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Research Article

Analyzing the effect of ICT engagement on academic performance: A PLS-SEM approach mediated by intrinsic motivation

Luis Miguel Olórtegui-Alcalde [1*]
0000-0002-1072-4497

Franklin Cordova-Buiza [2]
0000-0002-7623-7472

[1] Professional School of Business Administration, Universidad Autónoma del Perú, Lima, PERU
[2] Department of Research, Innovation and Sustainability, Universidad Privada del Norte, Lima, PERU
[*] Corresponding author: lolorteguia@autonoma.edu.pe

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ABSTRACT

This study examines how engagement with information and communication technologies (ICT) relates to university students' academic performance, considering intrinsic motivation as a mediator and platform usability as an enabling condition. A quantitative, cross-sectional, correlational, and descriptive design was implemented with 385 students from a university in Lima (Peru), selected through non-probability convenience sampling. Data were collected using a structured 5-point Likert questionnaire measuring platform usability, ICT engagement, intrinsic and extrinsic motivation. Academic performance was operationalized as self-reported semester GPA using the national 0-20 grading scale. The model was tested using PLS-SEM (SmartPLS 4) with a bootstrapping procedure of 5,000 subsamples. Results indicated a strong association between platform usability and ICT engagement (β = 0.78). ICT engagement showed positive effects on intrinsic motivation (β = 0.64) and extrinsic motivation (β = 0.42). Intrinsic motivation was positively related to academic performance (β = 0.55) and mediated the relationship between ICT engagement and performance (indirect effect = 0.35). Platform usability also exerted an indirect effect on performance through engagement and intrinsic motivation (0.43). Overall, the findings suggest that ICT engagement translates into better academic outcomes primarily when digital platforms are usable and instructional strategies foster intrinsic motivation and autonomous learning.

Keywords: ICT, student engagement, intrinsic motivation, academic performance, PLS-SEM

INTRODUCTION

Information and communication technologies (ICT) have profoundly transformed higher education by facilitating access to digital content and promoting new pedagogical strategies. However, the impact of these technologies on academic performance depends on the commitment and motivation of students. Digital platform adoption has expanded across higher education systems worldwide, including Latin American universities, where learning management systems and other digital tools have become central components of the learning environment (Anthonysamy et al., 2020). Recent research has highlighted that the adoption and effective use of these systems depend not only on technological availability but also on students' acceptance and engagement with digital platforms. For example, Korsah (2024) analyzed the adoption of Moodle learning management systems during emergency remote teaching and found that technological acceptance significantly shapes students' interaction with digital learning environments. However, the impact of ICT on academic performance varies depending on students' engagement and motivation (Henrie et al.,

2015; Schindler et al., 2017). Intrinsic motivation is recognized as a determining factor in maximizing the benefits of ICT in education by promoting active interaction with digital environments and improving academic performance (Broadbent & Poon, 2015).

Previous studies have shown that access to digital platforms does not always guarantee effective learning. According to OECD (2022), 42% of university students in Latin America use digital platforms only to fulfill mandatory assignments, while only 28% use them regularly as a tool for autonomous learning. This lack of active integration in digital environments may be due to a combination of factors, including the perceived usability of the platforms and the quality of the design of their interfaces (Al-Fraihat et al., 2025; Davis, 1989; Venkatesh et al., 2003). In this sense, intrinsic motivation is a determining factor in ICT engagement, since students who perceive these technologies as an opportunity to improve their knowledge show higher academic performance (Deci & Ryan, 2016).

In the Peruvian context, El Instituto Nacional de Estadística e Informática [INEI] (2022) reported that only 58% of university students consider that the digital platforms used in their institutions are intuitive and facilitate learning. This finding highlights the importance of improving the usability of these environments to optimize the educational experience and strengthen student engagement with digital learning. According to Kannan et al. (2020), an intuitive and accessible design not only allows for greater interaction with educational materials but also encourages greater student engagement through interactive strategies and real-time feedback mechanisms. In this sense, the interrelationship between platform usability, intrinsic motivation, and academic performance deserves further analysis to understand how these factors can enhance the impact of ICT in higher education (Garrison & Kanuka, 2004; Salazar-Rebaza et al., 2023).

This study contributes to the literature by integrating platform usability, ICT engagement, and intrinsic motivation within a single structural model in a Latin American higher education context. Recent studies have highlighted the need for empirical research examining how ICT adoption influences learning processes in universities. For instance, Sakhieva et al. (2025) analyzed patterns of ICT adoption among university students, while Navarro-Ibarra et al. (2023) identified significant research gaps in the literature on ICT and education. Responding to these calls, the present study examines how ICT engagement and motivation interact to influence academic performance in higher education. It also responds to calls for empirical research examining integrated models of usability, engagement, and motivation within emerging digital higher education ecosystems, particularly in underrepresented Latin American contexts.

LITERATURE REVIEW

This study is based on five key constructs: platform usability, ICT engagement, intrinsic motivation, extrinsic motivation, and academic performance. Platform usability is understood as students' perception of the ease of use of the virtual learning environment, including aspects such as intuitive navigation, accessibility of learning resources, and the overall organization of the digital interface. Previous research highlights that the effective integration and design of digital learning tools play a crucial role in enhancing student engagement and academic outcomes in higher education (Fuentes & LaBad, 2025). This variable is fundamental in determining whether the technological environment facilitates or hinders students' engagement in the learning process, particularly when digital environments provide timely and meaningful feedback mechanisms that support active participation and learning progression (Cavalcanti et al., 2021; Fang & Thomas, 2025).

In addition, evidence shows that learning analytics and LMS log-data can support engagement through actionable feedback, early-warning indicators, and dashboard-based self-monitoring in higher education (Banihashem et al., 2022; Dobashi et al., 2022; Jung & Wise, 2025; Larrabee Sønderlund et al., 2019; Linden et al., 2023).

