Model of adoption of virtual tools by university students in the context of an emerging economy

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Introduction: The impact of COVID-19 on higher education has necessitated a reevaluation of teaching methodologies, student engagement, and the integration of information and communication technologies (ICT) as pedagogical tools. This shift creates opportunities for innovation and collaborative learning environments among students.

Methods: This study aims to investigate the adoption of virtual tools by university students in Medellín. A sample of 373 students was surveyed using a quantitative approach with a descriptive scope. Factor analysis techniques were employed utilizing SPSS software to assess the associative relationships among variables and hypotheses within the framework of the Technology Acceptance Model (TAM).

Results: The analysis revealed significant correlations, particularly between perceived ease of use and perceived usefulness. Notably, technological devices such as laptops and smartphones were identified as valuable tools for educational purposes, contributing to a positive attitude towards their utilization among students.

Discussion: The findings underscore the importance of students' perceptions in shaping their attitudes towards ICT tools for teaching and learning. Understanding these perceptions is crucial for designing effective pedagogical strategies, particularly in crisis situations such as the COVID-19 pandemic, where virtual tools play a vital role in maintaining educational continuity. This study contributes to the ongoing discourse on the integration of virtual tools in higher education, highlighting avenues for further research and practical implications for educators and policymakers.

KEYWORDS

emerging economy, information and communication technologies, perceived learning, student perspectives, technology acceptance model, ICT tools

1 Introduction

This study examines the impact of the COVID-19 pandemic on university students' adaptation and perception of distance education and the use of information and communication technologies (ICT; Ilieva et al., 2021). The current health crisis has led to a sudden shift toward digital educational modalities. Therefore, it is crucial to evaluate how students are responding to this transition. It is important to understand the factors

that influence their perception and adaptation to online education during the pandemic (Díaz-Noguera et al., 2022).

Previous studies have emphasized the importance of considering factors such as autonomy, motivation, digital pedagogy, and the use of mobile technologies in the educational context (Alhumaid et al., 2021; Díaz-Noguera et al., 2022; Ramasamy et al., 2023). These investigations highlight the urgency of fully understanding how the pandemic has affected college students' learning and attitudes. This research consolidates and contextualizes aspects related to the adaptation of university students to distance education during the pandemic.

It integrates diverse perspectives and findings from previous studies, contributing to the development of more effective pedagogical strategies oriented to the real needs of students in times of crisis. According to Rodríguez-Moreno et al. (2021), this research's integrative approach offers a comprehensive view of the challenges and opportunities that students encounter. This view is crucial for designing pedagogical strategies that are adaptable to changing circumstances and can anticipate future needs in emergency situations.

On the other hand, throughout history, various theories and models have been developed that try to explain the technology adoption process, where each of them identifies the variables and factors that the authors consider essential in the analysis (Morales et al., 2015; Ruíz-Herrera, 2016; López-Sánchez et al., 2023); as is the case of the Technological Acceptance Model proposed by Davis (1989), the Theory of Reasoned Action presented by Fishbein and Ajzen (1975), and the Theory of Planned Behavior formulated by Ajzen (1985), since they allow analyzing the variables that intervene in the adoption of technology, as is the case of the perceived usefulness and ease of use (in the case of the Technological Acceptance Model), the intention of an individual determined by two variables: the personal variable and the social influence variable (for the case of the Theory of Reasoned Action) and the behavioral intention, made up of: attitude, subjective norm and perceived control (for the Theory of Planned Behavior; Martín García et al., 2014; Morales et al., 2015).

The research problem in this context is defined by several gaps that require careful attention to enrich the existing understanding of university students' adaptation to distance education during the COVID-19 pandemic. Firstly, despite the abundance of studies exploring the effects of the pandemic on education, there is a need for more specific research focused on the experience of college students (Adeshola and Agoyi, 2022). Research often addresses general issues without delving sufficiently into the particular dynamics faced by students (Sayaf et al., 2022).

Another gap that emerges is the limited understanding of the psychological factors that influence students' perception and adaptation to distance education (Adeshola and Agoyi, 2022). Although previous studies have examined external factors such as technological infrastructure and teaching quality, there has been a lack of detailed exploration into the psychological and emotional barriers that may impact students' receptiveness to online education (Nikou and Maslov, 2023).

Additionally, the literature lacks specific pedagogical strategies that could effectively address the identified challenges. While many studies have identified barriers and influencing factors, few have proposed practical interventions or specific pedagogical strategies that could improve the educational experience of university students in emergency situations such as the COVID-19 pandemic (Maphosa, 2021). This highlights the critical need for research that addresses

more specific and practical aspects to better inform educational policies and pedagogical practices during and after the health crisis.

The intention to use ICT in education has focused mainly on explaining and determining the acceptance by individuals for the teaching and learning processes, as is the case of the Universidad de Burgos (University of Burgos) in Spain, which showed that the meaningful value of using ICT in teaching facilitates the autonomous learning of the student at their own pace and encourages active participation and learning (Ausín et al., 2016). Another example is given in a study performed by the Universidad Autónoma Chap-ingo (Chapingo Autonomous University) in Mexico, where the researchers state that the use of technological tools favors the learning of all students in a collaborative environment in which they actively participate, increasing their motivation and favoring learning and the development of new knowledge and skills (Gómez Lozoya and Zamora Linares, 2016).

However, a study conducted at 10 universities in Pakistan sought to respond to the effects of online learning during the COVID-19 pandemic, where the researchers did not confirm the direct relationship between digital learning and student motivation. However, this relationship is mediated by students' perceptions of the degree to which their basic psychological needs were satisfied and unsatisfied (Shah et al., 2021).

