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Electronic Learning Modules in Mobile Devices: A Technology Acceptance Model Approach Using PLS-SEM

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***Abstract*—** Adopting new information technology (IT) solutions has been one of the most effective means to improve the quality of instruction delivered to students. With the spread of the coronavirus 2019 pandemic, many learning institutions have shifted from the conventional mode of learning, where instructions are usually delivered inside the classroom, into a more flexible mode. Thus, integrating new IT solutions plays a big part in these changes. This study aimed to identify relationships among the variables contained in the Technology Acceptance Model (TAM) to use electronic learning modules on an application installed on mobile devices using partial least square–structural equation modelling (PLS-SEM). Sixty-five-point-nine percent of males and thirty-four-point-one percent of females participated in this study, which made up the eighty-two total number of respondents. Analysis shows that this number of respondents was sufficient for this study. Using WarpPLS 7.0, analysis was performed. Results revealed that there were significant positive relationships between perceived ease of use and perceived usefulness; perceived ease of use and attitude toward using; attitude toward using and intention to use; and perceived usefulness and intention to use. However, the analysis revealed that there was no significant relationship between perceived usefulness and the attitude toward using it. A revised TAM model was presented based on parameter estimates.

Keywords—Electronic Learning PLS-SEM, Modules, Technology Acceptance Model

I. INTRODUCTION

Schools all across the world have been forced to close because of the coronavirus (COVID) 2019 pandemic. Over 1.2 billion children were out of school worldwide. Due to the lack of students in schools, school officials had to devise ways to continue providing services. It also necessitated them to look for ways in which students could continue their education. One recent technological advancement that has emerged is the use of electronic learning materials uploaded on different electronic platforms. The use of various electronic learning platforms, including mobile learning, has risen due to this rapid transformation in education.

In today's era, phones have evolved into a vital part of everyday lives. An increasing number of smartphone users has been dramatically observed, and in the coming years, rapid growth and development in this technology is expected to be seen. This provides an opportunity to maximize the use of mobile technology in the teaching and learning process. Mobile learning is the use of technologies such as smartphones, tablets, and laptops in the teaching and learning process. When using smartphones for mobile learning, it is very easy to install applications for quick access to learning materials. Using learning materials in offline mode is doable using mobile technologies. Typically, accessing material in online mode has been a problem for students. That is why storing learning resources which can be accessed in offline mode is of great help to different students from different social statuses.

As mentioned, a large number of learning materials have been made available on the internet and can be accessed through mobile devices. Different learning applications are available for students to acquire new knowledge and develop new sets of skills. This makes mobile learning more efficient and effective. However, this can be challenging for new courses under the new curriculum implemented by the Commission on Higher Education (CHED) of the Philippines in 2018. The Bachelor of Science in Information Technology (BSIT) is now composed of new courses as expressed in the CHED Memorandum Order No. 25 series of 2015. One of which is the Application Development and Emerging Technologies course.

In 2020, when learning institutions in the Philippines decided to not allow students to physically report to school because of COVID-19, flexible learning modalities were implemented. The concepts of synchronous and asynchronous learning have been utilized. Face-to-face,

remote learning, blended learning, and home-schooling have been made available as cited by [1]. For instance, the use of learning management systems has been greatly observed and implemented by different learning institutions to mitigate the increasing number of active COVID-19 cases. In a study, the perceptions of undergraduate students using learning management systems in online classes were investigated. Researchers found that the student profile does not significantly affect their perception of the online classes [2]. The use of learning management systems, video conferencing software, instant messaging, and even social media platforms have also been employed by different learning institutions to continue delivering instruction to different students.

Having an internet connection is a pre-requisite for using these technologies. However, not all students have a stable internet connection. This is one of the common problems of undergraduate students in the Philippines — limiting them to accessing learning resources over the internet. Because of this common problem, learning institutions had to provide a means to produce learning materials in printed form. In a higher learning institution in Central Luzon, Philippines, the contents of the learning modules in printed formats were prepared by faculty members. Contents were based on the syllabi of instruction aligned with the prescribed topics and conforming to set standards by different accrediting bodies.

