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SKILLS, BARRIERS AND PREDISPOSITION TO SUSTAINABLE ENTREPRENEURSHIP IN HIGHER EDUCATION

Orlando Meneses Quelal[1*]

[1]*Carrera de Alimentos. Universidad Politécnica Estatal del Carchi. Tulcán, Ecuador. Email: orlando.meneses@upec.edu.ec*

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Corresponding Author: Orlando Meneses Quelal (orlando.meneses@upec.edu.ec)

ABSTRACT

The study analyzed the factors associated with the intention to pursue sustainable entrepreneurship among university students, considering their level of knowledge, professional experience, and perceived barriers. A quantitative approach was used with a sample of 227 students from the State Polytechnic University of Carchi, Ecuador, using a structured questionnaire that assessed sociodemographic data, knowledge of sustainability, entrepreneurial aspirations, and reported obstacles. This was complemented by descriptive statistics, factor analysis, and penalized logistic regression. The results showed a low level of conceptual understanding of sustainability, with a mean of 2.38 and a standard deviation of 0.71, as well as a low preference for entrepreneurship, reflected in only 7.5% of interested students. The identified barriers were organized into two latent dimensions that explained 99.3% of the total variance: technical limitations and structural resistances. In the predictive model, technical knowledge significantly increased the probability of entrepreneurial intention with a β coefficient of 0.203 and a p-value of 0.024; technical limitations reduced it with a β coefficient of -0.269 and a p-value of 0.004; and structural resistances showed a moderate positive effect with a β coefficient of 0.185 and a p-value of 0.026. The findings indicate that the willingness to engage in sustainable entrepreneurship depends not only on personal motivation but also on the combination of individual skills and institutional support. Therefore, simultaneously strengthening sustainability training and university mechanisms that support entrepreneurship becomes essential to encourage student participation in sustainable initiatives.

KEYWORDS: Sustainable Entrepreneurship, Factor Analysis, Penalized Logistic Regression, Higher Education.

1. INTRODUCTION

Over the past two decades, sustainability has evolved from an ethical or environmental concept to a structuring axis of economic and social development (Giraldo-Giraldo et al., 2025). Several recent analyses agree that dominant production and consumption patterns account for most global greenhouse gas emissions. For example, Dawkins et al. (Dawkins et al., 2024) They show, from consumption-based accounting, that final demand is associated with more than two-thirds of emissions. Huang et al. (2024) They quantify how changes in income and lifestyles increase household carbon footprints, while Wang et al. (2022) Multiregional input-output models demonstrate-that supply chains linked to consumption concentrate environmental pressures.

In this context, sustainable entrepreneurship emerges as a key strategy for linking economic growth, innovation, and environmental sustainability. However, the scientific literature warns that its implementation faces structural and cognitive limitations: a shortage of technical skills, institutional weaknesses, and a lack of ecosystems that foster the transformation of entrepreneurial intention into effective action (Aguirre Benalcázar et al., 2025).

Globally, the scientific community has focused much of its effort on understanding the psychological and contextual determinants of sustainable entrepreneurship. From the Theory of Planned From behavioral studies to contemporary models of sustainable business ecosystems (Vera et al., 2024), empirical evidence agrees that entrepreneurial intention is formed from the interaction between attitudes, perceived behavioral control, and social norms. However, global studies underscore a persistent gap between knowledge and action. According to Chupin et al. (2025), only 9% of sustainable projects developed in universities manage to reach the market, mainly due to a lack of technical capabilities and institutional support. In regions of Asia and Europe, recent research shows that strengthening technological, financial, and environmental skills increases the likelihood of sustainable entrepreneurship by up to 40% (Joana Carolina et al., 2024), highlighting the crucial role of specialized human capital in the transition to green economies.

In Latin America, the challenge is compounded by a combination of educational gaps, infrastructure limitations, and fragile institutional environments. Although scientific output on sustainability in higher education has increased in the last decade, the results show that the integration of sustainability as a cross-cutting theme remains partial and heterogeneous (Anzules-Falcones et al., 2025).

Regional mapping studies in Latin American universities demonstrate that, while there are multiple institutional initiatives focused on the Sustainable Development Goals, their deep integration into curricula and educational experiences remains limited, with uneven progress across countries (Robles Moral et al., 2025). Regional research on competencies in education for sustainable development indicates that training remains predominantly theoretical and with little practical connection to local productive contexts. Likewise, recent empirical studies in countries such as Colombia, Mexico, Chile, and Ecuador agree that the low entrepreneurial intention among university students is not solely due to a lack of financial resources, but primarily to the absence of practical experiences, university environments conducive to innovation, and educational models geared toward sustainability and environmental entrepreneurship (Mendizabal et al., 2021).

In Ecuador, university education and the entrepreneurial ecosystem show significant shortcomings in terms of sustainability. Although there has been progress, the scientific literature reveals that their integration remains limited. Aguirre Benalcázar et al. (2025), studies show that factors such as financial planning and environmental awareness drive sustainable entrepreneurship, but there are no clear estimates of its magnitude or survival rate. Likewise, Vallejo & Robalino (2025) point out that universities develop technical capabilities but face institutional barriers that hinder the creation of ventures based on sustainable innovation.

Studies of student populations, such as that of Zapata & González (2021), show a strong predisposition toward green entrepreneurship, although this rarely materializes into consolidated projects. Complementarily, Ayaviri-Nina et al. (2023) highlight that human capital and social networks influence business success without distinguishing green initiatives, reflecting a lack of solid evidence on the actual performance of sustainable entrepreneurship in the country. Overall, the literature confirms the gap between education, entrepreneurial skills, and the development of sustainable businesses in Ecuador.

