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Learning strategies (acra) among university applicants for the tourism degree: a structural equation modeling and neural network approach

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ABSTRACT

Learning strategies play a fundamental role in the development of academic and professional competencies in the field of tourism, particularly during the transition to higher education. This study analyzes learning strategies based on the ACRA model among university applicants to the Tourism degree, using a combined approach of neural networks and structural equation modeling (SEM). A quantitative, correlational-explanatory, and cross-sectional design was employed, with a probabilistic sample of 136 Tourism students from the Pontificia Universidad Católica del Ecuador. The abbreviated version of the ACRA questionnaire was applied, which evaluates cognitive and control strategies, learning support strategies, and study habits—key competencies for training in dynamic, service-oriented contexts such as the tourism sector. Data analysis was conducted using SPSS 25 and AMOS 24 software. The results show high internal consistency ($\alpha = 0.912$; $\omega = 0.912$) and factor loadings above 0.70, confirming construct validity. The KMO index (0.811) and Bartlett's sphericity test ($p < 0.001$) support the adequacy of the factor analysis. Furthermore, significant structural relationships were identified, with strong associations between cognitive strategies and learning processes (0.80), and moderate associations with study habits (0.63), in line with self-regulated learning principles. In conclusion, the ACRA model is confirmed as a valid and reliable instrument for evaluating learning strategies among university applicants in the tourism field, providing relevant empirical evidence for improving educational processes and decision-making in higher education oriented toward tourism.

Keywords: learning strategies, ACRA model, neural networks, SEM, tourism, higher education

INTRODUCTION

The transition to higher education constitutes a critical stage in students' academic trajectories, particularly in service-oriented programs such as Tourism, where not only the acquisition of theoretical knowledge is required, but also the development of practical competencies, interpersonal skills, and the ability to adapt to dynamic environments (Zimmerman, 2020; Panadero, 2017). In this context, the effective use of learning strategies becomes a determining factor for academic performance, persistence in the educational system, and future employability in a highly competitive and constantly evolving industry (UNWTO, 2023). Tourism education requires the development of transversal competencies—such as adaptability, problem-solving, intercultural communication, and

customer orientation—which largely depend on students' ability to self-regulate their learning and transfer knowledge to real service contexts.

Learning strategies comprise a set of cognitive, metacognitive, and behavioral processes that students use to acquire, organize, and apply information in a meaningful way (Broadbent & Poon, 2015; Dunlosky & Rawson, 2013). In the field of tourism, these strategies acquire a particular dimension, as students must integrate multidisciplinary knowledge—such as management, culture, sustainability, and customer service—with practical experiences and real service contexts. However, empirical evidence suggests that students enter higher education with heterogeneous levels of self-regulation, motivation, and study habits, which generates gaps in academic performance and in the development of key competencies for the tourism sector. This issue is especially relevant in Latin American contexts, where inequalities in the quality of prior education and limitations in access to educational resources persist (Xue et al., 2024; Arce et al., 2025).

In this scenario, the ACRA model (Acquisition, Coding, Retrieval, and Support) has been consolidated as a relevant theoretical-methodological framework for analyzing learning strategies in university students, including those in tourism-related programs. This model allows identifying how students process information, organize knowledge, and use support resources to optimize their learning—fundamental aspects in training professionals capable of responding to the demands of the contemporary tourism market (De la Fuente & Justicia, 2017; Román & Gallego, 1994). Likewise, its multidimensional approach facilitates the evaluation of transferable skills such as problem-solving, decision-making, and knowledge management in real service contexts.

On the other hand, recent advances in data analysis techniques, particularly in the field of artificial intelligence and neural networks, offer new opportunities to understand the complexity of learning processes in applied educational contexts (Chen et al., 2020; LeCun et al., 2015). In programs such as Tourism, where cognitive, emotional, and contextual variables converge, these approaches allow identifying non-linear patterns and hidden relationships that influence academic performance and the acquisition of professional competencies.