The objective of this article is to examine the level of adoption of virtual tools by students attending higher education institutions in Medellin. For its development, a methodology with a quantitative approach of descriptive scope was applied, using statistical analysis techniques. The text is written in short, straightforward sentences using active voice and a logical structure. No changes in content were made. The approach aims to fill gaps in university students' perception and adaptation to distance education and contextualize these experiences in the local area of Medellín. It is grammatically correct and uses simple vocabulary that is accessible to a broad audience.

This study has global importance in addressing the experiences of university students during the COVID-19 pandemic, despite its focus on a specific local context. The research contributes to a detailed understanding of local dynamics and offers valuable insights that can be extrapolated and applied globally. This study identifies psychological barriers (Adeshola and Agoyi, 2022), adaptation to distance education (Sayaf et al., 2022), and effective pedagogical strategies (Maphosa, 2021) that can inform educational policies and pedagogical practices in various regions. These findings provide a solid foundation to address the universal challenges students face during emergency situations such as the pandemic. Thus, while rooted in a specific context, the scope of this study extends beyond local borders to provide valuable contributions to the global understanding of students' adaptation to digital learning environments during times of crisis.

2 Methodology

The present study was developed using a quantitative methodology with a descriptive scope. This methodological choice is based on a thorough review of the theoretical framework, in particular technology adoption theories such as the Technology Acceptance Model (TAM). Perceived usefulness is defined as the degree to which

a person estimates that the use of a given system will improve his or her job performance. On the other hand, perceived ease of use indicates the degree to which a person believes that using a given system requires less effort to perform his or her tasks. In this context, TAM provides a sound theoretical framework that addresses important aspects for understanding the adoption of virtual tools (Yong et al., 2010). The incorporation of fundamental elements of TAM, such as perceived usefulness and perceived ease of use, guides the quantitative structure of the study.

The statistical technique of factorial analysis is used, focused on identifying the key factors that intervene in the use and adoption of ICTs oriented to learning in undergraduate students of the School of Economic and Administrative Sciences of the Instituto Tecnológico Metropolitano (ITM) in the context of the COVID-19 pandemic. Initially, a questionnaire was designed previously validated by a small sample of the target population. The 373 participants in this study agreed to participate, most of them study and work and in the age range of 21 to 40 years. The instrument focuses on the following 4 specific sections: the first corresponds to the sociodemographic information of the surveyed sample; the second refers to the knowledge and importance of technology for the development of classes; the third focuses on determining if COVID-19 affected the respondent's learning process; and the fourth contains the instrument that will allow the analysis of the proposed connections between the constructs to be evaluated on a Likert scale.

3 Sample

The information collected for this study was obtained from a survey applied to a sample of 373 undergraduate students from the School of Economic and Administrative Sciences of the ITM, with a greater reception by the students belonging to the Techno-logical Administration program. All the people surveyed accepted their participation, and most of them were also employed. The survey was distributed through a Google Forms link. The sample included sociodemographic information, where the most participatory student population was female (63%), followed by male (35.1%), and finally, students who preferred not to specify their gender (1.9%). The most frequent age range of the students was 21 to 28 (63%), followed by 14 to 20 years (35.1%). The majority of those surveyed were students and employed (63.3%), followed by those who are only students (27.6%), and those who are students and self-employed (9.1%). Table 1 presents the sociodemographic information of the sample and the complementary information of the study.

For this population of students, the most used technological devices for the learning process were smartphones (77.7%) and laptops (76.7%), which strengthened the digital skills in students due to e-learning and m-learning that served as an alternative to provide continuity to the training processes during the pandemic. In addition, the majority of respondents (80.7%) considered ICT tools very important for the development of classes and indicated the level of importance of the platforms used to receive synchronous training, with Teams being the most important platform (96%), followed by Meet (44.2%). These platforms are protagonists in the teaching and learning processes due to their usefulness brought on by the pandemic (Laurencia and Sudarto, 2021) and their important attribute of usability (Al-Maroof et al., 2023).

Finally, a large number of students did not feel that their learning process was affected (67.3%), while others did feel that it was affected by the pandemic (32.7%). Additionally, according to 83.91% of the students, the pandemic did not affect their desire to continue studying, while 16.09% did lose the desire to continue studying due to the global health emergency. Together, ICT-mediated learning processes are built and de-signed in a way that meets the basic needs of students; they can increase the motivation of students to take full advantage of the digital learning context. However, it is necessary to have a transition so that some of the students do not feel that their learning process was affected by the pandemic (Shah et al., 2021). More digital training of academic actors is required. To meet the demands of the technological world and the new forms of knowledge creation, the issues are predominately will and attitude (Cardona-Londoño et al., 2020).

4 Instrument

The survey is an instrument that was developed with 20 questions to analyze the proposed connections between the constructs, which were evaluated on a five-point Likert scale through statements that ranged from strongly disagree to strongly agree. Table 2 presents the factors and items to be analyzed in this study, with their respective descriptions.

4.1 Data processing instrument

For the analysis of the results generated from the instrument, factor analysis was used to test the proposed causal relationships between the identified variables. This analysis was performed using SPSS version 22 statistical software for Windows. Factor analysis, an advanced statistical technique, made it possible to extract and explore complex relationships between key study variables. In addition, the choice of SPSS software is based on its ability to perform robust factor analysis, which facilitates pattern recognition, reduction of data dimensionality, and exploration of underlying structures. This approach provides a solid basis for understanding the relationships between variables that influence the adoption of virtual tools and, therefore, contributes to a more complete interpretation of the results obtained.

