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Digital Communication: Information and Communication Technology (ICT) Usage for Education Sustainability

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Abstract: Today, developments in information and communication technology (ICT) have a significant influence on education sustainability. In this study, the factors influencing students' intentions towards using ICT in education sustainability, as well as their satisfaction from its use, were examined. This study aims to investigate student intentions to use information and communication technology, as well as their satisfaction with such use. Therefore, this study employed an extended model of the Technology Acceptance Model (TAM) as the research framework, and adopted quantitative data collection and analysis methods by surveying 502 university students who were chosen through stratified random sampling. Using structural equation modeling (SEM), student responses were sorted into eight study constructs and analyzed to explain their intentions towards technology use and satisfaction. A significant relationship was found between computer self-efficacy (CSE), subjective norms (SN), and perceived enjoyment (PE), which were significant determinants of perceived ease of use (PEU) and perceived usefulness (PU). PEU, PU, and attitudes towards computer use (ACU) influenced students' intentions to use (SIU) ICT and students' satisfaction (SS). The constructs succeeded in explaining usage intentions towards ICT among students and their satisfaction from this usage.

Keywords: Technology Acceptance Model (TAM); information and communication technology (ICT); computer self-efficacy; structural equation modeling (SEM); students' satisfaction

1. Introduction

Information and communication technology (ICT) has had a tremendous influence on aspects of our lives (professional and personal) by improving knowledge sharing and increasing information and communication flow. Ongoing ICT development has led to innumerable challenges for individuals. ICT has transformed work processes in organizations, has caused paradigm shifts in the educational sector, and has changed student learning methods. The former consists of physical telecommunication systems and networks in the form of cellular, voice, mail, radio, and television technologies, whereas the latter consists of the hardware and software required to collect, store, process, and present information [1]. Sarkar [1] brought forward the notion that female empowerment and societal education are primary development strategies, and that technology use in enhanced learning elevates women and unlocks their potential to contribute to society [1].

The core of ICT is comprised of software, hardware, networks, and media, which are primarily utilized to gather, present, process, store, and transmit information via voice, data, text, and images,

as well as providing other services. There are two components of ICT, namely Information and Communication Infrastructure (ICI and ICT). The use of an ICT infrastructure in technology-enhanced learning enables efficient educational sustainability using ICT tools and their processes [2]. In many countries, ICT infrastructure availability is one of the main concerns for education [1]. The ultimate influence of ICT on education sustainability is still being discovered [3]. ICT-improved education sustainability is defined as the application of ICT in learning and teaching, which supports learning and teaching processes, delivery mechanisms, and design parameters to enhance knowledge [4].

An answer to this problem is the use of modern ICTs and technology-enhanced learning (TEL) tools in education sustainability while maintaining international standards of education [5]. Evidently, there has been a tremendous contribution from ICT to teaching quality. Such technologies have led to enhanced teaching and learning using dynamic interactive and engaging content and have opened up opportunities for instructions to be individually catered. According to Roztocki and Weistroffer [6], ICT research has not provided an overall view of the current situation, as it mainly focuses on a few developed nations. In general, assessment is an indispensable aspect of teaching, training, and learning.

According to Bennett, Dawson, Bearman, Molloy, and Boud [7], assessment is an important factor for student engagement, as it has a critical impact on both student learning and certification. Despite the ubiquity of ICT applications, there have been few investigations into the contributing dimensions of ICT satisfaction in tertiary education sustainability [8,9]. According to Wu, Tennyson, and Hsia [10], satisfaction is the most recognized measurement of quality and usefulness in teaching and learning.

Despite technology playing a crucial role in promoting efficient instructions, there is evidence that students do not always apply technology in a way that maximizes its effect on teaching and learning [11]. In such a case, satisfaction could be one of the reasons why students are not willing to frequently use ICT in their teaching and research activities in universities. Nevertheless, teachers' gratification in using ICT in the context of education sustainability has rarely been assessed. Lacking an assessment, it is not clear how best to train and support teachers in effective technology integration in learning and instruction [8].

Therefore, a starting point for assessing and then designing technology integration training is to assess ICT uses and attitudes among students to see to what extent they adopt and are satisfied with using available ICTs. Therefore, this study aims to investigate students' intentions to use (SIU) ICT (SIU-ICT) as well as their satisfaction with such use. This study backs the Technology Acceptance Model (TAM) literature by investigating the relationship between the TAM variables, SIU-ICT, and students' satisfaction (SS) with ICT.

Consequently, this study employed eight factors: computer self-efficacy (CSE), subjective norms (SN), perceived enjoyment (PE), perceived ease of use (PEU), perceived usefulness (PU), attitudes towards computer use (ACU), SIU-ICT, and SS; these factors will be explained later in Section 2. This study could be useful for developing and testing theories related to ICT scheme recognition, as well as for practitioners who design and encourage ICT in education sustainability. While the second part of the current study deals with the model development and hypotheses, the third part deals with research methodology and the fourth part deals with the results and analysis, as well as the discussion and implications. The last part of the study is the conclusion and describes future work.

2. Model Development and Hypotheses

The Theory of Planned Behavior (TPB) was proposed by [12] as an extension of the Theory of Reasoned Action (TRA) by [13]. In the TPB, behavioral intentions are influential behavior predictors, as argued by [12], which are influenced by ACU, SN, and perceived behavioral control. Additionally, stemming from the TRA is the Technology Acceptance Model (TAM) of Davis et al. [14], which assesses technology acceptance among users using various technological tools [15–18]. In this study, the TAM was adopted as the underpinning study framework to tackle the question as to how users accept and use ICT, specifically student ACU, intentions towards ICT usage, and satisfaction. Accordingly,

the proposed hypotheses for every construct were developed as described in Section 2.1, Section 2.2, Section 2.3, Section 2.4, Section 2.5, Section 2.6, Section 2.7.

