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Evaluating Technological Acceptance of Virtual Learning Environments (VLE) in an Emergency Remote Situation*

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The digital acceleration that took place in the middle of COVID-19 pandemic made the universities implement strategies to face the challenges brought about by the irruption of non-face-to-face education. In Guatemala, the universities opted for online, virtual, and distance learning methodologies where in a short time they organized themselves to build a learning system to solve the emergency, which in the beginning was considered to last a few weeks; however, the digital learning ecosystems were consolidated, as time went by, and to the extent that all agents of the educational community were involved in the process. The higher education institutions implemented strategies to continue providing instruction, and the academic year ended with a full distance education system, using virtual educational platforms and networked communities to optimize time and resources that are transforming university management worldwide. This work presents a theoretical model that assessed teachers' technological acceptance of virtual learning environments (VLE) in an emergency remote situation. The study was prepared from the perspective of 345 teachers from different faculties in a higher education institution. The work is complemented with recommendations and best practices from the experience with a special focus on the use of learning analytics techniques in virtual engineering education.

Keywords: virtual learning environments; engineering education; technology acceptance; learning analytics

1. Introduction

The spread of a pandemic in the year 2020, caused transformations in higher education in a short time. According to the United Nations Educational, Scientific, and Cultural Organization (UNESCO), in April 2020, higher education institutions were closed in more than 185 countries, affecting a large educational population [1].

From this perspective, it is necessary to reflect on how teachers have faced the emergency. Have they been trained to adapt to virtual learning environments, and what tools and strategies have they used to facilitate their teaching practice and student follow-up? Considering that education in virtual environments involves knowledge of instructional design, digital pedagogy, didactic strategies, assessment techniques, and online communication to develop learning experiences [2], teachers carried out various initiatives to communicate with their students [3], and this implied a challenge of techno-pedagogical skills, based on sustainable, dynamic and flexible methodologies.

UNESCO and other institutions emphasize that relevant teaching and learning methods and content that meet the needs of all learners and are delivered by teachers with adequate qualifications, training, remuneration, and motivation, using appropriate pedagogical approaches and supported by emerging technologies, are essential to address the current situation [4–6].

In the studies of [7, 8], it is proposed that in order to face the current situation, governments, and higher education institutions must have a (a) basic infrastructure of Information and Communication Technologies (ICT) that allow carrying out distance education; in this sense, it is essential to equip teachers and students with ICT tools that can be used from home to continue with the formative processes, then, awareness will be created that the adoption of an online learning environment is not only a technical issue but also a

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pedagogical one. To make this possible, [5–9] suggests that among the actions that should be considered in universities are: (a) integrating health courses into the curriculum, (b) strengthening environmental policies and hygiene practices, (c) incorporating online medical and mental health services, (d) migrating face-to-face courses to virtual, (e) aligning curricular competencies, (f) training professors in online teaching, (g) evidence-based practices, (h) adapting learning and assessment activities, and (h) strengthening data tracking (Learning Analytics). Although this last element's practice has become the focus of educational researchers' attention, it continues to be a discipline in constant evolution and to be explored to improve learning [10]; however, the other elements are not. The importance of Learning Analytics (LA) lies in the fact that the available data are used to understand the behavior of students regarding the educational process to provide them with additional support [11, 12] and thus improve their experience [13]. The actions carried out were based on four priority areas: administration, research, teaching and university outreach.

The present research arose from three questions: (RQ1) what the perceived technological acceptance of USAC professors regarding the use of virtual learning environments in emergency remote teaching is? (RQ2) what is the level of interest professors have in using Learning Analytics in these environments? Moreover, (RQ3) what are the good practices implemented at USAC to carry out emergency remote teaching?

To answer RQ1, 4 hypotheses (H1, H2, H3, and H4) were posed based on the Technology Acceptance Model (TAM), which consists of the dimensions (1) Perceived usefulness; (2) Ease of use; (3) Attitude towards use; and (4) Intention to use [14, 15]. In this sense, the relationships between dimensions were analyzed using structural equation modeling in which each construct was measured through multiple items with a 5-point Likert scale.

To answer RQ2, 2 hypotheses were established (H5 and H6). A one-way ANOVA analysis of variance was used to identify the levels of teachers' interest in using LA in virtual learning environments.

The response of RQ3 was obtained from the experiences shared by teachers and the actions taken at USAC during the pandemic.

The paper continues as follows: section 2 background (a) higher education and COVID-19, (b) TAM application, (c) virtual environments and Learning Analytics; sections 3 and 4 present the research hypotheses and the proposed model; then, section 5 presents an analysis of the data, closing with conclusions.

2. Background

The COVID-19 pandemic has affected approximately 1.570 million students in 191 countries, with 23.4 million students in higher education and 1.4 million teachers in Latin America and the Caribbean [16]. Different measures have been taken to address the situation in each country and continue developing the educational process. This section analyzes the different (a) actions taken to respond to remote teaching because of the COVID 19 pandemic, (b) application of the Technology Acceptance Model (TAM), and (c) virtual tutoring and Learning Analytics.

2.1 Higher Education Practices in the Face of COVID-19

In the international context in 2020, the Organization for Economic Cooperation and Development (OECD) focused on three aspects that teachers should consider ensuring the continuity of high-quality educational service: (a) cognitive skills: processing, creativity, and knowledge; (b) interpersonal skills including teamwork and leadership skills, and (c) intrapersonal skills, oriented to intellectual openness, work ethic, responsibility, and self-efficacy [17]. However, there were a lack of clarity about teaching, teaching, teacher and student workload, the teaching environment, and educational equity implications [18]. The online teaching infrastructure's weakness, teachers' inexperience, the information gap, and the difficult context for conducting educational processes from home [19].

