

# DEVELOPMENT AND VALIDATION OF THE 3S-T E-LEARNING EDUCATIONAL MODEL TO MEASURE EDUCATIONAL ICT USAGE AND THE IMPACT OF COVID-19 PANDEMIC ON HIGHER EDUCATION. MODERATING CROSS CULTURAL TENDENCIES

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## ABSTRACT

E-learning was a vital tool for education during the global lockdown, as it was the only alternative for billions of students worldwide to continue learning amid the COVID-19 crisis. However, despite the importance and relevance of E-learning, there is a significant lack of studies that examine E-learning success under heterogeneity effects, such as gender, cross-cultural, or level of education. A clear and comprehensive framework that encompasses all necessary e-learning services is crucial to ensure their effective implementation, use, and impact on student learning and achievement. For this purpose, we used a new version of the original 3S-T model that measured the E-learning success based on self-student assessment through a survey study with 136 students from the Universitat Politècnica de València (Spain) and 81 from the Central University of Ecuador (Ecuador). This model that expands the existing theoretical framework of models related to E-Learning (Technology Acceptance Model (TAM), Extensions of TAM model, and Information Systems Success Model (ISSM)) identifies a broad range of success predictors that help to achieve success, such as learning and academic outcomes. The success predictors include factors related to the surrounding conditions, the system features, the tutor's development, the student's performance, accessibility, interactivity, content quality, assessment methods, learning outcomes, and student engagement. This conference paper uses a multigroup Analysis (MGA) using Partial Least Squares (PLS-SEM) to evaluate moderation across both countries over the depurate 3S-T model, including the assessment measurement invariance of composite models (MICOM) procedure.

## KEYWORDS

3S-T model, E-learning Methodology, Student Self-Assessment, Multigroup Analysis (MGA), PLS-SEM

## 1. INTRODUCTION

Information and Communication Technologies (ICT) have undergone significant advancements in recent decades, leading to numerous changes across various disciplines (Zhao et al., 2022). Specifically, the COVID-19 pandemic forced changes in the educational response, involving the intensive use of ICT, among other interventions. The rapid development of new technologies has led to the creation of new products, markets, processes, and services. Education is one field that has been greatly impacted by these technologies, giving rise to significant changes. The use of these new technologies on a global scale has introduced new learning paradigms such as E-Learning and mobile learning, replacing the traditional face-to-face classroom. E-Learning has proven to be a crucial resource, enabling learning to continue during the COVID-19 lockdown (Baber, 2021).

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Following the description in the previous paragraph, e-learning has proven to be the most utilized method for accessing remote educational resources with the aid of computers, laptops, tablets, internal networks, and any other current technological device. This utilization of the latest technologies provides an additional advantage in an ever-changing field such as education, where the teaching-learning process must remain dynamic. Unlike traditional forms of learning, E-Learning has many advantages, among which quick and smooth communication can be mentioned, allowing greater access to educational material and greatly facilitating the possibility of academic collaboration between students and teachers. In summary, E-Learning systems should be considered a major advancement, as these systems can even compensate for the weaknesses of traditional learning methods, in addition to offering the possibility of extending knowledge to a greater number of students, since even when located on the other side of the world, the student-teacher relationship can continue without major impediments. Therefore, leveraging all these possibilities offered by new technologies provides great opportunities for young people and anyone seeking to learn about any field of knowledge. However, once E-Learning has been implemented, in order to assess whether its implementation truly represents an improvement over traditional classroom-based education, it is essential to have tools to measure the degree of success achieved. In order to obtain information about the added value provided, the effect of management operations, and the return on investment, this measurement/estimation of the success of E-Learning initiatives has been widely researched since the early years of distance education. Among the studies related to this evaluation of E-Learning success, a recent model, the 3S-T model (Martínez-Gómez et al., 2022) based on different theoretical frameworks, has been validated with a sample of high school students to assess student satisfaction and E-Learning performance. The 3S-T model builds upon various previous models, such as the Technology Acceptance Model (TAM) (Davis, 1989), the revised D&M model (Venkatesh and Davis, 2000) and the Information Systems Success or D&M Model (Delone and McLean, 2003).