ICT engagement is defined as students' active, emotional, and behavioral involvement in the use of digital tools for educational purposes. This engagement is reflected in sustained participation in virtual learning environments and the effort invested in technology-mediated academic tasks. Evidence from recent systematic reviews suggests that well-integrated digital learning tools can strengthen student engagement and support positive academic outcomes in higher education settings (Fuentes & LaBad, 2025). In terms of motivation, two dimensions are distinguished: intrinsic and extrinsic motivation. Intrinsic motivation is related

to the genuine interest in learning, the enjoyment of the educational process, and the perception of autonomy in the management of knowledge. In contrast, extrinsic motivation is driven by external stimuli, such as obtaining grades, fulfilling tasks out of obligation, or seeking recognition from teachers and peers (Deci & Ryan, 2016; Johar et al., 2023).

Academic achievement, as the dependent variable of the model, is conceived as the quantifiable result of student learning and is represented by the average grade point average obtained (Anthonysamy et al., 2020; Broadbent & Poon, 2015). Each of these variables has been operationalized in the model through observable dimensions. The usability of the platform has been measured by considering the clarity of the design, the fluid navigation, and the quality of the feedback offered. Engagement with ICT use has been assessed through the student's active participation in digital activities, the frequency with which they access the platform, and the level of effort invested in the tasks. Intrinsic motivation has been examined in terms of personal interest, satisfaction with learning, and perceived control over their learning process, while extrinsic motivation has been assessed considering external incentives, academic demands, and the search for recognition. Finally, academic performance has been estimated based on GPA as an indicator of the student's overall performance in the university environment (Anthonysamy et al., 2020; Broadbent & Poon, 2015).

In the educational context, ICTs have transformed learning environments through accessible, collaborative, and flexible tools that favor the development of digital competencies (Almarghani & Mijatovic, 2017). Recent studies highlight their ability to foster innovation in teaching and learning methods, allowing students to access didactic materials autonomously. It has been found that digital educational platforms not only facilitate access to knowledge but also improve information retention and academic performance (Anthonysamy et al., 2020; Emerson et al., 2020; Machuca-Vílchez et al., 2023).

A growing body of research suggests that well-structured virtual learning environments enhance students' focus and comprehension. ICT engagement includes active participation, frequency of interaction, and effort invested in the use of educational platforms (Henrie et al., 2015; Salazar-Rebaza et al., 2022). Engagement is considered a key factor in learning, as students who are actively engaged tend to demonstrate higher levels of academic achievement and satisfaction (Bergdahl et al., 2024; Broadbent & Poon, 2015).

Usability, interactivity, and real-time feedback have been widely recognized as critical factors in enhancing students' engagement with ICT (Deci & Ryan, 2016; Zegarra-Alva et al., 2024). An intuitive and accessible design of educational platforms facilitates active participation and enhances the learning experience. In this context, the PLS-SEM model has been employed in recent studies to analyze the influence of these factors on the use of digital tools in higher education (Chiu, 2022; Gallagher et al., 2024). The relationship between ICT engagement and academic performance is not direct but is mediated by intrinsic motivation; ease of use of platforms has been found to significantly boost interaction with ICT, promoting more autonomous learning (de Vreugd et al., 2025; Lee & Kim, 2025; Wang et al., 2025). Thus, a well-designed digital environment not only encourages participation but also optimizes the educational process. This reinforces the importance of investing in intuitive platforms that boost motivation and academic performance (Broadbent & Poon, 2015; Huang & Wang, 2023).

In educational research, motivation is commonly examined through two complementary dimensions: intrinsic and extrinsic motivation (Sánchez & Hueros, 2010). Intrinsic motivation refers to learning driven by genuine interest and personal satisfaction (Deci & Ryan, 2016). In digital learning environments, intrinsic motivation is associated with greater self-directed learning and deeper engagement, whereas extrinsic motivation is shaped by external contingencies such as grades, rewards, or recognition (Abbad, 2021; Davis, 1989; Venkatesh et al., 2003). Although extrinsic motivation may be less enduring, it can still encourage ICT use, particularly when platforms incorporate badges or other reward mechanisms (Sailer & Homner, 2020; T. Li et al., 2023).

It is important to highlight the usability of educational platforms, referring to the ease with which students can interact with technological tools. Recent studies have addressed the importance of intuitive interface design and simple navigation to enhance the user experience and encourage continued use of ICT (Venkatesh et al., 2003). Factors such as clarity in the layout of elements, accessibility of interactive features, and simplicity in navigation have been identified as essential to improve learners' perception of the platform and their willingness to interact with it (Al-Fraihat et al., 2025; Cavalcanti et al., 2021).

Regarding engagement and academic performance, prior evidence indicates that students with higher levels of engagement tend to achieve better academic results, especially when learning is facilitated by technologies that stimulate interaction. Engagement has been shown to facilitate greater retention of knowledge and application of practical skills (Hasan & Bao, 2020). Studies have explored how intrinsic motivation acts as a crucial mediator in the relationship between engagement with ICT use and academic performance. Intrinsic motivation, driven by genuine interest in learning, is associated with greater autonomy and willingness to participate in the educational environment, which impacts better academic outcomes (Lin, 2024; Martin & Bolliger, 2018; Sweller, 1988).

PLS-SEM has become increasingly common in educational research to examine complex relationships among engagement, motivation, and performance, including mediation effects (Hair et al., 2019). PLS-SEM is a particularly useful tool for small to medium-sized samples and for exploratory models that include mediating variables. Recent studies recommend its use in educational research due to its ability to identify complex and specific relationships within multifactorial educational data (Hair et al., 2019; Larrabee Sønderlund et al., 2019).

