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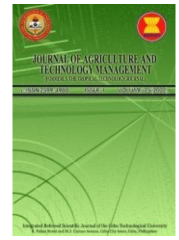

Original article

Empirical assessment on simulation-based learning for higher electronics in setting up greenhouse automation

Eric G. Pardiñan

Department of Electrical – Electronics Technology, Cebu Technological University, Cebu City, Philippines

ABSTRACT

Many parts of our lives are now heavily influenced by technology. Technology is an essential complement to creative instructional techniques. Due to multimedia and network interactivity, students are taking on new roles as participants rather than observers in their learning process. The study's purpose was to evaluate how pleased individuals were with simulation software and whether they would utilize it as a foundation for technology adoption in higher education, mainly teaching higher electronics that deals with automation processes such as greenhouse automation. The study utilized the Modified TAM and DeLone & McLean IS Success Model in determining the respondents' acceptance of simulation-based learning for instruction. Functional constructs from the Modified TAM and D&M IS Model were then validated based on the product quality model ISO/IEC 25010. The research results using Confirmatory Factor Analysis (CFA), Kaiser – Meyer – Olkin (KMO), Cronbach Alpha, and Bartlett's test validated the study's consistency. The majority of the respondents agreed that simulation-based learning is acceptable. The behavioral intention and attitude toward using technology were confirmed by the acceptance of using a simulation software platform in teaching-learning higher electronics. On the other hand, the study recommended that needs be assessed, that suitable orientation be provided, and that technology be evaluated. Since technology is continuously improving and becoming more accessible, further studies incorporating a bigger pool of specialists from diverse sectors and continuous research may be advantageous.

KEYWORDS: *engineering, technology, simulators, TAM, electronics*

1 INTRODUCTION

Today's technologies continue to change every element of our lives, causing societal paradigm shifts in all areas. According to Ray et al. (2016), the impact of technological advancements outweighs traditional education. They went on to say that traditional teaching and learning have always depended on language, concepts, and abstract concepts, resulting in a lack of knowledge of the subject matter's depth and breadth.

According to Campbell et al. (2002), some colleges have implemented cutting-edge learning environments better to prepare students for the real world of employment. Laboratories are crucial for learners to expand their knowledge and abilities by providing access to complementary instruments in the workplace, which would give a fulfilling learning experience. Dogan (2010), on the other hand, refuted the notion that, despite the many benefits of laboratories, they also have many drawbacks. The expense of starting up a laboratory, the cost of maintaining an existing laboratory, and the cost of acquiring current technology are just a few of the disadvantages, according to Loro et al. (2016). Virtual laboratories and simulators are thus a first and cost-effective way to bring students closer to the corporate world.

For its ability to reflect on abstract and complex topics such as electronics, analog communication, temperature and heat, basic electrical concepts, and the formation of light, simulation-assisted learning is becoming more widely used in teaching and learning, especially in classrooms, laboratories, and workshops (Elias et al., 2017). Teaching higher electronics to students is difficult since it necessitates circuit diagrams, mathematical equations, function charts, and other complex ideas effectively (Kapoor et al., 2014). While a teaching device like a projector or a PowerPoint presentation can shorten the time to educate, it does not leave much room for interaction. Unlike real labs, virtual labs make it easier for students to develop, design, analyze, and verify electrical circuit assignments (Rahman, 2014). Virtual labs are significantly more cost-effective and time-saving. As a result, simulation boosts traditional learning and assists students in achieving a better degree of cognition and insight as they learn new skills and knowledge (Zavalani, 2015).

The study focused on the satisfaction and intention of using the simulation software as an instructional tool, mainly teaching higher electronics that deals with automation processes. The study focused on utilizing

*corresponding author: eric.pardinan@ctu.edu.ph
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simulation tools for setting up an automated greenhouse monitoring and control system. The integration of IoT-based systems to facilitate and easily manage greenhouses will be highlighted in the study. The study utilized the Updated DeLone & McLean IS Success Model in determining the respondents' acceptance of simulation-based learning for electronics instruction. The success of new technologies introduced in an academic setting is determined by their acceptability and utilization in the classroom. Nowadays, there is much research on how to adopt the technology. On the other hand, effective digital transformation is not just about technology but also about the ability to look at technology from a distinct perspective to prepare for the future digital workforce.