In China's case, a policy of suspending classes without stopping learning was created [18]. On the other hand, in the Philippines, upon the arrival of COVID-19, universities were closed. They immediately opted for online learning, where teachers recorded and uploaded lessons online using platforms such as Google Classrooms [5].

In India [20], a study was developed to evaluate the adoption of virtual classrooms. The results showed that the average actual benefits were significantly lower than the expected benefits, highlighting network problems, lack of training, and lack of awareness. Also, in Saudi Arabia, actions were taken to continue with higher education management in crises. For this purpose, the Pandemic Framework of King Abdulaziz University (KAU) was established. A methodological approach was proposed to take advantage of social networks for higher education's sustainable management [21].

Italy was the first country to be strongly affected in Europe by COVID-19. As a consequence, in higher education institutions, multidisciplinary

committees against the coronavirus were created, as well as communication channels that allowed scenarios for communication between members of the educational community to continue the processes; also work platforms and distance learning were offered to students and researchers and organized to protect campuses [22]. In the United States of America, they focused on supporting academic staff and students' safety, belatedly consolidating distance, and online education in several universities [23].

The COVID-19 has created significant challenges for the global higher education community. Government and university responses have been diverse, ranging from lack of response to on-campus social isolation strategies and rapid curriculum remodeling for fully online offerings [24].

2.2 Application of the Technology Acceptance Model (TAM)

The Technology Acceptance Model (TAM) is one of the most relevant methodological approaches in studying Internet usage [25]. Several studies exploring technology acceptance have shown that TAM can predict and explain why users prefer to use information systems in various disciplines [26]. The study by [27] presents a comparative analysis of two Learning Management Systems (LMS): Moodle and Blackboard. The study was conducted to evaluate the acceptance of both systems by students of the Faculty of Engineering Sciences at the State University of Milagro, and the results showed statistically that the Blackboard platform has greater acceptance because it offers greater ease of use and therefore has an impact on the intention to use it.

On the other hand, the study of [28] sought to evaluate teachers' attitudes towards the use of LMS and how it influenced the adoption of the use of LMS in the institution. The instrument was applied to professors of the Faculty of Information Technology. It contained the TAM dimension, which through the correlation coefficient, found a positive linear relationship between the ease of use of LMS and the perception of usefulness, suggesting that, although the use of LMS was positive because of its ease of use, it was equally perceived as useful. Furthermore, a positive relationship between intention to use and perceived ease of use as indicated. Meanwhile, the paper [29] provides empirical evidence on students' perception of adopting and using virtual environments in face-to-face teaching to enhance learning. In this study, a questionnaire based on extended TAM was applied to students of the Faculty of Economics at the University of Valencia and empirically evidenced, through the results obtained through structural equations, the positive relationship and influence between the perceived usefulness and the subjective norm towards the intention to use the variable, this being a determinant in the learning perceived by students.

The research [30] presents an empirical study on WeChat, the most popular mobile social network in China, and TAM was applied to study the reasons for the popularity of games in mobile social networks. Also, factors from social and mobile perspectives were incorporated into TAM to study their influence and relationships. In other research, purposive sampling methods were adopted to choose students from technological universities who were taking or had taken courses related to e-book production; structural equation modeling (SEM) was used to assess the cause-effect path, connections between dimensions of computer self-efficacy, perceived usefulness, perceived ease of use, and users' availability. It was concluded that the technology acceptance model could be applied to explain users' willingness to adopt a web-based evaluation system [15].

Like the previous study, in the research [31] based on TAM, aimed to study the antecedents of teacher adoption of ICT in the teaching and learning process, hierarchical regression analysis was used to test the incremental influence of additional explanatory variables identified in the exploratory phase of the study after the effects of control variables and TAM factors taken into account. The findings are in line with previous studies that found that perceived usefulness was an important determinant of ICT use and tested the effects of additional variables on adopting ICT in education.

2.3 Virtual Tutoring and Learning Analytics (LA)

Virtual tutors or online teachers are professionals who develop a set of roles and responsibilities specific to virtual learning environments (VLEs) [32]. Several works have shown that these roles are centralized in using LMSs; they store valuable student learning data, and these data can help teachers make pedagogical decisions [33]. In this sense, as an emerging discipline of educational research, LA uses techniques to facilitate virtual tutors' work and improve the teaching-learning processes.

The work of [34] presents that LA can be used to improve student participation and performance in VLEs and that the virtual tutor can make use of the data collected and analyze the contexts in which teaching practice is developed to improve it. On the other hand, [35] demonstrates that by applying LA in teaching practice, it is possible to analyze login behaviors, resource utilization, questionnaires, academic performance, and student engagement. Also,

in [36], it is highlighted that LA can be used to predict students' learning performance and promote adaptive learning.

One of the studies conducted in the context of the COVID-19 pandemic [37] used LA techniques to make online learning predictions through educational materials provided to students. With the current situation, there has been a paradigm shift within the educational sector, and LA has provided insight into the impact of visual media on educational platforms [38]. Another study [39] shows how LA's use helped the teacher adapt teaching to this sudden change to an online learning environment.

All studies have shown that LA can have different uses and that when the teacher is interested in its use, he/she can find it a valuable tool to develop learning management.

3. Research Model and Hypotheses

The structural equation model (SEM) was used to carry out the study, which is characterized by: (1) assessing both multiple and cross-dependent relationships and (2) representing unobserved concepts in the relationships, taking into account measurement error in the estimation processes [40, 41]. SEM adopts a confirmatory approach to analyzing a structural theory about some phenomenon [42, 43]. The theoretical model presented in Fig 1 was structured under TAM proposed by [44], which aims to explain and predict information technology's acceptability by analyzing and exploring the factors that influence the acceptability of given information technology [45].