Given this reality, Ecuadorian universities play a crucial role as generators of knowledge, human capital, and innovative entrepreneurship. However, the national literature shows a limited scientific

output regarding the factors that determine students' intention to engage in sustainable entrepreneurship (D'Armas Regnault et al., 2024). Most available studies adopt qualitative or descriptive approaches, without incorporating robust statistical analyses that would allow for modeling the relationship between the cognitive, attitudinal, and contextual variables involved (Vera et al., 2024). This methodological gap prevents a deep understanding of the mechanisms that explain why young people, even while recognizing the importance of sustainability, do not translate it into concrete initiatives.

This study proposes to analyze, using a quantitative approach, how cognitive, technical, and contextual factors, including technical knowledge, perceived limitations, experience, and structural barriers, influence the intention to undertake sustainable entrepreneurship among students at the Universidad Politécnica Estatal del Carchi, with the purpose of generating evidence to support strategies for strengthening green entrepreneurship in Ecuador and the Andean region.

2. METHODOLOGY

2.1. Research Approach and Design

The research was framed within a quantitative, empirical, and analytical approach, aimed at establishing causal and predictive relationships between sustainability competencies, perceived barriers, and the aspiration for sustainable entrepreneurship among university students. A non-experimental, cross-sectional, and correlational-predictive design was adopted, appropriate when working with observational data and the objective is to infer structural patterns from empirical evidence (Kumari & Sudha, 2026).

The study employed a multi-block approach, combining descriptive, inferential, exploratory factor analysis, penalized modeling, and multivariate segmentation techniques. This methodological sequence allows progress from the characterization of observed variables to the identification of latent factors and the prediction of entrepreneurial intention.

2.2. Population, Sample and Sampling

The target population for the study consisted of all students enrolled in undergraduate programs at the State Polytechnic University of Carchi (UPEC) during the 2024–2025 academic year (N ≈ 4,800). Given that the research focuses on analyzing technical skills and sustainable entrepreneurial aspirations among university students, the unit of analysis was the currently enrolled undergraduate student.

The final sample consisted of 227 students who fully completed the university's institutional questionnaire on sustainability and entrepreneurship.

Given the exploratory nature of the study, the institutional access available to students, and the need to ensure representativeness of students exposed to academic content related to innovation and sustainability, purposive non-probability sampling was used. Inclusion criteria were: (i) being a currently enrolled student, (ii) taking courses directly or indirectly related to entrepreneurship or sustainability and (iii) agreeing to participate voluntarily in the research. Selection was carried out in coordination with the faculties, distributing the questionnaire during academic sessions to ensure that all participants met the inclusion criteria.

Although the non-probabilistic procedure limits strict population inference, the sample size was considered sufficient for multivariate analysis, as it meets the minimum requirements for logistic regression (≥10 cases per predictor) and factor analysis (≥200 cases and >5 participants per measured variable). Furthermore, considering the total population and an expected proportion of maximum variability ($p = 0.5$), the theoretical sampling error was estimated at ±6.3% with a 95% confidence level, a value that indicates adequate internal precision for estimating descriptive proportions within the evaluated university context.

To ensure transparency and methodological traceability, **Table 1** details the structure of the dimensions and the types of variables collected through the research questionnaire, which are fundamental for inferential and predictive statistical analyses.

The instrument is organized into six key dimensions that allow for a comprehensive assessment of the factors affecting the intention to pursue sustainable entrepreneurship. These dimensions include sociodemographic data, professional experience, knowledge of sustainability, areas of interest, career aspirations, and perceived barriers.

Each dimension has been designed to capture specific aspects that, when integrated, provide a complete view of the skills and challenges students face on their path to sustainable entrepreneurship.

Table 1: Dimensional Structure, Operationalization of Variables and Measurement Scales Used in the Characterization of the Sample.

Dimension	Description	Variable type	Scale
I. Sociodemographic data	Gender, age, education level, area of training	Nominal	Categorical selection
II. Professional Experience	Years and type of experience	Ordinal	Structured text/selection
III. Knowledge in sustainability	Self-assessment of knowledge level	Ordinal	Numerical Likert scale (1-5)
IV. Areas of interest	Multiple selection of training topics	Multiple nominal	Multiple choice
V. Professional aspirations	Textual description of aspirations	Categorical	Textual response
VI. Perceived barriers and supports	Challenges and expected resources	Multiple nominal	Multiple choice

This dimensional structure underpins the multi-block approach implemented in the statistical analysis, allowing for the modeling of sustainable entrepreneurial behavior through cognitive (block III), contextual (block VI), experiential (block II), attitudinal (block V), and demographic (block I) variables. The sample used, therefore, directly addresses the research objective by capturing the necessary components to explain the aspiration for sustainable entrepreneurship among university students from a predictive and inferential perspective.

2.3. Validation And Quality Control of the Instrument

The final questionnaire consisted of 34 items distributed across six thematic dimensions. To ensure its technical quality before mass application, an expert review validation process was implemented. Content validity was determined using the inter-expert agreement coefficient (IAC_{global}), which yielded a value of 0.91, reflecting a high level of consensus on the relevance, clarity, and conceptual alignment of the items with respect to the constructs being assessed.

The content validity coefficient estimate was calculated using Equation 1:

Equation 1	$IAC_{global} = \frac{\sum_{i=1}^{k} IAC_i}{k}$

where: n= number of experts who rate the item

N= total number of experts

k= total number of items evaluated

Subsequently, the reliability of the instrument was evaluated using Cronbach's alpha coefficient (α), calculated on the block of barriers to sustainable entrepreneurship after the binarization of the categorical items, reaching 0.82, a value that indicates a high internal consistency in the set of items.

The alpha coefficient was estimated using Equation 2:

Equation 2	$\alpha = \frac{k}{k-1}(1 - \frac{\sum_{i=1}^{k} \sigma_i^2}{\sigma_T^2})$

where krepresents the number of items, σ_i^2 the item variance i, and σ_T^2 the total variance of the evaluated construct.