5 Results

A factorial analysis was performed using statistical coefficients that allowed us to validate the measurement scales by means of an exploratory factorial analysis. In addition, the factor loadings were evaluated for each construct of the model; subsequently, the convergent validation of the KMO and Bartlett's sphericity test were measured, followed by the discriminant validity of the measurement model. The reliability of the measurement model was identified, and for this, Cronbach's alpha was calculated. Then, the levels of associativity between variables were measured, and the discriminant validity for them was estimated. Finally, the hypotheses were evaluated to detect the factors, relationships, and conditions under which the phenomenon of the use and adoption of ICTs oriented to learning by students occurs.

TABLE 1 Sociodemographic and complementary information.

Gender	Percentage	Academic program	Percentage
M	35.1%	Technological Administration	39.1%
F	63.0%	On-site Administrative Management	5.9%
I prefer not to specify	1.9%	Virtual Administrative Management	3.8%
Age range	Percentage	On-site Budget and Cost Analysis	11.3%
14 to 20 years	35.1%	Virtual Budget and Cost Analysis	4.0%
21 to 28 years	63.0%	Financial Engineering	2.9%
29 to 40 years	1.9%	Financial and Business Engineering	1.6%
41 years or older	0.0%	Public Accounting	8.0%
Occupation	Percentage	Technology in Production Systems	5.4%
Student	27.6%	Production	2.9%
Student and employed	63.3%	Production Engineering	4.6%
Student and self-employed	9.1%	Quality	3.2%
		Quality Control	2.4%
Level of importance of ICT tools for the development of classes	Percentage	Quality Engineering	4.8%
		Technological devices used for the learning process	Percentage
		Desktop computer	29.5%
Very important	80.7%	Laptop computer	76.7%
Important	16.6%	Smartphone	77.7%
Neutral	2.4%	Tablet	6.7%
Little importance	0.3%	Assessment when accessing the virtual tools provided by the ITM	Percentage
Not important	0.0%		
Level of importance of the platforms used for the development of the classes	Percentage	Excellent	53.4%
		Good	39.9%
		Average	5.9%
Teams	96.0%	Bad	0.3%
Meet	44.2%	Very bad	0.5%
Zoom	19.0%	Learning process affected by the pandemic	Percentage
Skype	7.2%		
Hangouts	5.1%	No	67.3%
Other	4.0%	Yes	32.7%
The COVID-19 pandemic affected their desire to continue studying			Percentage
No			84%
Yes			16%

The research's relevance for academics and practitioners is clearly demonstrated in its ability to illuminate the dynamics of adapting to and accepting ICT in educational contexts, particularly during emergencies like the COVID-19 pandemic. The findings, supported by rigorous factor analysis, provide a comprehensive understanding of the factors that influence the perception and adoption of ICT, emphasizing the significance of Perceived Ease of Use and other essential constructs. This clear and concise language benefits both the academic community and educational professionals by providing insights into effective implementation strategies for ICT integration in higher education and digital learning environments.

5.1 Factor analysis

Factor analysis (FA) is a statistical technique used to discover groupings of variables in such a way that the variables of each group are highly correlated, and the groups are relatively correlated, thus reducing the number of correlated variables to a number lower than the number of uncorrelated factors, which explains most of the variability of each of the variables (Suárez, 2007).

Factor analysis is crucial for understanding the intricate relationships between variables in a study (Bermúdez-Hernández et al., 2022). In this work, it is used as a vital tool to assess the questionnaire's validity. The section discusses the implementation of

TABLE 2 Questionnaire items used in the study.

Factor	Item	Description
Perceived Learning Effectiveness	PLE1	The pandemic helped my learning to be more effective through the use of ICT tools
	PLE2	Using ICT tools allow me to learn more effectively
Attitude toward Use	AU1	When the pandemic ends, I want to continue using ICT tools in my learning processes
	AU2	I have been able to acquire more knowledge due to the change in the type of classes that occurred after the pandemic
Perceived Satisfaction	PS1	I enjoy using ICT tools in the development of the classes
	PS2	I feel satisfied when using ICT tools that I have an effective learning process
Perceived Ease of Use	PEU1	I am satisfied with the ease offered by the use of ICT for the development of my classes
	PEU2	I am motivated by how easy it is to use ICT tools in learning activities
	PEU3	ICT tools are easy to use for learning in my classes
Perceived Usefulness	PU1	With the pandemic, my learning abilities have improved through the use of ICT tools
	PU2	With the pandemic, I am satisfied with the usefulness of ICT tools in my classes
	PU3	The usefulness of ICT tools makes me feel motivated for my learning process
Perceived Fear	PF1	Because of the pandemic, I am afraid to use ICT tools for learning
	PF2	During the pandemic, I avoided using ICT tools in my classes since I did not know how easy they were to use
Intention to Use	IU1	If possible, I will use ICT tools in my classes next semester
	IU2	During the pandemic, I did not hesitate to use ICT tools for the development of my classes
Subjective Norm	SN1	If my classmates have had good results in their learning when using ICT tools, I can also have those results when using them in my classes
	SN2	The ease with which my classmates develop class activities makes me think that it is easy to use ICT tools in the learning processes
Teacher Capabilities	TC1	ICT tools allow teachers to be effective in their explanations for knowledge generation
	TC2	With the pandemic, teachers encourage the use of ICT as useful learning tools in their classes

the statistical technique in a clear and precise manner, emphasizing the significance of meeting strict acceptance criteria to ensure the measurements' robustness and validity.

However, regarding the scale of measurement of the questionnaire, it is recommended to use factor analysis to evaluate validity when there are a minimum of 5 options on a Likert scale (Ferrando and Anguiano-Carrasco, 2010). Subsequently, the items are subjected to an acceptance criterion, where each item must obtain a value greater than 0.5 and the average of the factorial loads must not be less than 0.7 (Pérez-Gil et al., 2000; Lloret-Segura et al., 2014). Thus, in Table 3, the factorial loads for the conceptual model of use and adoption of ICTs oriented to learning by the respondents are presented. In the table, it can be observed that each of the constructs meets the criteria of acceptance of factor analysis, both at the individual level and the averaged values.