2.1. Subjective Norm (SN)

SNs are an individual's beliefs on what the people around them think if they would perform or refrain from performing certain behavior [19]. In a study by [17], the authors evidenced a significant effect of SNs on PU, as well as behavioral intentions towards mandatory technology usage. With voluntary technology usage, a significant influence was still noted from SN on PU, but not on behavioral intentions. On the basis of the voluntary case findings, it is proposed that a similar result will occur in this study. The TAM was used by [20] to examine technology acceptance among 284 surveyed individuals, and the findings indicated that SNs significantly predicted PU and PEU, but had no direct influence on intentions towards technology usage, indicating an indirect influence of SNs on intentions towards technology usage via PU and PEU. Hence, this study proposes the following hypotheses:

Hypothesis 1 (H1). *SNs have a significant influence on the PU of technology among students.*

Hypothesis 2 (H2). *SNs have a significant influence on the PEU of technology among students.*

2.2. Computer Self-Efficacy (CSE)

CSE refers to an individual's belief in their ability to perform a certain task [21]. In a specific task, performance refers to a function of individual perceived self-efficacy. On the basis of the literature, CSE positively influences PEU and PU [22,23]. The hypothesis proposed for this construct is that perceived self-efficacy concerning ICT use is positively influenced by ICT usefulness and ease of use. In prior findings, such as those of [24–26], CSE was found to be a significant predictor of PU. It is argued that if students perceive that they have the capability to use computers, they will tend to use an ICT that allows them to be more productive in completing their tasks (PU). According to Durndell and Haag [27], the greater the CSE level, the better the ACU will be. Thus, this study proposes the following hypotheses:

Hypothesis 3 (H3). *The CSE of students significantly influences their ICT-PU.*

Hypothesis 4 (H4). *The CSE of students significantly influences their ICT-PEU.*

2.3. Perceived Enjoyment (PE)

PE refers to the level to which an activity offered by a Learning Management System (LMS) is perceived to be pleasant, independently of expected performance outcomes [28]. This construct can be viewed as a form of bi-perspective enjoyment from using ICT with friends and helping others [26]. In this study, the PE of students is defined as the level to which they enjoy using ICT. Thus, this study has the following hypotheses:

Hypothesis 5 (H5). *PE of students from using ICT significantly influences their PU.*

Hypothesis 6 (H6). *PE of students for using ICT significantly influences their PEU.*

2.4. Perceived Usefulness (PU)

PU is the level to which an individual is convinced that technology use will improve their work performance [14]. In this study, PU is the level to which students consider ICT use as enriching their learning experience. In recent studies, PU was evidenced to influence attitudes towards technology

and usage intentions [24,29–31]. Owing to the direct influence of PU on attitudes, it is assumed that it will have an indirect influence on intention towards technology usage and, therefore, this study proposes that:

Hypothesis 8 (H8). *PU of ICT significantly influences SIU-ICT.*

Hypothesis 9 (H9). *PU of ICT significantly influences students' ACU.*

2.5. Perceived Ease of Use (PEU)

PEU is the level to which a user is convinced that ICT use is effort-free. According to the findings of [14,32], when a technology is viewed as being easy to use, it is likely that individuals will develop a positive attitude towards it [24]. In this study, PEU refers to the level to which a student is convinced that ICT use is both easy and beneficial. While PU addresses a technology's impact on job performance, perceived ease is a technology's influence on performance processes [14]. As a consequence, this study proposes the following hypotheses:

Hypothesis 7 (H7). *PEU of ICT significantly influences students' PU of ICT.*

Hypothesis 10 (H10). *PEU of ICT significantly influences SS with ICT.*

Hypothesis 11 (H11). *PEU of computers significantly influences students' ACU.*

2.6. Attitude towards Use (ACU)

The literature shows that students' ACU are influenced by their classroom [33] or by their commitment to and acceptance of their learning tasks [34]. According to Davis et al. [14], PEU and the TAM affect PU, and, in combination, affect user approaches towards ICT usage. In a related study, PEU and PU were considered core signals for virtual course recognition [29,35]. PEU affects learners' ACU online learning systems (ICT) and their behavioral intentions towards using them. In this study, ACU for ICT use refers to the level to which students are convinced that using ICT enriches their learning, which, in turn, heightens their SIU-ICT. Therefore, this study proposes the following hypotheses:

Hypothesis 12 (H12). *The attitudes of students towards computer use significantly influence their intentions towards ICT use.*

Hypothesis 13 (H13). *The attitudes of students towards computer use significantly influence their satisfaction with ICT use.*

2.7. Student Intentions to Use ICT

An intention to use ICT refers to the inclination of an individual to use and continue using ICT. SIU-ICT is a determinant of technology use [36,37]. In this study, a student's intention towards ICT usage was their inclination to use ICT to increase their learning satisfaction. Using ICT for learning is a major element of developmental technology use models [14,32]. In the literature on technology acceptance, an intention towards use represents the inclination of an individual towards using a technology in the near future. It was used as an outcome variable in this study owing to its reliability in predicting actual technology use [24]. Hence, this study proposes the following hypothesis:

Hypothesis 14 (H14). *The intention of students to use ICT significantly influences their satisfaction with its use.*

2.8. Students' Satisfaction (SS) with ICT Usage

In this study, SS with technology use refers to the level to which a technology is aligned with their current values, needs, and experiences [9]. In this study, the satisfaction of students with using ICT for learning stems from the enrichment of such learning. Based on the TAM model of Davis et al. [14], PEU and PU were the primary components of technology acceptance among users. Additionally, based on the TSM model [8], these two antecedents were proven to be powerful enough to measure SS. More importantly, both PEU and PU were deemed to be significant user post-adoption beliefs that led to high levels of satisfaction and ongoing usage intentions [38]. In this regard, Kim [39] revealed that individuals that use ICT view their system interactions in a more positive light and form high intentions towards system use. As the underpinning theory is the TAM, the constructs considered in this study were SN, CSE, and PE, which were used to examine students' ACU, intentions towards ICT usage, and satisfaction. Overall, the research model was developed to contain and examine SN, CSE, PE, PU, PEU, ACU, SIU-ICT, and satisfaction among students' see Figure 1.

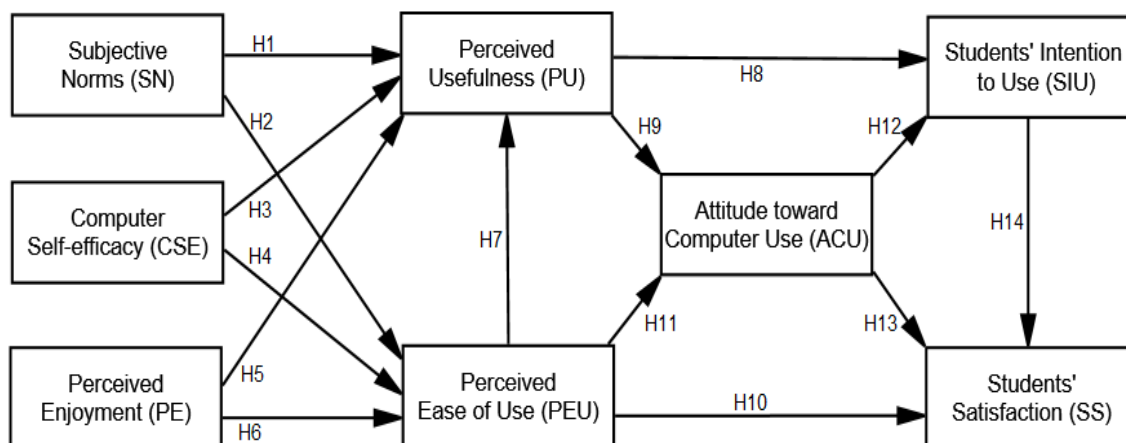


Figure 1. Research model and hypotheses.