To explain the technological acceptance perceived by USAC professors in the use of virtual learning environments (VLE) implemented for emergency remote teaching, four variables were contemplated:

- **Perceived usefulness (PU):** the degree to which a person believes that the use of a particular system would be effortless, i.e., free of difficulty [46].
- **Perceived ease of use (PE):** the degree to which a person believes that a system would improve their job performance and make more effort if using it provided incentives such as raises and promotions [44].
- **Attitude toward using (A):** any favorable or unfavorable evaluation of a given behavior [47].
- **Behavioral intention to use (I):** recommendation to others and continued use [48].

Following the objective of this study, the following hypotheses are proposed and will be tested:

H1: Attitude toward the VLE has a direct and positive influence on using the VLE.
H2: Perceived usefulness has a direct and positive influence on the attitude towards the VLE.
H3: Perceived ease of use has a direct and positive influence on attitude toward the VLE.
H4: Perceived ease of use has a direct and positive influence on perceived usefulness.
H5: There are differences between interest in using the LA and perceived usefulness of the VLE.
H6: There are differences between interest in LA use and perceived ease of use of VLEs.

The first 4 hypotheses seek to respond to RQ1 and the last 2 to RQ2.

4. Research Method

4.1 Study Context

The research was carried out in the context of the Universidad de San Carlos de Guatemala (USAC); a generalist institution with more than 200,000 students distributed in 10 faculties, 9 non-faculty schools, 22 departmental university centers, and 2 technological institutes, with 10,989 teachers and 5,734 administrative and service workers [49], with an educational system at the service of the population and coverage in all departments of the country through university centers. As a result of the health emergency, actions were carried out in three priority areas: (1) policy implementation, (2) administrative management and, (3) academic strengthening.

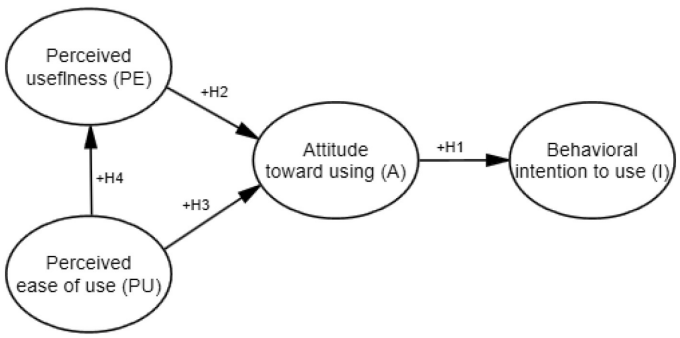

Fig. 1. TAM Theoretical Model.

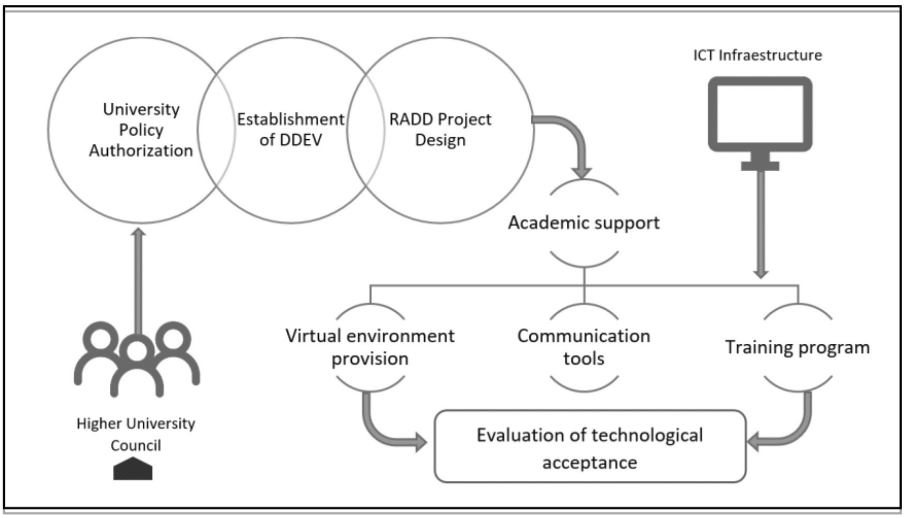

Fig. 2. USAC Pandemic Context.

In the sequence of actions, the first was carried out in 2019, when the University Superior Council – CSU – authorized the Distance Education Policy in Virtual Environments – DEPVE –, to regulate all non-face-to-face education modalities [50, 51]. As a result, the Division of Distance Education in Virtual Environments (DDEVE) was subsequently formed, a body whose main function is to implement the policy through planning, organization, direction, execution, evaluation, and monitoring of educational practices through virtual media, based on educational development and innovation in the various modalities [49].

In response to the emergency of the suspension of on-site activities and national confinement, when it was speculated that the country would soon be affected, the DDEV designed the project: Digital Teacher Support Network (RADD), to guarantee the continuity of educational services in the event of the closure of physical facilities, derived from any factor that puts the integrity of the university community at risk [52]. This network contemplated three technological strategies that allowed the teachers of the academic units of USAC to continue with normality the development of the contents of their courses through digital tools [49]: (1) virtual classrooms through the Moodle platform, (2) videoconferencing system through Google Hangouts Meet and (3) programming of teacher training and updating.

The implementation of the RADD program, proposed by the DEDEV, was carried out in the different degrees of the School of Engineering, especially in the Science and Systems Engineering and Virtual Education specialization for the Higher Level taught in that house of studies.

Fig. 2 presents the context in which actions were developed due to the COVID-19 pandemic to continue with learning at the national level at USAC.

4.2 Participants

The sample consisted of 345 professors from various academic units of the USAC. This group consisted mostly of women (61%). The age range was between 24 and 59 years (M = 41.10; SD = 8.61). In terms of educational level, 100% had at least a bachelor's degree. Regarding the time of experience using virtual learning environments in their teaching practice, 54% had more than two years of experience using them, and 46% had less than one year. Regarding the completion of training courses on virtual learning environments, 81% have received at least one course of this nature. More than half (66.1%) are not familiar with the concept of Learning Analytics. The above variables are shown in Table 1.