The TAM suggests that three particular beliefs, PU, PEOU, and PE, are the primary drivers for explaining and predicting user acceptance of IS (Sánchez and Hueros, 2010). PU is defined as 'the degree to which a person believes that using a particular system would enhance their job performance,' and PEOU is defined as 'the degree to which a person believes that using a particular system would be free from physical and mental effort' (Davis et al., 1989). The revised D&M model includes six dimensions: (1) information quality, (2) system quality, (3) service quality, (4) use/intention to use, (5) user satisfaction, and (6) net benefits (Delone and McLean, 1992 and 2003). After the completion of the D&M Model, many researchers argued that the D&M model was incomplete; and many additional measures have been proposed and used to capture the system quality construct in its entirety (del Barrio-García et al., 2015; Adetimirin, 2015).

This conference paper presents the capability of the 3S-T model for measuring the performance of E-learning systems based on students' academic achievements and learning outcomes. Its primary purpose is to evaluate the validation of this 3S-T model in higher education students, which was also proposed by the current authors (Martínez-Gómez et al., 2022), and to assess the moderating effect of cross-cultural tendencies. This model provides a quantifiable tool to better understand the factors influencing students' E-learning, and not only this, but also to estimate the importance of each of them. In this regard, the current model is not only capable of conducting the measurement of importance for each validated construct, but also the relationships between the measurement model and the structural model were determined. Therefore, the objective of this research is to examine the acceptance of E-learning among university students from different nationalities, so that conclusions can be drawn about the differences and similarities between them. It should be noted that the 3S-T model was validated in a previous study only with high school students, subsequently in further studies on students from a single university, so within the framework of this study, it has been extended to university students from two countries on different continents, although presenting certain similar cultural traits, namely Spain and Ecuador.

## 2. THEORETICAL FRAMEWORK

E-learning is a contemporary educational method that uses technology to access resources remotely, offering advantages over traditional learning. It saves time and money, enhances retention, provides accessibility to teaching material, and facilitates fast communication and academic collaboration.

Authors vary in their definitions, with some considering it the delivery of learning content and activities, while others perceive it as an information system integrating various educational resources and tools.

Assessing the success of an e-learning system involves multiple models, such as the Information Systems Success Model (ISSM), TAM, User Satisfaction Model (USM), and E-Learning Quality (ELQ) models.

This study incorporates insights from various theories and acceptance models in the literature to establish a comprehensive and inclusive definition of E-learning and assess its success. In this context, the authors introduced a novel model, the 3S-T model, which enhances and integrates aspects of the ISSM, TAM, USM, and ELQ. This model underwent development and testing based on analyzing approximately 300 questionnaires from secondary school students (Martínez-Gómez et al., 2022). The current study extends this evaluation to university students of two countries, testing the 3S-T model's capabilities and assessing its performance. The aim of this work is twofold. On the one hand, to validate the 3S-T model in higher students of Ecuador and secondly, to capture the distinct characteristics of both cross-cultural universities for a better understanding of the model's effectiveness.

### 3. CONCEPTUAL ANALISIS

In our study, a version of the validated 3S-T model has been used to identify the major dimensions that significantly impact E-learning achievements, which also considers the four most widely used approaches for evaluating E-learning over the past decades. These dimensions include Social aspects, Student factors, System factors, and Tutor's capabilities. We further divided the student's factors into three sub-factors: individual factors, user beliefs, technology acceptance, and the student's performance. Student satisfaction has consistently emerged as a robust indicator for measuring the success of E-learning implementations (Kerzic et al., 2021; Sun et al., 2008; Eom et al., 2006; Gray & DiLoreto, 2016; Marks et al., 2005) and Student Learning Achievements (SSA) have been extensively employed as an evaluation mechanism in the field of education (León et al., 2021; Ganji, 2017). SSA emerges as a potent tool for assessing the effectiveness of E-learning strategies in higher education. Hence, it becomes imperative to employ group comparison analysis to assess the moderating effect of individual-level cultural values on users' acceptance of E-learning in different countries that help education authorities and institutions review and rethink their particular strategies.

The version of 3S-T model comprises five independent constructs: technical system quality, information quality, self-efficacy, subjective norm, and tutor quality and preserves the nine dependent constructs: perceived satisfaction, perceived usefulness, use as sustainability, student satisfaction, engagement, strategy student satisfaction, students' self-assessment, and student learning achievements, as we can see in Figure 1. A description of each construct that includes some variables related to the COVID-19 pandemic, along with the indicators utilized to represent them, supported by relevant studies, can be found in Martínez-Gómez et al. (2022).