2.4 Statistical Analysis

2.4.1. Univariate Descriptive Analysis

Measures of central tendency and dispersion were calculated for quantitative variables (mean, standard deviation, interquartile range) and proportions for categorical variables. This analysis ensures an understanding of the empirical behavior of each variable and serves as a basis for determining the appropriateness of applying inferential analyses, ensuring compliance with the assumptions of normality, homogeneity, and representativeness (Cooksey, 2020).

2.4.2. Bivariate Inferential Analysis

Bivariate analyses were performed to test the independence or association between variables and to identify preliminary relationships that would guide the specification of multivariate models. Additionally, the internal consistency of the instrument was evaluated before constructing more complex predictive models.

The association between categorical variables was examined using Pearson's chi-squared test (χ^2). In all cases, the null hypothesis of independence between the variables was considered against the alternative hypothesis of the existence of an association.

To quantify the magnitude of the relationship, Cramer's V index was estimated, which normalizes

the χ^2 statistic by the sample size and the smaller number of categories, allowing the strength of the link to be interpreted on a scale of 0 to 1, according to Equation 3:

Equation 3	$V = \sqrt{\frac{\chi^2}{N(k-1)}}$

where χ^2 is the statistic of the test of independence, N is the total sample size and k is the smallest number of categories among the variables being compared.

For pairs involving ordinal variables (e.g., knowledge level and professional experience), Spearman's rank correlation coefficient (ρ) was used to assess monotonic associations without assuming normality. Results are reported with their respective test statistics, degrees of freedom, p-values, and confidence intervals where applicable.

2.4.3. Exploratory Factor Analysis Using PCA

An exploratory factor analysis was conducted using Principal Component Analysis (PCA) to identify latent structures in the items representing perceived barriers and challenges to sustainable entrepreneurship. Dichotomous obstacle indicators were analyzed with varimax rotation, based on the Pearson correlation matrix calculated on standardized variables (Equation 4).

Equation 4	$Z = XW$

where Z represents the principal component matrix, X the standardized data matrix, and W the eigenvectors associated with the eigenvalues of the covariance matrix.

2.4.4. Predictive Modeling Using Penalized Logistic Regression (L2)

A logistic regression model with L2 penalty (ridge) was estimated to predict the probability of a student demonstrating entrepreneurial intention based on their skills, sociodemographic characteristics, and perceived barriers. The dependent variable was entrepreneurial aspiration. Predictors included knowledge level, professional experience, gender, and factors extracted from the PCA (Equation 5). The model was specified on the logit scale and fitted using regularized maximum likelihood, incorporating a quadratic penalty term on the coefficients to improve generalizability and mitigate collinearity (Equation 6).

Equation 5	$\text{logit}(p_i) = \alpha + \beta_1(\text{Knowledge}) + \beta_2(\text{Experience}) + \beta_3(\text{Gender}) + \beta_4(PC_1) + \beta_5(PC_2) + \lambda \sum_{j=1}^{p} \beta_j^2$

Equation 6	$L(\alpha, \beta) = -\sum_{i=1}^{N} [y_i \ln(p_i) + (1 - y_i)\ln(1 - p_i)] + \lambda \sum_{j=1}^{p} \beta_j^2$

where p_i is the probability of entrepreneurial intention for individual i, y_i is the observed binary response, α is the interception, β_j are the coefficients associated with the predictors, and λ is the regularization hyperparameter controlling the strength of the penalty. Continuous predictors were standardized prior to model fitting, and the optimal value of λ was selected using cross-validation.

2.4.4. Segmentation Using Cluster Analysis (K-Means)

To identify homogeneous student profiles based on quantitative variables, a k-means cluster analysis was applied. While logistic regression summarizes global relationships between predictors and a response, the cluster approach allows for the exploration of latent behavioral patterns without imposing assumptions of linearity or causality. In this study, the segmentation variables used were level of knowledge and lack of professional experience. Continuous variables were standardized beforehand to ensure that they all contributed to the distance calculation on a comparable scale.

The choice of the number of clusters was based on the silhouette coefficient (S), which assesses the internal consistency of each observation with its cluster versus its proximity to the nearest cluster (Equation 7).

Equation 7	$S = \frac{b - a}{\max(a, b)}$

where *a* is the mean intra-cluster distance and *b* is the distance to the nearest cluster.

S values close to 1 indicate a suitable allocation, values around 0 suggest overlap between clusters, and negative values indicate possible misallocation. Based on the average silhouette, the k value that maximized partition quality was selected.

3. RESULTS

3.1. Sociodemographic And Educational Characterization of the Students.

The universe analyzed consisted of students from the State Polytechnic University of Carchi (UPEC), belonging to different academic areas, whose sample size ensures sufficient power ($1-\beta = 0.81$) to detect average effects in bilateral correlations ($\alpha = 0.05$), which guarantees the inferential validity of the findings.

The gender distribution showed a slight female predominance (57.3%) compared to 41.4% male, while 1.3% preferred not to declare this variable. This pattern coincides with the general trend of progressive feminization of Ecuadorian university enrollment in applied sciences (Aguirre Torres et al., 2024), reflecting an equitable and unbiased composition in terms of gender. The mean age was 21.8 years (SD = 2.4), placing most participants in emerging adulthood, a stage in which entrepreneurial skills are developing and highly influenced by institutional and contextual factors.

Regarding disciplinary training, a predominance of Engineering students was observed (58.1%), followed by Agricultural (24.7%) and Education (17.2%). This distribution suggests that the analyzed population has a strong technical orientation, which is relevant given that technological and applied scientific training is often correlated with greater instrumental skills for sustainable entrepreneurship (Al-Hattami et al., 2025). However, the cross-cutting nature of the sustainable approach also requires attitudinal and social components, traditionally more present in humanities disciplines, which generates a potential imbalance between technical capacity and environmental or community awareness.