DeLone & McLean IS Success Model

The three significant dimensions of quality, according to Delone and McLean (2003), are "information quality," "systems quality," and "service quality," each of which should be measured or controlled separately because they will affect subsequent "use" and "user satisfaction" when measured or controlled separately.

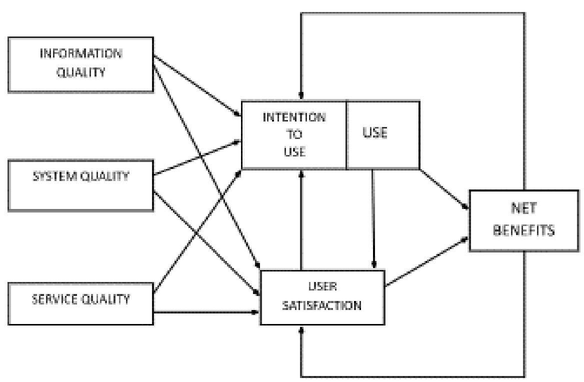

Figure 1. Updated DeLone & McLean IS Success Model (DeLone & McLean, 2003)

"Use" and "user satisfaction" are inextricably linked, as mentioned in the original D&M Model formulation. In a procedural sense, "use" must precede "user satisfaction," but in a causal sense, a positive experience with "use" will lead to increased "user satisfaction." Similarly, increasing "user satisfaction" will lead to higher "intention to use," and therefore "use," as well as "net benefits" as a result of this "use" and "user satisfaction." Achieving a positive outcome for the Information System (IS) or service may influence and reinforce subsequent "use" and "user satisfaction" by assuming that the "net benefits" from the perspective of the system's owner or sponsor are positive. Arrows are included in the modified D&M IS Success Model to show proposed relationships between process success dimensions. In a causal sense, these relationships do not exhibit positive or negative signals for such associations but rather generate hypotheses in the context of a specific study. A high-quality system will result in favorable outcomes on proposed associations with higher use, more user satisfaction, and positive net benefits.

The Technology Acceptance Model presented by Davis and Bagozzi appears to be the most extensively utilized innovation adoption model (Mohammadi, 2014). In various research, this model has been used to investigate the factors influencing how people adopt new technology. We can utilize TAM to estimate how users will use new technologies in the future. TAM was based on TRA (Theory of Reasoned Action), a model that examines the factors influencing consciously intended acts. (Liu et al., 2003). Beliefs, according to TRA, influence attitudes, which in turn lead to intentions, which in turn lead to practices. The critical determinants of information technology/information system adoption in businesses, according to TAM, are always attitudes about usefulness and ease of use. According to TAM, these two factors provide the foundation for how people feel about using a system and how they will use it in the future. Perceived usefulness refers to a person's belief that a system will assist him or she perform better at work. Ease of use is described as the degree to which a person believes that using a system will need no mental effort.

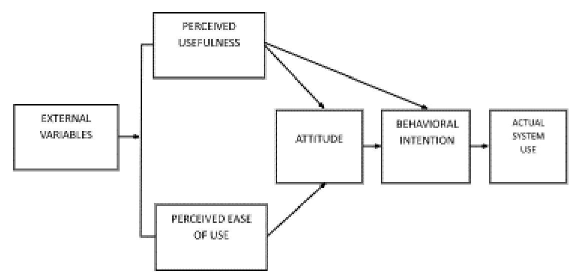

Figure 2. Technology Acceptance Model (Davis et al., 1989, Lu et al., 2003)

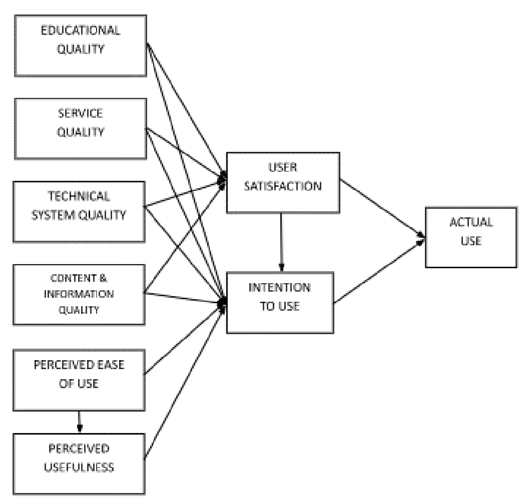

Figure 3. Modified TAM and D&M IS Success Model (Mohammadi, 2014)

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Educational Quality

As a new component of the IS success model, educational quality is viewed as system quality in terms of the characteristics. It provides users features that make learning and training easier (Hassanzadeh et al., 2012). Educational quality may be defined as the extent to which an IS system could provide a collaborative learning environment that is conducive to learning. (Hassanzadeh et al., 2012; Kim et al., 2012).

