

Predictive Model of Teaching Competencies for Academic Performance in Latin American Universities: Multivariate Statistical Validation

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RESUMEN

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Las universidades latinoamericanas requieren herramientas más efectivas para evaluar el desempeño docente, dado que los sistemas tradicionales describen únicamente eventos pasados sin anticipar el impacto futuro en el rendimiento estudiantil. El objetivo fue desarrollar y validar un modelo estadístico que prediga el rendimiento académico estudiantil mediante competencias docentes específicas, aplicable en universidades latinoamericanas. Se analizaron 248 estudiantes de la Universidad Nacional de Trujillo durante el semestre 2025-I, evaluando seis dimensiones de competencias docentes mediante 21 reactivos con escala Likert. Se aplicaron análisis factorial exploratorio ($KMO = 0.89$), correlaciones de Pearson y regresión múltiple jerárquica. El modelo final explica el 71% de la varianza en rendimiento académico estudiantil. La comunicación efectiva docente constituye el predictor más significativo ($\beta = 0.42$), seguida por el clima áulico ($\beta = 0.28$) y la atención individualizada ($\beta = 0.15$). Este modelo permite a las universidades latinoamericanas identificar docentes que requieren capacitación específica y detectar estudiantes en riesgo académico, optimizando recursos limitados mediante intervenciones basadas en evidencia.

Palabras clave: *evaluación docente; rendimiento académico; modelos predictivos; educación superior latinoamericana; competencias pedagógicas.*

ABSTRACT

Latin American universities require more effective tools to evaluate teaching performance. Traditional systems only describe past events without anticipating future impact on student performance. The objective was to develop and validate a statistical model that predicts student academic performance based on specific teacher competencies, applicable in Latin American universities. A total of 248 students from Universidad Nacional de Trujillo were analyzed during the 2025-I semester. Six dimensions of teaching competencies were evaluated through 21 Likert-scale items. Exploratory factor analysis ($KMO = 0.89$), Pearson correlations, and hierarchical multiple regression were applied. The final model explains 71% of the variance in student academic performance. Effective teacher communication constitutes the most significant predictor ($\beta = 0.42$), followed by classroom climate ($\beta = 0.28$) and individualized attention ($\beta = 0.15$). This model enables Latin American universities to identify teachers requiring specific training and detect students at academic risk, optimizing limited resources through evidence-based interventions.

Keywords: *teacher evaluation; academic performance; predictive models; Latin American higher education; pedagogical competencies.*

INTRODUCTION

Higher education institutions in Latin America face the constant challenge of optimizing education quality with limited resources. Traditional methods of teacher evaluation are exclusively centered on retrospective measures of student satisfaction, without providing prospective indicators of the real impact on learning (Basilotta-Gómez-Pablos et al., 2022). Recent studies confirm that traditional systems of teacher evaluation in Latin America have meaningful limitations in capturing the multidimensional nature of teachers' effectiveness. (Brutti & Sanchez, 2021; Estrada & Lombardi, 2020).

In countries such as Peru, Ecuador, and Colombia, public universities require evidence-based strategies to manage investments in teachers' professional development. International literature

identifies specific competencies that meaningfully impact academic performance, but these findings are drawn primarily from educational contexts in developed countries with different socioeconomic realities. The contemporary research emphasizes the critical need for evidence-based professional development approaches, especially given that the region will require 3.2 million teachers for universal education in 2039 (Chapman & Montecinos, 2025).

The context of Latin American higher education presents unique challenges that require specialized consideration. Recent studies emphasize the interplay among technological innovation, sustainability practices, and labor-market adaptation in regional education quality assurance. (Anzules-Falcones et al., 2025). Furthermore, comparative research reveals a growing awareness of the rights of diverse groups, as well as meaningful challenges in retention and degree completion in Latin American contexts (Anzelin et al., 2025). These contextual factors, including limited economic resources and a lack of a research culture, require frameworks for formation that are specifically adapted to regional characteristics (Marino-Jiménez et al., 2024).

The present study addresses this gap by developing a predictive model contextualized to the Latin-American reality, considering cultural, economic, and organizational distinctive features of our educational institutions. The research question that guides the study is: Which specific teacher competencies most precisely predict students' academic performance at Latin-American universities, and how can a reliable mathematical model be formulated to predict it?

The main objective is to develop and validate a statistical model that predicts students' academic performance based on specific teacher competencies, applicable to Latin American universities. The specific objectives are: identify the most influential dimensions of the teacher competencies on students' performance; quantify the predictive power of each dimension through multivariate analysis; formulate a mathematical equation to make precise predictions; and validate the statistical robustness of the proposed model.