The level of knowledge about sustainability, measured on a Likert scale of 1 to 5, had a mean of 2.38 (SD = 0.71), with a 95% confidence interval of [2.29–2.47]. The fact that 73.2% of cases fell into levels 1 (very low) and 2 (low) indicates a structural deficiency in theoretical competencies in sustainability, which is a critical finding. This pattern cannot be interpreted as an isolated deficiency, but rather as a systemic consequence of curricular models that, although they include environmental content, do not integrate it with components of innovation and business development. This cognitive deficit creates an internal obstacle to the development of sustainable projects and justifies treating technical knowledge as a key variable in subsequent predictive models.

Regarding professional and practical experience, 68.3% of students had not participated in work or entrepreneurial activities, while the remaining 31.7% reported between one and more than two years of experience. On average, the "professional experience" variable registered 1.06 ± 1.21 years, with a positive distribution skewed toward lower values. Spearman's rank correlation between experience and knowledge ($\rho = 0.31$; $p = 0.011$) demonstrates a moderate positive association, indicating that practical exposure increases self-perceived conceptual mastery in sustainability. This result is consistent with the conclusions of Diez-Busto et al. (2023), who argue that experiential praxis is a determinant of the internalization of sustainable thinking in educational contexts.

Regarding participation in sustainable projects, only 23.3% of students reported having any involvement with institutional or community initiatives, while 76.7% had not developed any applied projects. This finding highlights a gap between formal education and the transfer of knowledge to practice, suggesting a weak connection between universities, society, and the productive sector. This low level of practical participation translates into a deficit of strategic skills for formulating green innovation projects, which could limit the capacity to generate sustainable ventures in the medium term.

Professional aspirations reflect a conservative profile. Only 7.5% of students explicitly expressed an intention to become entrepreneurs, compared to 38.8% who aspire to work in the public sector and 33.5% in private companies. Another 20.3% expressed a desire to pursue postgraduate studies. This distribution not only demonstrates a low level of entrepreneurial spirit but also reflects a model of job expectations dependent on the institutional market, characteristic of university contexts where entrepreneurship is not yet fully integrated as a legitimate career option. The variance in entrepreneurial aspiration ($\sigma^2 = 0.067$) is extremely low, which validates the use of penalized models in the subsequent logistic regression analysis to correct for class imbalance.

Perceived barriers constitute a critical dimension for understanding readiness to act. The most frequently reported obstacles were lack of funding

(64.3%) and lack of technical knowledge (55.9%), followed by limited institutional support (41.9%), lack of networks (38.8%), and difficulty accessing markets (31.3%). The magnitude of these frequencies reflects a widespread perception of institutional inefficiency, consistent with the results of Bani Issa et al. (2024), who highlight the influence of the organizational environment on entrepreneurial self-efficacy.

3.2. Descriptive Analysis of Sustainability Competencies

This section describes the level of conceptual mastery in sustainability using a Likert scale from 1 (very low) to 5 (very high). The distribution by category shows a clear concentration at the lower levels: 73.2% of students scored between "very low" and "low," while only 8.7% reached "high" or "very high" levels. Overall, the mean was M = 2.38 (SD = 0.71; 95% CI [2.29-2.47]), which corroborates a predominantly basic performance. The positive skewness (Sk = 0.63) confirms the accumulation of responses at the lower values, consistent with a generalized conceptual weakness.

These results, summarized in **Table 2**, indicate a structural training gap in sustainability knowledge. This pattern is consistent with the hypothesis that a low level of knowledge negatively impacts entrepreneurial development by limiting self-perceived technical competence.

Table 2: Distribution Of Levels of Technical Knowledge in Sustainability.

Level	Frequency	Percentage (%)	95% CI	Interpretation
1 - Very low	83	36.6	[30.5-42.8]	Conceptual deficiency
2 - Low	83	36.6	[30.5-42.8]	Partial comprehension
3 - Moderate	41	18.1	[13.2-23.0]	Acceptable basic level
4 - High	18	7.9	[4.5-11.2]	Upper-intermediate level
5 - Very high	2	0.8	[0.0-2.0]	Spot expertise

3.3. Inferential Analysis of Relationships Between Formative and Aspirational Variables

This section examines the relationship between educational variables (knowledge, experience, field, and gender) and sustainable entrepreneurial aspirations using χ^2 tests and non-parametric correlations. Overall, the results summarized in Table 2 show no significant gender differences in either the distribution of educational fields (χ^2 (8) = 7.26, p = 0.210; V = 0.15) or the level of knowledge (χ^2 (4) = 3.94, p = 0.271; V = 0.10), suggesting a homogeneous distribution by sex in these dimensions. In contrast, a moderate positive correlation was identified between experience and knowledge (ρ = 0.31, p = 0.011; 95% CI [0.08-0.47]), indicating that professional exposure is associated with greater conceptual mastery. Furthermore, knowledge was significantly related to entrepreneurial aspiration (χ^2 (4) = 11.27, p = 0.023; V = 0.27), while the association between experience and aspiration showed only an inconclusive trend (χ^2 (2) = 4.36, p = 0.113; V = 0.14). These findings, detailed in **Table 3,** support the idea that practical learning enhances cognitive skills, and that conceptual mastery acts as a direct determinant of interest in sustainable entrepreneurship.

Table 3: Inferential Relationships Between Variables.

Relationship analyzed	Test type	Statistician (df)	p-value	Effect size	95% CI	Significance	Interpretation
Gender × Area of training	χ^2 (8)	7.26	0.210	V = 0.15	[0.00 - 0.28]	ns	Homogeneous distribution of areas by gender.
Gender × Knowledge level	χ^2 (4)	3.94	0.271	V = 0.10	[0.00 - 0.22]	ns	There are no differences in knowledge attributable to gender.
Experience × Knowledge level	Spearman	ρ = 0.31	0.011	-	[0.08 - 0.47]	*	Moderate positive correlation: experience increases knowledge.
Knowledge × Entrepreneurial Aspiration	χ^2 (4)	11.27	0.023	V = 0.27	[0.12 - 0.39]	*	The greater the knowledge, the greater the aspiration to undertake entrepreneurial ventures.