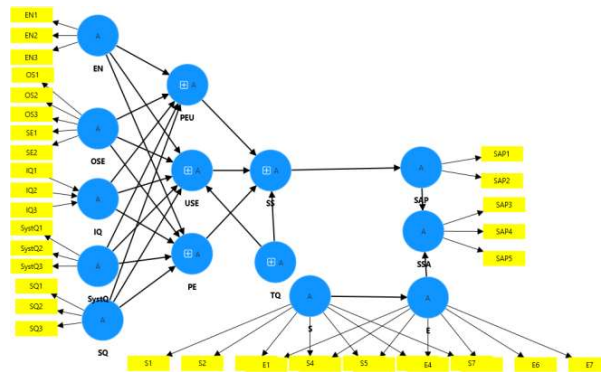


Figure 1. Validated 3S-T model version used in this study.

Note: OLE, Online Learning Environment; OLSE Online learning self-efficacy; OSE, One-Self Efficacy; PE, Perceived Enjoyment; PEU, Perceived Usefulness; S, Strategy; SAP, Student Academic Performance; SN, Subjective Norm; SEQ; Service Quality; SQ, System Quality; SS, Student Satisfaction; SSA, Student Self-Assessment

## 4. RESEARCH METHOD

In this study, we performed a two-step analysis. In the first step, a confirmatory analysis (CFA) with structural equation modeling using partial least squares SEM (PLS-SEM) was used to examine the measurement model and structural model (x items and x constructs) of the new version of the 3S-T model, based on composites factors formulated as type A. This technique was preferred for its ability to simultaneously examine a series of dependence relationships, especially when the model has first-order and second-order latent variables (Hair et al., 1998).

The model was measured and evaluated through data computation in SmartPLS 4. The measurement model evaluates the relationship between indicators reflecting each construct and tests the reliability and validity of measures. Assessment criteria included:

1. Indicator Reliability: Indicators should have outer loadings  $\geq 0.70$  (Hair et al., 2010).
2. Internal Consistency Reliability: Assessed via Cronbach's alpha ( $\alpha$ ) and Composite reliability (CR), with a cutoff of  $\geq 0.70$  for both tests (Urbach & Ahlemann, 2010).

Three conditions must be assessed:

- a. Validity:
- b. Convergent Validity: Average Variance Extracted (AVE) should be  $\geq 0.50$  (Fornell & Larcker, 1981).
- c. Discriminant Validity: Assessed through the Fornell-Larcker criterion, cross-loadings, and Heterotrait-Monotrait ratio (HTMT) (Henseler et al., 2015).

Structural models describe relationships among constructs. The assessment criteria proposed by Hair et al. (2011) include:

- Collinearity Issues: Evaluated using Variance Inflation Factor (VIF)  $< 5$ ;
- Significance and Relevance of Structural Relationships:  $p < 0.05$ ;
- $R^2$  Levels: Categorized as weak (0.190), moderate (0.333), or substantial (0.670);
- $Q^2$  Levels: Should be more significant than zero;
- Model Fit: Assessed using Standardized Root Mean Square Residual (SRMR)  $\leq 0.08$  and Root Mean Square Error of Approximation (RMSEA)  $\leq 0.12$ .

In the second step, a multigroup analysis (MGA) was developed. MGA is used to evaluate differences across groups defined by a categorical moderate variable. In our research, we develop the three-step of Measurement Invariance of Composite Models MICOM procedure, based on a non-parametric test that involves the assessment of configural invariance (i.e. equal parameterization and way of estimation), compositional invariance (i.e. equal indicator weights), and the equality of a composite's mean value and variance across groups. Configural invariance is the most important step and is a precondition for compositional invariance, which is again a precondition for significantly assessing the equality of composite mean values and variance. If configuration and compositional invariance are established, it can be confirmed that partial measurement invariance and it can be compared to the standardized path coefficients of structural relationships across the groups.

## 5. RESULTS

The instrument used to measure the variables of this research was structured in two parts. The first one deals with general issues relating to age or center of study. The second part focuses on factors related to Students Performance and Students Satisfaction including perceived usefulness, perceived ease of use, tutor quality, strategy, subjective norm, self-efficacy, information quality, system quality, service quality and intention of use.