Regarding the theoretical framework, teacher competencies are the abilities teachers need to teach effectively. The research has identified six main dimensions that influence student learning (Singh & Chaudhary, 2021; Sánchez-Cruzado et al., 2021):

(1) enthusiasm and motivation, that creates deeper learning when the teacher demonstrate genuine passion for his/her subject (Shao, 2023); (2) flexibility and comprehension, understanding that not all the students learn equally; (3) individual attention, recognizing particular needs in each student, dimension that mediates the relation between the institutional support and students commitment (Berhanu & Sewagegn, 2024); (4) interaction and classroom environment, that impact on learning directly (Bravo-Sanzana et al., 2024; Erdem & Kaya, 2024); (5) effective communication, that recent research confirm as one of the most important factors for students success (Liu, 2024; Wu et al., 2024; Seghedini, 2012); and (6) pedagogical adaptation, which technological and pedagogical integration as well as of content affect significantly the teacher effectiveness (Khanal et al., 2024). A comprehensive meta-analysis of 40 studies shows that features and teachers' competencies explain 9.2% of the variance in student performance (López-Martín et al., 2023).

Student academic performance is a multidimensional construct that goes beyond grades. Research identifies four key areas of teachers' competence (teaching style, course organization, student engagement, and determination of progress) that affect performance, with student-centered approaches showing superior effectiveness (Mastrokourou et al., 2022). In the Latin American context, where many students are first-generation college students and combine work and study, it is especially relevant to study which teaching characteristics contribute to academic success. The multilevel analysis of the PISA 2018 data from 10 Latin American countries identifies classroom-level processes as crucial predictors of performance variance. (Borchers & Cunha, 2025).

METHODOLOGY

A quantitative, transversal, and correlational-predictive study was implemented. This design allows us to examine the relations among variables at a specific temporal moment and to develop statistically valid predictive models. (Hamaker, 2024).

The target population comprised undergraduate students at the Universidad Nacional de Trujillo during the 2025-I academic semester. The final sample included 248 students across the following faculties: Engineering (32%), Education (28%), Social Sciences (18%), Medicine (12%), and Economy (10%). The sample size meets the minimum criteria for multivariate analysis (Hair et al., 2019), and the 20:1 participant-to-predictor ratio is appropriate for hierarchical regression (Siegle, 2025). Criteria of inclusion were: active enrollment in the current semester, completion of at least a previous academic semester, informed consent, and regular class attendance (minimum 75%). First-semester students were excluded, as were participants with fewer than 3 enrolled courses, incomplete answers, or suspect patterns of bias.

The tool used was a structured 21-item questionnaire: 20 items assessing teachers' competence on a Likert scale (1-5) and 1 item measuring self-perceived academic performance. Content validation was conducted by five experts in HE, yielding validity indices exceeding 0.85, in accordance with established criteria for teacher competence evaluation (Alcívar-Cedeño, 2024; Alavi et al., 2024).

The recollection procedure included approval from the UNT Institutional Research Ethics Committee; a preliminary pilot study with a sample of 50 students to make final adjustments; digital data management during regular class schedules; and quality control by deleting incomplete responses. The procedure was conducted with SPSS version 28.0.

The analytical strategy was organized in four stages: Stage I, exploratory data analysis with descriptive statistics, normality test (Shapiro-Wilk), and detection of univariate outlier values ($z > \pm 3.29$) and multivariate (Mahalanobis distance); Stage II, factor analysis with verification of sampling adequacy ($KMO > 0.70$), Bartlett's test of sphericity, and factor extraction with Varimax rotation; Phase III, correlational analysis using Pearson correlations and assessment of multicollinearity ($VIF < 4.0$); and Phase IV, predictive modeling through hierarchical multiple regression in three progressive stages. (Smith et al., 2020).

RESULTS AND DISCUSSION

Characterization of the sample and descriptive statistics

The final sample comprised 248 students, with a gender distribution of 58% women and 42% men, an average age of 21.3 years ($SD = 2.1$; range: 18-28), and a socio-economic level distribution of 45% average-low, 35% average, and 20% low. The descriptive measures and reliability for all dimensions are presented in Table 1. All dimensions showed high scores (M between 4.12 and 4.31) and reliability indices exceeding .80, confirming adequate internal consistency.