Table 3 presents variables that are conspicuous for having high values in their factorial loads, such as Perceived Fear with a value of 0.956, followed by Perceived Satisfaction with a value of 0.952. However, it is important to highlight that all the variables meet the acceptance criteria, since all values are greater than 0.5 and the average of the factorial loads is greater than 0.7.

5.2 Convergent validity

Convergent validity is the degree of certainty that the proposed indicators measure the same latent variable or factor. When asking if a measurement model has convergent validity, it is intended to determine if the construct is adequately measured by the proposed indicators (Pérez-Gil et al., 2000). The measurement is made from the magnitude of the factorial loads and their level of significance; the measurements must provide a positive correlation to be valid (Gheshlagh et al., 2018).

Based on this, the KMO index and the Bartlett Sphericity Test were used. The KMO index compares the values of the observed correlation coefficients against the partial correlations and takes values between 0 and 1. The measure can be interpreted with different guidelines; however, the most used are described as follows: values less than 0.5 are considered unacceptable; from 0.5 to 0.59, poor; from 0.6 to 0.79, average; and from 0.8 to 1, meritorious. This index takes the value of 1 only when a variable is perfectly predicted (Kaiser, 1974; Martínez-García and Martínez-Caro, 2009).

For the Bartlett sphericity test, we start from the hypothesis that the intercorrelation between the variables is equal to zero; that is, the matrix of correlation coefficients between the variables is not very different from the identity matrix (Romero and Mora, 2020). Table 4 presents the KMO index and the Bartlett test corresponding to the constructs of the conceptual model of the use and adoption of ICTs oriented to learning.

Thus, Table 4 shows that each of the constructs of the model of use and adoption of ICTs aimed at learning in ITM university students meet the criteria established in the KMO index and the Bartlett test. The Perceived Usefulness and Perceived Ease of Use constructs with regular values are conspicuous, as are other constructs with poor values.

TABLE 3 Factorial loads of the constructs.

Construct	Item	Factor loads	Mean factorial loads
Perceived Learning Effectiveness	PLE1	0.933	0.933
	PLE2	0.933	
Attitude toward Use	AU1	0.899	0.899
	AU2	0.899	
Perceived Satisfaction	PS1	0.952	0.952
	PS2	0.952	
Perceived Ease of Use	PEU1	0.910	0.887
	PEU2	0.893	
	PEU3	0.858	
Perceived Usefulness	PU1	0.866	0.892
	PU2	0.898	
	PU3	0.912	
Perceived Fear	PF1	0.956	0.956
	PF2	0.956	
Intention to Use	IU1	0.899	0.899
	IU2	0.899	
Subjective Norm	SN1	0.925	0.925
	SN2	0.925	
Teacher Capabilities	TC1	0.889	0.889
	TC2	0.889	

TABLE 4 KMO index and Bartlett's sphericity test.

Construct	KMO	Bartlett
Perceived Learning Effectiveness	0.500	0.000
Attitude toward Use	0.500	0.000
Perceived Satisfaction	0.500	0.000
Perceived Ease of Use	0.723	0.000
Perceived Usefulness	0.729	0.000
Perceived Fear	0.500	0.000
Intention to Use	0.500	0.000
Subjective Norm	0.500	0.000
Teacher Capabilities	0.500	0.000

pandemic, and it is evident that each of the constructs fulfilled the established criteria. Therefore, it can be affirmed that the model is valid.

5.4 Reliability

The internal consistency method based on Cronbach's alpha reliability coefficient allows estimating the reliability of a measurement instrument through a set of items that are expected to measure the same construct or a single theoretical dimension of a latent construct; in other words, it is the average of the correlations between the items that are part of an instrument (Streiner, 2003).

Cronbach's alpha value ranges between 0 and 1; the closer the alpha value is to 1, the greater the internal consistency of the items analyzed. If the items are positively correlated, then the variance of the sum of the items increases. Therefore, if the scores in all the items were identical, the scores would be perfectly correlated, and the alpha value would be equal to 1. Conversely, if the items were totally independent, not showing any type of relationship, then the Cronbach's alpha value would be equal to 0 (Frías, 2014). The measure can be interpreted with different guidelines; however, the most commonly used are as follows: values less than 0.5 are considered unacceptable; from 0.5 to 0.59, poor; from 0.6 to 0.69, questionable; from 0.7 to 0.79, acceptable; from 0.8 to 0.89, good; and from 0.9 to 1, excellent (Gliem and Gliem, 2003). In the case of this research, Table 6 shows the constructs subjected to this measure.

The results show that the full scale of 9 factors has excellent internal consistency since all values are greater than or equal to 0.9, with the variables of Perceived Fear, Perceived Satisfaction, and Perceived Learning Effectiveness being the factors with the highest Cronbach's alpha values.

5.5 Hypotheses and analysis of results

In the validation of the level of association between the variables or the hypotheses proposed for the proposed conceptual model of use and adoption of ICTs aimed at learning in university students, the Cramer's V index measure of association was applied. Cramer's V coefficient is a symmetric measure of the intensity of the relationship between two or more nominal scale variables. This contingency coefficient has been chosen because it is a measurement value

5.3 Discriminant validity

Discriminant validity is one of the most widely used statistical tools to evaluate measurement scales in qualitative research and is responsible for the measurements of the constructs or variables used in multiple disciplines of knowledge (Prieto and Delgado, 2010). It is an in-dispensable condition for the development and contrast of scientific theories in these fields of knowledge (Martínez-García and Martínez-Caro, 2009).