The scientific literature presents diverse backgrounds on the impact of engagement with the use of ICT on the motivation and academic performance of university students. Several studies have analyzed how the implementation of technological tools influences the learning process and students' perception of their academic performance (Martin & Bolliger, 2018). According to a study by Lee and Kim (2025), the use of digital platforms in higher education has proven to be an effective strategy to improve academic performance when integrated in a structured manner and aligned with active teaching methodologies. In addition, intrinsic motivation plays a crucial role in the adoption and use of ICT, as it influences student persistence and autonomy in digital environments (Huang & Wang, 2023; Lee & Kim, 2025).

Current educational research has increasingly examined how ICT engagement relates to students' learning motivation. For example, Lin et al. (2024) found that students who use digital platforms show greater autonomy and willingness for self-directed learning. In a similar line of research, Fuentes and LaBad (2025) examined the impact of digital learning tools on student engagement and academic outcomes, highlighting that well-integrated, interactive, and accessible digital environments can enhance student participation and support effective learning processes. Some authors have argued that ICT can generate higher levels of academic engagement when collaborative learning strategies are incorporated in digital environments (Anthonysamy et al., 2020; Broadbent & Poon, 2015; Henrie et al., 2015).

On the other hand, some studies have warned about the challenges in the implementation of ICT in higher education. Previous research suggests that insufficient teacher training and the lack of pedagogical approaches specifically adapted to digital learning environments can limit the potential benefits of ICT use for improving academic performance (Sanhueza et al., 2025). Similarly, Kebritchi et al. (2017) identified that information overload and lack of extrinsic motivation can negatively affect the learning experience in virtual environments. This research suggests that technology alone does not guarantee academic success but must be effectively integrated with student-centered pedagogical strategies (Lee & Recker, 2021).

The impact of the usability of educational platforms has also been widely examined. Previous research suggests that factors such as ease of navigation, interactivity, and intuitive interface design in virtual learning environments can significantly influence students' engagement with digital learning technologies (Al-Fraihat et al., 2025). Similarly, Cavalcanti et al., 2021 study highlights that real-time feedback and accessibility to digital materials favor knowledge retention and improve academic satisfaction. In this context, the adaptation of ICTs to the needs of students is fundamental to optimizing their impact on academic performance (Drugova et al., 2024).

Recent research has addressed the relationship between intrinsic motivation and ICT engagement. In a longitudinal study, Wang et al., (2025) demonstrated that students with high intrinsic motivation have a greater predisposition to use digital tools for their academic training. Similarly, prior research has shown that gamified learning environments can enhance intrinsic motivation and promote more active participation in the learning process (Sailer & Homner, 2020; Y. Li et al., 2024). In this sense, the importance of designing educational strategies that foster motivation and academic engagement through the effective use of ICT is increasingly emphasized.

According to the literature analyzed, it is considered that the implementation of ICT in university environments should be accompanied by a user-centered design and a focus on fostering intrinsic motivation (Henrie et al., 2015; Schindler et al., 2017). Furthermore, given the indirect impact of engagement on academic performance, universities should offer not only intuitive technological tools but also training programs that enable students to better understand and leverage the value of these tools in their learning (Kebritchi et al., 2017; Sanhueza et al., 2025).

Another important finding based on the literature reviewed is the moderate relationship between engagement in ICT use and extrinsic motivation (de Vreugd et al., 2025; Lee & Kim, 2025; Wang et al., 2025). While ICT may offer external rewards, such as grades and recognition, these types of incentives do not seem to be as powerful in fostering active and lasting engagement in the use of digital tools (Deci & Ryan, 2016; Sailer & Homner, 2020). In this sense, the results indicate that external motivations may have limited impact, suggesting that, to maximize the benefits of ICT in education, platforms should focus on fostering an environment that nurtures students' curiosity, interest, and self-satisfaction (Kebritchi et al., 2017).

It is highlighted that the combination of an accessible, user-centered platform design with a focus on intrinsic motivation can enhance learning and improve students' academic performance. These findings provide a solid foundation for research that seeks to optimize the use of ICT in educational contexts and develop interventions that promote more autonomous and effective learning (Anthonysamy et al., 2020; Broadbent & Poon, 2015).

This study aims to analyze the effect of engagement with the use of ICT on university students' motivation and academic performance, considering the usability of digital platforms as a key factor. The general hypothesis states that engagement with ICT influences academic performance indirectly through intrinsic motivation and that the usability of digital platforms strengthens this engagement. In turn, the specific hypotheses propose that ICT engagement positively impacts intrinsic motivation, that usability of digital platforms influences ICT engagement, and that intrinsic motivation mediates the relationship between ICT engagement and academic performance, such that greater ICT engagement is positively associated with academic performance.

This research is relevant because intrinsic motivation and the use of ICT are determining factors in the academic performance of university students. Understanding how these elements interact in the Peruvian context will allow designing more effective educational strategies, improve the quality of teaching, and contribute to the development of competent professionals in an increasingly digitalized world.

METHOD

This study adopted a quantitative approach to examine the relationships between platform usability, ICT engagement, intrinsic motivation, extrinsic motivation, and academic performance among university students in higher education. To test the proposed relationships, the analysis was conducted using partial least squares structural equation modeling (PLS-SEM), given its suitability for evaluating models that include multiple latent constructs, mediation effects, and both direct and indirect relationships. This approach is widely recommended when the research objective includes prediction and explanation of complex structural relationships in educational settings, and when the model integrates latent and observed variables (Flanagan et al., 2022).