A total of 81 students of the Central University of Ecuador (UCE) (Ecuador) with 38 males and 43 females and 137 students of the Universitat Politècnica de València (UPV) (Spain) with 85 males and 52 females, from different degrees and masters, participated in this study. The sample size is in line to other contemporary works in this purpose (Zobeidi et al., 2023; Wu, 2024)

This study performs three-step approaches: assessment measurement model, structural model, and multigroup analysis (MGA) (Hair et al., 2019).

## 5.1 Measurement Model

### 5.1.1 Outer Loading, Internal Consistency and Reliability

To examine the reliability of each item, we assess the loadings of the indicators in both groups following the suggestion of Hair et al. (2010), which states that:

- If the external loading is lower than 0.4, remove the indicator.
- If the external load is above 0.7, keep the indicator.
- If the external load is between 0.4 and 0.7, assess the impact of dropping the indicator on the Extracted Variance (AVE) and Composite Reliability (CR). Table 1 shows these statistics, in both groups.

Table 1. Measures of Internal Consistency Reliability and Validity of Both Groups

	UPV Student			UCE Student		
	Cronbach's alpha	Composite reliability (rho_a)	Average variance extracted (AVE)	Cronbach's alpha	Composite reliability (rho_a)	Average variance extracted (AVE)
E	0,833	0,907	0,559	0,933	0,940	0,721
EUS	0,701	0,711	0,623	0,905	0,924	0,839
OSE	0,829	0,850	0,596	0,895	0,915	0,705
PE	0,805	0,814	0,718	0,936	0,937	0,888
PEU	0,899	0,900	0,833	0,936	0,937	0,887
S	0,710	0,782	0,627	0,784	0,816	0,693
SAP	0,853	0,859	0,872	0,943	0,944	0,946
SystQ	0,861	0,869	0,783	0,943	0,943	0,878
SQ	0,568	0,724	0,683	0,853	0,855	0,871
SS	0,889	0,890	0,900	0,862	0,863	0,879
SSA	0,860	0,862	0,781	0,962	0,963	0,930
TQ	0,910	0,941	0,692	0,948	0,956	0,796

### 5.1.2 Discriminant Validity

Discriminant validity is the extent to which a construct is different from other constructs. The Fornell-Lacher criterion indicates a satisfactory level of discriminant validity for both groups, and we also evaluated the Heterotrait-Monotrait ratio (HTMT) following the recommendation of Henseler et al. 2015. Again, in both cases, the value does not exceed the threshold (values  $\leq 0.9$  are accepted); we can conclude that the study's measurement parameters provide sufficient evidence of reliability and convergent and discriminant validity for both groups.

### 5.1.3 Significance of Outer Loading

The bootstrapping algorithm with samples 50000 to estimate the t and p values to test the significance of the outer loadings with a 5 % probability of error has been used. The results indicate that all outer values are significant, with p-values lower than 0.05.

## 5.2 Structural Model

The path coefficients ( $\beta$  values) of the relationships between constructs and constructs are shown in Figure 2 and Figure 3. It can be appreciated that the coefficients differ in some of the relationships according to the university, for example, there is a notable effect of the tutor's role in UCE students on strategy and engagement, which has a positive effect on SAP, but this is not so higher in UPV students. All path coefficients were significant using the bootstrapping algorithm (p-values lower than 0.05).

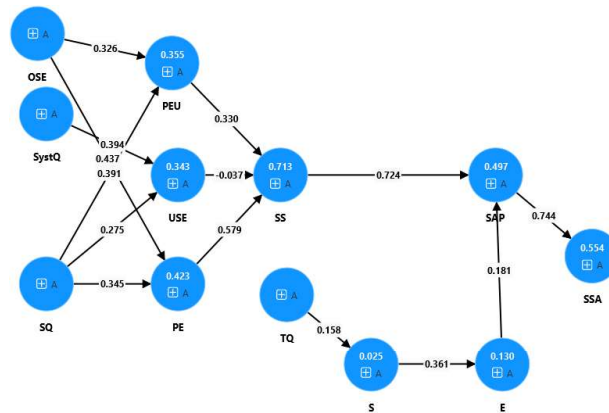


Figure 2. Structural Model Path Coefficients for UPV students

The coefficient of determination ( $R^2$ ) of the endogenous variables can be interpreted as the predictive accuracy of the proposed model are shown in Figures 2 and Figure 3. Hair et al. (2010) stated that values of 0.75 are substantial, 0.5 moderate and 0.25 weak. In both cases, the results of  $R^2$  show a sufficient level of this measure.