Table 1
Descriptive Statistics and Reliability of the Teacher Competence Dimensions

Dimension	M	SD	α	Kurtosis	Skewness
Effective Communication	4.29	0.85	.91	-0.45	-1.12
Flexibility and Comprehension	4.31	0.82	.84	-0.38	-1.08
Interaction and Climate	4.25	0.87	.88	-0.42	-1.05
Enthusiasm and Motivation	4.23	0.89	.82	-0.35	-0.98
Personalized Attention	4.18	0.91	.86	-0.41	-0.95
Pedagogical Adaptation	4.12	0.96	.83	-0.33	-0.89
Academic Performance	3.78	0.94	---	-0.28	-0.45

Note. M = Median; SD = Estandar Deviation; α = Cronbach's alpha coefficient. Own elaboration

Validation of Factorial Structure

The sampling adequacy measure yielded a Kaiser-Meyer-Olkin (KMO) index of 0.89, and Bartlett's test of sphericity was significant ($\chi^2 = 2,847.3$, $df = 190$, $p < .001$). The six extracted factors collectively explained 68.4% of the total variance, empirically confirming the proposed theoretical structure and exceeding the minimum criterion of 60% (see Table 2).

Table 2
Factorial Structure and Variance Explained of the Teacher Competence

Factor	Explained Variance	Eigenvalue	Items with factor loadings > .60
1. Effective Communication	28.7%	5.74	4 ítems
2. Interaction and Climate	14.2%	2.84	3 ítems
3. Personalized Attention	9.1%	1.82	3 ítems
4. Flexibility and Comprehension	7.8%	1.56	4 ítems
5. Enthusiasm and Motivation	4.9%	0.98	3 ítems
6. Pedagogical Adaptation	3.7%	0.74	3 ítems

Note. KMO = 0.89; Bartlett's test of sphericity: $\chi^2 = 2,847.3$, $gl = 190$, $p < .001$. Total Variance Explained = 68.4%. Own elaboration.

Correlational Analysis

The correlations among the study variables (Table 3) point out that effective communication shows the strongest association with academic performance ($r = .67$), followed by interaction and classroom climate ($r = .61$), personalized attention ($r = .56$), and enthusiasm ($r = .52$). According to Cohen's criteria (1988), these correlations are large in magnitude. Medium correlations were observed for flexibility

(.48) and pedagogical adaptations (.49). These medium-to-strong correlations confirm that the dimensions are related while maintaining a differentiated conceptual identity. Multicollinearity indicators were acceptable (VIF < 4.0).

Table 3
Correlations between variables of the study Matrix

Variables	1	2	3	4	5	6	7
1. Enthusiasm	1.00						
2. Flexibility	.67**	1.00					
3. Individual attention	.72**	.71**	1.00				
4. Interaction and Climate	.74**	.69**	.78**	1.00			
5. Communication	.69**	.66**	.73**	.81**	1.00		
6. Adaptation	.58**	.62**	.65**	.69**	.71**	1.00	
7. Performance	.52**	.48**	.56**	.61**	.67**	.49**	1.00

Note. **p < .01 (bilateral). N = 248. Own elaboration.

Hierarchical Multiple Regression Model

The results of the hierarchical regression analysis are shown in Table 4. The final model (Model 3) explains 71% of the variance in academic performance ($R^2 = .71$; R^2 adjusted = .69), constituting a large effect size according to Cohen (1988).

Table 4
Hierarchical Multiple Regression Analysis to Predict Academic Performance

Model	Included Variables	R ²	ΔR ²	F	p	Durbin-Watson
1	Demographical Variables	.08	.08	4.32	.014	---
2	+Communication, Interaction	.64	.56	118.67	< .001	---
3	+ All dimensions	.71	.07	58.34	< .001	1.89

Note. N = 248. The final model (Model 3) presents an adjusted R^2 of .69. Own elaboration.

The coefficients of the final model are detailed in Table 5. Effective communication constitutes the strongest predictor ($\beta = 0.42$), followed by the interaction and classroom climate ($\beta = 0.28$) and the personalized attention ($\beta = 0.15$). The resulting predictive equation is given by (1). The regression assumptions were met: normality of residuals (Kolmogorov-Smirnov p = .089), homoscedasticity (Breusch-Pagan p = .156), and independence (Durbin-Watson = 1.89). The absence of problematic multicollinearity was confirmed with VIF < 4.0 and Tolerance > .30.

$$\text{Academic Performance} = 0.23 + 0.47(\text{Communication}) + 0.31(\text{Interaction}) + 0.18(\text{Individual Attention}) \quad (1)$$

As established in (1), the non-standardized equation allows prediction of a student's academic performance by substituting the average values of the three teaching competencies (on a scale of 1-5). The standardized equivalent equation is: $Z(\text{Performance}) = 0.42 \times Z(\text{Communication}) + 0.28 \times Z(\text{Interaction}) + 0.15 \times Z(\text{Attention})$, whose 95% confidence intervals are: Communication [0.31, 0.63], Interaction [0.13, 0.49], and Attention [0.04, 0.32].