3. Research Methodology

The use of available ICTs for education sustainability has been encouraged by many universities. Therefore, this research aims to develop a model of measurement of students' intention to use and their satisfaction through an empirical investigation of students' acceptance of ICT for education sustainability. The chosen study sample was comprised of undergraduate and postgraduate students (blended learning) that used ICT for learning. The survey items were gauged using a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree) for items comprised of the TAM constructs and demographic characteristics. Self-administration was adopted for survey distribution, and respondents were requested to provide feedback on the use of ICT, its influence on their satisfaction, and their intention towards using it in the future. The gathered data were then analyzed with the help of the Statistical Package for the Social Sciences (SPSS) and Partial Least Squares–Structural Equation Modeling (PLS-SEM) using Smart PLS 3.0 to confirm both the validity and reliability of the measurement model. For the model's goodness of fit, factor loadings were employed to ensure construct validity, composite reliability, Cronbach's alpha, and convergence validity, as recommended by Hair et al. [40].

3.1. Sample Characteristics and Data Collection

For the purpose of the study, we distributed 570 questionnaires, of which 557 were answered. After the manual analysis of the questionnaires, 19 of the 557 questionnaires were incomplete (students did not finish the survey) and had to be dropped, making the remaining number 538. Of the remaining 538 questionnaire copies, 12 had missing data (missing values in the survey) when entered into SPSS, and 24 contained outliers (the data had an abnormal distance from other values in a random sample), making the number of remaining useable questionnaires 502. Such exclusions were recommended by [40], who related that outliers could lead to inaccurate statistical results and have to be eliminated. Of the 502 useable questionnaires, 291 were from female respondents (58.0%), while 211 (42.0%) were from male respondents. In addition, 229 respondents (45.6%) were 18–20 years old, 228 (45.4%) were 21–24 years old, 24 (4.8%) were 25–30 years old, and 21 (4.2%) were 31 years old. For educational level, 13 respondents were undergraduate students in their first year (2.6%), 65 respondents were undergraduate students in their second year (12.9%), 138 respondents were undergraduate students in their third year (27.5%), 137 respondents were undergraduate students in the fourth year (27.3%), and 149 were post-graduate students (master's students were 13.2% and PhD students were 16.5%). The distribution of respondents based on specialization was as follows: 177 respondents were from science and technology (35.3%), 149 respondents were from the social sciences (29.7%), and 176 respondents were from engineering (35.1%).

3.2. Measurement Instruments

The content validity of the measurement scales was confirmed by the construct items being adopted from prior studies. The study questionnaire was comprised of two parts: Questionnaire items that collected basic demographic data (gender, age, educational level, and specialization) and questionnaire items measuring SN and CSE (four items each; adopted from [41] as well as items measuring PE, PEU, PU, ACU/ICT usage, intentions towards ICT use, and SS (five items each; adopted from the TAM model of [14,17] for 38 total items.

4. Results and Analysis

The reliability of the factors that influenced SS through ICT usage intentions in education sustainability was measured using the Cronbach's alpha reliability coefficient and was found to be 0.911. Discriminant validity was evaluated on the basis of three conditions: Variable indexes had to be lower than 0.80, as recommended by [40], the Average Variance Extracted (AVE) of each construct had to be equal to or greater than 0.5, and the AVE square root of each construct had to be higher than the Inter-Construct Correlations (IC) for a factor, as established by [42]. Aside from the above conditions, construct factor analysis outcomes with factor loadings equal to or greater than 0.70 were acceptable (Cronbach's alpha ≥ 0.70 and composite reliability ≥ 0.70) [40].

4.1. Construct Validity of Measurements

The level to which specific items measure the concept they are developed to measure is referred to as construct validity [40]. This was calculated using a systematic literature review of previously assessed items. Items and their loadings are tabulated in Table 1, where they are expected to load onto the construct that they were developed to measure [15].

Table 1. Loadings and cross-loadings of items.

No	Factors	Code	SN	CSE	PE	PU	PEU	ATU-ICT	SIU-ICT	SSU-ICT
1		SN1	0.831	0.562	0.493	0.412	0.425	0.524	0.507	0.413
2	Subjective Norms	SN2	0.874	0.647	0.557	0.457	0.461	0.577	0.562	0.535
3		SN3	0.863	0.578	0.511	0.388	0.419	0.559	0.512	0.511
4		SN4	0.843	0.603	0.515	0.433	0.439	0.595	0.529	0.563
5		CSE1	0.519	0.805	0.474	0.392	0.425	0.488	0.576	0.492
6	Computer Self-Efficacy	CSE2	0.622	0.880	0.587	0.451	0.477	0.562	0.622	0.576
7		CSE3	0.622	0.826	0.606	0.454	0.475	0.595	0.609	0.568
8		CSE4	0.539	0.776	0.464	0.441	0.438	0.499	0.570	0.553
9		PE1	0.527	0.525	0.831	0.382	0.435	0.613	0.514	0.409
10	Perceived Enjoyment	PE2	0.500	0.505	0.850	0.415	0.449	0.642	0.514	0.454
11		PE3	0.488	0.516	0.861	0.407	0.436	0.624	0.519	0.414
12		PE4	0.478	0.539	0.818	0.467	0.472	0.598	0.490	0.408
13		PE5	0.515	0.580	0.778	0.577	0.618	0.641	0.555	0.539
14		PU1	0.437	0.470	0.504	0.820	0.608	0.458	0.488	0.468
15	Perceived Usefulness	PU2	0.403	0.433	0.502	0.875	0.640	0.481	0.512	0.502
16		PU3	0.391	0.441	0.454	0.839	0.584	0.409	0.480	0.493
17		PU4	0.424	0.422	0.427	0.784	0.623	0.387	0.471	0.457
18		PU5	0.415	0.439	0.433	0.844	0.626	0.395	0.464	0.488
19		PEU1	0.350	0.464	0.484	0.667	0.815	0.461	0.564	0.553
20	Perceived Ease of Use	PEU2	0.475	0.416	0.422	0.622	0.796	0.389	0.486	0.512
21		PEU3	0.375	0.454	0.533	0.570	0.817	0.475	0.514	0.461
22		PEU4	0.406	0.421	0.429	0.508	0.754	0.446	0.498	0.471
23		PEU5	0.437	0.434	0.496	0.556	0.779	0.491	0.452	0.490
24		ATU-CT1	0.440	0.443	0.630	0.320	0.383	0.670	0.460	0.390
25	Attitude towards ICT Use	ATU-CT2	0.562	0.497	0.635	0.346	0.413	0.777	0.497	0.409
26		ATU-CT3	0.401	0.460	0.456	0.298	0.369	0.733	0.427	0.433
27		ATU-CT4	0.584	0.558	0.601	0.457	0.468	0.849	0.610	0.576
28		ATU-CT5	0.551	0.555	0.617	0.515	0.546	0.827	0.598	0.577
29		SIU-ICT1	0.490	0.589	0.515	0.483	0.527	0.548	0.837	0.592
30	Students' Intentions to Use ICT	SIU-ICT2	0.524	0.632	0.538	0.519	0.577	0.598	0.871	0.673
31		SIU-ICT3	0.535	0.631	0.520	0.490	0.540	0.569	0.868	0.645
32		SIU-ICT4	0.529	0.623	0.564	0.520	0.527	0.595	0.856	0.633
33		SIU-ICT5	0.558	0.599	0.552	0.454	0.530	0.577	0.820	0.588
34	Students' Satisfaction with ICT Use	SSU-ICT1	0.479	0.575	0.464	0.523	0.556	0.542	0.667	0.851
35		SSU-ICT2	0.533	0.557	0.495	0.503	0.565	0.541	0.620	0.835
36		SSU-ICT3	0.545	0.594	0.472	0.501	0.536	0.532	0.653	0.885
37		SSU-ICT4	0.498	0.573	0.450	0.489	0.523	0.542	0.603	0.854
38		SSU-ICT5	0.479	0.546	0.455	0.445	0.498	0.519	0.597	0.839