4.3 Instrument

To measure the relationships between the variables, an instrument composed of 40 items divided into nine dimensions was used: (D1) Perceived usefulness in teaching-learning strategies; (D2) Perceived usefulness in evaluation activities; (D3) Perceived usefulness of educational communication tools; (D4) Ease of use when developing teaching-learning strategies; (D5) Ease of use when developing evaluation activities; (D6) Ease of use of educational communication tools; (D7) Attitude towards use; (D8) Intention to use the VLE, and, (D9) Intention to use the LA. Each construct was measured via a 5-point Likert-type scale (ranging from 1 = strongly disagree/unlikely to 5 = strongly agree/very likely).

Table 1. Frequency characteristics and percentages of study participants

Variable	N	%
Gender		
Female	210	61%
Male	135	39%
Age group		
24 to 30	40	11.6%
31 to 40	130	37.7%
41 to 59	175	50.7%
Level of study		
Bachelor's degree	169	49%
Master's degree	150	43%
Doctorate	26	8%
Time using a VLE		
First time	20	5.8%
Less than one year	138	40%
More than two years	187	54.2%
Training in the use of VLE		
None	17	4.9%
This is the first time	48	13.9%
Less than three	138	40%
More than four	142	41.2%
Interest in LA		
Low	68	19.7%
Medium	112	32.5%
High	165	47.8%
Total	345	100%

4.4 Procedure

4.4.1 Structural Equation Modeling (SEM) – RQ1

Initially, a confirmatory factor analysis (CFA) was performed for each of the scales (usefulness, ease, attitude, and intention) to assess the evidence of validity based on the scales' internal structure. The process began with calculating the polychoric correlations matrix for each scale, given the ordinal nature of the items (Likert type). The estimator used was the WLSMV (weighted least squares with mean and variance adjusted); this estimator was used because of its robustness for dealing with ordinal type indicator scales [53, 54].

The overall evaluation of the fit of each CFA and the general model was obtained with the comparative fit index (CFI), Standardized Root Mean Square Residual (SRMR), and the Root mean square error of approximation (RMSEA). Values ≥ 0.90 in CFI are interpreted as favorable evidence of model fit [55], as well as ≤ 0.08 for RMSEA and SRMR [56].

For the reliability analysis, consistency analysis was considered with the alpha coefficient and the omega coefficient [57]. The omega was used because of the limitations of the alpha coefficient [58, 59].

To evaluate the structural model (Fig. 1) that describes the research hypotheses under an explanatory relationship between the variables studied, the sum of each item according to the dimension was performed to obtain a single indicator for each dimension of the scale. Meanwhile, the estimator used was the MLR (robust maximum likelihood); it was used for its robustness to treat numerical variables and with multivariate normality corrections involved in the inferential results such as the standard error of estimation [53, 60].

The CFA procedures' software was the lavaan package in its version 0.6–3 in R Studio [61]. The polychoric correlation matrices' estimation was the psych package in version 1.8.12, also in R Studio. IBM SPSS Statistics software version 26 was used for descriptive analysis and initial database management.

4.4.2 One-way ANOVA – RQ2

To carry out the analysis of teachers' interest in LA, a one-way ANOVA was performed to compare the mean scores of the variables considered concerning the three levels of interest in LA's use. To obtain the levels of interest, all items were summed (number), and then three groups were constructed with the total obtained: low, medium, and high. Finally, all the usefulness scores were added to obtain a total and the same for ease.

4.4.3 Interpretation and Documentation – RQ3

In order to identify the good practices that have been implemented at USAC to carry out emergency remote teaching, an interpretation of the answers given by the professors in the open response questions was carried out, based on the experiences that they presented, a web review was carried out in the information portals of the academic units, especially those corresponding to engineering and systems, and documentary research techniques were also developed in order to locate relevant information for the study.

5. Results

5.1 Technological Acceptance of Teachers in the use of VLE – RQ1

Initially, to develop the SEM structural model, evidence of validity based on the internal structure was carried out using the AFC for each scale involved in the analysis. For this purpose, the respective polychoric correlation matrices shown in Tables 2 to 5 were obtained.

5.1.1 CFA for Utility

A first result from Table 2 with the WLSMV estimator, indicated an inadequate fit to the three-

Table 2. Matrix of polychoric correlations of the Utility items with three dimensions

Ítem	PE1_1	PE1_2	PE1_3	PE1_4	PE1_5	PE2_1	PE2_2	PE2_3	PE3_1	PE3_2	PE3_3	PE3_4	PE3_5
PE1_1	–												
PE1_2	0.85	–											
PE1_3	0.80	0.91	–										
PE1_4	0.81	0.84	0.85	–									
PE1_5	0.76	0.70	0.72	0.82	–								
PE2_1	0.81	0.83	0.81	0.82	0.81	–							
PE2_2	0.81	0.83	0.83	0.81	0.77	0.90	–						
PE2_3	0.81	0.82	0.81	0.79	0.71	0.87	0.90	–					
PE3_1	0.72	0.76	0.79	0.79	0.74	0.75	0.74	0.74	–				
PE3_2	0.79	0.86	0.88	0.85	0.70	0.83	0.80	0.82	0.81	–			
PE3_3	0.82	0.82	0.79	0.81	0.77	0.81	0.81	0.81	0.82	0.88	–		
PE3_4	0.73	0.69	0.71	0.80	0.81	0.77	0.74	0.70	0.84	0.77	0.83	–	
PE3_5	0.73	0.79	0.76	0.70	0.60	0.73	0.76	0.78	0.73	0.80	0.76	0.68	–

Note: Perceived usefulness of the teaching-learning strategies, PE2 = Perceived usefulness of evaluation activities; PE3 = Perceived usefulness of educational communication tools.