Service Quality

The quality of the IS's support to users is service quality, such as training and helpdesk. As a subordinate variable to system quality, the inclusion of this success dimension is unquestionable, given the recent change in the importance of IS. Some academics believe that it should be regarded as an independent variable. (Pham et al., 2019).

Technical System Quality

The D&M IS Success Model measures system quality in ease-of-use, functionality, reliability, flexibility, data quality, portability, integration, and importance (DeLone & McLean, 2003). Most of these tests focus on the system's usability and performance features (Urbach et al., 2011).

Information Quality

According to DeLone and McLean (2003), information quality is judged in its correctness, timeliness, completeness, relevance, and consistency. The individual impact was measured by performance in decision-making, job effectiveness, and work quality. Parameters such as system and information security, relevance, and ease of understanding are now included in the new model. It encompasses a variety of measurements that focus on the system's ability to create high-quality data and its utility to the user (Mohammadi, 2014, Urbach et al., 2011).

Perceived Ease of Use

Perceived ease of use was used to determine a person's belief that using a particular system will be simple. It is a driver of new technology-based applications' acceptability soon. The more positive the intention to utilize the e-learning system is, the greater the perceived ease of using it. (Mohammadi, 2014, Venkatesh, 2000, Davis, 1989).

Perceived Usefulness

According to Mohammadi (2014), perceived usefulness is a critical factor of intention, encouraging 21st-century consumers to adopt more creative and user-friendly technologies that provide them more freedom. It refers to a person's belief that employing a particular system will help them perform better at work. It has been discovered that it has a considerable favorable impact on the intention to use.

User Satisfaction

Individuals' perceptions of the level to which their needs, aspirations, and ambitions have been fully realized are referred to as satisfaction (Mohammadi, 2014). The success dimension of user satisfaction represents the user's comfort level when using an Information System. When using an IS is required, and the amount of use is not a reliable predictor of system success (Mohammadi, 2014, Urbach et al., 2011), it is imperative to measure user satisfaction. DeLone & McLean (2003), in their modified D&M Model, stressed the importance of this success factor in determining one's satisfaction with the system or the experience of using it.

Intention to Use

The Intention to Use success dimension represents the degree and manner in which an Information System's users use it. TAM uses the independent variables of perceived ease of use and perceived usefulness to determine how people feel about using it, how they wish to use it, and how they use it to determine how they feel about it. DeLone and McLean recommend that intention to use as an alternate measure for particular situations (Mohammadi, 2014, Urbach et al., 2011) due to challenges in interpreting the dimension usage. According to Mohammadi (2014), Intention to Use is the possibility that a person would use a system, which is a significant factor in the actual use of new technology.

2 MATERIALS AND METHODS

The study utilized an adapted and modified questionnaire based on the different readings from related research. The respondents administered the surveys to determine the acceptability of the simulation software as an instructional tool, mainly teaching higher electronics to highlight IoT-based systems to facilitate and efficiently manage the greenhouse. Since the study involves students and instructors from nine different campuses, this paper used Cochran's large population sampling formula. A total of 666 students and teachers with electronics disciplines from Cebu Technological University's nine campuses were randomly picked for this paper. For each of the university's nine branches, there were 74 respondents. Simulated circuit activities and design were provided to accurately identify the respondents' behavioral intention in terms of the following success dimensions Educational Quality, Service Quality, Technical System Quality, Information Quality, Perceived Ease of Use, Perceived Usefulness, Satisfaction, Intention to Use and Actual Use. The study utilized the Modified TAM and DeLone & McLean IS Success Model in determining the respondents'

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acceptance of simulation-based learning for instruction. Functional constructs from the Modified TAM and D&M 0IS Model were then validated based on the product quality model ISO/IEC 25010. The research results using Confirmatory Factor Analysis (CFA), Kaiser – Meyer – Olkin (KMO), Cronbach Alpha, and Bartlett's test validated the study's consistency.