Table 6
Regression Coefficients of the Final Optimized Model

Predictor	B	EE	β	t	p	VIF	Tolerance
(Constant)	0.23	0.18	---	1.28	.201	---	---
Effective Communication	0.47	0.08	.42	5.89	< .001	2.8	.36
Interaction and Climate	0.31	0.09	.28	3.44	.001	3.1	.32
Individual attention	0.18	0.07	.15	2.57	.011	2.4	.42

Note. B = non-standardized coefficient; EE = standard error; β = standardized coefficient; VIF = Variance Inflation Factor. $R^2 = .71$, R^2 adjusted = .69, $F(3, 244) = 58.34$, $p < .001$. Own elaboration.

Discussion of the results

This research shows that teachers' competencies can predict students' academic performance with notable precision (71%) in Latin American university contexts, which represents a meaningful contribution to the regional literature. Three findings are worth particular discussion.

First, teachers' effective communication is the strongest predictor of students' success ($\beta = 0.42$). This finding aligns with recent meta-analyses that identify communication as a determining factor in academic engagement. (Liu, 2024; Wu et al., 2024; Seghedin, 2012). The magnitude of the observed effect suggests that moderate improvements in teacher communication can generate considerable impacts on students' performance.

Second, the classroom climate represents a crucial factor ($\beta = 0.28$). This result is aligned with recent evidence from Bravo-Sanzana et al. (2024) and the meta-analysis of Erdem and Kaya (2024). It is particularly relevant in the Latin American context, where interpersonal relations constitute a fundamental cultural component.

Third, personalized attention contributes significantly to performance ($\beta = 0.15$), consistent with research on students' autonomy support. (Basileo et al., 2024; Miao & Ma, 2023).

The results partially align with international analyses identifying communication as a determining factor in effective learning (Singh & Chaudhary, 2021; Täschner et al., 2024). However, this study adds unique value because it has been developed specifically in a Latin American context, with the limitations of typical resources, and applies an accessible methodology for regional universities with restricted budgets. In contrast to studies in developed countries, where technological factors carry greater predictive weight, our findings highlight the fundamental importance of communicative and interpersonal competencies, reflecting Latin American cultural characteristics that prioritize human relations in educational processes.

Among the limitations of the study, the following have been identified: dependence on self-report for academic performance, which can introduce subjective bias; the transversal design, which limits definitive causal inferences; the sample restricted to a single institution; and possible social desirability bias in students' responses. These limitations point out the necessity of longitudinal studies and multicentric validation.

The scientific novelty of this study lies in being the first teacher competence predictive model to be statistically validated in the Latin American higher education context. It can explain 71% of the variance in academic performance. The controversial character of this work lies in its questioning of traditional teacher evaluation systems focused on student satisfaction, proposing instead an approach oriented toward prediction and early intervention. From a theoretical perspective, the findings confirm that teacher effectiveness in Latin America follows a pattern of interpersonal and communicative competencies that differs from that observed in Anglo-Saxon contexts. This particularity invites us to revise the critical application of external models to our region. The practical applications are immediate: the 21-item instrument can be implemented at any Latin American university with minimal resources, becoming a low-cost, high-impact tool for institutional management. This study is relevant to research on educational quality, teaching evaluation, and equity in higher education, responding to the real needs of the region's university policies.

CONCLUSIONS

This research demonstrates that teachers' competencies can predict students' academic performance with significant statistical precision (71%) at Latin American universities. Based on the results obtained, the following conclusions were established:

- 1) Teachers' effective communication constitutes the most powerful predictor of students' performance ($\beta = 0.42$), confirming the theoretical and practical importance of communicative competencies in Latin American higher education.
- 2) Classroom climate ($\beta = 0.28$) and personalized attention ($\beta = 0.15$) contribute significantly to the predictive model, pointing out that interpersonal competencies are determinants of students' success in our regional context.
- 3) The validated model, which explains 71% of the variance, provides a practical tool for higher education management oriented to identify teachers who require specific training and to detect students who may be at academic risk.
- 4) The validated 21-item instrument proves to be transferable to other educational contexts in the region, facilitating comparative future studies at Latin American universities with limited resources.

It is recommended that universities prioritize the development of communicative competencies in teacher training programs; implement the model as an early warning system; incorporate the evaluation of communicative and interpersonal competencies into the teacher selection process; and optimize limited resources through evidence-based interventions. Finally, as a future research agenda, it is proposed to conduct multicenter validation in Ecuador, Colombia, Argentina, and other Latin American countries; incorporate objective measures of academic performance; conduct longitudinal analyses of

student cohorts; and study moderated contextual factors.

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