4.2. Convergent Validity of Measurements

The factor loadings of 38 items were deemed acceptable as they exceeded 0.70, and their composite reliability generated satisfactory results (above 0.70), ranging from 0.881 to 0.930. Cronbach's alpha coefficient results ranged from 0.832 to 0.906, which showed satisfactory results. With regards to AVE, values ranged from 0.599 to 0.728. Confirmatory Factor Analysis (CFA) results are listed in Table 2.

Table 2. Constructs, items, and Confirmatory Factor Analysis results.

No	Factors	Code	Factors Loading	Cronbach's Alpha	AVE	Composite Reliability	R-Square
1		SN1	0.831				
2	Subjective Norms	SN2	0.874	0.870	0.727	0.914	0.000
3		SN3	0.863				
4		SN4	0.843				
5		CSE1	0.805				
6	Computer Self-Efficacy	CSE2	0.880	0.840	0.677	0.893	0.000
7		CSE3	0.826				
8		CSE4	0.776				
9		PE1	0.831				
10	Perceived Enjoyment	PE2	0.850	0.886	0.686	0.916	0.000
11		PE3	0.861				
12		PE4	0.818				
13		PE5	0.778				
14		PU1	0.820				
15	Perceived Usefulness	PU2	0.875	0.889	0.694	0.919	0.579
16		PU3	0.839				
17		PU4	0.784				
18		PU5	0.844				
19		PEU1	0.815				
20	Perceived Ease of Use	PEU2	0.796	0.852	0.628	0.894	0.412
21		PEU3	0.817				
22		PEU4	0.754				
23		PEU5	0.779				
24		ATU-ICT1	0.670				
25	Attitude towards ICT Use	ATU-ICT2	0.777	0.832	0.599	0.881	0.345
26		ATU-ICT3	0.733				
27		ATU-ICT4	0.849				
28		ATU-ICT5	0.827				
29		SIU-ICT1	0.837				
30	Students' Intentions to Use ICT	SIU-ICT2	0.871	0.904	0.723	0.929	0.535
31		SIU-ICT3	0.868				
32		SIU-ICT4	0.856				
33		SIU-ICT5	0.820				
34		SSU-ICT1	0.851				
35	Students' Satisfaction with ICT Use	SSU-ICT2	0.835	0.906	0.728	0.930	0.603
36		SSU-ICT3	0.885				
37		SSU-ICT4	0.854				
38		SSU-ICT5	0.839				

4.3. Convergent Validity of Measurements

Discriminant validity refers to differences between sets of concepts and their indicators. All constructs' discriminant validities were confirmed with values exceeding 0.50 and significant at $p = 0.001$, a condition established by [42]. The AVE square root shared by a single construct's items should be lower than the correlations between the items in the two constructs [40] (refer to Table 3 for results).

Table 3. Discriminant validity.

No	Factors	1	2	3	4	5	6	7	8
1	Subjective Norms	0.915							
2	Computer Self-Efficacy	0.382	0.893						
3	Perceived Enjoyment	0.437	0.411	0.911					
4	Perceived Usefulness	0.532	0.543	0.598	0.899				
5	Perceived Ease of Use	0.434	0.481	0.548	0.406	0.874			
6	Attitudes towards ICT Use	0.388	0.501	0.359	0.541	0.527	0.909		
7	Students' Intentions to Use ICT	0.320	0.458	0.397	0.509	0.468	0.499	0.893	
8	Students' Satisfaction with ICT Use	0.546	0.349	0.391	0.476	0.512	0.503	0.492	0.907

4.4. Analysis of the Structural Model

The research hypotheses were tested and construct relationships were examined using Smart PLS 3.0. The hypothesis development is depicted in Figure 1, path coefficient findings are depicted in Figure 2, and path coefficient (T-Values) findings are depicted in Figure 3.