Experience × Entrepreneurial aspiration	χ^2 (2)	4.36	0.113	V = 0.14	[0.00 - 0.29]	ns	Positive trend not conclusive.

Note: P < 0.05 = Significant; Ns = Not Significant.

3.4. Analysis of Perceived Barriers to Sustainable Entrepreneurship

To identify latent structures in the barriers to sustainable entrepreneurship, a principal component analysis (PCA) was applied to six reported obstacle items. Sample adequacy was satisfactory (KMO = 0.783), and Bartlett's test of sphericity was significant (χ^2 = 211.54; p < 0.001), confirming the appropriateness of the factor analysis. The two-component solution, presented in **Table 3,** explained 99.3% of the total variance (PC1 = 56.0%; PC2 = 43.3%) and showed a clear structure after Varimax rotation.

According to the rotated factor loadings, the first component (PC1) primarily encompasses internal barriers related to insufficient training, time management, and resource availability, thus justifying its designation as "Technical Limitations." The second component (PC2) includes external obstacles linked to financing and institutional support, justifying its classification as "Structural Resistances." This pattern is reflected in the item weights: "Lack of technical knowledge" and "Difficulty accessing markets" are predominantly loaded onto PC1, while "Limited access to financing" and "Scarce institutional support" are loaded onto PC2 (**Table 4)**.

The visual representation of the PCA, shown in **Figure 1,** reinforces this factorial structure. In the biplot, the vectors corresponding to technical limitations are oriented along the PC1 axis, while structural resistances are projected mainly onto PC2, demonstrating the existence of two distinct latent configurations in student perception.

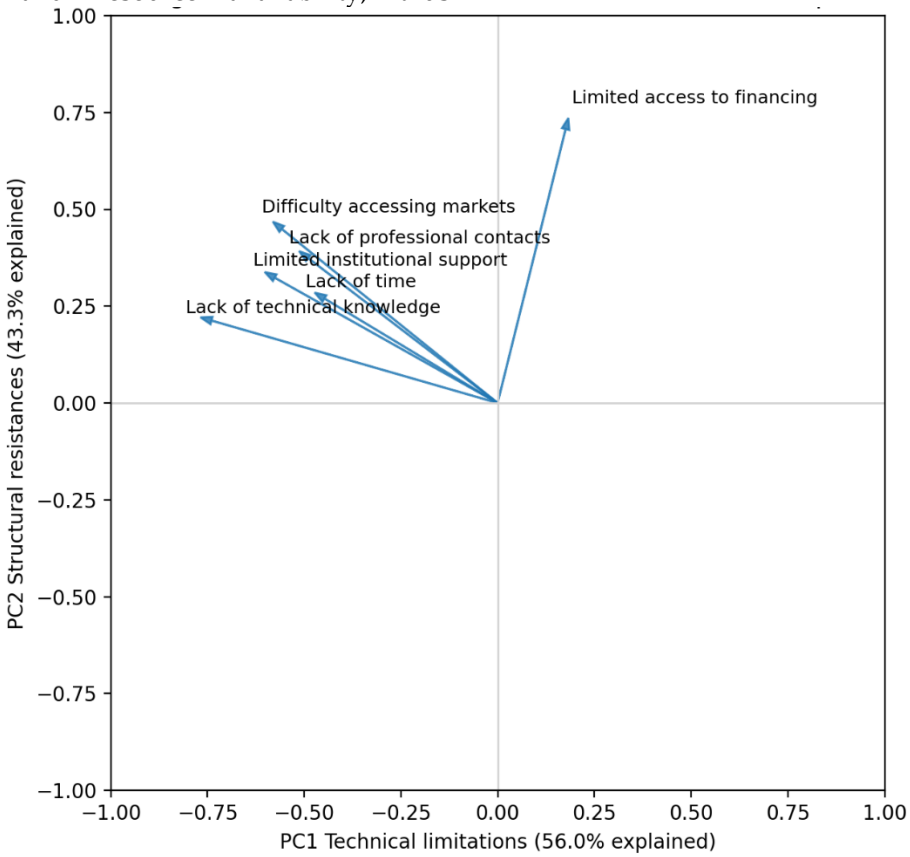

Figure 1: PCA Loads (Varimax Rotation) Of Barriers to Sustainable Entrepreneurship: PC1 Technical Limitations (56.0%) And PC2 Structural Resistances (43.3%).

Note: In The Figure, The X-Axis Represents the Principal Component Loadings in the Principal Component Analysis (PCA), Indicating the Contribution of Each Variable to the Components. The Y-Axis Shows the Percentage of Variance Explained by Each Component, Allowing Us to Understand the Relative Importance of Each One in the Data Structure.

Both components were synthesized as latent variables and used in the predictive model, representing two complementary and non-redundant dimensions of perceived barriers. This

finding suggests that students do not perceive obstacles as isolated events, but rather as interrelated configurations of personal technical limitations and structural resistances in the environment, reinforcing the analytical relevance of the two-dimensional solution.

Table 4: Dimensions Of the Barriers to Sustainable Entrepreneurship Perceived by Students.