Complementarily, structural equation modeling (SEM) has been consolidated as a robust tool for the validation of psychometric instruments and the analysis of latent variables, allowing precise examination of the relationships between learning dimensions (Hair et al., 2022; Kline, 2016). The integration of SEM with neural network models represents, in this sense, an innovative and relevant approach for the study of learning strategies in tourism students, by combining the explanatory capacity of statistical models with the predictive potential of artificial intelligence. This hybrid approach not only contributes to a deeper understanding of learning processes but also provides valuable inputs for the design of educational interventions aimed at improving the training of professionals in the tourism sector (Goodfellow et al., 2016; Schmidhuber, 2015).

Literature Review

Learning strategies in Higher Education and the ACRA model

Learning strategies constitute fundamental predictors of academic performance in higher education, as they facilitate the acquisition, processing, and retention of knowledge (Dunlosky et al., 2019; Zimmerman, 2020; Credé & Phillips, 2011). In particular, cognitive strategies—such as elaboration, organization, and repetition—are significantly associated

with better learning outcomes, as they promote a deeper, structured, and long-lasting understanding of content (Weinstein et al., 2011). In tourism education, these strategies are especially relevant due to the need to integrate theoretical knowledge with practical skills and real service contexts.

Likewise, metacognitive regulation plays a key role in planning, monitoring, and evaluation of learning processes, allowing students to adjust their strategies according to their objectives and performance (Panadero, 2017; Usher & Schunk, 2018). This component becomes particularly important in programs such as Tourism, where students must develop adaptive capacity, decision-making, and problem-solving skills in changing and highly interactive environments.

Recent research highlights that self-regulated learning strategies are especially relevant in digital, hybrid, and technology-mediated environments, where students assume a more active and autonomous role in their learning process (Azevedo & Gašević, 2019; Jansen et al., 2022; Wong et al., 2023). In this line, studies such as that of Anyoka et al. (2025) analyze the impact of learning management systems (LMS) on academic performance, identifying challenges associated with their adoption and proposing evidence-based recommendations to optimize their use. Complementarily, Ha et al. (2023), through hierarchical linear models (HLM), show that the relationship between the use of self-regulated learning strategies and academic performance varies at both the individual and institutional levels, highlighting the influence of the educational context on these processes.

Within this framework, the ACRA model (Acquisition, Coding, Retrieval, and Support) constitutes a consolidated theoretical reference for the evaluation of learning strategies in various educational contexts (Román & Gallego, 1994; De la Fuente & Justicia, 2017). This model organizes strategies according to information processing processes, integrating cognitive, metacognitive, and learning support dimensions. The short version of the instrument, used in this study, is structured into three main dimensions: (i) cognitive and control strategies, (ii) learning support strategies, and (iii) study habits, allowing a comprehensive evaluation of students' strategic behavior. Recent evidence has confirmed the reliability and validity of the ACRA model in different educational levels and cultural contexts, highlighting its usefulness both for psychopedagogical diagnosis and for the design of interventions aimed at improving learning, especially in applied fields such as tourism education.

NEURAL NETWORKS AND STRUCTURAL EQUATION MODELING IN EDUCATION

Artificial intelligence (AI) techniques, particularly neural networks, have acquired an increasingly relevant role in educational research due to their ability to model complex and non-linear relationships between variables, as well as to improve the accuracy in predicting academic outcomes (Chen et al., 2020; LeCun et al., 2015; Zawacki-Richter et al., 2019). In this sense, AI not only contributes to the advanced analysis of educational data, but also facilitates personalized learning processes, since, through pattern recognition, it allows identifying students' strengths and weaknesses and adapting pedagogical strategies to their specific needs (Roshanaei, 2023). These applications are especially relevant in dynamic educational contexts, such as tourism education, where the diversity of student profiles and the applied nature of learning require flexible and innovative approaches.