A non-experimental, cross-sectional, correlational, and descriptive design was implemented. The target population consisted of undergraduate university students enrolled in a higher education institution in Lima, Peru. A total of 385 valid responses were obtained and retained for analysis. Participants were selected through nonprobability convenience sampling, based on accessibility to the population and feasibility of data collection within the institutional context. Although this sampling strategy may reduce statistical representativeness and limit broad generalization, it is commonly used in educational technology research where access to specific student groups is required, and it remains appropriate when limitations are explicitly acknowledged and interpreted with caution.

Instrument Development and Questionnaire Design

A structured questionnaire was developed specifically for this study to measure platform usability, ICT engagement, intrinsic motivation, and extrinsic motivation. Item development was informed by an extensive review of prior research on ICT use, student engagement, and academic motivation in higher education, and the final wording was adapted to the characteristics of the local university context to ensure conceptual clarity and contextual relevance (Rets et al., 2021). All latent constructs were specified as reflective. The questionnaire used a five point Likert response format ranging from 1 (strongly disagree) to 5 (strongly agree). The final instrument included four items to measure platform usability, five items to measure ICT engagement, four items to measure intrinsic motivation, and four items to measure extrinsic motivation. Example items included the following: for platform usability, "the digital learning platform is easy to navigate," for ICT engagement, "I actively participate in learning activities using digital technologies," for intrinsic motivation, "I use digital learning tools because I enjoy learning through them," and for extrinsic motivation, "I use digital learning platforms mainly to obtain good grades."

Pilot Testing and Content Validity

Before the main data collection, the questionnaire was pilot tested with a group of university students to assess wording, clarity, and completion time. Minor adjustments were made to improve readability and avoid ambiguity. Content validity was then examined through expert review. Specialists in educational technology and higher education research evaluated item relevance, clarity, and alignment with the intended constructs, and their feedback was incorporated into the final version of the questionnaire.

Operationalization of Academic Performance

Academic performance was operationalized using students' semester grade point average. GPA was self-reported by participants and recorded using the national grading scale ranging from 0 to 20, where higher values indicate higher academic achievement. Because the GPA measure was self-reported rather than obtained from institutional academic records, the study did not require access to confidential academic files. Although self-reported GPA may introduce potential reporting bias, this study ensured anonymity and confidentiality to reduce social desirability and encourage accurate reporting.

Data Analysis Procedure

Data were analyzed using PLS-SEM with SmartPLS software, version 4. The analysis followed commonly accepted reporting guidelines for PLS SEM, applying established criteria for evaluating both the measurement model and the structural model. For the measurement model, indicator reliability was assessed through standardized loadings, with values of 0.70 or above considered acceptable. Internal consistency reliability was evaluated using Cronbach's alpha and composite reliability, adopting a minimum threshold of 0.70. Convergent validity was assessed using the average variance extracted (AVE), with values above 0.50 indicating adequate convergence.

Discriminant validity was assessed using two complementary criteria. First, the Fornell Larcker criterion was examined by comparing the square root of the AVE for each construct with its correlations with other constructs. Second, the heterotrait-monotrait (HTMT) ratio was evaluated, using the conservative threshold of 0.90 to confirm adequate discriminant validity.

For the structural model, the evaluation included the estimation and interpretation of path coefficients, coefficients of determination (R^2), effect sizes (f^2), and predictive relevance (Q^2). Statistical significance of the structural relationships was assessed using a bootstrapping procedure with 5,000 subsamples and a two tailed test. Path coefficients were considered statistically significant when p values were below 0.05 and corresponding t values exceeded 1.96. The measurement and structural models results are reported in tables.

Ethical Considerations

This study involved adult university students and collected data using an anonymous and voluntary survey, without gathering sensitive personal information. The research was conducted in accordance with institutional research guidelines applicable to minimal risk survey studies. Participation was entirely

Table 1. Reliability and validity indices of the constructs

Construct	Cronbach's alpha	Composite reliability	AVE
ICT engagement	0.88	0.91	0.67
Intrinsic motivation	0.85	0.89	0.63
Extrinsic motivation	0.80	0.84	0.61
Platform usability	0.90	0.93	0.72

Table 2. Discriminant validity assessment using Fornell-Larcker criterion

Construct	ICT engagement	Intrinsic motivation	Extrinsic motivation	Platform usability
ICT engagement	**0.82**	0.64	0.42	0.78
Intrinsic motivation	0.64	**0.79**	0.40	0.45
Extrinsic motivation	0.42	0.40	**0.78**	0.30
Platform usability	0.78	0.45	0.30	**0.85**

Note. Diagonal values represent the square root of AVE & off-diagonal values are inter-construct correlations

Table 3. Discriminant validity assessment using HTMT

Construct	ICT engagement	Intrinsic motivation	Extrinsic motivation	Platform usability
ICT engagement	-	0.71	0.64	0.83
Intrinsic motivation	0.71	-	0.68	0.62
Extrinsic motivation	0.64	0.68	-	0.55
Platform usability	0.83	0.62	0.55	-

Note. Diagonal values represent the square root of AVE & off-diagonal values are inter-construct correlations

voluntary, informed consent was obtained from all participants prior to data collection, and respondents were informed that they could withdraw at any time without consequences. Data were collected anonymously and analyzed in aggregate form, in line with internationally recognized ethical principles for research involving human participants. Ethics approval was not applicable for this minimal risk anonymous survey research.

RESULTS

PLS-SEM allows us to examine complex relationships between the variables of interest: engagement in ICT use, intrinsic and extrinsic motivation, platform usability, and academic performance. This approach is suitable for this study, given its predictive power and its ability to handle latent and mediating variables.

The data obtained from the sample were processed using SmartPLS 4.0. Standardized coefficients, fit indices, and significant relationships between constructs are presented.