Proteus Virtual System Modelling (VSM) combines mixed-mode Simulation Program with Integrated Circuit Emphasis (SPICE) simulation with the fastest microcontroller simulation available. It enables both hardware and firmware concepts to be prototyped quickly. Proteus VSM bridges the gap between schematic capture and Printed Circuit Board (PCB) layout in the design life cycle. It allows users to develop and apply the firmware to a compatible microcontroller on the schematic, then co-simulate the program with

Table 1. Research Instrument

Success Dimension	Question	Source
Educational Quality	The simulation software provides collaborative learning The simulation software provides possibility of learning evaluation The simulation software is appropriate with my learning style	Mohammadi (2014) & Hassanzadeh et al. (2012),
Service Quality	The simulation software provides assistance or explanation	Wang and Wang (2009)
Technical System Quality	The simulation software is aesthetically satisfying The simulation software is user-friendly The simulation software provides interactive features The simulation software optimizes response time	Mohammadi (2014), Ho and Dzeng (2010), Ozkan and Koseler (2009), DeLone & McLean (2003)
Information Quality	The simulation software provides information relevant to my needs The simulation software provides comprehensive information The simulation software provides me with organized and up to date content	Mohammadi (2014), Ozkan and Koseler (2009)Au et al. (2008), Wang et al. (2007)
Perceived ease of use	The simulation software is easy to use The simulation software is easy to learn The simulation software is easy to access or navigate The simulation software is convenient to use	Mohammadi (2014), Wang & Liao (2008), DeLone & McLean (2003)
Perceived Usefulness	The simulation software helps save time The simulation software helps save cost The simulation software improved my knowledge The simulation software improved my performance The simulation software is effective The simulation software is efficient	Mohammadi (2014), Hassanzadeh et al. (2012), Ho & Dzeng (2010), Chiu & Wnag (2008), DeLone & McLean (2003)
Satisfaction	Using simulation software is enjoyable The simulation software satisfies my educational needs I am satisfied with the performance of the simulation software The simulation software boost my self-confidence in design I highly recommend the use of simulation software	Mohammadi (2014), Urbach & Müller (2011), Wu et al. (2010), DeLone & McLean (2003),
Intention to Use	I tend to use simulation software I am likely to use simulation software in the near future I tend to use simulation & design software to mass produce circuits	Mohammadi (2014), Urbach & Müller (2011) Lin (2007)
Actual Use	I will use simulation software frequently I will use simulation & design software in all of my design process I will use simulation & design software to mass produce circuits	Mohammadi (2014), Urbach & Müller (2011)DeLone & McLean (2003)

The Simulation Software

Proteus Virtual System Modelling

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Microcontroller Unit (MCU) peripherals in a mixed-mode SPICE circuit simulation. Proteus VSM provides a design entry and development environment with our tried-and-true Schematic Capture software. The capacity of Proteus VSM to simulate the interaction between software running on a microcontroller and any analog or digital devices linked to it is its most intriguing and crucial feature.

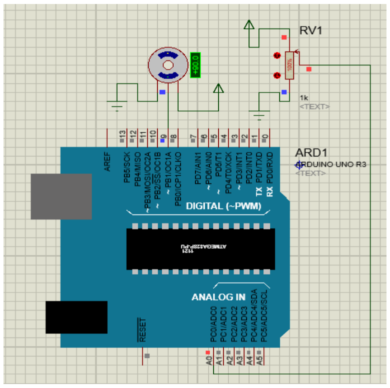

Figure 4. Simulated Motor Control Circuit using Arduino UNO R3

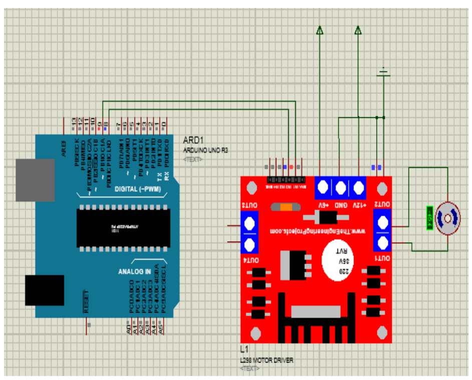

Figure 5. Simulated Motor Control Circuit using Arduino UNO R3 and L298N Motor Shield