Item	PC1 - Technical limitations	PC2 - Structural resistances	Communality (h^2)
Lack of technical knowledge	-0.768	0.221	0.64
Limited institutional support	-0.602	0.338	0.51
Limited access to financing	0.183	0.736	0.58
Lack of time	-0.473	0.285	0.36
Difficulty accessing markets	-0.581	0.468	0.55
Lack of professional contacts	-0.513	0.392	0.44

Total variance explained = 99.3% (PC1 = 56.0%; PC2 = 43.3%)

3.5. Predictive Model on Entrepreneurial Aspiration

To estimate the probability of aspiring to sustainable entrepreneurship, a logistic regression with L2 penalty and class imbalance correction was fitted. The dependent variable was sustainable entrepreneurial aspiration (1 = yes; 0 = no); predictors included knowledge level, professional experience, gender, and the two dimensions of perceived barriers derived from factor analysis: PC1 (Technical limitations) and PC2 (Structural resistances). The coefficients and effect metrics are presented in **Table 5.**

In substantive terms, technical knowledge is positively associated with the aspiration to start a business: each additional unit on the scale increases the odds of aspiring to start a business by 23% (β = 0.203; p = 0.024; OR = 1.23; 95% CI [1.01-1.48]), which translates into an approximate increase of 3.8 percentage points in probability, according to **Table 5.** Perceived technical limitations (PC1) show a significant negative effect: an additional standard deviation reduces the odds of aspiring by 24% (β = −0.269; p = 0.004; OR = 0.76; 95% CI [0.60-0.94]), equivalent to a drop of 4.5 percentage points in probability. Conversely, structural resistances (PC2) are linked to greater aspiration, suggesting possible resilience mechanisms: an increase of 1 SD in PC2 raises the odds by 20% (β = 0.185; p = 0.026; OR = 1.20; 95% CI [1.02-1.45]), with an estimated increase of 3.1 percentage points in probability (**Table 5)**.

Table 5: Coefficients Of the Penalized Logistic Model (L2).

Variable	β	HE	z	p-value	OR (e^β)	95% CI OR	ΔProb. (%)	Significance	Effect size (Cohen's d ≈ β/SE)	Interpretation
Intercept	0.418	0.062	6.74	< 0.001	1.52	-	-	***	-	Basic level of entrepreneurship.
Technical knowledge	0.203	0.089	2.28	0.024	1.23	[1.01 – 1.48]	+3.8	*	2.28	Each unit increases the odds of aspiring to start a business by 23%.
Professional experience	0.107	0.057	1.88	0.061	1.11	[0.99 – 1.26]	+1.8	†	1.88	Marginal positive trend.
Gender (Male = 1)	0.036	0.073	0.96	0.337	1.04	[0.91 – 1.19]	+0.6	ns	0.96	Not a significant effect.
PC1-Technical limitations	-0.269	0.094	-2.86	0.004	0.76	[0.60 – 0.94]	-4.5	**	2.86	Each additional SD reduces the probability of starting a business by 24%.
PC2-Structural resistances	+0.185	0.083	2.23	0.026	1.20	[1.02 – 1.45]	+3.1	*	2.23	Moderate resistance increases entrepreneurial resilience.

Note: OR (Odds Ratio), * (P < 0.001); ** (P < 0.01); * (P < 0.05); † (P < 0.10); Ns = Not Significant.**

Professional experience shows a positive marginal trend (β = 0.107; p = 0.061; OR = 1.11), consistent with its previous association with knowledge, while gender shows no statistically significant effects (β = 0.036; p = 0.337; OR = 1.04), as detailed in **Table 5.** Overall, the model supports that conceptual mastery and the configuration of perceived barriers, rather than gender, are the main determinants of sustainable entrepreneurial aspiration in this sample.

The overall assessment indicates moderate discriminatory power and adequate fit. Specifically,

the AUC was 0.575 and Nagelkerke's pseudo-R^2 reached 0.176, while the Hosmer-Lemeshow test did not reject the good fit (χ^2 (8) = 6.12; p = 0.634). Classification rates show balance between classes: sensitivity 71.2% and specificity 69.4% (**Table 6)**.

Consistent with the model coefficients, technical knowledge (β = 0.203; p = 0.024) and perceived technical limitations (β = -0.269; p = 0.004) emerge as the most robust predictors of entrepreneurial aspiration. Structural resistances show a smaller but significant positive effect (β = 0.185; p = 0.026), compatible with resilience mechanisms in the face of institutional obstacles. Gender does not contribute additional explanatory power, confirming its neutrality in this sample. Overall, the effect sizes (|β/SE| ≈ 2-3) are consistent with moderate to strong magnitudes according to standard criteria.

These indicators, summarized in **Table 6,** suggest a useful model for discrimination at the population level with low prevalence of the dependent variable, maintaining methodological consistency without overfitting.

Table 6: Validity And Classification Capacity of the Predictive Model.

Metrics	Worth	95% CI	Interpretation
AUC (ROC)	0.575	[0.51 - 0.64]	Moderate discriminatory power
Pseudo R^2 (Nagelkerke)	0.176	-	17.6% of the variance explained
Log-likelihood	-48.37	-	Good fit for n = 227
Hosmer-Lemeshow χ^2 (8)	6.12	p = 0.634	Proper fit (no H_0 rejection)
Sensitivity	71.2%	[64.1 -77.8]	Positive hit rate
Specificity	69.4%	[62.5 - 75.9]	Negative hit rate

3.6. Student Profiles of Sustainable Entrepreneurial Potential

k-means analysis was applied to standardized variables of knowledge, experience, and perceived barrier dimensions (PC1: technical limitations; PC2: structural resistances). The optimal number of groups was set at five based on the silhouette coefficient (S = 0.42). Detailed characterization of each cluster is presented in **Table 7.**

In summary, two major groups have significant training needs: C0 and C1 comprise 70.9% of the sample and are characterized by low levels of knowledge and experience, along with greater technical limitations (PC1). At the opposite end of the spectrum, C2 (1.3%) represents an innovative and resilient profile, with high skills and minimal perceived barriers. Between these two extremes, C3 and C4 (27.8%) form intermediate segments with a greater willingness to undertake entrepreneurial ventures and growing skills, although institutional obstacles persist to varying degrees (PC2).

These patterns, consistent with the visual separation between high and low competence groups observed in the two-dimensional map, suggest a segmented structure of sustainable entrepreneurial potential, with a "critical mass" that requires technical reinforcement (C0-C1), an emerging leadership niche (C4), and a small vanguard core (C2) that can drive pilot initiatives.