At the same time, advances in the internet and mobile technologies have generated profound transformations in the tourism sector, modifying both business models and the traveler's experience. In this digital environment, the intention to purchase tourism services online is influenced by variables such as attitude, trust, and perceived risk, the latter being a

key factor in the gap between attitude and purchase intention. Likewise, subjective norm reinforces this relationship, evidencing the influence of the social environment on consumer decision-making (Sadiq et al., 2022). Altogether, these changes reflect how data analysis and the understanding of user behavior have become strategic elements for service personalization and the improvement of tourism experience.

In line with the above, recent studies have demonstrated the usefulness of artificial intelligence in the analysis of learning behavior, educational personalization, and the early detection of academic risks (Hwang et al., 2020; Mian et al., 2022). Complementarily, in the tourism field, research such as that of Higuerey et al. (2025) shows, through econometric models (logit and probit), the influence of financial variables on the probability of accelerated growth in tourism companies. Likewise, Wang and Wang (2022) analyze the validity and reliability of instruments associated with the use of artificial intelligence, providing relevant evidence on the measurement of emerging constructs in digital environments.

For its part, structural equation modeling (SEM) continues to consolidate itself as a robust methodological approach for the validation of psychometric instruments and the analysis of latent constructs, allowing the evaluation of complex causal relationships within well-founded theoretical frameworks (Hair et al., 2022; Kline, 2016; Byrne, 2016). Model fit quality is determined through widely accepted indicators such as the root mean square error of approximation (RMSEA), the comparative fit index (CFI), and the Tucker-Lewis index (TLI) (Hu & Bentler, 1999; Hair et al., 2022; Ha et al., 2023). In the tourism field, studies such as that of Ruiz et al. (2023) integrate the Technology Acceptance Model (TAM) and the Theory of Planned Behavior (TPB) through SEM, demonstrating its usefulness for analyzing technology adoption in young consumers. Complementarily, Islam et al. (2023) highlight the explanatory capacity of TAM to understand changes in purchasing behavior in digital markets.

In this context, the integration of neural networks and SEM represents an innovative methodological approach that combines the explanatory capacity of statistical models with the predictive power of artificial intelligence, fostering a deeper understanding of complex phenomena in both education and tourism (Goodfellow et al., 2016; Schmidhuber, 2015; Lundberg & Lee, 2017). This hybrid approach allows not only the validation of theoretical models, but also the identification of hidden patterns and emerging relationships in large volumes of data. Recent evidence, such as the study by Wei and Mega (2025), demonstrates the usefulness of component-based SEM to analyze the impact of instructional design in gamified learning environments, providing relevant implications for the development of innovative educational platforms.

From an applied perspective, these advances suggest that higher education institutions, particularly in programs such as Tourism, should strengthen the cognitive and metacognitive skills of first-year students through self-regulated learning strategies, in order to improve academic performance and reduce dropout rates (Zimmerman, 2020; Panadero, 2017). In this sense, the ACRA model is positioned as a useful diagnostic tool to identify deficiencies in learning strategies and to guide specific interventions, in addition to its potential integration into curriculum design to promote student autonomy (De la Fuente & Justicia, 2017). At the theoretical level, this approach reinforces the relevance of self-regulated learning and SEM as a robust validation method, while highlighting the value of incorporating artificial intelligence techniques for the advanced analysis of contemporary educational processes (Hair et al., 2022).

Objective

The present study aims to analyze learning strategies and competency development in applicants and professionals in the tourism sector through the combined application of structural equation modeling and neural networks. In this way, it seeks to contribute both to the validation of measurement instruments and to a better understanding of training and adaptation processes in dynamic tourism contexts, providing relevant empirical evidence for tourism research and for decision-making in the management and planning of the sector.