Learning module design and development has been a collaborative effort made by educators to devise means in order to effectively deliver quality instruction to undergraduate students. While printed modules are still an effective instructional material, the digitalization and digitization of education seek to encourage educators to utilize information technology solutions in the teaching and learning process. Hence, the term "technology integration" comes into play. Developing methods for converting traditional learning materials into electronic or digital formats necessitates significant effort and acceptance from target beneficiaries. That is why the need to conduct an assessment on how students accept this technology is necessary.

Most students enrolled in the information technology undergraduate program of a college or higher learning institution in Central Luzon possess smartphones. These mobile devices have become an inevitable device or tool for learning and socialization. They use mobile phones for programming courses, research, and even designing digital media outputs. Because of the current context experienced in the college using mobile phones, converting printed learning modules to electronic materials which can be found in a mobile application is a possible solution so that printed modules can be shortened. Also, the cost of producing it can be decreased, and converting it to electronic materials allows access by many undergraduate students. Therefore, access to instructional materials can be easier.

The use of mobile technologies also contributes to student learning engagement. Ensuring utmost learning engagement among the students lead to better learning outcomes whether in asynchronous or synchronous mode [2]. In higher learning institutions, learning experiences play an important role in the overall holistic development of the college students [3].

This study sought to determine the perceptions of the Information Technology (IT) students on the usefulness, ease of use, attitude towards, and intention to use electronic learning (e-learning) modules prepared by the instructors for the Application Development and Emerging Technology course. These variables are vital constructs of the Technology Acceptance Model by [4]. The study provides a solution to existing difficulties experienced when learning materials are in printed format by using mobile technology for teaching and learning. The overall goal of this study was to provide new insights and information about undergraduate students' acceptance of the use of mobile technologies in incorporating electronic learning modules.

The following sections of this paper cover a brief discussion on mobile learning and its application in teaching and learning and the technology acceptance model. This is then followed by the methodology; results and discussion; and conclusion and future scope of this study.

II. RELATED WORK

Mobile Learning and Its Application in Teaching and Learning

Mobile learning, often known as MLearning, is a teaching and learning approach that makes use of wirelessly connected mobile devices. Due to the use of mobile devices, students may learn whenever and wherever they choose [5]. This feature of mobile learning allows learners to have better access to a wide range of learning resources. Thus, mobile technology, when integrated into the teaching and learning process, increases the motivation of learners [6]. Also, when mobile computing devices are introduced in the classroom, both teachers and students increase the quality and quantity of their work, leading to a more productive learning process [7].

Mobile learning deals with the accessibility of the learner. Learners should be able to participate in academic activities without needing to do so in a physically constrained environment. When learners take advantage of learning opportunities offered by mobile technologies, mobile learning becomes more effective [8]. Mobile learning includes characteristics such as portable and lightweight gadgets that may sometimes fit in a pocket or in the palm of one's hand. Smartphones, palmtops, portable computers, tablet PCs, laptop computers, and personal media players are all examples of mobile devices that may be used for mobile learning [9].

The success of mobile learning is influenced by several factors, including the availability of the technology; institutional support; connectivity; integration into the everyday lives of the learners and the teachers; and the ownership of the learners [6]. However, there are a few challenges to mobile learning. This include enhancing the usability of mobile learning technology, creating novel informal learning models supported by mobile devices, and evaluating outdoor and multi-location learning [6].

The advantages of mobile learning include its accessibility anywhere and anytime, the range it can reach since distance is not an issue in mobile learning, the variety of content, and the opportunity for learners to perform better in class due to the benefits that mobile learning can bring. Some of the benefits of mobile learning include digital-first thinking. Since the current workforce is comprised of a large number of millennials and Generation Zs, it is important to understand the importance of integrating technologies into the teaching and learning process [10]. This includes mobile devices and employing mobile learning, especially in difficult times where teaching and learning can't happen in an actual school setting.