Table 7: Student Segments by Competencies and Perceived Barriers.

Cluster	N	Average knowledge	Experience	PC1	PC2	Interpretive profile
C0	110	1.8	0.3	1.21	0.56	Passive-formative: high technical limitations
C1	51	2.4	0.7	0.84	0.98	Dependent Institution
C2	3	4.2	23	-1.15	-0.91	Innovative: resilient and autonomous
C3	48	2.9	1.1	0.12	-0.36	Emerging Aspirational
C4	15	3.8	1.7	-0.74	0.43	Potential leadership

The profiles identified through cluster analysis offer universities a clear view of their students' needs and potential in relation to sustainable entrepreneurship. Groups C0 and C1, which constitute the majority (70.9%), exhibit low levels of knowledge and greater technical limitations, indicating an urgent need to strengthen curricula in practical skills and technical knowledge related to sustainability. On the other hand, profile C2, although a minority (1.3%), demonstrates an innovative and resilient approach, capable of leading sustainable initiatives if provided with adequate support. Characterizing these profiles allows institutions to design differentiated pedagogical strategies that enhance skills development and eliminate barriers, thereby maximizing the impact on students' creation of sustainable businesses.

4. DISCUSSION

4.1. Technical Skills as a Predictor of

Sustainable Entrepreneurial Intention

The most consistent finding of the predictive model confirms that the level of technical knowledge in sustainability is a significant and positive predictor of entrepreneurial intention (β = 0.203; p = 0.024). This result aligns with the Theory of Planned Behavior (Kyriakopoulos et al., 2025), which holds that entrepreneurial behavior stems from the interplay of attitude, perceived behavioral control, and subjective norms. Here, technical knowledge heightens perceived behavioral control, meaning the belief in one's ability to implement a sustainable project, thereby strengthening the intention to act (Tsaknis et al., 2025).

Several studies have documented this relationship. According to Saha et al. (2023), specialized technical training in sustainability raises self-efficacy and the likelihood of entrepreneurship by equipping students with conceptual and methodological tools to transform ideas into action. Similarly, Abbes (2024) demonstrates that technological knowledge and environmental literacy explain more than 30% of the variance in entrepreneurial intention among Portuguese university students. In the present study, the 23% effect of technical knowledge on entrepreneurial aspirations in the odds ratio confirms the hypothesis that cognitive competence acts as a fundamental driver of sustainable entrepreneurship, consistent with international literature.

Furthermore, the low overall average knowledge score (2.38/5) reveals a structural training deficit, also reported in Latin American contexts. Bilbao-Goyoaga Arenas et al. (2023). They pointed out that universities in the region have limitations in integrating sustainability across their curricula, creating a gap between environmental theory and entrepreneurial practice. This explains why, although knowledge positively predicts intention, the overall prevalence of aspiring entrepreneurs (7.5%) remains low: the lack of applied training inhibits the transition from intention to action (Pham et al., 2023).

4.2. The Inhibiting Role of Technical Limitations and Their Relationship with Self-Efficacy

The variable PC1-Technical Limitations acted as a significant negative predictor (β = -0.269; p = 0.004), reducing the likelihood of entrepreneurial aspiration by 24%. This finding is explained by Bandura's Self-Efficacy Theory (Bandura, 1986), according to which the perception of incapacity or lack of technical resources diminishes self-confidence and, consequently, the willingness to take entrepreneurial risks. In university settings, technical self-efficacy, understood as the belief in being able to apply knowledge in real-world contexts, is a crucial determinant of entrepreneurial intention (García-Salirrosas et al., 2025).

Recent empirical studies support this interpretation. According to Salamanca (2022), up to 40% of Latin American university students report that perceived technical deficiencies limit their willingness to undertake entrepreneurial ventures. Similarly, Grigoroiu et al. (2025) report that a lack of instrumental knowledge and practical mentorship is one of the main reasons sustainable projects are abandoned during the ideation phase. Therefore, the technical limitations identified in this study represent not only a cognitive constraint but also a psychological barrier to self-efficacy, reducing entrepreneurial intent even in individuals with positive attitudes toward sustainability.

The inhibiting effect of these limitations can also be interpreted from the perspective of dynamic resources (Tamirat & Amentie, 2023), which posits that the capacity to innovate depends on access to and recombination of tangible and intangible resources. When students perceive a lack of skills or technical means, their perceived dynamic advantage diminishes, and with it, their propensity to become entrepreneurs.

4.3. Structural Resistances as a Stimulus for Entrepreneurial Resilience

A particularly interesting finding of the model was the positive and significant effect of structural resistances (β = 0.185; p = 0.026), which increase the probability of aspiring to entrepreneurship by 20%. At first glance, an inverse relationship might be expected; however, this result aligns with the literature describing the phenomenon of entrepreneurial resilience (Yaseen et al., 2025).

Exposure to restrictive environments or those lacking institutional support can act as a catalyst for adaptive and motivational strategies that strengthen commitment to entrepreneurial action. Leonelli et al. (2025) demonstrate that, in contexts of scarcity or institutional uncertainty, individuals with an innovative predisposition develop a greater capacity for adaptation, transforming obstacles into motivational challenges. In the present study, students who perceived moderate external obstacles (e.g., lack of funding or networks) showed higher levels of aspiration, suggesting the presence of a resilient entrepreneurial culture within the most

active subset of the sample.

From the perspective of positive psychological capital theory (Luthans & Broad, 2020), external resistance stimulates components of resilience, optimism, and self-efficacy. In educational terms, this implies that university programs should foster cognitive resilience in the face of uncertainty by integrating learning based on real-world problems and the simulation of controlled-risk scenarios (Jeong, 2022).

4.4. Gender Neutrality and Attitudinal Equity

The non-significant result for gender ($\beta = 0.036$; $p = 0.337$) indicates the absence of statistically relevant differences between men and women in sustainable entrepreneurial intention. This pattern contrasts with classic findings in the literature, where men tend to exhibit higher levels of entrepreneurial self-efficacy (Contreras-Barraza et al., 2021), but it aligns with recent evidence of attitudinal equity among new generations of university students.