Table 1 presents the reliability and convergent validity indices for the reflective latent constructs included in the measurement model. Academic performance was modeled as a single-indicator observed variable (GPA); therefore, internal consistency reliability and AVE were not applicable to this variable. All the constructs exceed the recommended threshold of 0.70 in both metrics, which confirms that the measurements are reliable and reproducible. This result is fundamental to ensure the reliability of the analysis and supports the adequate conceptualization of the dimensions assessed, such as engagement in ICT use, motivation (both intrinsic and extrinsic), platform usability, and ICT engagement.

In addition, the AVE values are greater than 0.50 for all constructs, thus meeting the criterion of convergent validity. This implies that each construct adequately captures the variance of its individual indicators, which is crucial for the meaningful interpretation of each variable and to ensure that the associated items consistently represent the core concept being measured. This robustness in the reliability and validity of the constructs supports the robustness of the model proposed in the study and its ability to explore the relationships between the factors analyzed. Discriminant validity results are reported in **Table 2** and **Table 3**.

As shown in **Table 2**, the correlation between platform usability and ICT engagement is relatively high and similar in magnitude to the corresponding structural path coefficient. However, collinearity diagnostics reported in **Table 4** confirm that variance inflation factors (VIFs) remained below conservative thresholds (VIF < 3), indicating that multicollinearity does not threaten the stability or interpretability of the structural estimates. Additional evidence of discriminant validity is provided by the HTMT criterion, as reported in **Table 3**.

Table 4. Collinearity assessment using VIF

Path	VIF
Usability → ICT engagement	2.4
ICT engagement → intrinsic motivation	2.1
ICT engagement → extrinsic motivation	1.9

Table 5. Explanatory power and Q^2

Construct	R^2	Q^2
ICT engagement	0.6	0.4
Intrinsic motivation	0.6	0.4
Extrinsic motivation	0.3	0.2
Academic performance	0.5	0.3

Table 6. f^2

Path	f^2	Interpretation
Usability → ICT engagement	0.4	Large
ICT engagement → intrinsic	0.3	Medium
ICT engagement → extrinsic	0.2	Medium
Intrinsic → performance	0.3	Medium

HTMT values for all reflective latent constructs were below the conservative threshold of 0.90, confirming adequate discriminant validity. Before evaluating structural relationships, multicollinearity was assessed using the VIF. Discriminant validity was assessed exclusively among the reflective latent constructs. Academic performance, modeled as a single-indicator observed variable, was not included in discriminant validity analyses.

Table 4 presents the variance inflation factor values used to assess multicollinearity. All values were below 3, indicating that collinearity does not pose a concern for structural estimation.

The explanatory power and Q^2 of the structural model were assessed using R^2 and Q^2 values. These results are reported in **Table 5**.

The R^2 values suggest moderate to substantial explanatory power for the endogenous constructs according to established PLS-SEM benchmarks. All Q^2 values were above zero, indicating predictive relevance of the structural model.

f^2 was calculated to evaluate the relative impact of each structural relationship. The f^2 results are presented in **Table 6**. The f^2 values ranged from medium to large effects across structural relationships.

Additionally, model fit was assessed using the standardized root mean square residual (SRMR). The SRMR value obtained was 0.056, which is below the recommended threshold of 0.08 and close to the stricter threshold of 0.06, indicating a very good model fit and supporting the adequacy of the proposed structural model according to current PLS-SEM guidelines.

Figure 1 presents the structural model proposed using partial least squares structural equations (PLS-SEM), which analyzes the relationships between platform usability, ICT engagement, academic motivation (intrinsic and extrinsic), and academic performance. It is observed that usability directly influences engagement with ICT (**β = 0.78**), and that this engagement has a positive effect on intrinsic (**β = 0.64**) and extrinsic motivation (**β = 0.42**). Intrinsic motivation, in turn, is positively related to academic performance (**β = 0.55**), while ICT engagement and usability also exert indirect effects on performance (**β = 0.35** and **β = 0.43**, respectively). **Figure 1** includes latent constructs in blue ovals, observable indicators in yellow rectangles, and structural relationships represented by arrows accompanied by standardized coefficients.

Table 7 presents the coefficients of direct relationships in the structural model and provides evidence that engagement in ICT use exerts a positive and significant effect on intrinsic motivation (β = 0.64), which supports the hypothesis that greater interaction with technologies can strengthen students' interest and autonomy in their learning process. This effect is even more notable in comparison with extrinsic motivation, where engagement shows a positive impact, although of smaller magnitude (β = 0.42), suggesting an inclination of students towards internal motivations, especially when the technological environment provides them with an active, meaningful, and stimulating experience.