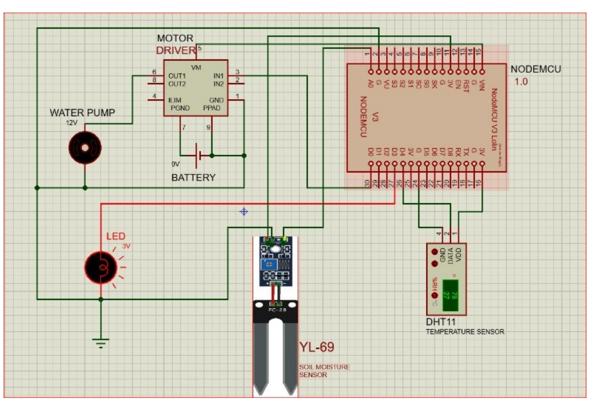

Figure 6. Simulated Automated Watering System for Greenhouse using DHT11 Sensor and YL-69 moisture Sensor

Fritzing

Fritzing is a free and open-source platform for teaching, sharing, and electronic prototyping projects. It enables the user to create a schematic and component, which may subsequently be used to create professional-looking wiring diagrams

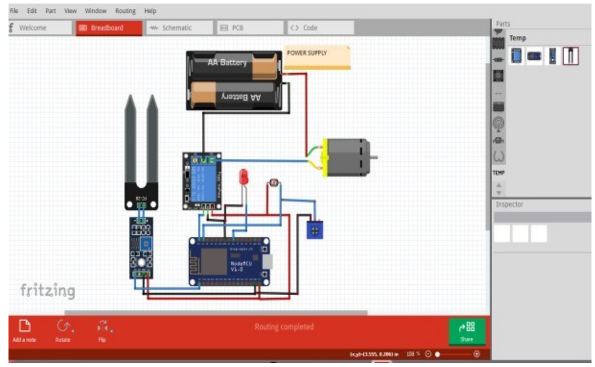

Figure 6. Wiring Diagram of an IOT based actual monitoring and control system for Greenhouse using DHT11 Sensor, YL-69 moisture Sensor and NODE MCU module.

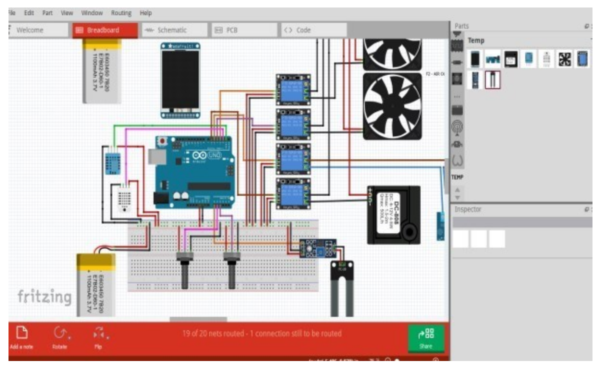

Figure 7. Wiring Diagram for Greenhouse with for IOT based actual monitoring and control system.

3 RESULTS AND DISCUSSION

Data Analysis

Stratified sampling was used to take into account the different characteristics of the study population. The new research model, the modified TAM, and the updated D&M IS Success Model was used to analyze the varied points of view presented by the respondents.

Since the study involves students and instructors from nine different campuses, this paper used Cochran's large population sampling formula.

$$n_0=\frac{Z2pq}{e2}$$

Where n0 is the sample size, Z2 is the desired confidence level, e is the desired level of precision, p is the estimated proportion of an attribute that is present in the population, and q is 1-p.

Supposedly set maximum variability, which is equal to 50%, thus, p = 0.5 and taking the 99% confidence level ±5% precision, the calculation for the

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required sample size will be as follows.

p = 0.5 and hence q = 1 – 0.5; e = 0.05; Z = 2.58

$$n_0 = \frac{(2.58)^2(0.5)(1-0.5)}{(0.05)^2} = 665.64 = 666$$

As a result, a total of 666 students and teachers with electronics disciplines from Cebu Technological University's nine campuses were picked at random for this paper. For each of the university's nine branches, there were 74 respondents.

For each of the nine campuses, 100 questionnaires were distributed, much exceeding the aim of 74 respondents per branch of the institution, ensuring a high percentage of surveys were returned.

Table 2. Selection of Sample

Campus	n for each campus	Frequency of sample/population	Percentage
Argao	74	97/100	11.31
Barili	74	95/100	11.07
Carmen	74	93/100	10.84
Daanbatayan	74	90/100	10.49
Danao	74	97/100	11.31
Main	74	100/100	11.66
Moalboal	74	92/100	10.72
San Francisco	74	98/100	11.42
Tuburan	74	96/100	11.19
TOTAL	666	858/900	100

The findings of the descriptive statistics of the nine factors are shown in Table 3. The majority of respondents strongly agree on the following factors when using circuit simulation and design software in teaching-learning electronics.