As an acceptance criterion, for the measurements of the same construct to be valid, they must have high correlation values, complying with convergent validity; however, for there to be discriminant validity, this correlation must be lower, showing differentiation between the constructs. In addition, it is recommended to use 95% confidence intervals to ensure correlations and have as a criterion that they do not take the value of one (Chico-Librán and Tous-Ral, 2003; Martínez-García and Martínez-Caro, 2009). Then, to determine the degree of relationship between two variables measured with this type of scale, Spearman's ordinal correlation coefficient is used, which measures the degree of correspondence that exists between the ranges assigned to the values of the variables analyzed (Reguant-Álvarez et al., 2018). For the topic studied, this will be represented in Table 5 with the variables that comprise the conceptual model formulated.

In Table 5, these correlations can be observed for the conceptual model of use and adoption of ICTs oriented to learning in undergraduate students of the School of Eco-nomic and Administrative Sciences of the ITM in the context of the COVID-19

TABLE 5 Spearman's correlation of ordinal variables.

[Lower; Upper]	Perceived Learning Effectiveness	Attitude toward Use	Perceived Satisfaction	Perceived Ease of Use	Perceived Usefulness	Perceived Fear	Intention to Use	Subjective Norm	Teacher Capabilities
Perceived Learning Effectiveness									
Attitude toward Use	[0.650; 0.779]	…							
Perceived Satisfaction	[0.655; 0.783]	[0.619; 0.762]	…						
Perceived Ease of Use	[0.496; 0.663]	[0.502; 0.675]	[0.613; 0.763]	…					
Perceived Usefulness	[0.708; 0.818]	[0.644; 0.777]	[0.724; 0.843]	[0.625; 0.767]	…				
Perceived Fear	[−0.046; 0.153]	[−0.033; 0.168]	[−0.076; 0.124]	[−0.116; 0.075]	[−0.007; 0.190]	…			
Intention to Use	[0.231; 0.417]	[0.206; 0.403]	[0.237; 0.454]	[0.252; 0.449]	[0.277; 0.477]	[−0.039; 0.162]	…		
Subjective Norm	[0.494; 0.657]	[0.401; 0.585]	[0.463; 0.637]	[0.456; 0.625]	[0.532; 0.696]	[−0.054; 0.149]	[0.298; 0.493]	…	
Teacher Capabilities	[0.547; 0.695]	[0.521; 0.680]	[0.521; 0.681]	[0.434; 0.607]	[0.584; 0.735]	[0.038; 0.239]	[0.197; 0.389]	[0.543; 0.695]	…

TABLE 6 Model reliability.

Construct	Cronbach's alpha
Perceived Learning Effectiveness	0.942
Attitude toward Use	0.900
Perceived Satisfaction	0.959
Perceived Ease of Use	0.921
Perceived Usefulness	0.926
Perceived Fear	0.966
Intention to Use	0.909
Subjective Norm	0.937
Teacher Capabilities	0.900

TABLE 7 Hypothesis testing.

H	Hypothesis	Cramer's V
H1	Perceived Learning Effectiveness → Perceived Usefulness	0.529
H2	Perceived Learning Effectiveness → Intention to Use	0.262
H3	Attitude toward Use → Perceived Learning Effectiveness	0.586
H4	Attitude toward Use → Intention to Use	0.294
H5	Perceived Satisfaction → Perceived Learning Effectiveness	0.535
H6	Perceived Satisfaction → Attitude toward Use	0.521
H7	Perceived Ease of Use → Perceived Satisfaction	0.487
H8	Perceived Ease of Use → Attitude toward Use	0.517
H9	Perceived Ease of Use → Perceived Usefulness	0.599
H10	Perceived Usefulness → Attitude toward Use	0.594
H11	Perceived Usefulness → Perceived Satisfaction	0.552
H12	Perceived Usefulness → Intention to Use	0.424
H13	Perceived Fear → Perceived Usefulness	0.262
H14	Perceived Fear → Perceived Ease of Use	0.221
H15	Subjective Norm → Perceived Ease of Use	0.438
H16	Subjective Norm → Intention to Use	0.389
H17	Teacher Capabilities → Perceived Fear	0.211
H18	Teacher Capabilities → Subjective Norm	0.391

independent of the sample size (Arias et al., 2014), which assumes values between 0 and 1, where values close to 0 indicate a very low association between the variables and values close to 1 indicate a strong association. In addition, this can be interpreted as follows: values less than 0.2 are considered to have a low association; values between 0.2 and 0.3, a medium association; and values greater than 0.3, a high or strong association, which will serve as a reference to interpret the research results (Fierro, 2010).

In Table 7, the values obtained are presented, where the results of the proposed model show a fulfillment of criteria in most of the associations in accordance with what is proposed in the literature and a hypothetically strong level of relationship when obtaining maximum values compared to the usual Cramer's V values, as is the case of Hypotheses 9 and 10, where it is stated that the Perceived Ease of Use is associated with the Perceived Usefulness and that the Perceived Usefulness is associated with the Attitude toward Use.

The extraction of the statistical coefficient Cramer's V was developed through SPSS software, and later, the values were placed in a hypothesis contrast table so that it was possible to observe the degree of association between the factors that were part of the hypotheses to check the degree of association for the hypothetical relationships. For improved understanding, the model represented in Figure 1 was obtained after performing the FA with the association values between the variables.

Thus, the structured model of use and adoption of ICTs aimed at learning in undergraduate students of the School of Economic and Administrative Sciences of the ITM in the context of the COVID-19 pandemic proved to be valid and reliable. Additionally, the results of the association hypotheses that are graphically presented in Figure 1 proved to be strong, in addition to being an introduction to the discussion of the results.