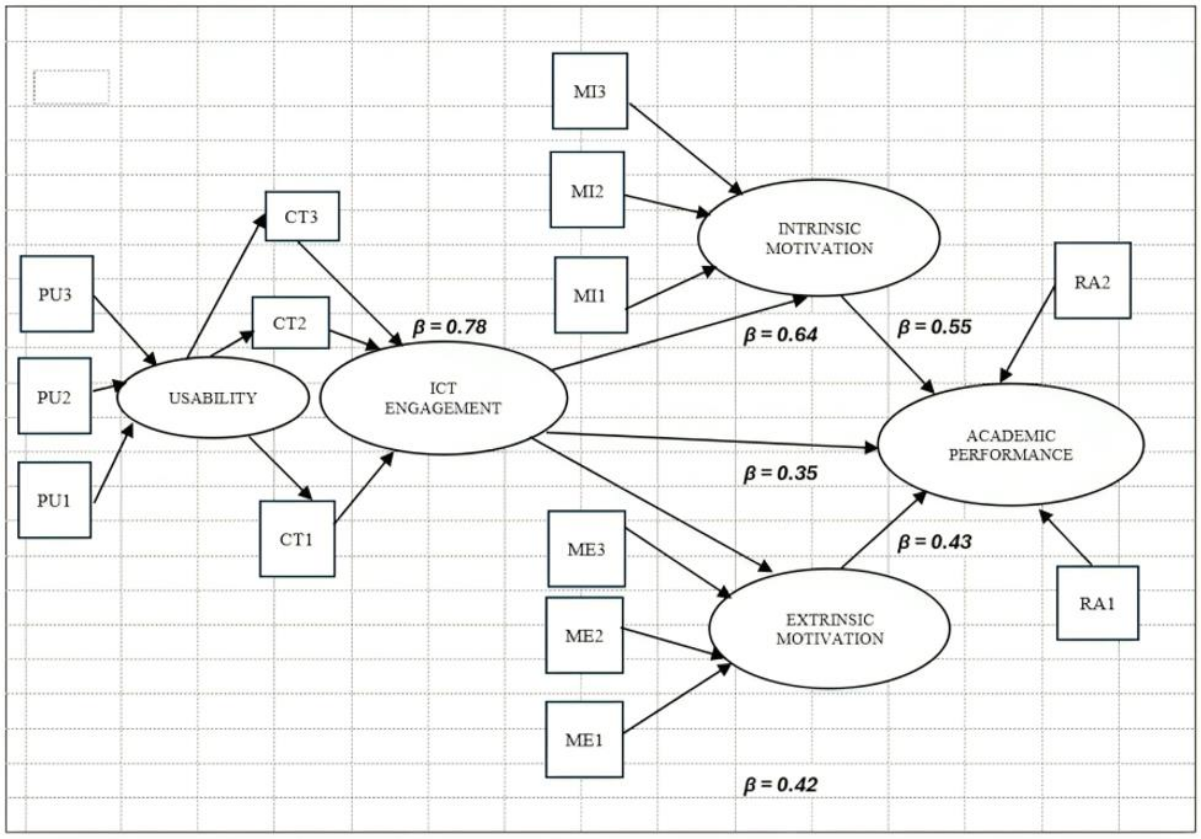

Figure 1. PLS-SEM structural model of the study (Source: Authors' own elaboration based on SmartPLS results)

Table 7. Direct relationships between latent variables in the structural model

Relation	Coefficient (β)	t-value	Significance level
ICT engagement → intrinsic motivation	0.64	11.35	p < 0.001
ICT engagement → extrinsic motivation	0.42	8.20	p < 0.050
Usability of the platform → ICT engagement	0.78	12.56	p < 0.001
Intrinsic motivation → academic performance	0.55	10.72	p < 0.010

Note. β: Standardized regression coefficient & p: Statistical significance level

On the other hand, platform usability emerges as a central determinant of engagement with ICT use (β = 0.78), showing that ease of use is not only a complement but a key requirement for a high level of engagement. Finally, intrinsic motivation presents a positive and significant coefficient concerning academic performance (β = 0.55), suggesting that, when students feel internally motivated, they tend to have a more successful academic performance. This finding reaffirms the importance of a user-centered design approach to promote meaningful and sustained learning.

Table 8 presents the indirect and total effects of latent relationships in the structural model, highlighting the mediating role of intrinsic motivation in the relationship between ICT engagement and academic performance. The indirect effect, with a value of 0.35, indicates that while engagement does not directly influence academic performance, it does so significantly through its impact on intrinsic motivation. This finding suggests that sustained engagement with ICT does not necessarily translate into improved academic performance unless it is accompanied by authentic internal motivation for learning, reinforcing the importance of fostering personal interest as a driver of student performance.

Likewise, platform usability has a considerable positive indirect effect on academic performance (0.43), by mediating through engagement and intrinsic motivation. This suggests that ICT usability is critical not only to attract students to interact with the tools but also to foster a chain of positive effects that culminate in superior academic performance. These results support a holistic approach to the design of ICT platforms in education,

Table 8. Indirect and total effects

Relation	Direct effect	Indirect effect	Total effect
ICT engagement → academic performance (via intrinsic motivation)	0.00	0.35	0.35
Platform usability → academic performance (via ICT engagement and intrinsic motivation)	0.00	0.43	0.43

Note. Indirect effects show the mediated influence of one variable on another, while the total effect represents the sum of the direct and indirect effects

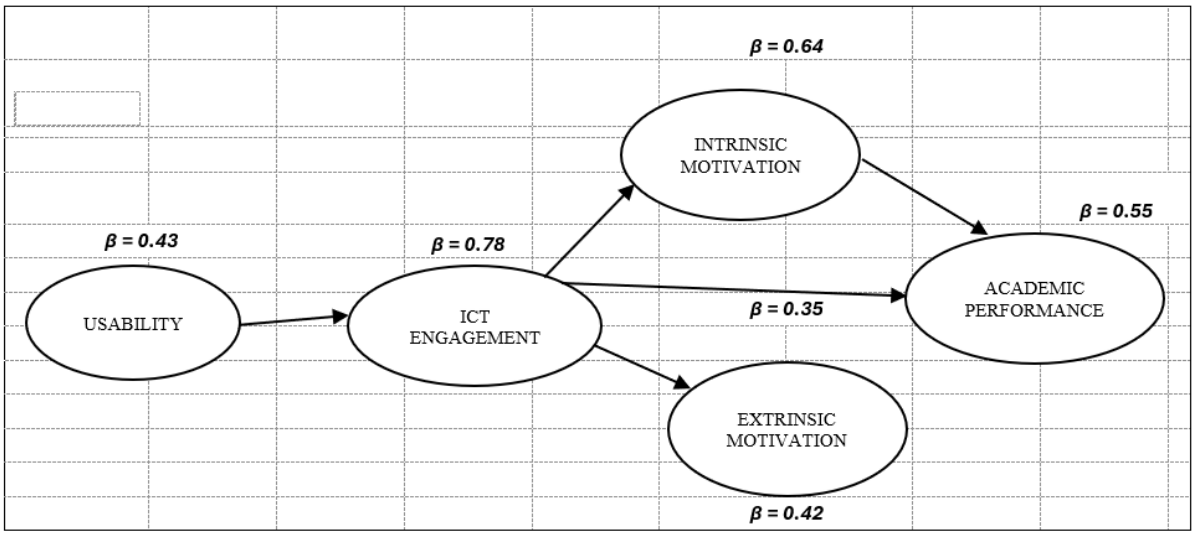

Figure 2. Direct and indirect effects model (Source: Authors' own elaboration based on SmartPLS results)

considering not only the basic functionality but also how this can influence key motivational factors that, in turn, improve academic performance.