The ISO/IEC 25010 was used to validate the results further. The degree to which a system meets its various stakeholders' stated and implicit needs have been used to determine its quality.

The software used for the study is proprietary and requires subscriptions for upgrades and security. Commercial proprietary software has the best software usability since it comes with complete manuals, multichannel support from the software manufacturer, and efforts by the vendor to make the product as user-friendly as possible (Sen, 2007). Default installation settings, a user-friendly graphical user interface (GUI), contextual help, demos and examples, and the software's fault-tolerance characteristics, among other things, provide a considerable advantage. In addition, the study assumed that once the program has passed the beta testing stage and is ready for sale, the product's compatibility and security characteristics, based on ISO/IEC 25010, are in place.

The validation matrix for the ISO/IEC 25010 structures is shown in Table 4. Every mean is above 4.0, indicating that most respondents agree on the following constructs, as shown in the table. The average mean of 4.4528 for Functional Suitability may indicate that the set of functions covers all of the user's duties and objectives; features deliver the correct outcomes with the level of accuracy required; and, as a result, services make it easier to complete the tasks and goals provided. Based on applicable conceptions that may also indicate a high degree of efficiency based on-time behavior or response times and the appropriate resources to execute each activity, Performance Efficiency gained an average mean of 4.4479. According to the average mean of 4.4685 for usability, employing simulation software in terms of aesthetic presentation, user-friendliness, and allowing more freedom to the user while learning the process is highly acceptable. The simulation software's fault-tolerant capabilities and the availability of necessary functions and components meet the requirements for the simulation software's reliability, with an average mean of 4.4514. The researcher took the ability to test the integrity of various circuits into account while assessing the software's maintainability. With an average mean of 4.4580, it added the benefit of using such, resulting in a high acceptance level. In the Portability ISO criteria, the simulation software's capacity to perform effectively and efficiently on diverse or evolving hardware adapted to the needs of the time received an average mean of 4.4685.

The reliability of factors was examined using Cronbach's Alpha, and the data's fit to the model was determined using Confirmatory Factor Analysis (CFA).

The factor loadings for the sample of 666 respondents as the unit of analysis of the questionnaire for adopting circuit simulation and design software in teaching-learning electronics are shown in Table 5. The Likert 5-point scale was used to create the survey questionnaire. As research indicators, respondents indicated their level of agreement with each proposition. According to Napitupulu (2017), this approach would examine whether the study model was necessary to gauge or measure the user's acceptance of the technology. The model's validity can also be determined via a factor analysis.

The KMO (Kaiser-Meyer-Olkin) score, which goes from 0 to 1, was used to determine whether or not the data should be further investigated. The data were eligible for further factor analysis if the KMO value was equal to or more than 0.5 and the significant value (sig) or probability (p) was less than 0.05. (Napitupulu, 2017). The Kaiser – Meyer – Olkin (KMO) test and Bartlett's Test both had significant values, ranging from 0.738 to 0.889. Significant values (sig) of .000, respectively, and the data were eligible for factor analysis because they met the KMO requirements of being greater than or equal to 0.5 and a significance value of less than 0.05.

The Confirmatory Factor Analysis (CFA) findings confirmed that the scales were valid and trustworthy for the parameters under consideration, as shown in Table 5. According to Cronbach's Alpha, all of the measures used in this investigation had good internal consistency, ranging from 0.968 to 0.999, above the recommended reliability estimates of α = 0.

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Table 3. Summary of Means and Standard Deviations (N= 666)