The strongest relationships in terms of symmetric measures are H9, the Perceived Ease of Use with respect to the Perceived Usefulness (0.599), which represents a maximum value above the usual for the Cramer's V index, and, very close to the maximum value is the relation of H10, the Perceived Usefulness with respect to the Attitude toward Use (0.594), followed by the relation of H3, the Attitude toward Use with respect to the Perceived Learning Effectiveness (0.586). Other high relations are H1 (0.529), H5 (0.535), H6 (0.521), H7 (0.487), H8 (0.517), H11 (0.552), H12 (0.424), H15 (0.438), H16 (0.389), and H18 (0.391).

The hypotheses that presented an average association are H4, the Attitude toward Use with respect to the Intention to Use (0.294),
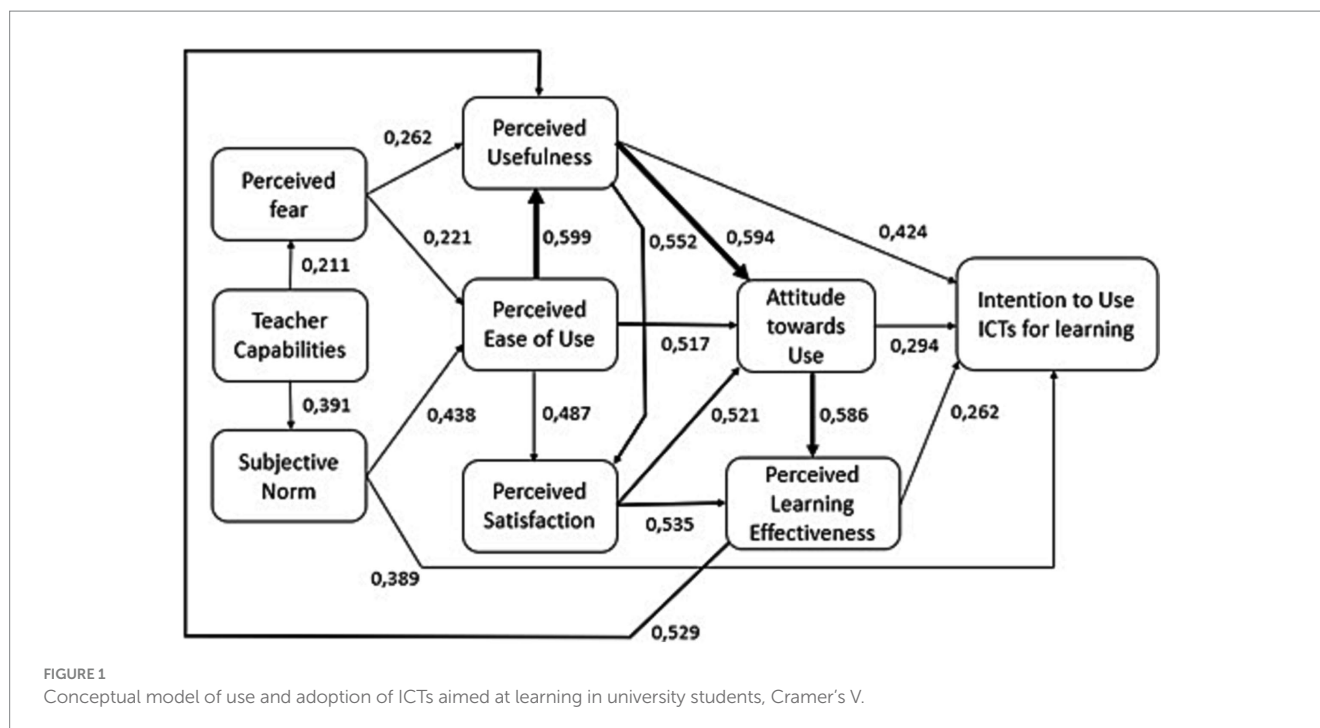
which represents a maximum value in the range of average association of the Cramer V index, and, very close to the maximum value are the relationships H2, the Effectiveness of the Perceived Learning with respect to the Intention to Use, and H13, the Perceived Fear with respect to the Perceived Usefulness (0.262). Finally, Hypotheses H14 (0.221) and H17 (0.211) are also some average relationships.

In summary, it seems logical and reasonable to consider that, as technological devices such as laptops and smartphones are perceived as useful for their use in the training processes by students, students

FIGURE 1
Conceptual model of use and adoption of ICTs aimed at learning in university students, Cramer's V.

will develop a positive attitude toward the use of these devices. In this sense, their intention to use them has a great impact on the ease of use, usefulness, and attitude toward use, which play a key role in determining the perceptions of the students about the use and adoption of ICT tools oriented to learning in the current context.

6 Discussion

One of the significant aspects to evaluate in the implementation of a model or theory of adoption in university education is the technological tool used by the target actor, since this can lead to strong relationships in the intention to adopt technology. In Dabbagh et al. (2010), the authors presented in their research that the use and value of technology for students were closely related to laptops and mobile devices to support training processes oriented to learning anywhere and at any time.

In the same way, the research in its descriptive analysis had similar results compared to those of Dabbagh et al. (2010), where the technological devices most used by students for the learning process were the smartphone and laptop, strengthening digital skills in students, thanks to e-learning and m-learning that served as an alternative to give continuity to the training processes during the pandemic. It should be added that the appearance of new ICTs has affected the massification and flexibility strategies for training in some HEIs (Naffah et al., 2016).