Table 3. CFA results for Utility with three dimensions

Dimension	Item	D1	D2	D3
Perceived usefulness of teaching teaching-learning strategies	PE1_1	0.85		
	PE1_2	0.89		
	PE1_3	0.88		
	PE1_4	0.88		
Perceived usefulness of evaluation activities	PE2_1		0.92	
	PE2_2		0.91	
	PE2_3		0.90	
Perceived usefulness of educational of educational communication tools	PE3_1			0.82
	PE3_2			0.90
	PE3_3			0.92
	PE3_4			0.79
	PE3_5			0.80
Correlation between factors				
Dimension 1 (D1)		–		
Dimension 2 (D2)		0.93	–	
Dimension 3(D3)		0.96	0.91	–

factor correlated model, χ^2(45) = 92.6; CFI = 0.945; RMSEA = 0.094 and SRMR = 0.076. According to the reading of the modification indexes and reviewing the items' content, it is concluded not to consider item U1_5. From the above it is concluded in a structure with satisfactory fit, χ^2(41) = 77.79; CFI = 0.921; RMSEA = 0.051; SRMR = 0.026 and the standardized factor loadings for the AFC are between the values λ = 0.79 and λ = 0.91 and the correlations between factors are between r = 0.91 and r = 0.93 as can be seen in Table 3.

5.1.2 AFC for Ease

Table 4 was used to obtain the fit using the WLSMV estimator, the results indicate a satisfactory fit, χ^2(32) = 50.51; CFI = 0.966; RMSEA = 0.041; SRMR = 0.024. Meanwhile the standardized factor loadings for the AFC are between the values λ = 0.31 and λ = 0.95 and the correlations between factors are between r = 0.91 and r = 0.94 as shown in Table 5.

5.1.3 AFC for Attitude

From Table 6 the fit indices were obtained using the WLSMV estimator. The results showed a satisfactory fit, $\chi^2(9)$ = 12.86; CFI = 0.988; RMSEA = 0.034; SRMR=0.017 and the standardized factor loadings for the AFC are between the values λ = 0.71 and λ = 0.87.

5.1.4 CFA for intention to use

A first result from Table 7 with the WLSMV estimator indicated an inadequate fit to the one-factor model for intention to use χ^2(9) = 71.03; CFI = 0.735; RMSEA = 0.142; SRMR = 0.046.

Table 4. Matrix of polychoric correlations of the Ease items with three dimensions

Item	PU1_1	PU1_2	PU1_3	PU1_4	PU2_1	PU2_2	PU2_3	PU2_4	PU3_1	PU3_2
PU1_1	–									
PU1_2	0.38	–								
PU1_3	0.36	0.85	–							
PU1_4	0.36	0.77	0.82	–						
PU2_1	0.32	0.85	0.84	0.82	–					
PU2_2	0.28	0.76	0.74	0.70	0.81	–				
PU2_3	0.36	0.73	0.76	0.78	0.83	0.78	–			
PU2_4	0.33	0.68	0.76	0.71	0.76	0.79	0.82	–		
PU3_1	0.31	0.76	0.76	0.82	0.78	0.69	0.76	0.73	–	
PU3_2	0.38	0.76	0.79	0.73	0.78	0.69	0.75	0.76	0.81	–

Note: PU1 = Ease of use when developing teaching-learning strategies. PU2 = Ease of use when developing evaluation activities; PU3 = Ease of use of educational communication tools.

Table 5. AFC results for Ease with three dimensions

Dimension	Item	D4	D5	D6
Ease of use when developing teaching-learning strategies	PU1_1	0.87		
	PU1_2	0.85		
	PU1_3	0.86		
	PU1_4	0.85		
Ease of use when developing evaluation activities	PU2_1		0.90	
	PU2_2		0.87	
	PU2_3		0.86	
	PU2_4		0.83	
Ease of use of the educational communication tools.	PU3_1			0.84
	PU3_2			0.86
Correlation between factors				
Dimension 4 (D4)		–		
Dimension 5 (D5)		0.94	–	
Dimension 6 (D6)		0.95	0.92	–

Table 6. Matrix of polychoric correlations of the Attitude items with one dimension

Item	A_1	A_2	A_3	A_4	A_5	A_6
A_1	–					
A_2	–0.10	–				
A_3	0.57	–0.14	–			
A_4	0.67	–0.03	0.72	–		
A_5	0.69	–0.14	0.70	0.83	–	
A_6	0.69	–0.14	0.67	0.79	0.81	–

Note: A = Attitude towards the use of the VLE.

According to the reading of the modification indexes and reviewing the content of the items, it is concluded not to consider items In_2 and In_4. From the above it is concluded in a structure with satisfactory fit, χ^2(2) = 3.18; CFI = 0.992; RMSEA = 0.041; SRMR = 0.011 and the standardized factor loadings for the AFC are between the values $\lambda = 0.73$ and $\lambda = 0.88$.

On the other hand, Table 8 shows that the mean and standard deviation for the scores of the dimensions representing each construct presented a significant variability, which means that the respondents were positioned throughout the scale range from 1 to 5 points. Likewise, when evaluating each dimension's internal consistencies, Table 9 shows that the estimated alpha and omega coefficients were higher than the 0.70 threshold suggested by [62, 63], which accumulates evidence of acceptable reliability for each dimension and therefore for each particular scale.

5.1.5 Evaluation of the Hypothetical Model

Prior to the evaluation of the model, the addition of the each of the items was performed in order to

Table 7. Matrix of polychoric correlations of the Intention items with one factor

Item	I_1	I_2	I_3	I_4	I_5	I_6
I_1	–					
I_2	0.77	–				
I_3	0.72	0.63	–			
I_4	0.72	0.63	0.77	–		
I_5	0.83	0.89	0.72	0.78	–	
I_6	0.84	0.81	0.73	0.75	0.88	–

Note: I = Intention to use the VLE.