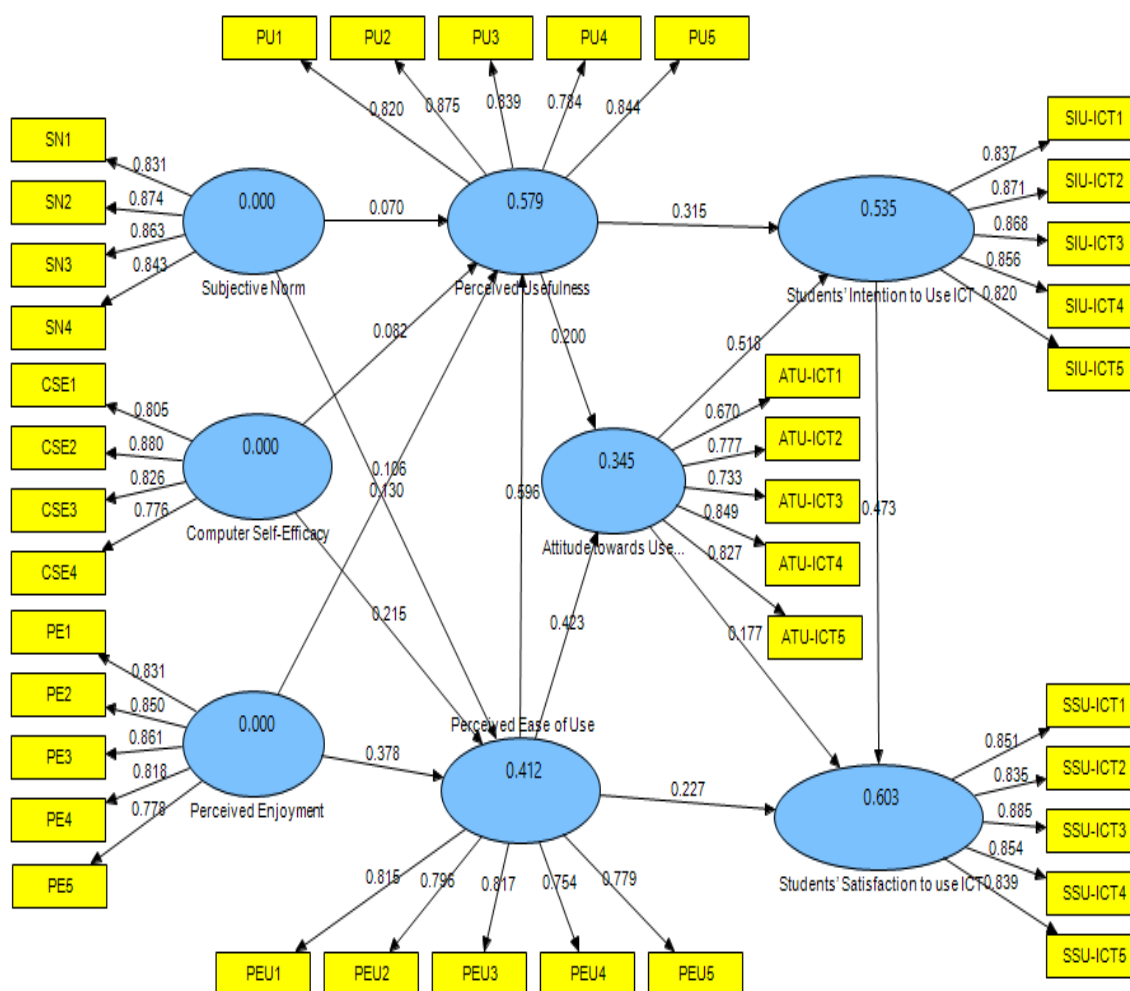


Figure 2. Path coefficient results.

Figure 3 illustrates that all of the hypotheses concerning the relationships among the eight key constructs were accepted, with the following having the greatest direct influence on ICT; PEU with PU was 19.027, attitude towards ICT use with SS was 16.124, SIU-ICT with SS was 11.489, and PU with SIU-ICT was 10.199 (see Figure 3 and Table 4).

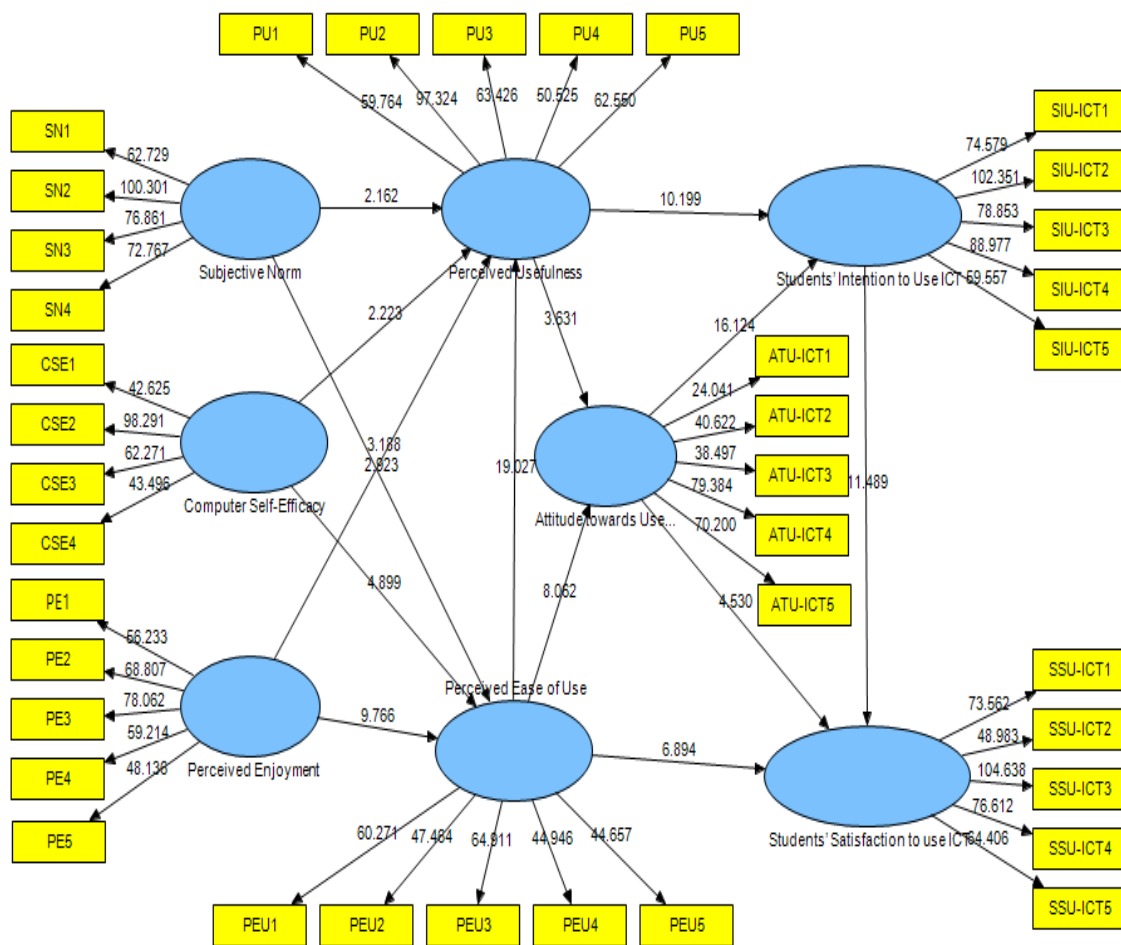


Figure 3. Path coefficients' T-values.

Table 4. Hypothesis testing results of the structural model.

H	Independent	Relationship	Dependent	Path	S.E.	T. Value	Result
H1	SN	→	PU	0.070	0.032	2.162	Supported
H2	SN	→	PEU	0.130	0.046	2.923	Supported
H3	CSE	→	PU	0.082	0.037	2.223	Supported
H4	CSE	→	PEU	0.215	0.044	4.899	Supported
H5	PE	→	PU	0.106	0.033	3.188	Supported
H6	PE	→	PEU	0.378	0.039	9.766	Supported
H7	PEU	→	PU	0.596	0.031	19.027	Supported
H8	PU	→	SIU-ICT	0.315	0.031	10.199	Supported
H9	PU	→	ATU-ICT	0.200	0.055	3.631	Supported
H10	PEU	→	SSU-ICT	0.227	0.033	6.894	Supported
H11	PEU	→	ATU-ICT	0.423	0.053	8.062	Supported
H12	ATU-ICT	→	SIU-ICT	0.518	0.032	16.124	Supported
H13	ATU-ICT	→	SSU-ICT	0.177	0.039	4.530	Supported
H14	SIU-ICT	→	SSU-ICT	0.373	0.041	11.489	Supported

Note: S.E: standard error.