Methodology

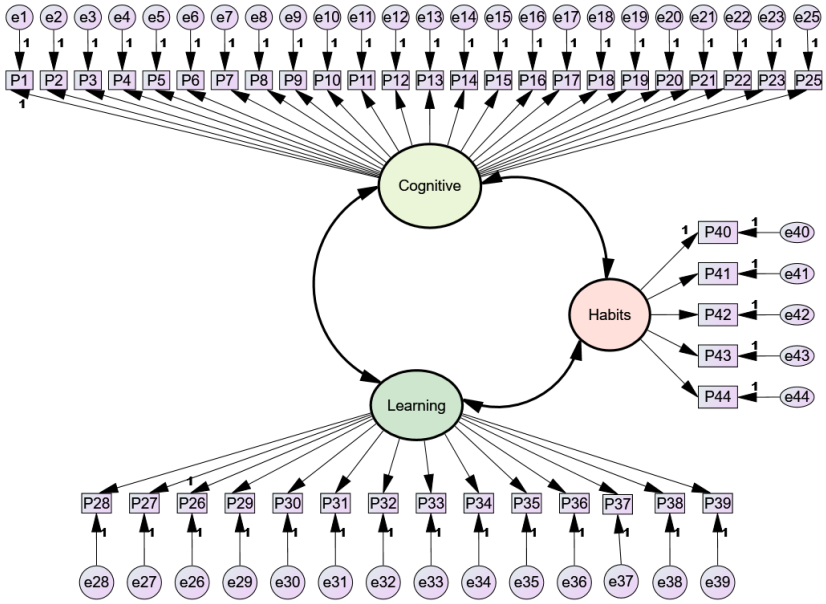
The present study is framed within a quantitative approach, incorporating advanced data analysis techniques, including neural networks, to strengthen the explanatory and predictive capacity of the model (Hair et al., 2022; Chen et al., 2020). A non-experimental, cross-sectional research design was adopted, which allowed data to be collected at a single point in time without manipulation of variables, a characteristic of observational studies (Hernández & Mendoza, 2018). The level of research was correlational-explanatory, as it sought to analyze and explain the relationships between cognitive and control strategies, learning support strategies, and study habits. These variables were examined in a probabilistic sample of 136 students from the Tourism program at the Pontificia Universidad Católica del Ecuador. This approach allowed not only the identification of associations between constructs, but also the provision of evidence regarding their influence on learning processes (Kline, 2016; Byrne, 2016).

Instrument

For data collection, the ACRA Questionnaire in its abbreviated version was used, developed by De la Fuente and Justicia (2017), widely validated in educational contexts for the assessment of learning strategies (Román & Gallego, 1994). According to Figure 1, the instrument evaluates three main dimensions: (i) cognitive and control strategies, (ii) learning support strategies, and (iii) study habits, providing a comprehensive measurement of the learning behavior of students in the Tourism program.

The questionnaire uses a four-point Likert-type scale, with response options ranging from 1 = “Never or almost never”, 2 = “Sometimes”, 3 = “Quite often”, and 4 = “Always”. This format allows capturing the frequency of use of learning strategies, facilitating subsequent statistical analysis (Likert, 1932; Boone & Boone, 2012). The use of this instrument is appropriate due to its adequate internal consistency and validity reported in previous studies, which supports its application in university populations and Latin American contexts (Arce, 2025).

Figure 1 – Structural equations of the observed and latent variables of the ACRA model



Data Analysis

Data analysis was carried out using descriptive, correlational, and explanatory statistical techniques, considering both observed variables and latent constructs. For this purpose, SPSS version 25 and AMOS version 24 were used, widely recognized tools in quantitative research for multivariate analysis and structural equation modeling (Hair et al., 2022; Byrne, 2016).

In a first phase, the internal consistency of the instrument was evaluated using Cronbach's alpha coefficient (Cronbach, 1951) and McDonald's omega coefficient (McDonald, 1999), in order to estimate the reliability of the scales used. Subsequently, data reduction techniques were applied through factor analysis, previously verifying sample adequacy using the Kaiser-Meyer-Olkin (KMO) index and Bartlett's test of sphericity, which are fundamental criteria to determine the suitability of factor analysis (Kaiser, 1974).