Table 8. Reliability analysis of variables

Construct	Dimension	M	SD	Alpha	Omega
Usefulness	Perceived usefulness of teaching-learning strategies	4.34	1.02	0.930	0.930
	Perceived usefulness of evaluation activities	3	1.09	0.934	0.935
	Perceived usefulness of educational communication tools	4.21	1.08	0.923	0.924
Ease of use	Ease of use in developing teaching-learning strategies	3.92	1.05	0.818	0.839
	Ease of use in developing evaluation activities	3.98	1.04	0.914	0.915
	Ease of use of educational communication tools	3.09	1.07	0.853	0.856
Attitude	Attitude towards the use of the VLE	3.42	1.09	0.803	0.845
Intention	Intention to use the VLE	3.16	1.01	0.910	0.911

Note: M = Mean. SD = standard deviation.

obtain a single indicator for each dimension as shown in Fig. 3 and given the variability in the indicators, the MLR estimator was chosen for its robustness with numerical variables and multivariate normality correction (Muthen and Muthen, 2017). The overall fit for the model indicates a good fit, χ^2(18) = 31.10; CFI = 0.995; RMSEA = 0.046; SRMR = 0.016.

Regarding the structural results, Table 9 shows the results of the research hypotheses. The findings indicate that the signs of the parameters representing the hypotheses are as expected. In other words, H1, the direct and positive influence of the attitude towards the ELV and the intention to use it, is verified, given that the regression coefficient is high and statistically significant β = 0.94: p < 0.001. Similarly, H2 the influence of perceived usefulness β = 0.26; p < 0.001; H3 the influence of perceived Ease on attitude towards the use of the VLE β = 0.67; p < 0.001 and H4 the influence of perceived Ease on perceived Usefulness β = 0.78; p < 0.001 are verified. Likewise, the variability explained in Usefulness is 61%, Attitude 79%, and Intention 88%.

5.2 Niveles de interés de los profesores en el uso de LA – RQ2

To explain teachers' interest in using the LA, a one-way ANOVA was performed to compare the mean

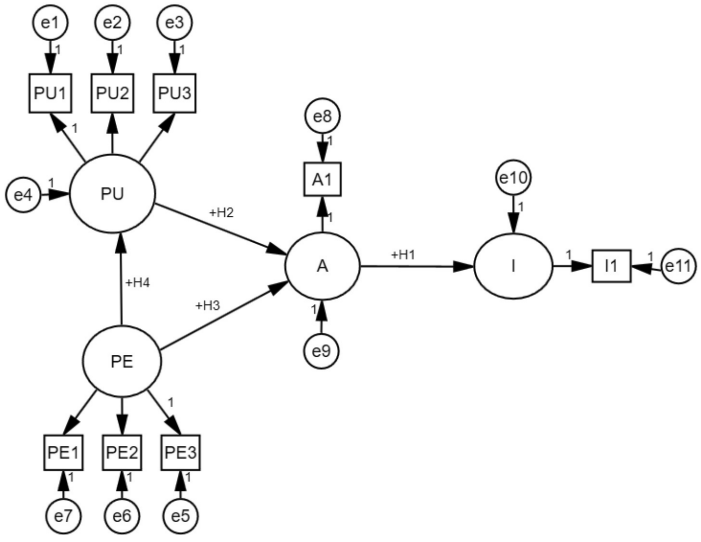

Fig. 3. Structural model of the dimensions of the TAM.

Table 9. Evaluation of the structural model

Parameter	β	R^2	Hypothesis	Decision
Ease → Utility	0.78***		H4	Accept
		0.61		
Utility → Attitude	0.26***		H2	Accept
Facilidad → Attitude	0.67***		H3	Accept
		0.79		
Attitude → Intention	0.94***		H1	Accept
		0.88		

Note: *** p< 0.001; β = standardized estimate.

scores of Usefulness (M = 42.43; SD = 9.25) and Ease (M= 35.79; SD = 7.68) concerning the three levels (Table 1) of interest in using the Learning Analytic. Differences in Usefulness (F (2, 342) = 95.56; p = 1.09E-33) and Ease (F (2, 342) = 130.34; p = 8.37E-43) were found for each level of interest. Table 10 shows the post hoc comparisons assuming variances other than Games-Howell. The results indicate statistically significant differences ($p < 0.05$) for each level evaluated.

Taken together, these results suggest that the levels of interest in the Learning Analytic have a positive effect on the perceived usefulness and perceived ease of using the VLE in the participants studied. Specifically, the findings show that the higher the level of interest in the Learning Analytic, the higher the score or the rating on the Perceived Usefulness and Ease of using the VLE. Likewise, the effect size through eta squared (η^2) for Ulility (η^2 = 0.36) and Ease (η^2 = 0.43). Overall, each construct's levels of interest can be considered to have a small to medium effect [64].

5.3 Best Practices Implemented at USAC During the COVID-19 Pandemic

The digital acceleration brought about by the COVID-19 pandemic implied great challenges and actions that would allow the digital transformation and monitoring of activities related to administration, research, teaching and university outreach. These challenges implied technological strengthening at the university level, since the situation demanded social distancing and, in this sense, the implementation of technologies contributed to continue with the university's work. As part of the best practices, the following are considered: (a) virtual environment provision; (b) communication tools, (c) training program (d) evaluation of technological acceptance (e) computer systems for student attention; (f) volunteer programs; (g) research calls; (h) design of hospital devices; (i) web storage systems and (j) information portals that are grouped in the following categories.

5.3.1 University Management

To continue with the administrative processes, the university implemented computerized systems to assist students in administrative management and the loan of technical equipment.