Figure 2 presents a visual summary of the direct and indirect effects identified in the structural model validated by partial least squares (PLS-SEM). The solid arrows represent statistically significant direct relationships between constructs, while the dashed lines indicate indirect effects mediated by intermediate variables. It is observed that platform usability has a direct effect on ICT engagement (**β = 0.78**), which directly influences academic motivation, both intrinsic (**β = 0.64**) and extrinsic (**β = 0.42**). In turn, intrinsic motivation exerts a direct effect on academic performance (**β = 0.55**). In addition, significant indirect effects of ICT engagement (**β = 0.35**) and usability (**β = 0.43**) on academic performance are evident, confirming mediating role of engagement and motivation in the relationship between digital environments and learning outcomes.

DISCUSSION

The findings indicate that engagement with ICT use indirectly influences academic performance through intrinsic motivation. This result aligns with previous research suggesting that the educational benefits of digital technologies depend on the way students interact with these tools and the motivational processes that support their use. Similar conclusions have been reported in studies examining students' adoption and use of learning management systems in higher education, which highlight how technological acceptance influences engagement with digital learning environments (Korsah, 2024). Recent studies have also emphasized that effective integration of ICT in higher education requires not only technological infrastructure but also meaningful engagement with digital learning environments (Sakhieva et al., 2025).

In this sense, ICT engagement may only translate into improved academic performance when students develop intrinsic motivation toward learning activities supported by digital technologies. This result is consistent with Self-Determination Theory, which emphasizes the importance of internal motivation in digital environments. In this sense, it was observed that ICT engagement did not directly influence academic performance; however, it did when student intrinsic motivation increased (β = 0.35). This suggests that students who used ICT as part of their learning process did so effectively only when they manifested a genuine interest in their academic development (Ryan & Deci, 2000). This finding aligns with self-determination Theory,

which postulates intrinsic motivation as a central axis for sustaining persistence and engagement in learning processes (Deci & Ryan, 2016; Sánchez & Hueros, 2010).

Likewise, the usability of digital platforms was identified as a crucial determinant of engagement with ICT use (β = 0.78). Students who perceived platforms as intuitive and user-friendly were more likely to engage actively in digital learning. These results were in line with previous studies that highlighted the importance of user-centered design in fostering the adoption of educational technologies (Almarghani & Mijatovic, 2017; Kannan et al., 2020; Tepgec, 2025). Consequently, platform accessibility and usability were crucial in enhancing students' engagement and motivation in digital environments (Herodotou et al., 2021).

The findings of this study confirmed the importance of intrinsic motivation in academic performance mediated using ICT. Numerous studies have postulated that students with high levels of intrinsic motivation are more likely to engage in self-directed learning activities, resulting in better academic performance (Deci & Ryan, 2016). Other studies supported this claim by demonstrating that internal motivation was a crucial factor for success on digital platforms (Henrie et al., 2015). In this study, intrinsic motivation acted as a key mediator between ICT engagement and academic performance, reinforcing the need to design pedagogical strategies that enhance students' genuine interest in learning.

On the other hand, the usability of digital platforms has been widely recognized as a determining factor in ICT engagement. Previous research suggests that well-designed, accessible, and pedagogically integrated digital learning tools can significantly enhance student engagement in digital learning environments. In line with these findings, the present study demonstrated that platform usability had a positive relationship with ICT engagement, suggesting that improving the user experience was key to fostering the effective use of technology in education (Al-Fraihat et al., 2025; Cavalcanti et al., 2021; Fuentes & LaBad, 2025).

However, there were discrepancies with some previous studies. For example, some research concluded that the simple frequent use of ICT improved academic performance, without the need for high intrinsic motivation (Hasan & Bao, 2020). In contrast, the results of the present study indicated that internal motivation was essential for translating ICT engagement into improvements in academic performance. This difference could be explained by variations in the methodological design of the studies or by the type of platforms used in each investigation.

Likewise, concerning extrinsic motivation, its influence on ICT engagement was found to be lower compared to intrinsic motivation (β = 0.42 vs. β = 0.64). This contradicted research that suggested that external incentives, such as grades and digital rewards, could be determinants in the adoption of educational technologies (Deci & Ryan, 2016). The difference in findings could be explained by the nature of the incentives evaluated in each study and their effectiveness in the university educational context. The weaker effect of extrinsic motivation observed in this study deserves further contextual and theoretical interpretation. While previous studies have highlighted the positive role of external incentives in promoting technology adoption, the present findings suggest that, within the analyzed context, extrinsic motivators may primarily operate as initial triggers for platform use rather than sustained drivers of academic performance.

One explanation may be associated with contextual and cultural characteristics. In many Latin American higher education environments, academic success is often linked to long-term professional aspirations and social mobility expectations. Under these conditions, students may rely more strongly on internally regulated learning processes rather than externally imposed incentives. Therefore, ICT engagement may be more strongly sustained when students perceive digital tools as supporting personal learning goals rather than merely fulfilling institutional requirements.