The first hypothesis proposed a relationship between SN and PU. The results showed a positive and significant relationship ($\beta = 0.070$, $t = 2.162$, $p < 0.001$), indicating support for the first hypothesis (H1). Stated clearly, SNs positively supported ICT-PU. For the second hypothesis (H2), the analysis

results showed a positive and significant relationship between SN and PEU ($\beta = 0.130$, $t = 2.923$, $p < 0.001$), supporting the hypothesis. This indicates that SNs positively support ICT-PEU. For the third hypothesis, it was proposed that CSE and PU has a positive and significant relationship, and the analysis results indicated support at $\beta = 0.082$, $t = 2.223$, and $p < 0.001$. The same was true for the fourth hypothesis, which proposed a positive and significant relationship between CSE and ICT on PEU, with results of $\beta = 0.215$, $t = 4.899$, and $p < 0.001$. The next hypothesis predicted a direct effect between PE and PU, and the results of $\beta = 0.106$, $t = 3.188$, and $p < 0.001$ supported this hypothesis (H5), indicating that PE influenced perceived ICT usefulness among students. The sixth hypothesis (H6) proposed a positive and significant relationship between PE and PEU, and the results showed support for this relationship ($\beta = 0.378$, $t = 9.766$, $p < 0.001$), indicating that PE positively supported perceived ease of use of ICT. In the next hypothesis (H7), the study proposed a positive relationship between PEU and PU, and the results supported this proposed linkage ($\beta = 0.596$, $t = 19.027$, $p < 0.001$). This shows that ICT-PEU was supported by PU. In the eighth hypothesis (H8), the relationship between PU and students' intentions towards ICT use was proposed to be significant and positive, and the results supported this ($\beta = 0.315$, $t = 10.199$, $p < 0.001$), indicating that the PU of ICT among students supported their usage intentions. Furthermore, a positive and significant relationship was proposed between PU and student ACU-ICT use in the ninth hypothesis (H9), and on the basis of the obtained results ($\beta = 0.200$, $t = 3.631$, $p < 0.001$), the hypothesis was supported. This shows that the PU of ICT positively supported student ACU-ICT. The tenth hypothesis (H10) assumed that the relationship between ICT-PEU and ICT usage satisfaction among students was positive and significant, and the results supported this hypothesis ($\beta = 0.227$, $t = 6.894$, $p < 0.001$). In other words, the model correctly predicted that ICT-PEU supported ICT usage satisfaction among students. In the eleventh hypothesis (H11), it was proposed that a positive and significant relationship lies between student ACU-ICT, PEU, and their satisfaction with ICT usage, and the results obtained supported this hypothesis ($\beta = 0.423$, $t = 8.062$, $p < 0.001$). Stated clearly, the model indicated that ICT-PEU was positively associated with satisfaction with ICT use. The twelfth hypothesis (H12) proposed a positive and significant relationship between student ACU-ICT usage and their intention to use ICT technologies, which was supported by the results ($\beta = 0.518$, $t = 16.124$, $p < 0.001$). The model thus indicated that student ACU-ICT usage had positively and significantly supported SIU-ICT among students. The thirteenth hypothesis (H13) proposed a positive and significant relationship between student ACU-ICT use and their satisfaction with ICT technologies. The results showed that this hypothesis (H13) was supported at $\beta = 0.177$, $t = 4.530$, and $p < 0.001$. Stated plainly, the attitudes of students towards ICT use had a positive and significant influence on their satisfaction with using ICT. The last hypothesis (H14) predicted a positive and significant relationship between SIU-ICT and their satisfaction with ICT technologies, and the results supported this relationship at $\beta = 0.373$, $t = 11.489$, and $p < 0.001$, meaning that student intentions towards ICT use positively influenced their satisfaction with ICT technologies (see Table 4).

4.5. Description and Analysis of Factors

Mean and Standard deviation (SD) are numbers used to tell how measurements for a group are spread out from the average (mean) or expected value. A low standard deviation means that most of the numbers are close to the average. A high standard deviation means that the numbers are more spread out. Therefore, according to the results showed in Tables 5–12, all values were accepted, which means that using available ICTs among university students enhanced academic performance. The numbers mean the following: 1: "Strongly disagree"; 2: "Disagree"; 3: "Neutral"; 4: "Agree"; 5: "Strongly agree"; F: "Frequency"; %: "Percentages". The results show that the majority of the students agree and strongly agree on SNs for ICT use for education sustainability. Therefore, this study defines SNs as the degree to which a student believes that ICT use would enrich their academic performance (see Table 5).

Table 5. Measuring subjective norms (SNs) for information and communication technology (ICT) use.

Variable	Code	1	2	3	4	5	Mean	SD
		<i>f</i> (%)	<i>f</i> (%)	<i>f</i> (%)	<i>f</i> (%)	<i>f</i> (%)		
Subjective Norms	SN 1	12 (2.4)	18 (3.6)	79 (15.7)	223 (44.4)	170 (33.9)	3.68	0.866
	SN 2	12 (2.4)	38 (7.6)	59 (11.8)	207 (41.2)	186 (37.1)	3.52	0.884
	SN 3	8 (1.6)	27 (5.4)	76 (15.1)	235 (46.8)	156 (31.1)	3.69	0.850
	SN 4	14 (2.8)	52 (10.4)	78 (15.5)	201 (40.0)	157 (31.3)	3.55	0.967

Table 6. Measuring computer self-efficacy (CSE) for ICT use.

Variable	Code	1	2	3	4	5	Mean	SD
		<i>f</i> (%)	<i>f</i> (%)	<i>f</i> (%)	<i>f</i> (%)	<i>f</i> (%)		
Computer Self-Efficacy	CSE 1	7 (1.4)	32 (6.4)	67 (13.3)	214 (42.6)	182 (36.3)	3.60	0.848
	CSE 2	11 (2.2)	33 (6.6)	90 (17.9)	205 (40.8)	163 (32.5)	3.66	0.912
	CSE 3	3 (0.6)	35 (7.0)	76 (15.1)	189 (37.6)	199 (39.6)	3.60	0.848
	CSE 4	4 (0.8)	30 (6.0)	65 (12.9)	219 (43.6)	184 (36.7)	3.62	0.814

Table 7. Measuring perceived enjoyment (PE) of ICT use.