However, the variables linked to the TAM constructs used in this research resulted in strong and adequate relationships that allowed us to examine the variables associated with the use and adoption of ICTs oriented to learning. This result was similar to those generated by Naffah et al. (2016), Sun et al. (2019), and Unal and Uzun (2020). Likewise, all the authors expressed in their research the favorable

properties of TAM and its applicability in higher education. In turn, some of the research, such as that of Naffah et al. (2016) and Valencia-Arias et al. (2018) was developed in similar contexts, emerging economies, and developing countries.

Like the study by Valencia-Arias et al. (2018), where one of the strongest associations was between Perceived Ease of Use and Perceived Usefulness, it was important to predict the acceptance and use of technology by students. Certainly, this reinforces the results obtained in the research, since the strongest relationship in terms of symmetric measures was H9, the Perceived Ease of Use with respect to the Perceived Usefulness (0.599), which represents a maximum value for Cramer's V index.

Conversely, the results by Al-Maroof et al. (2023) established that perceived fear, which has an important effect on measuring the influence of COVID-19 on a group of students, was directly related to perceived ease of use and perceived usefulness and to another external variable of the TAM, which is the subjective norm. Likewise, Hu et al. (2022) revealed in their research that the TAM is relevant to explain the intention to use technology among university students with fear generated by the pandemic, where effects associated with the perceived usefulness and the perceived ease of use were identified. These results coincide with those obtained in this research, specifically in the validation, due to the association of the variables with Perceived Fear.

It is important to highlight that incorporated variables such as Perceived Fear and Perceived Learning Effectiveness had excellent reliability, as represented by the Cronbach's alpha measure. Therefore, although no TAM has used the Perceived Learning Effectiveness variable, it had a strong relationship with respect to Perceived Usefulness and was notable with respect to Intention to Use, having a high functionality to know the degree to which students achieve expected or desired learning. However, Perceived Fear was a variable with great diversity in relation to its influence on the use of ICTs

aimed at learning, also with medium associations to Perceived Usefulness and Perceived Ease of Use. This study provides theoretical contributions that influence the intention of using and adopting ICTs aimed at learning in university students and identifies the most relevant variables.

The practical implications of this research have several aspects in the variables used for the conceptual model. The first is that Perceived Fear is a variable that promotes the strengthening of soft skills in an industrialized era such as the fourth industrial revolution, since, with the influx of new technologies, it is key to use and adoption. As a second aspect, Ease of Use and Intention to Use are variables that promote the incorporation of Industry 4.0 in the curricula of administrative careers due to the emergence of new ICTs and the digitization of many processes, which reduce the effort on the part of students, providing preparation and continuous updating that will boost their skills for the labor market.

However, during a pandemic, the challenge is not digitization, it is the generation and use of capabilities, like the intention of using ICT tools that promote new approaches in careers such as social or administrative sciences with skills in industry 4.0, promoting training and research processes. In turn, the health emergency accelerates internationalization strategies in HEIs, taking advantage of the use of ICTs, as reflected in multiple events and activities around the world mediated by technology.

For higher education students, this research highlights the significance of promptly adjusting to novel ICT tools during emergency situations like the COVID-19 outbreak. It is mandatory to possess technical proficiency in using these tools, along with the mental readiness to surmount psychological obstacles like technology-related anxieties. Incorporating ICT in the educational process provides flexibility in learning methods and enhances digital skills, thereby improving preparedness for a constantly evolving labor market. Perceived ease of use and usefulness of technological tools serve as determinants of intention to use, which, in turn, can influence academic performance and readiness for future challenges.

On the other hand, university personnel must emphasize the necessity of offering appropriate and continuous ICT training, in addition to pedagogical resources that are in line with student needs and expectations. It is imperative that academic institutions provide emotional and technical resources alongside digital platforms, to surmount obstacles relating to fear and reluctance to change. Additionally, the university should consider adopting educational resources that can improve the learning experience for students, without bias toward subjective evaluations. The information presented should be clear, concise, and organized logically to ensure a cohesive flow of information. It is important to adhere to conventions of standard academic writing, including conventional structure and terminology. The language used should be objective, value-neutral, and consistent, with a formal register and precision in word choice. Any quotes or citations used should be properly formatted according to the style guide. Attention should also be given to grammar, spelling, and punctuation, ensuring accuracy and clarity in expression.

After the declaration of the COVID-19 pandemic, HEIs had to transfer their methodology from face-to-face training activities to developing them from ICT tools that would facilitate the normal teaching and learning process. In addition, it is important that universities design or adapt new ICT tools to guarantee teaching and

learning, since often they are not exempt from issues that may affect curriculum development. This input will allow the results presented in the research to explain the intention to use and adopt ICT tools oriented to the learning by undergraduate students, not only in the IES of Medellín or Colombia but also in other countries that have the same adaptation needs that the ITM had when the health emergency was declared. However, it is important that its applicability is conditioned on a similar context, so it would not be useful and advisable to replicate it directly in a developed country.

One limitation of this study concerns the students' exclusive perspective of ICT adoption in education. It is crucial to acknowledge the significant role that university staff, including teachers, administrators, and other collaborators, play in the successful implementation of technological tools. The integration of ICT into teaching is greatly influenced by the objective evaluation of university staff members' perception, adaptability, and skills. By gaining a more complete and holistic view of how ICT is perceived as a learning tool, educational institutions can address possible reluctance or barriers, resulting in a smoother and more effective transition toward a predominantly digitalized teaching model.

The advancement of information and communication technology fosters a significant transformation of the university's conventional learning process. The study's proposed model centers on adopting ICT as complementary tools while also envisioning a significant reconfiguration of educational dynamics. Traditional master classes and classroom sessions could transition toward more interactive, personalized, and flexible modalities. ICT promotes autonomous learning, allowing students to access content at their desired pace, reinforce concepts using digital platforms, and collaborate with peers and teachers in real time through virtual tools. This approach creates more adaptive learning environments that adjust to each student's individual needs and pace.