Convergent validity was evaluated using the Average Variance Extracted (AVE), considering as an acceptance criterion values greater than 0.50, which indicates that the construct explains more than half of the variance of its indicators (Fornell & Larcker, 1981). Likewise, standardized factor loadings were analyzed, establishing as a threshold value greater than 0.70, which indicates an adequate representation of the items in their respective constructs.

For the evaluation of the structural model, various goodness-of-fit indices widely accepted in the literature were used, such as the root mean square error of approximation (RMSEA), the comparative fit index (CFI), the Tucker-Lewis index (TLI), and the standardized root mean square residual (SRMR) (Hu & Bentler, 1999; Kline, 2016). Strict criteria were adopted to determine an adequate model fit: RMSEA < 0.08, CFI > 0.90, TLI > 0.90, and SRMR < 0.08 (Guay et al., 2003; Hair et al., 2022). This methodological approach allowed not only the validation of the factorial structure of the ACRA instrument, but also the analysis of causal relationships between latent constructs, ensuring the robustness of the results and providing a comprehensive understanding of learning strategies in university students, particularly in the context of tourism education.

RESULTS

In this section, the results of the statistical analysis applied to the collected data are presented, with the purpose of evaluating the reliability and validity of the ACRA questionnaire in university students of the Tourism program. First, the instrument showed a high level of internal consistency. Both Cronbach's alpha coefficient and McDonald's omega reached overall values of 0.912, indicating high reliability of the questionnaire as a whole.

At the dimensional level, the results also reflect adequate levels of internal consistency. Dimension 1, corresponding to cognitive and learning control strategies, presented a coefficient of 0.850; Dimension 2, learning support strategies, obtained a value of 0.839; while Dimension 3, study habits, recorded a coefficient of 0.749. These values are considered acceptable and consistent with the criteria established in the literature, which suggest minimum thresholds of 0.70 for studies in the social sciences (Nunnally & Bernstein, 1994; Tavakol & Dennick, 2011).

On the other hand, Table 1 shows the results of the Kaiser-Meyer-Olkin (KMO) sample adequacy test and Bartlett's test of sphericity. The KMO index reached a value of 0.811, which indicates adequate sample sufficiency for the application of factor analysis (Kaiser, 1974), since values greater than 0.80 are considered meritorious. This result is consistent with previous research that has reported similar levels of sample adequacy in psychometric studies (Jamal & Anwar, 2021).

Regarding Bartlett's test of sphericity, a statistically significant result was obtained ($p < 0.05$), which allows rejecting the null hypothesis of an identity matrix and confirming that the variables present sufficient correlations to proceed with factor analysis (Kline, 2016). Overall, these findings support the suitability of the data and the robustness of the ACRA instrument for its application in the analyzed context.