Variable	Code	1	2	3	4	5	Mean	SD
		<i>f</i> (%)	<i>f</i> (%)	<i>f</i> (%)	<i>f</i> (%)	<i>f</i> (%)		
Perceived Enjoyment	PE 1	10 (2.0)	18 (3.6)	109 (21.7)	217 (43.2)	148 (29.5)	3.79	0.890
	PE 2	5 (1.0)	44 (8.8)	69 (13.7)	205 (40.8)	179 (35.7)	3.58	0.869
	PE 3	6 (1.2)	31 (6.2)	67 (13.3)	207 (41.2)	191 (38.0)	3.59	0.840
	PE 4	6 (1.2)	40 (8.0)	87 (17.3)	206 (41.0)	163 (32.5)	3.65	0.898
	PE 5	13 (2.6)	32 (6.4)	77 (15.3)	204 (40.6)	176 (35.1)	3.60	0.912

Table 8. Measuring perceived ease of use (PEU) of ICT.

Variable	Code	1	2	3	4	5	Mean	SD
		<i>f</i> (%)	<i>f</i> (%)	<i>f</i> (%)	<i>f</i> (%)	<i>f</i> (%)		
Perceived Ease of Use	PEU 1	5 (1.0)	13 (2.6)	86 (17.1)	253 (50.4)	145 (28.9)	4.04	0.808
	PEU 2	3 (0.6)	12 (2.4)	105 (20.9)	248 (49.4)	134 (26.7)	3.88	0.782
	PEU 3	9 (1.8)	25 (5.0)	107 (21.3)	229 (45.6)	132 (26.3)	3.80	0.893
	PEU 4	10 (2.0)	23 (4.6)	102 (20.3)	237 (47.2)	130 (25.9)	3.79	0.885
	PEU 5	10 (2.0)	23 (4.6)	103 (20.5)	235 (46.8)	131 (26.1)	3.79	0.887

Table 9. Measuring the perceived usefulness (PU) of ICT use.

Variable	Code	1	2	3	4	5	Mean	SD
		<i>f</i> (%)	<i>f</i> (%)	<i>f</i> (%)	<i>f</i> (%)	<i>f</i> (%)		
Perceived Usefulness	PU 1	8(1.6)	16(3.2)	96(19.1)	236(47.0)	146(29.1)	3.99	0.869
	PU 2	8(1.6)	35(7.0)	68(13.5)	197(39.2)	194(38.6)	3.56	0.869
	PU 3	6(1.2)	16(3.2)	93(18.5)	251(50.0)	136(27.1)	3.81	0.811
	PU 4	6(1.2)	16(3.2)	105(20.9)	255(50.8)	120(23.9)	3.87	0.817
	PU 5	11(2.2)	15(3.0)	96(19.1)	240(47.8)	140(27.9)	3.79	0.862

Table 10. Measuring attitudes towards computer use (ACU) for ICT use.

Variable	Code	1	2	3	4	5	Mean	SD
		<i>f</i> (%)	<i>f</i> (%)	<i>f</i> (%)	<i>f</i> (%)	<i>f</i> (%)		
Attitudes towards ICT Use	ATU-CT1	4 (0.8)	16 (3.2)	117 (23.3)	234 (46.6)	131 (26.1)	3.88	0.825
	ATU-CT2	1 (0.2)	24 (4.8)	92 (18.3)	263 (52.4)	122 (24.3)	3.84	0.781
	ATU-CT3	4 (0.8)	15 (3.0)	114 (22.7)	240 (47.8)	129 (25.7)	3.89	0.815
	ATU-CT4	5 (1.0)	26 (5.2)	99 (19.7)	232 (46.2)	140 (27.9)	3.78	0.853
	ATU-CT5	6 (1.2)	12 (2.4)	105 (20.9)	232 (46.2)	145 (28.9)	3.84	0.822

Table 11. Measuring students' intentions to use (SIU) ICT.

Variable	Code	1	2	3	4	5	Mean	SD
		<i>f</i> (%)	<i>f</i> (%)	<i>f</i> (%)	<i>f</i> (%)	<i>f</i> (%)		
Students' Intentions to Use ICT	SIU-ICT1	2 (0.4)	24 (4.8)	92 (18.3)	245 (48.8)	139 (27.7)	3.80	0.805
	SIU-ICT2	8 (1.6)	22 (4.4)	70 (13.9)	203 (40.4)	199 (39.6)	3.60	0.839
	SIU-ICT3	6 (1.2)	23 (4.6)	83 (16.5)	219 (34.6)	171 (34.1)	3.70	0.841
	SIU-ICT4	6 (1.2)	22 (4.4)	106 (21.1)	238 (47.4)	130 (25.9)	3.83	0.852
	SIU-ICT5	6 (1.2)	17 (3.4)	117 (23.3)	233 (46.4)	129 (25.7)	3.87	0.847

Table 12. Measuring students' satisfaction with using ICT.

Variable	Code	1	2	3	4	5	Mean	SD
		<i>f</i> (%)	<i>f</i> (%)	<i>f</i> (%)	<i>f</i> (%)	<i>f</i> (%)		
Student's Satisfaction	SSU-ICT 1	18 (3.6)	23 (4.6)	83 (16.5)	213 (42.4)	165 (32.9)	3.64	0.933
	SSU-ICT 2	21 (4.2)	29 (5.8)	65 (12.9)	215 (42.8)	172 (34.3)	3.55	0.935
	SSU-ICT 3	13 (2.6)	32 (6.4)	69 (13.7)	201 (40.0)	187 (37.3)	3.56	0.898
	SSU-ICT 4	9 (1.8)	27 (5.4)	72 (14.3)	245 (48.8)	149 (29.7)	3.69	0.848
	SSU-ICT 5	13 (2.6)	30 (6.0)	74 (14.7)	215 (42.8)	170 (33.9)	3.61	0.899

As shown in Table 6 below, the majority of the students agree and strongly agree that CSE, ease of use, and usefulness influence ICT use for education sustainability. Therefore, this study defines CSE as the degree to which a student believes that ease of use and usefulness of ICT would enrich their academic performance.

The results in Table 7 show that the majority of the students agree and strongly agree on the PE of ICT use for education sustainability. Therefore, this study defines PE as the degree to which a student believes that enjoyment of ICT use would enrich their academic performance.

The results shown in Table 8 indicate that the majority of the students agree and strongly agree on the PEU of ICT for education sustainability. Therefore, this study defines PEU as the degree to which a student believes that the ease of use of ICT would enrich their academic performance".

The results shown in Table 9 indicate that the majority of the students agree and strongly agree on the PU of ICT for education sustainability. Therefore, this study defines PU as the degree to which a student believes that ICT is useful and would enrich their academic performance.

