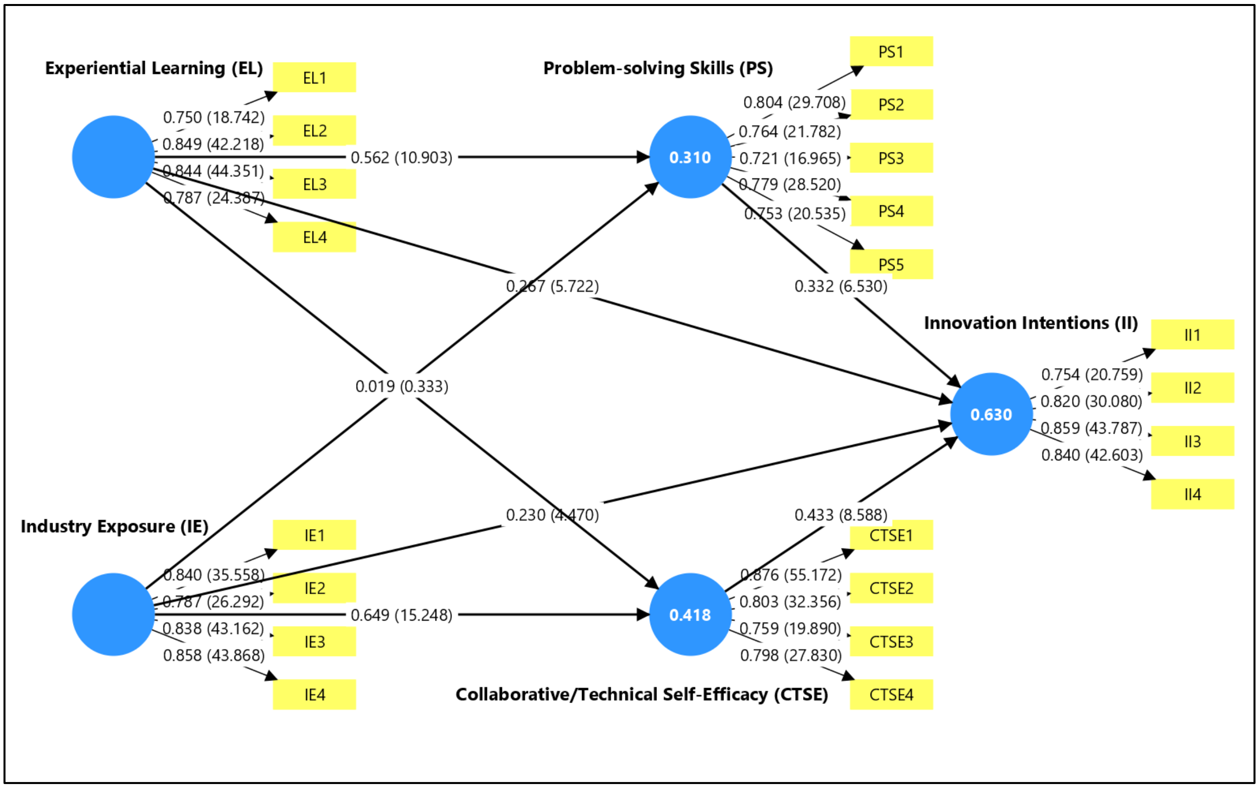

Figure 1: Structural assessment model

5. Discussion

This study examined how experiential learning (EL) and industry exposure (IE) influence innovation intentions (II) among final-year engineering and construction management students in Nigeria, with problem-solving skills (PS) and collaborative/technical self-efficacy (CTSE) as mediating factors. The findings provide both theoretical and practical insights into how higher education can promote innovation capabilities in engineering graduates. The results indicate that EL significantly enhances problem-solving skills, which in turn positively influences innovation intentions. This aligns with prior research emphasizing that hands-on, project-based learning improves students' analytical and creative capacities (Kolb *et al.,* 2014). By engaging students in laboratory exercises, design challenges and group-based projects, EL appears to provide a strong foundation for identifying and implementing innovative solutions, consistent with studies in engineering and technical education contexts (Aliu *et al.,* 2023; Tembrevilla *et al.,* 2024). Interestingly, EL did not show a significant direct effect on collaborative/technical self-efficacy

(CTSE). This may reflect the limited emphasis on structured team-based exercises within existing Nigerian construction curricula, where individual assessment often dominates group collaboration. In practice, students may complete experiential tasks independently or in loosely organized groups, reducing opportunities for confidence-building in collaborative technical application. Therefore, the non-significant path (EL → CTSE) underscores the need for curricula to more intentionally incorporate structured teamwork-focused experiential activities, such as group-based capstone design projects or multi-disciplinary site simulations.

Industry exposure (IE) showed a strong positive effect on CTSE, supporting previous studies that emphasize the role of internships, industrial visits and professional networking in developing students' confidence and technical competence (Aliu and Aigbavboa, 2021). By interacting with professionals and experiencing real-world challenges, students gain both practical knowledge and self-assurance in their ability to contribute to technical projects. However, IE had a limited effect on problem-solving skills (IE → PS), likely due to the nature of typical industrial placements in the local construction industry, which may prioritize observation, routine task completion, or safety compliance rather than active problem-solving and analytical engagement. This highlights an opportunity for industry partners and universities to co-design placement experiences that challenge students to tackle real-world construction problems in a structured manner, thereby linking IE more directly to problem-solving skill development.