Table 1 – KMO and Bartlett's Test of the ACRA and student sample

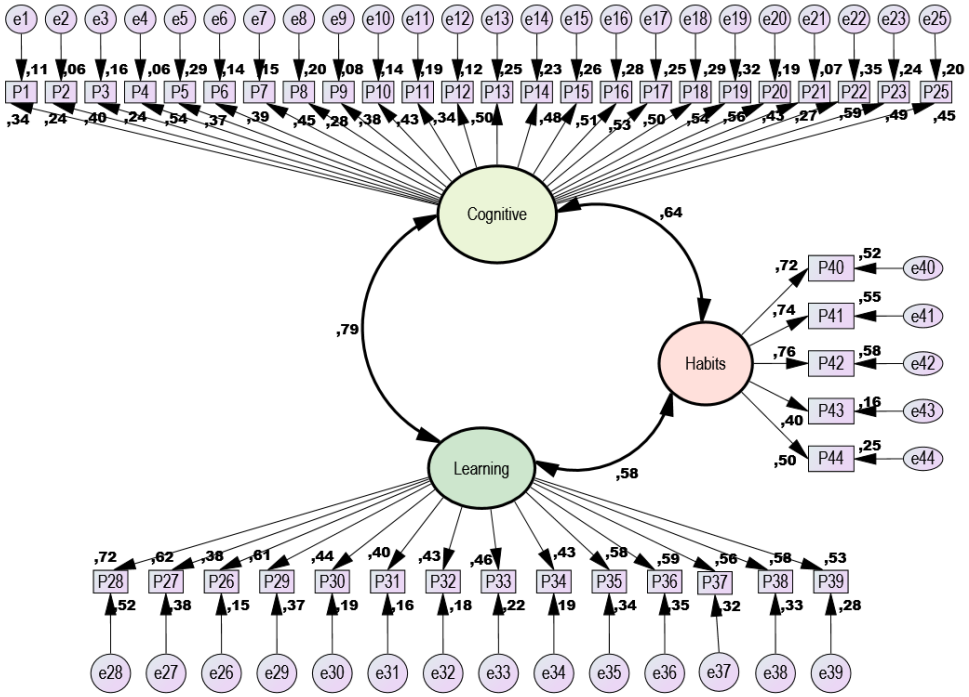
\		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0,811
Bartlett's Test of Sphericity	Approx. Chi-square	2601,516
	gl	946
	Sig.	0,000

Figure 2 presents the structural relationships between the analyzed variables. In particular, it is observed that the relationship between cognitive strategies and study habits shows a standardized loading of 0.63, indicating a positive association of moderate magnitude. This result suggests that both dimensions are interrelated and tend to coexist in different learning contexts.

Likewise, the relationship between cognitive strategies and learning shows a standardized loading of 0.80, reflecting a strong and significant association. This finding highlights the relevance of cognitive strategies as a central component in learning outcomes, in line with the literature on self-regulated learning (Zimmerman, 2020; Panadero, 2017). On the other hand, a positive covariance is identified between study habits and learning (0.58), indicating a moderate relationship between both variables. This result suggests that the consolidation of appropriate study habits is associated with better performance in learning processes.

Overall, the high standardized loadings among these variables show that students in the Tourism program have a higher probability of consistently using learning strategies both in the development of practical classroom activities and at home. These results are consistent with previous studies that highlight the interdependence between cognitive strategies, study habits, and academic performance (Broadbent & Poon, 2015).

Figure 2 – Standardized factor loadings of the observed and latent variables of the ACRA model



According to Table 2, the estimated model shows an adequate level of overall fit. In particular, the CMIN/DF index (χ^2/df = 1.94) falls within the recommended values, indicating a satisfactory fit of the model to the data, since values below 3 reflect good parsimony. Likewise, the root mean square error of approximation (RMSEA = 0.076) suggests an acceptable fit of the model. According to the criteria established in the literature, values below 0.05 indicate an excellent fit, while values between 0.05 and 0.08 represent a reasonable or adequate fit (Henseler et al., 2015). In this sense, the obtained value supports the validity of the proposed model.

Overall, these results confirm that the model based on the ACRA questionnaire presents a consistent structure, in which both latent variables and observed indicators are coherently related to their respective constructs. This demonstrates that the instrument validly and reliably measures the use of learning strategies in applicants to university studies in the Tourism program. It is worth noting that, although reference is made to the complementary use of neural networks to strengthen the predictive capacity of the analysis, the reported indices correspond specifically to the fit of the structural equation model (SEM), considered a robust standard for the validation of psychometric instruments.