Factors	Items	Mean	Standard Deviation
	The simulation software provides collaborative learning.	4.4565	0.49847
Educational Quality	The simulation software provides possibility of learning evaluation.	4.4429	0.49711
	The simulation software is appropriate with my learning style.	4.4805	0.49860
	The simulation software provides assistance or explanation.	4.5105	0.50027
Service Quality	The simulation software provides course management capability.	4.4399	0.49675
	The simulation software provides online assistance or updates.	4.4670	0.49928
	The simulation software is aesthetically satisfying.	4.4384	0.49657
Technical Quality System	The simulation software is user-friendly.	4.4399	0.49675
	The simulation software provides interactive features.	4.4429	0.49711
	The simulation software optimizes response time.	4.4429	0.49711
	The simulation software provides information relevant to my needs.	4.4444	0.49728
Information Quality	The simulation software provides comprehensive information.	4.4580	0.49860
	The simulation software provides me with organized and up to date content.	4.4565	0.49847
	The simulation software is easy to use	4.4805	0.49999
	The simulation software is easy to learn	4.5105	0.50027
Perceive Ease of Use	The simulation software is easy to access or navigate	4.5045	0.50036
	The simulation software is convenient to use	4.4835	0.50010
	The simulation software helps save time	4.4790	0.49993
	The simulation software helps save cost	4.4580	0.49860
	The simulation software improve my knowledge	4.4655	0.49918
Perceive Usefulness	The simulation software improve my performance	4.4625	0.49896
	The simulation software is effective	4.4625	0.49896
	The simulation software is efficient	4.4610	0.49885
	Using simulation software is enjoyable	4.4610	0.49885
	The simulation software satisfies my educational needs	4.4640	0.49907
User Satisfaction	I am satisfied with the performance of the simulation software	4.4625	0.49896
	The simulation software boost my self-confidence in design	4.4640	0.49907
	I highly recommend the use of simulation software	4.4670	0.49928
	I tend to use simulation software as soon as possible	4.4640	0.49907
Intention to use	The use of simulation & design software is far better than traditional way of designing circuits	4.4595	0.49873
	I tend to use simulation & design software to mass produce circuits	4.4580	0.49860
	I will use simulation software frequently	4.4279	0.49515
	I will use simulation & design software in all of my design process	4.4369	0.49638
Actual Use	I will use simulation & design software to mass produce circuits	4.4580	0.49860
	The use of simulation software is practical	4.4610	0.49885
	The simulation & design software is cost effective	4.4580	0.49860

The Average Variance Extracted (AVE) determined the Convergent validity of the structures of this study. According to Sevim et al. (2017), the AVE (Average Variance Extracted) should be greater than 0.5 to indicate sufficient convergent validity. All of the structures tested in this study had good results, as they were above the acceptable level. Using the Construct Reliability (CR)

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values of all the latent variables in this study's theoretical model, the internal consistency of all the model's constructs was also checked. The results showed that all constructs had higher CR values than the prescribed 0.70.

The results showed the measurement model's acceptable reliability (Hong & Walker, 2015). As a result, the internal consistency of the elements for each construct was high.

Table 4. Validation Results on the Applicable constructs from the Modified TAM and D&M IS Model based on product quality model ISO/IEC 25010

ISO/IEC 25010	Applicable constructs based on the Modified TAM and D&M IS Model	Mean
Functional Suitability This characteristic represents the degree to which a product or system provides functions that meet stated and implied needs when used under specified conditions		4.4444
	The simulation software provides information relevant to my needs	4.4580
	The simulation software provides comprehensive information	4.4565
	The simulation software provides me with organized and up to date content	
	Average Mean:	4.4528
Performance Efficiency the degree to which the response and processing times and throughput rates of a product or system, when performing its functions, meet requirements degree to which the maximum limits of a product or system parameter meet requirements		4.4429
	The simulation software optimizes response time	
	The simulation software provides information relevant to my needs	4.4444
	The simulation software provides me with organized and up to date content	4.4565
	Average Mean:	4.4479
Usability Degree to which a product or system can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use.		4.4640
	The simulation software satisfies my educational needs	4.4625
	I am satisfied with the performance of the simulation software	4.4670
	I highly recommend the use of simulation software	4.4595
	The use of simulation & design software is far better than traditional way of designing circuits	4.4805
	The simulation software is easy to use	4.5105
	The simulation software is easy to learn	4.5045
	The simulation software is easy to access or navigate	4.4835
	The simulation software is convenient to use	4.4399
	The simulation software is user-friendly	4.4429
	The simulation software provides interactive features	4.4384
	The simulation software is aesthetically satisfying	
	Average Mean:	4.4685
Reliability Degree to which a system, product or component performs specified functions under specified conditions for a specified period of time.		4.4595
	The use of simulation & design software is far better than traditional way of designing circuits	4.4369
	I will use simulation & design software in all of my design process	4.4580
	I will use simulation & design software to mass produce circuits	
	Average Mean:	4.4514
Maintainability This characteristic represents the degree of effectiveness and efficiency with which a product or system can be modified to improve it, correct it or adapt it to changes in environment, and in requirements.		4.4580
	The simulation & design software is cost-effective and easily updated	
	Average Mean:	4.4580
Portability Degree of effectiveness and efficiency with which a system, product or component can be transferred from one hardware, software or other operational or usage environment to another.		4.4835
	The simulation software is convenient to use	4.4610
	The use of simulation software is economical	4.4610
	The use of simulation software is practical	
	Average Mean:	4.4685