5.3.1.1 Loans of Technical Equipment

The educational resource center and the central library made available the loans of technical equipment such as tablets and laptops for students and

Table 10. Levels of interest in the use of LA

Construct	I	J	I-J	SD	Sig.
Usefulness	Low *(M= 32.21)*	Medium *(M= 41.93)*	–9.72269*	1.14208	*
		High *(M= 46.98)*	–14.76988*	1.07055	*
	Medium *(M= 41.93)*	Low *(M= 32.21)*	9.72269*	1.14208	*
		High *(M= 46.98)*	–5.04719*	0.90952	*
	High *(M= 46.98)*	Low *(M= 32.21)*	14.76988*	1.07055	*
		Medium *(M= 41.93)*	5.04719*	0.90952	*
Facility	Low *(M= 26.53)*	Medium *(M= 35.22*)	–8.69380*	0.89238	*
		High *(M= 39.99)*	–13.46453*	0.83648	*
	Medium *(M= 35.22)*	Low *(M= 26.53)*	8.69380*	0.89238	*
		High *(M= 39.99)*	–4.77073*	0.71067	*
	High (*M= 39.99)*	Low *(M= 26.53)*	13.46453*	0.83648	*
		Medium *(M= 35.22)*	4.77073*	0.71067	*

Note: M = Mean; * p < 0.005; = Standard deviation.

teachers who did not have the necessary equipment to develop distance learning academic programs. This practice was beneficial because it facilitated the execution of the process.

5.3.1.2 Web Storage System

USAC invested in technological infrastructure for web storage of virtual classrooms and, in this way, offer an optimal service because of the extensive demand of users it has.

5.3.2 Research

The university developed calls for proposals for the development of science-based university initiatives that contribute to Guatemalan society to understand or mitigate the impact of Covid-19. In addition, the Fabrication Laboratory Fab-Lab was created, where face shields and hospital protection devices were massively designed for the intubation process of patients with respiratory problems.

5.3.3 Teaching

To continue with the teaching-learning processes at the university, different actions were developed in which educational platforms, communication systems, the development of information applications and the development of training and updating programs were implemented.

5.3.3.1 Virtual Environment Provision

The Division of Distance Education in Virtual Environments (DDEVE), through the RADD program, designed virtual learning environments (VLE) based on the Moodle LMS for the different academic units, non-faculty schools, and university centers of the USAC and to support users in the implementation and use of these VLEs, a collection of multimedia materials and resources such as manuals for teachers and students was designed.

5.3.3.2 Communication Tools

To continue with the classes and to ensure that the process was not interrupted, teachers were provided with an institutional e-mail to facilitate synchronous distance sessions. The DDEV, through the RADD program, facilitated three scenarios to continue with the communication processes of this nature, utilizing 3 digital tools.

- **Tool #1. Collaboratory.** This tool was developed from BigBlueButton, an open-source web conferencing system. Most frequently, this option was used by the administrative sector, University Superior Council, Boards of Directors of academic units, commissions, and other entities with administrative purposes.
- **Tool #2. Google Meet.** With the creation of institutional e-mails, professors used Google Meet with great acceptance as a tool to develop synchronous learning management processes. Particularly because it allowed cloud recording of video lectures, it is important to highlight that the virtual classroom structured in the Moodle LMS is the official means of direct communication, where the links to enter the session are incorporated and, also, the recorded sessions are shared so that students can watch them asynchronously.
- **Tool #3. Cisco Webex Meeting.** As a result of various agreements, USAC acquired Webex licenses for professors and research personnel, but it was mostly used by the research teams, considering data safeguarding.
- **Tool #4. WhatsApp.** To find tools to strengthen tutoring, WhatsApp groups by the subject were formed in the teaching sector. Although it was not a generalized practice, many teachers have indicated that they use this tool to develop processes of accompaniment and follow-up of students.

5.3.3.3 Training Program

From the training programs that were promoted, the teaching staff changed teaching and learning strategies, implemented new evaluation activities, innovated with the application of communication tools for learning management in a distance emergency environment. Among the teacher education and training programs, the following stand out (Table 11):

(a) Diplomate in digital teaching
(b) E-training

5.3.4 University Outreach

USAC developed services to the population such as: (a) online medical consultations; (b) implementation of the popular clinical laboratory to analyze Covid-19 tests; (c) informative portals about Covid-19; and (d) development of a volunteer program for Covid-19 care.

6. Finding and Discussion

This study's results reveal a direct and positive influence of the attitude of use on the intention to use the VLE (H1), and this attitude is influenced by the perceived usefulness of the teachers (H2). Consequently, when the teacher perceives that using the VLE is easy, this directly and positively influences the attitude (H3) and usefulness for its use (H4).

In the context of the study, [27–29] demonstrated that technological acceptance of using VLE develops from the direct and positive influence of per-

Table 11. Description of the training program

Descriptor	Diplomate in digital teaching	E-Training
Conceptualization	Teacher training programs teach and learn through digital environments and thus develop techno pedagogical skills that help them have a better performance in their work as educators and achieve significant learning in their students.	A set of training programs conducted through electronic/digital media, usually with an internet connection. The resources used are; videos, presentations, interactive texts, links, or any other element that can be accessed online.
Design	Open-virtual; the learning modules are open in four different sequential forms to be addressed according to the users' training needs and learning pace.	At the user's pace, providing the freedom to define when and where the training starts. Contents, examples, templates, and practice spaces are provided for practice.
Approach	Socio-constructivist; learning by doing in a network (connectivism, constructionism).	Socio-constructivist; learning by doing in a network (connectivism, constructionism).
Approval/ certification	It is continuous; it is approved by completing the four learning modules' activities (8 learning activities, 4 evaluation tests, participation in the live classes, and the communication forums). Each module is equivalent to 25% of the Diplomate.	Complete teaching practice exercises in virtual learning environments enabled for this purpose.

ceived ease toward attitude toward use (H3) and usefulness (H4). This usefulness influences attitude (H2), and attitude influence the intention to use the VLE (H1).