As shown in Table 10, the majority of the students agree and strongly agree on students' ACU for ICT use for education sustainability. Therefore, this study defines ACU for ICT use as the degree to which a student believes that ICT is useful and would enrich their academic performance.

The results shown in Table 11 indicate that the majority of the students agree and strongly agree on SIU-ICT for education sustainability. Therefore, this study defines SIU-ICT as the degree to which a student believes that ICT useful and would enrich their academic performance.

The results of the final measurement are shown in Table 12; the majority students agree and strongly agree on students' satisfaction with ICT use for education sustainability. Therefore, this study defines a student's satisfaction with ICT use as the degree to which a student is satisfied with and believes that ICT is useful and would enrich their academic performance.

5. Discussion and Implications

This study is one of the first to use the TAM model to examine ICT. On the basis of the proposed model, the results indicated that CSE, SN, and PE significantly determined PEU and PU. Moreover, PEU, PU, and ACU significantly determined SIU-ICT and SS with ICT technologies. The constructs constituted 53.5% variance in SIU-ICT and 60.3% variance in satisfaction with ICT technologies. The results supported the developed research model and the proposed hypotheses. The research findings provide a deeper insight into the use of the TAM constructs SN, CSE, and PE (independent variables), as well as PU and PEU (mediating variables), in the measurement of SIU-ICT and SS with ICT technologies. Based on the findings, several constructs, including SN, CSE, PE, PU, PEU, and usefulness, had a positive and significant relationship with student ACU-ICT use, indicating an increase of their usage intentions and satisfaction with ICT use. Prior studies support these study findings on the significant positive effects of SN, CSE, PE, PU, PEU, ACU, and SS with ICT technologies. It can thus be inferred that before students decide to use ICT, they evaluate its ability to meet their study requirements and its relevance towards their education sustainability. Upon perceiving that ICT is capable of meeting such requirements, students are more likely to consider the technology to be useful [20,24,25,43–45]. Undoubtedly, ICTs are both well-known and extensively utilized in education sustainability with students already familiar with ICTs. It goes to show that their PU and PEU significantly influence usage intentions and usage satisfaction. According to the statistical analysis results in Table 4, all hypothesized relationships were supported. Some of hypothesis results opposed those reported in prior literature, such as [24], who reported that CSE significantly and positively influences PU. These mixed findings call for more studies in this area to examine the relationship between the two constructs. In addition, CSE had a significant and positive impact on PU, while SN and PE significantly and positively impacted PU and PEU. This is supported by prior findings from [9,20,24,25].

The TAM posits that PE, PEU, and PU positively and directly influence usage attitudes, usage intentions, and usage satisfaction. This was evidenced in this study in that ICT users were convinced that higher PU and PEU contributed to better ACU-ICT use, which heightened SIU-ICT and satisfaction with such use. The fact that this study reported a positive and direct effect between PEU and PU was supported by [17]. This study revealed that students perceive ICT as easy to use if it is useful towards their studies. If the students are provided opportunities to use ICT, they are likely to perceive it as being easy to use. Therefore, to enhance perceived ease of use, ICT developers should develop systems that are user-friendly and relevant to student education sustainability. In addition, managers should provide students with support in using ICT.

The findings concerning system characteristics clearly indicated that developers, designers, and purchasers of ICT (like institutions of higher learning) should take user needs and values into consideration to guarantee that the system meets student demands. This perceived match between system features and student requirements can enhance ICT adoption. Furthermore, factors like SN, CSE, and PE influence the SIU-ICT among students in an indirect manner. With regards to this study's implications, this study confirms the acknowledged significance of belief constructs in that ICT-PEU influenced PU, with both belief constructs acting as determinants for ICT use. In other words, ICT has to be perceived as both easy to use and useful for ICT to be adopted. ICT should also be user-friendly and provide clear instructions. The findings also showed the importance of faculty in describing how ICT can be leveraged by students to learn course content, as SS increases ACU-ICT use and usage intentions.

This study provides three major empirical findings: ICT use via PU and PEU; ACU-ICT use via PU and PEU, affecting intentions towards ICT usage and ICT use satisfaction in higher educational institutions; PU and PEU via SN, CSE, and PE, influencing student ACU-ICT use and their SIU-ICT. The findings also provide significant contributions to the TAM in the context of education sustainability [9,14,24,25,46,47]. The growing use of ICT as an instructional medium is changing and will likely continue to change many of the strategies employed by both teachers and students in the

learning process [48]. Moreover, many ICT tools are available in the modern world that can be used to create and disseminate knowledge [49]. Using available ICTs is also useful in solving teachers' and students' doubts, gaining knowledge of current events, and also providing global connectivity and competitiveness [50]. In sum, this study's contributions are as follows:

- ICT use in learning strategies should boost student usage and SS with ICT. Additionally, support from lecturers and supervisors can motivate students to use ICT as they resolve ambiguities, share knowledge, and provide information to improve students' learning experiences, performance, and research skills.
- Higher educational institutions are advised to accept students who are familiar with using ICT for learning as opposed to forcing someone who is not familiar to do so. This is because the institutions need to integrate ICT components and tools throughout the learning process.
- Students' ACU-ICT use and their SIU-ICT concern both technology and resources. Opportunities should be leveraged by students to use ICT to enrich their learning experience.

Regardless of the insights provided by this study, it has its own limitations. First, this study's sample size was limited to a single university and its findings should be interpreted with caution, as behaviors in other universities (private universities, army universities, or other schools) may differ. Another limitation is the use of questionnaires—a qualitative data collection method (interviews or observations). This study's data were based on student perceptions, which could differ from teacher perceptions, meaning that differences between research fields were not considered. In this regard, future studies can replicate this study in other nations and cultures to resolve its limitations and extend its findings.

Conclusions and Future Work

In the 21st century, ICT plays an important role not only for school students, but also for university students in improving their quality of learning and research activities. However, no study has previously evaluated the students' intentions to use ICT and their satisfaction. This study was successful in validating the TAM model in education sustainability and provided information on student perceptions on using ICT in education sustainability. The study's contributions to theory and practice were discussed. This study highlighted the merits of the TAM and provided new information concerning user acceptance and adoption of ICT. It is therefore concluded that the TAM is robust enough to provide results regarding the studied phenomenon, which is student SIU-ICT usage and SS with ICT technologies. The significant contribution of this research is that it may be a useful guideline for researchers, practitioners, system developers, service providers, vendors, and academics to recognize systematic research approaches for model validation in education sustainability, especially by using structural equation modeling. This study used eight innovative TAM model characteristics as significant determinants of ICT adoption. However, mixed results in the literature call for further exploration of the relationship between CSE and PU. With regards to the limitations of the research design and the chosen quantitative approach, future studies can adopt interview techniques to resolve these issues. Moreover, it is recommended that future researchers explore these areas when using this model and cross-validate them in different cultures by including cultural dimensions.

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