Finally, we assess the predictive relevance, denoted as  $Q^2$ . If the model performs a predictive relevance (values of  $Q^2$  higher than 0), a study will show accuracy in predicting data points of items (Hair et al., 2019). Accordingly, Hair et al., 2019,  $Q^2$  value of 0.02 denotes low predictive relevance, a value of 0.15 indicates medium relevance and a value of 0.35 denotes high predictive relevance. In our research, in UCE Students except S ( $Q^2=0.277$ ) all factors have values of relevance predictive higher than 0.35 which means high relevance predictive. However, in UPV students, the value of  $Q^2$  is less than 0.15 in Strategy (S) and Engagement (E).

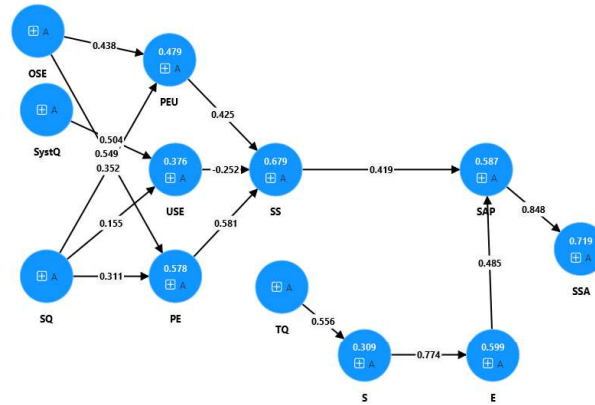


Figure 3. Structural Model Path Coefficients for UCE students

### 5.3 Multigroup Analysis

Finally, we perform an MGA. As established Henseler et al. (2016) to develop a MGA, it is necessary to confirm that differences between the two groups are due to differences in the structural model and not in the measurement model. The results of MICOM analysis for University confirm that partial invariance can be established, hence the moderating role is confirmed.

We can state that the tutor role, the strategy, and the engagement have a higher influence on Student's Academic Achievement and Performance and that USE, PEU and PE are most affected by on-line self-efficacy and System Quality UCE students. On the other hand, the path coefficient of the relationship between Student Satisfaction and Student academic performance is higher in UPV Students.

These differences in results can be partially attributed to the respective countries and their cultural dimensions similarly the results of Jorgji et al., 2023.

## 6. CONCLUSIONS

The Covid pandemic accelerated the E-learning process, where billions of students around the world were locked up receiving this teaching system. In this conference paper, we evaluate the success of E-learning using a 3S-T model already tested with secondary school students, but now testing its performance with university students (UCE students from Ecuador and UPV students from Spain). This 3S-T model was based on models in the existing specific literature (TAM, extensions of TAM, ISSM, SERVQUAL). Through this 3S-T model, we are validating E-learning success and gaining a better understanding of the factors that influence students' E-learning. Our research methodology consisted of two steps: (i) a confirmatory analysis (CFA), with structural equation modeling using partial least squares SEM (PLS-SEM), to examine the measurement model and the structural model and (ii), a multigroup analysis (MGA) to analyze the invariance. Through this procedure, we obtained results in two spheres, general issues related to age or center of study and factors related to Student Performance and Student Satisfaction including perceived usefulness, perceived ease of use, tutor quality, strategy, subjective norm, self-efficacy, information quality, system quality, service quality and intention of use. According to the results of CFA and PLS-SEM, a notable effect of the tutor's role in UCE students on strategy and engagement but not so high in UPV students has been found. Based on the results of MICOM analysis it has been found that the tutor role, the strategy, and the engagement have a higher influence on Students' Academic Achievement and Performance in UCE students; on the other hand, the path coefficient of the relationship between Student's Satisfaction and Student's academic performance is higher in UPV students than in those of UCE. In this sense, the discrepancies in results are due more to investments in digital infrastructure, economic disparity, accessibility and connectivity than to the cultural dimension (Ecuador and Spain share Hispanic culture). In UCE (Ecuador) these variables related to technological infrastructure are worse than in UPV (Spain) and even more so during the Covid-19 pandemic. Starting with this conference paper, we will expand the sample with more university students from other Hispanic countries and study additional cultural frameworks to analyze the cultural dimension in more depth.

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