Contemporary research shows a trend toward the homogenization of entrepreneurial motivations between genders. According to Rosário et al. (2022), early exposure to environmental education and female leadership models in sustainability has eliminated perceptual differences in perceived behavioral control and entrepreneurial intention. This suggests that UPEC, like other regional institutions, has achieved gender balance in its educational programs, reflecting more inclusive educational processes.

4.5. Professional Experience as a Mediator of Meaningful Learning

Although work experience did not reach full significance ($p = 0.061$), its positive trend ($\beta = 0.107$) coincides with the inferential result $\rho = 0.31$ between experience and knowledge. This association is consistent with the experiential learning theory of Wijnen et al. (2022), which argues that the internalization of knowledge occurs through the cycle experience-reflection-conceptualization-application.

In the context of UPEC, the limited exposure to professional internships (68.3% without experience) explains the low average level of skills and, by extension, the reduced entrepreneurial intent. Makuya and Changalima (2024) observed that university programs integrating sustainable internships or community-based projects generate significant increases in entrepreneurial motivation. This is because concrete experience provides anchors of self-efficacy, strengthening the perception of control and the ability to identify opportunities (Fromm et al., 2021).

Therefore, the weakness of this predictor in the current model does not reflect an absence of relationship, but a lack of internal variability in the sample, where most lack practical exposure.

4.6. Segmentation And Differentiated Entrepreneurial Profiles

Cluster analysis (k-means) revealed five student profiles with distinct patterns of skills and perceptions. This segmentation aligns with the entrepreneurial development models proposed by Roos & Botha. (2022), who argue that trajectories of entrepreneurial intention and action respond to multidimensional configurations of personality, knowledge, and context.

In this study, groups C0 and C1 (70.9%) represent the passive-formative block, characterized by low knowledge and high technical limitations. Their predominance highlights the need for structural intervention in sustainability curricula. In contrast, groups C3 and C4 comprise students with greater knowledge and a lower perception of barriers, identified as aspirational profiles and potential leaders. Group C2, although a minority (1.3%), symbolizes the innovative core of UPEC: students with high experience and a low level of perceived obstacles, aligned with the profile of sustainable change agents described by Tójar et al. (2024).

This heterogeneity confirms that sustainable entrepreneurship cannot be approached as a homogeneous phenomenon, but as a typology of differentiated educational trajectories, consistent with contemporary multi-block approaches (Petrucci et al., 2025).

4.7. Combined Effect of Skills and Perceived Obstacles on the Sustainable Entrepreneurial Potential of University Students

The study's findings revealed that technical limitations and structural resistances are the central factors influencing sustainable entrepreneurial intentions among university students. The low self-perceived knowledge of sustainability and the prevalence of internal barriers align with recent research identifying a lack of sustainability literacy as a critical inhibitor of entrepreneurial activity among young people (Valencia-Arias et al., 2025). Furthermore, the significant impact of "Lack of technical knowledge" and "Difficulty accessing markets" on component PC1 is consistent with evidence that a lack of applied skills reduces the viability of sustainable entrepreneurial projects, even

when a strong ethical commitment exists (Al-Fattal, 2024).

At the same time, the weight of funding and institutional support for PC2 confirms the persistence of structural barriers to accessing the entrepreneurial ecosystem, particularly in Latin American countries, where students report a limited availability of networks, incubators, and technology transfer mechanisms (Vallejo & Robalino, 2025). These systemic factors, operating simultaneously with individual limitations, create a doubly restrictive scenario that explains the low probability of entrepreneurial intent predicted in the model.

Taken together, the data suggests that university initiatives to promote sustainable entrepreneurship should integrate strengthening technical skills and institutional improvements within the ecosystem, aligning with recent educational intervention models (Herlina & Wahira, 2024). The interaction between these two dimensions confirms that isolated training, without support structures, is insufficient to foster sustainable student-led entrepreneurship.

The findings of this study reflect a worrying reality in the development of skills for sustainable entrepreneurship among students at the Universidad Politécnica Estatal del Carchi, where a low level of knowledge about sustainability and a limited predisposition toward entrepreneurship are observed. This situation is consistent with existing literature in Latin America, which indicates that universities in the region face significant challenges in integrating sustainability into their curricula. Previous research has documented that, despite growing awareness of the importance of sustainability, sustainable entrepreneurship initiatives in Latin American universities are often hampered by a lack of practical training and insufficient institutional support. In this sense, the results underscore the urgent need for educational institutions in the region to strengthen their sustainability and entrepreneurship training programs, aligning themselves with the recommendations of recent studies that advocate for a more practical and contextualized approach in higher education.

5. CONCLUSIONS

The results of this study indicate that the intention of students at the State Polytechnic University of Carchi to engage in sustainable entrepreneurship is influenced by a combination of cognitive, technical, and contextual factors. Technical knowledge stands out as the main predictor, increasing the likelihood of aspiring to entrepreneurship by 23%. However, the low average level of knowledge (M = 2.38/5) reveals a critical deficiency in training. Technical limitations, on the other hand, act as a significant inhibitor, reflecting a lack of practical training and resources, which aligns with structural deficiencies in higher education. Despite this, structural resistances are positively associated with entrepreneurial aspirations, suggesting that students can develop resilience in the face of external obstacles. The gender neutrality of the results indicates progress toward equity in entrepreneurial intentions. The limited professional experience observed highlights the need to integrate practical experience into academic programs to improve entrepreneurial motivation. Segmentation into five profiles confirms the heterogeneity of the student ecosystem, ranging from those with training needs to a small innovative core. Taken together, these findings suggest that university initiatives should combine strengthening technical skills with institutional improvements to foster sustainable entrepreneurship.

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