Finally, the proposed model recommends that students take greater responsibility and be more proactive in their educational process. ICTs not only facilitate access to information, but also demand the critical skills to discern, analyze, and apply said knowledge. In this new paradigm, teachers take on more guiding and facilitating roles, while students become active protagonists of their training. Moreover, the incorporation of ICT enables the implementation of innovative methodologies, like project-based learning, gamification, and virtual simulations, which can enrich and diversify the educational experience. Without a doubt, the proposed model expands and challenges the traditional concept of university education, preparing institutions and students for a more digital world. It maintains an objective approach that avoids biased or emotional language, utilizes precise word choice and conforms to academic conventions in style and formatting. The language remains formal, avoiding contractions, jargon and colloquial expressions, and is precise yet comprehensible. The text displays a clear and logical structure with causal connections between statements, avoids filler words, and maintains grammatical correctness throughout.

7 Conclusion

In relation to the result of the diagnosis and the descriptive analysis of the same, students are oriented to formative adaptation

during a pandemic, where despite the change of modality, they tend to use ICT for the development of their classes. However, the fear perceived by them is a variable to consider in future studies associated with a change in the training modality, since it could lead to possible risks in the use and adoption of ICT in students.

It should be added that these types of studies reveal the importance of knowing the variables involved in the intention to use and adopt learning-oriented ICTs during the COVID-19 pandemic, regardless of the population, in this case undergraduate university students. In turn, the type of technology such as smartphones or laptops allows recommendation of the inclusion of other variables that may become relevant according to the context in the case of two possible scenarios—the continuation of the pandemic or its end. The variables used in these models will look for the technology to be appropriate and to benefit the training processes.

The population of students surveyed considers that the ICT tools they use for the development of their training processes are important and of great value in acquiring knowledge and contributing to the continuous improvement of learning, despite the conditions presented due to the health emergency, where 67.3% of the students did not feel affected in their learning process. For 83.91% of the students, the pandemic did not affect their desire to continue studying, reflecting great adaptability to receive their classes without broadly affecting the academic calendar.

In relation to the constructs and variables applied to the proposed conceptual model, it is evident that Perceived Ease of Use is the variable that most influences the intention to use ICT because students consider it easy to use ICT tools for learning in their classes. Furthermore, this variable was the one that had the strongest relationship in terms of symmetric measures, being a determining factor in predicting the acceptance and use of technology by students.

Having this type of study allows us to explore other influential actors, such as teachers, and to generate complete coverage of the factors that intervene in the adoption of ICT for the normal development of training processes. Additionally, it allows us to determine which factors intervene in the use and adoption of ICTs aimed at learning in undergraduate students, to explore the same in non-COVID-19 conditions, and to be able to obtain a different set of results.

Undoubtedly, the pandemic promoted the development and strengthening of adaptive capacities by students to receive their learning processes. However, the approach to the end of the pandemic will open the way to research on contexts prior to, during, and after the COVID-19 pandemic, to understand and make a survey of its implications in the practicality of the training processes within the IES, with a main focus on students.

In conclusion, learning-oriented ICTs offer great opportunities that have even been adapted to the contexts of many countries and institutions due to the various conditions to which they may be exposed and their adaptability properties. Likewise, the pandemic gave way to developing and strengthening digital skills mediated by various technological tools in students.

It is concluded that the integration of ICT tools in higher education is essential, particularly in emergency situations such as the COVID-19 pandemic. This study emphasizes the importance of students adapting quickly to new technological tools, developing technical competencies, and mentally preparing to overcome psychological obstacles associated with technology. Understanding how students perceive and embrace virtual tools is crucial for ensuring a smooth transition to a predominantly digitalized teaching model. Flexibility in learning methods and the development of digital skills are crucial aspects that enhance students' preparation for a constantly evolving labor market.

Secondly, this research makes a significant contribution to the academic field by providing a comprehensive view of students' adaptation to training during the pandemic. It highlights the perception of fear as a variable of special relevance for future research in the transition to digital training modalities. The study emphasizes the importance of understanding the variables that affect the intention to use and adopt ICT in academic contexts. The text adheres to conventional structure and formatting features, with consistent citation and footnote style. The text is free from grammatical errors, spelling mistakes, and punctuation errors. No changes in content were made as per the instructions. Specifically, the identification of "Perceived Ease of Use" as the most significant variable suggests areas of focus to optimize technology acceptance and utilization, both in emergency situations and under normal conditions. The language used is clear, objective, and value-neutral, with a formal register and precise word choice. The sentences and paragraphs create a logical flow of information with causal connections between statements.

Therefore, this study recommends that the academic community conduct thorough research that goes beyond current circumstances. This research should explore the far-reaching implications of integrating ICT in higher education, as well as its influence on long-term preparation for future challenges. It offers a sturdy framework for future research that could be expanded to other parties, such as faculty, and establishes the basis for comprehending the evolving dynamics of the educational landscape in the post-pandemic context. The directive is evident: conduct scholarly and applied research that critically examines the efficacy of educational technology, acknowledging its crucial role in fostering digital skills and students' adaptability in the constantly evolving educational terrain.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by COMITÉ ETICA—CIES, Institución Universitaria Escolme. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

AV-A and JL-S: conceptualization. JL-S and AR: methodology. JP-V and AV-A: software. AV-A, JP-V, and JL-S: validation. AR and JP-V: formal analysis. AV-A and AR: resources. JL-S: data curation. JCP-V and AMRC: writing—original draft preparation. JL-S, JP-V, AV-A, and AR: writing—review and editing. All authors contributed to the article and approved the submitted version.

Acknowledgments

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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