Table 1 – Goodness-of-fit test and classification levels

Measure	Estimate	Threshold	Interpretation
CMIN	225,075	--	--
DF	116	--	--
CMIN/DF	1,94	Entre 1 y 3	Excellent
CFI	0,875	>0,95	Poor
RMSEA	0,076	<0,06	Acceptable
PClose	0,003	>0,05	Poor

DISCUSSION

The findings of this study provide strong empirical support for the validity and reliability of the ACRA questionnaire in assessing learning strategies in university applicants. The high internal consistency observed across all its dimensions is consistent with previous research highlighting the stability of the model in various educational contexts (García et al., 2024). Furthermore, a structural equation model with an acceptable fit error is observed, with excellent coefficients and a construct validity analysis that discriminates each component according to the obtained results (Ugando, 2024). One of the most relevant results is the strong relationship between cognitive and control strategies and learning processes, which reinforces the self-regulated learning approach, where cognitive and metacognitive strategies are determinants of academic performance (Zimmerman, 2020). In this sense, students who plan and regulate their learning tend to achieve better results.

On the other hand, the moderate relationship between cognitive strategies and study habits suggests that routines, although important, do not guarantee effective learning on their own. This is consistent with studies indicating that the quality of cognitive processing is more relevant than the frequency of study (Dunlosky & Rawson, 2013). Likewise, the positive covariance between study habits and support strategies highlights their complementary nature, emphasizing the role of motivation and self-regulation in sustaining learning (Broadbent & Poon, 2015).

From a methodological perspective, the use of SEM allowed the validation of relationships between variables, although the CFI value (0.875) suggests possible improvements through the inclusion of variables such as motivation or digital competencies (Hair et al., 2022). In addition, the integration of neural networks adds predictive value to the analysis. The results have practical implications for higher education institutions, which should strengthen cognitive and metacognitive strategies in students enrolled in tourism-related programs. This study contributes to the evidence in Latin American contexts by validating the ACRA model in an Ecuadorian population.

CONCLUSIONS

The study analyzed learning strategies in applicants to the Tourism program using the ACRA model and structural equation modeling (SEM), demonstrating adequate levels of reliability and validity of the instrument (α and ω = 0.912). The results highlight the central role of cognitive and control strategies as the main determinants of learning, which is key in the training of tourism professionals, who must develop analytical, adaptive, and decision-oriented skills in dynamic environments.

Likewise, the positive relationship between study habits and support strategies confirms the multidimensional nature of learning, suggesting the need for comprehensive training approaches. Although the model showed an acceptable fit, the CFI value indicates the

convenience of incorporating additional variables, such as academic motivation and digital competencies, especially relevant in the context of digital tourism.

Among the limitations, the cross-sectional design and the restricted sample scope are identified, which limit the generalization of the results. Consequently, future research should consider longitudinal approaches and larger samples. Finally, future research lines are proposed, including the integration of hybrid SEM–neural network models and the analysis of the impact of learning strategies on key variables such as academic performance and employability in the tourism sector.

The findings of the study have relevant implications for academic training and educational management in the field of tourism. First, they highlight the need to strengthen the development of cognitive and self-regulation strategies in students through active methodologies that promote meaningful learning and problem-solving in real tourism contexts.

Second, the importance of integrating digital competencies and the use of emerging technologies, such as artificial intelligence, into curricula is emphasized, to prepare future professionals for an increasingly digitalized tourism environment. Likewise, educational institutions should design academic support programs that strengthen study habits and support strategies, contributing to improved performance and student retention.

Finally, from an institutional and educational policy perspective, it is recommended to promote continuous learning assessment processes and the incorporation of advanced analytical models to better understand student behavior. This will facilitate evidence-based decision-making and contribute to the training of more competitive, innovative, and market-adapted tourism professionals.

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Conceptualization, MUP, AAHG; methodology, MUP, ERIL; formal analysis, DASD, RAH, PDDM, AAHG; investigation, MUP, RAH, PDDM, AAHG; data curation, RAH, BVLR, ARSG, AAHG; writing—original draft, MUP, ARSG; writing—review and editing, MUP, RAH, AAHG; supervision, MUP, RAH, PDDM, ERIL; funding acquisition, MUP, RAH, AAHG; project administration, MUP, PDDM, ERIL.

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The authors declare no conflict of interest.

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ETHICS STATEMENT

This study did not involve human participants or animals and therefore did not require ethical approval.

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