Additionally, the specific nature of extrinsic incentives available in the studied educational environment may influence these outcomes. Incentives such as grades, task completion requirements, or institutional recognition may encourage initial interaction with digital platforms; however, they may not necessarily foster deep cognitive engagement or long-term persistence in digital learning environments. This interpretation is consistent with theoretical perspectives suggesting that externally regulated behaviors often generate lower levels of sustained engagement compared to intrinsically regulated learning behaviors. Another relevant factor may be the degree of pedagogical integration of ICT tools. When digital platforms are primarily used as repositories or administrative tools, extrinsic motivation may dominate initial usage patterns. However, when ICT tools are embedded within interactive, student-centered pedagogical models, intrinsic motivation tends

to become a stronger predictor of learning outcomes. This may partially explain the stronger mediating role of intrinsic motivation observed in the present study.

Future research should examine whether different extrinsic incentives (e.g., gamified rewards, micro-credentials, or employability-linked recognition) produce stronger and more sustained effects on ICT engagement across cultural contexts.

Despite the robustness of the findings, this study presents several limitations that must be considered in interpreting the results. First, the cross-sectional design employed precludes establishing definitive causal relationships, which limits the possibility of determining whether engagement with ICT use directly influences academic performance or whether, on the contrary, it is the students with better performance who tend to be more involved with these technologies. Also, the sample was composed exclusively of students from a university located in Lima, which restricts the generalization of the results to other educational contexts, regions, and institutional realities. Finally, the use of self-reported scales could have introduced social desirability biases, compromising to some extent the precision of the responses and, therefore, the validity of the measurements.

Although the results provide strong empirical support, future studies should replicate these findings using multi-institutional samples and objective academic performance data obtained directly from institutional records. This would strengthen external validity and reduce potential bias associated with self-reported academic performance measures.

To overcome these limitations, future research could employ longitudinal designs that allow us to observe the evolution of ICT engagement and its impact on academic performance over time, providing a better basis for establishing causal relationships. It would also be advisable to extend the sample to educational institutions in different regions and with varied socioeconomic contexts, to improve the representativeness and applicability of the findings. In addition, it is proposed to investigate the design and implementation of digital platforms aimed at enhancing the intrinsic motivation of students through interactive, personalized, and adaptive strategies. Finally, it is pertinent to deepen the analysis of the role played by extrinsic motivation in the use of ICT in higher education, evaluating its effectiveness in different learning environments and with different student profiles.

Additionally, although convenience sampling enabled efficient access to the target population, it may limit statistical representativeness and introduce potential selection bias. Therefore, caution should be exercised when generalizing findings beyond similar higher education contexts.

Although the study followed ethical guidelines for anonymous survey research, future studies could include formal institutional ethics committee approval to further strengthen procedural transparency. In addition, future studies could incorporate multi-institutional and cross-cultural samples to further strengthen external validity and generalizability of the findings.

RECOMMENDATIONS

Based on the findings of this study, several recommendations can be proposed for higher education institutions seeking to enhance the educational impact of ICT in university environments.

First, universities should prioritize the development and implementation of user-centered digital learning platforms. The results demonstrate that platform usability strongly influences ICT engagement, which subsequently enhances intrinsic motivation and academic performance. Therefore, investing in intuitive and accessible learning management systems may significantly improve students' interaction with digital learning environments.

Second, instructional strategies should emphasize the promotion of intrinsic motivation rather than relying primarily on external incentives. Learning activities that incorporate collaborative work, interactive digital resources, and problem-based learning may foster deeper engagement with ICT and encourage autonomous learning behaviors among university students.

Third, higher education institutions should strengthen teacher training programs focused on the pedagogical integration of digital technologies. Faculty members require both technological and pedagogical

competencies to design effective digital learning experiences that promote engagement and meaningful learning.

Finally, institutional policies should support the strategic integration of ICT within broader digital transformation initiatives. Continuous evaluation of digital platforms, investment in technological infrastructure, and the use of learning analytics tools can help universities monitor engagement and improve the effectiveness of technology-mediated learning environments.

CONCLUSIONS

This study aimed to analyze the effect of ICT engagement on university students' motivation and academic performance, considering the usability of digital platforms as a key factor. The results obtained through the PLS-SEM model showed that ICT engagement does not have a direct impact on academic performance, but that this impact is mediated by intrinsic motivation. It was observed that students with a greater genuine interest in learning were able to benefit significantly from the use of ICT, which highlights the need to promote pedagogical approaches that stimulate this form of motivation. Likewise, the usability of digital platforms was identified as a decisive factor in fostering engagement with ICT use, since an intuitive, accessible, and user-centered design facilitates more active and sustained interaction with virtual learning environments.

In addition to its practical implications, this study contributes to the academic literature in several ways. First, it provides empirical evidence supporting an integrated model that connects platform usability, ICT engagement, and intrinsic motivation to explain academic performance in higher education. While previous research has examined these constructs separately, this study demonstrates how they interact within a unified structural model using PLS-SEM. Second, the study contributes evidence from a Latin American higher education context, which remains relatively underrepresented in the global literature on educational technology. Third, the findings highlight the mediating role of intrinsic motivation in transforming ICT engagement into improved academic outcomes, offering new insights into how digital learning environments can support meaningful and autonomous learning processes.

On a theoretical level, the results reaffirm the postulates of Self-Determination Theory, showing that intrinsic motivation mediates the relationship between engagement with ICT and academic performance. In practical terms, it is suggested that higher education institutions invest in intuitive digital platforms and pedagogical strategies that stimulate intrinsic motivation. To maximize the impact of ICTs in higher education, it is essential to design digital environments that integrate functional tools with pedagogical proposals focused on the development of autonomy, critical thinking, and self-regulation. This approach supports the development of meaningful and sustainable learning experiences, aligned with the demands of the contemporary educational context.

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