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Table 5. Results of confirmatory factor analysis and reliability test

Constructs	Items	Loadings	Construct Reliability	Average Variance Extracted	Cronbach's Alpha	KMO Test	Bartlett's Test
Educational Quality			0.992	0.978	0.993	0.785	.000
EQ1	The simulation software provides collaborative learning	0.994					
EQ2	The simulation software provides the possibility of learning evaluation	0.991					
EQ3	The simulation software is appropriate with my learning style	0.982					
Service Quality			0.991	0.974	0.991	0.767	0.000
SQ1	The simulation software provides assistance or explanation	0.985					
SQ2	The simulation software provides course management capability	0.979					
SQ3	The simulation software provides online assistance or updates	0.997					
Technical System Quality			0.992	0.971	0.993	0.866	.000
TQ1	The simulation software is aesthetically satisfying	0.979					
TQ2	The simulation software is user friendly	0.996					
TQ3	The simulation software provides interactive features	0.970					
TQ4	The simulation software optimizes response time	0.995					
Information Quality			0.991	0.974	0.999	0.762	.000
IQ1	The simulation software provides information relevant to my needs	0.994					
IQ2	The simulation software provides comprehensive information	0.997					
IQ3	The simulation software provides me with organized and up to date content	0.970					
Perceive Ease of Use			0.968	0.884	0.968	0.878	.000
PEOU1	The simulation software is easy to use	0.947					
PEOU2	The simulation software is easy to learn	0.933					
PEOU3	The simulation software is easy to access or navigate	0.913					
PEOU4	The simulation software is convenient to use	0.968					
Perceive Usefulness			0.994	0.970	0.995	0874	.000
PU1	The simulation software helps save time	0.998					
PU2	The simulation software helps save cost	0.999					
PU3	The simulation software improve my knowledge	0.989					
PU4	The simulation software improve my performance	0.973					
PU5	The simulation software is effective	0.983					
PU6	The simulation software is efficient	0.952					
User Satisfaction			0.997	0.985	0.997	0.889	.000
S1	Using simulation software is enjoyable	0.992					
S2	The simulation software satisfies my educational needs	0.992					
S3	I am satisfied with the performance of the simulation software	0.995					
S4	The simulation software boost my self-confidence in design	0.996					
S5	I highly recommend the use of simulation software	0.986					
Intention to Use			0.992	0.978	0.993	0.785	.000
ITU1	I tend to use simulation software as soon as possible	0.994					
ITU2	The use of simulation & design software is far better than traditional way of designing circuits	0.991					
ITU3	I tend to use simulation & design software to mass produce circuits	0.982					
Actual Use			0.985	0.957	0.985	0.738	.000
AU1	I will use simulation software frequently	0.999					
AU2	I will use simulation & design software in all of my design process	0.982					
AU3	I will use simulation & design software to mass produce circuits	0.953					

4 CONCLUSIONS AND RECOMMENDATION

The study's findings emphasized circuit simulation and design tools as part of the teaching-learning process

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for higher electronics. Not only does simulation software have a long list of advantages, but it also has a long list of benefits, according to the research. Cost-effective designs and advanced manufacturing processes match this technologically driven world. The academe's decision-makers gained insight into using simulation software in teaching-learning higher electronics, allowing them to develop successful techniques for teaching from simple to complicated theories in higher electronics relevant to real-world applications for sustainable development. Integrating simulation activities into the curriculum may also make it easier to transition from theory-based training to actual circuit development and testing.

Mohammadi (2014) stated that E-learning should provide a better value than other types of learning for users to continue using it. Aside from being a technology platform, the modified TAM and D&M IS Success model is also based on empirical research solely relevant to students. It is recommended to further research to see if the individual qualities of the users have an impact on the model's success. It would be helpful to conduct the same study among industry learners to see any similarities or differences between university students and trainees at a company.

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