On the other hand, [30] reveals several findings where perceived usefulness perception and ease of use are the main determinants of user attitudes. That is, if there is perceived ease and usefulness, this will influence the attitude towards usage. Consequently, the study of [31] shows that an important determinant of acceptance in the use of technology is perceived usefulness and that this influences the intention to adopt the technology.

Regarding teachers' interests in the use of LA, it was found that the higher the teacher's level of interest, the higher the rating in perceived usefulness (H5) and perceived ease (H6) on the use of the VLE.

In the work of [34–36], the LA can be used to improve participation, learning achievement, and student engagement. In a sense, when the teacher is interested in improving these aspects, he/she will be interested in using the VLE. He/she will value them as easy and useful tools to develop learning management.

Finally, regarding the practices implemented at USAC during the pandemic, it is discussed that the institution acted quickly in the situation of the closure of the institution; however, the training of professors and the implementation of a solid structure that would allow effective interaction constituted a significant challenge due to the number of users and requests in the system. The actions taken were quick and timely, considering the following as good practices: (a) technological strengthening; (b) implementation of policies; (c) implementation of educational platforms; (d) implementation of communication tools; (e) computer systems for student services; (f) volunteer programs; (g) research calls; (h) design of hospital devices; (i) web storage systems; and (j) information portals, among others. In the work presented by [19], weaknesses of the technological infrastructure, little experience of teachers, and the difficulties of continuing the educational processes from home are presented, on the other hand, some good practices that were implemented in some universities were: (a) implementation of policies [18], academic frameworks for sustainable management of higher education [21], (c) restructuring of curricula [24], (d) implementation of educational platforms [22], virtual classes [20], among others. As in these institutions, the authorities' rapid response and the creation of an implementation model that would allow the educational processes to continue were important.

Among the difficult challenges to overcome in emergency remote teaching is the massive assessment of learning. Although tools have been used to create supervised environments, it has been identified that some users have engaged in impersonation practices. This has an impact on the quality of education, especially in scientific areas. Another element identified was the difficulty of incorporating dynamic virtual classes with large groups of students. Since it is the only autonomous university in the country, each academic unit's student population is large.

Concerning the lessons learned during the pandemic, it can be said that teachers need to strengthen digital competencies in the use of learning analytics to optimize learning processes in the university classroom. It is also important that the good practices that have been strengthened since the beginning of the confinement, should continue to be practiced, even when returning to the new normality; this should be planned based on the positive experiences that these good practices brought with them, such as the systematic agility to carry out administrative processes, the versatility of exchanging information between teachers and

students, the ease with which academic research networks are built and especially the advantage of using learning analytics to intervene on time in tutoring and mentoring.

In this context, within the expectations, it is necessary to consider that some practices do not fully comply with the pedagogical intention or the achievement of certain competencies; although the practices and laboratories have been adapted, they should be rethought contemplating a fusion of what was done before the health emergency, with the elements of innovation and technology used during the pandemic, to generate a robust version that allows strengthening the procedural contents of the academy.

7. Conclusions

The present study developed a theoretical model that assessed teachers' technological acceptance of virtual learning environments (VLE) in emergency remote teaching. Besides, it compared the levels of interest of the teachers in the use of Learning Analytics (LA) and its effect on the perceived usefulness and ease of using VLEs. Finally, USAC's best practices for dealing with emergency remote teaching in the wake of the pandemic were described.

To evaluate technological acceptance in VLE, a questionnaire based on the Technology Acceptance Model (TAM) was distributed to professors from different academic units of USAC, and 345 responses were returned. The construct validity was measured through confirmatory factor analysis, and the reliability of the measurement was carried out with a consistency analysis through the alpha and omega coefficients.

The hypothesized model was evaluated using the SEM technique. The main conclusion indicates that teachers have perceived that using VLEs in teaching practice is easy; perceiving its ease, they consider it useful. Knowing that it is easy and that it is also useful, favors a positive attitude, which has an impact on the intention to use it properly; this means that even when returning to the classroom, teachers will continue to use those elements that are easy and useful, with a favorable and intentional attitude.

To compare the levels of teachers' interest in using Learning Analytics (LA) and its effect on perceived usefulness and ease of using VLE, a one-way ANOVA was applied. After establishing the levels, they were compared. It was immediately determined that those who show greater interest in the use of LA value more the perceived ease and usefulness in the use of VLE. In other words, the greater the interest in LA's use, the greater the acceptance of the use of VLE.

To identify good practices in the framework of higher education in times of pandemic, a web review and documentary research was carried out based on the answers obtained in the open-ended questions. Among the actions that will undoubtedly remain in force because they make up the accumulation of good practices of the USAC in the last academic year, the following stand out: (a) implementation of institutional policy to develop virtual and distance education; (b) creation of the unit responsible for implementing the policy and everything related to virtual or remote emergency education, as in this case; (c) design of a teacher support network to alleviate the need for training and support; (d) implementation of virtual learning habitats for each academic unit; (e) provision of communication tools for teaching practice; (f) design of a systematic training program and training for teachers; and digital orientation for students.

It is important to highlight that this research shows that in the midst of a situation such as the one the world has experienced, caused by the pandemic, professors are willing to acquire new competencies, to rethink their role, to innovate, and to apply technology as a means to improve teaching processes in higher education.

Considering the need to improve teaching practice in the Guatemalan context, this article presents higher education opportunities to respond to the educational problems that arise due to the COVID-19 pandemic. This research is of relevance for the university and for the construction of new knowledge based on the TAM model and contributing to the potential of LA for virtual tutoring and for overcoming the challenge of virtual education as a consequence of the Covid-19 pandemic.

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