The mediating role of PS and CTSE underscores their critical function in translating educational and professional experiences into innovation intentions. Problem-solving skills fully mediated the relationship between EL and II, indicating that experiential learning promotes innovation intentions primarily through the development of analytical and creative capabilities. Similarly, CTSE partially mediated the impact of IE on II, suggesting that confidence in technical application and teamwork is an important conduit for translating industry exposure into a stronger intention to innovate. These findings extend existing entrepreneurial intention models (Maheshwari *et al.,* 2023) by demonstrating the pathways through which engineering education can foster innovation-specific outcomes, rather than entrepreneurial intent alone. Generally, the study highlights the differential roles of EL and IE in shaping innovation intentions. While EL primarily strengthens problem-solving abilities, IE enhances confidence in collaborative and technical application. This distinction contributes to the literature by providing contextually grounded evidence from Nigerian universities, illustrating that different learning experiences may target distinct competencies.

6. Implications for curriculum, practice and policy

The differential effects of experiential learning (EL) and industry exposure (IE) provide clear guidance for curriculum design in engineering and construction management programs. The findings suggest that curricula should integrate hands-on, project-based learning with structured industry engagement to maximize innovation outcomes. Capstone design projects, laboratory-based design challenges and group-based assignments should emphasize both individual problem-solving and collaborative technical application, addressing the observed gap in EL → CTSE. Similarly, internships, industrial visits, and industry-led projects should incorporate clearly defined problem-solving tasks, mentorship and reflective activities, ensuring that students actively apply technical knowledge rather than passively observing. Group-based projects, site simulations, and interdisciplinary challenges can further foster collaborative confidence while reinforcing technical competencies. The non-significant paths observed in this study provide additional insights for curriculum and industry practice. The lack of a direct effect of EL on CTSE likely reflects the emphasis on individual assessment within current Nigerian construction curricula, where structured teamwork opportunities may be limited. Likewise, the non-significant impact of IE on problem-solving skills likely reflects the nature of local industrial placements, which often involve routine tasks, observation, or compliance-focused activities rather than complex, independent problem-solving. These findings highlight the need for intentional redesign of experiential and industry-based components, so students are actively engaged in real-world problem-solving while developing collaborative technical confidence.

From a policy and institutional perspective, the study underscores the importance of mandating innovation-focused experiential learning and structured industry engagement as core components of engineering programs. Regulators and institutional leaders should incentivize university–industry collaboration, ensuring placements are meaningful, supervised, and aligned with learning outcomes that target both problem-solving and collaborative confidence. Faculty and program coordinators should receive training to design experiential learning activities that explicitly foster both individual analytical skills and team-based competencies. Similarly, industrial mentors should be guided to provide structured challenges that actively engage students in problem-solving and technical collaboration, thereby enhancing the likelihood that industry exposure translates into innovation intentions. Finally, the study contributes to scholarly understanding by clarifying the mediating roles of PS and CTSE in shaping innovation intentions. Unlike many studies that focus exclusively on entrepreneurial outcomes, this research demonstrates that innovation-specific capabilities can be cultivated through well-designed educational and industry experiences. Future research could explore the long-term impact of EL and IE on graduates' actual innovative behaviors post-graduation or compare outcomes across engineering specializations and institutional contexts, providing additional guidance for curriculum and policy development.

7. Conclusion

This quantitative study, using a well-structured questionnaire, investigated the influence of experiential learning (EL) and industry exposure (IE) on the innovation intentions (II) of final-year engineering and construction management students in Nigeria, with problem-solving skills (PS) and collaborative/technical self-efficacy (CTSE) serving as mediating factors. The findings provide clear evidence that EL and IE contribute to innovation intentions through distinct but complementary pathways as EL primarily strengthens analytical and creative problem-solving capabilities, while IE enhances confidence in applying technical knowledge collaboratively. These results underscore the importance of designing higher education experiences that simultaneously develop both skills and self-efficacy to promote innovation-ready graduates.

The study makes several important theoretical contributions. First, it extends existing entrepreneurial intention frameworks by demonstrating that innovation intentions can be cultivated through skill- and confidence-based mediating mechanisms, rather than through direct exposure alone. Second, it clarifies the differential impact of educational and industry experiences, highlighting that EL and IE serve complementary roles in shaping distinct competencies. This context-specific evidence from Nigerian universities adds to the global literature on engineering education, particularly in emerging economies, where research on innovation intentions remains limited. From a practical perspective, the findings provide actionable guidance for curriculum designers, faculty and industry partners. Universities should integrate structured, team-based experiential learning activities alongside supervised industrial placements that challenge students to apply knowledge in real-world, collaborative settings. Policymakers and institutional leaders are encouraged to incentivize and support partnerships between academia and industry to ensure that students gain meaningful exposure that promotes both technical competence and confidence in teamwork.

Despite the relevance and practical contributions of this quantitative study, it has several limitations that should be acknowledged. First, the study employed a cross-sectional design, which limits the ability to establish causal relationships between experiential learning (EL), industry exposure (IE), mediating factors (PS and CTSE) and innovation intentions (II). Future research could adopt longitudinal designs to track how these variables evolve over time and to provide stronger evidence of causality. Second, the sample was restricted to final-year students from three Nigerian universities enrolled in engineering and construction management programs, which may limit the generalizability of the findings to other disciplines, universities, or international contexts. Future studies could conduct comparative analyses across different engineering disciplines, universities, or countries to examine the robustness and applicability of the model in diverse educational and cultural settings. Third, the study relied exclusively on quantitative questionnaire data, which could be influenced by response biases such as social desirability or overestimation of skills and intentions. Future research could incorporate mixed-methods approaches, including qualitative interviews, observational data, or supervisor/peer evaluations, to obtain a more comprehensive and objective understanding of how EL and IE influence innovation intentions.

Data availability statement

All data or codes generated or used during the study are available from the corresponding author upon request.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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