Another benefit was that mobile learning allows personalization of learning and dynamic teaching methodologies. For students and teachers, personalization of learning means flexibility. This enables students to easily catch lessons and teachers to prepare for the next one. It was mentioned that dynamic teaching methodologies may be observed because in mobile learning, teachers can embed audio, video, and images to supplement and complement the lesson. Hence, making it friendlier to new and seasoned educators for the effective delivery of instruction. On the other hand, some disadvantages include software compatibility issues, hardware issues, the distractions it may bring, misuse, and the lack of internet connectivity and even electricity. The use of mobile learning leads to an increasing reliance on technological tools. It is a problem, especially on the part of educators. When they fully rely on technology alone, the delivery of instruction becomes more challenging. Also, for students, too much reliance on technological tools may hinder the development of their creativity and resourcefulness.

Technology Acceptance Model

The Technology Acceptance Model (TAM) introduced two constructs: perceived usefulness and perceived ease of use [4]. Perceived usefulness pertains to the idea that using an application can help increase performance. Meanwhile, perceived ease of use refers to the belief that using the application can be free from excessive exertion of effort [11]. These core variables have been proven to be antecedent factors which affect the acceptance of technology [12]. As a result, TAM is an important model for understanding human behavior in terms of potential technology adoption [12]. It is relevant to note that the acceptance, adoption, and use of technology can be predicted through TAM [11].

A study has been conducted on the acceptance of instant messaging by students in one learning institution. The researchers asserted that when students feel that the technology to be used is useful and meaningful to them, they will use it [13]. Thus, it is necessary to conduct an assessment using TAM to know if the technology will be accepted by the intended beneficiaries or not. Another study was conducted using TAM to determine the feasibility of using virtual reality in shopping. Results indicated the initial acceptance of the respondents could be a basis for understanding the technology from other perspectives as well [14]. This means that the use of TAM effectively provides a basis for determining if a technological product or idea can prosper and be accepted or not.

In the educational landscape, research involving technology acceptance in teaching and learning has become an attractive trend [15, 16]. An increasing number of educators have engaged in conducting studies relating to how students accept new information technologies when integrated into the delivery of instruction. Since 21st century teaching and learning requires learners and educators to be equipped with digital knowledge and skills, it has become essential to integrate information technologies into the delivery of instructions. The meaningful inclusion of technology in an educational setting contributes to the effective learning process. However, there is still a gap in the existing knowledge about academic literature that applies to TAM in the educational setting [12]. Thus, new studies must be conducted to provide new knowledge and explore how TAM could affect an effective teaching and learning process. Setting this as one of the objectives of the current study is relevant to clearly identifying the direction of this academic endeavour.

This study has been undertaken to determine the relationship between perceived usefulness, perceived ease of use, attitude towards, and intention to use e-learning modules on mobile devices among IT students following the Technology Acceptance Model using PLS-SEM. Specifically, it sought to present the model based on the results of the analysis in this study.

III. METHODOLOGY

Research Design

This study employed a quantitative approach to research. Specifically, the Structural Equation Modelling (SEM) using the Partial Least Squares (PLS) technique has been utilized to explore the relationships of different variables and identify the impact on each other to provide an understanding of the interplay of these elements. Employing a quantitative research design approach enables the researchers to answer the research problems, which include understanding the causal relationships of the TAM variables and providing a revised model as a basis for drawing valuable insights for the acceptance of electronic learning modules on mobile devices by undergraduate students.

Research Locale

The research was carried out at a state university in Central Luzon, Philippines during the second semester of academic year 2020-2021. It involved undergraduate students enrolled in the Application Development and Emerging Technologies course to investigate their acceptance of the electronic modules integrated in information technology solutions like mobile applications to provide more accessible learning resources, whether in online or offline mode.

Respondents of the Study

A sufficient sample size is a necessary requirement when conducting PLS-SEM. To estimate the adequacy of the sample size, inverse square root and gamma-exponential methods were used [17]. Using WarpPLS version 7.0, with a minimum absolute significant path coefficient of 0.22, a significance level of 0.05, and a power level of 0.68, the inverse square root technique offered 93 samples, while the gamma-exponential method proposed 81 samples, as shown in Figures 1 and 2 [18]. The sample size in this study is 82, which is between 81 and 93. Thus, the sample size used in this study is sufficient to explain the results of the structural model.

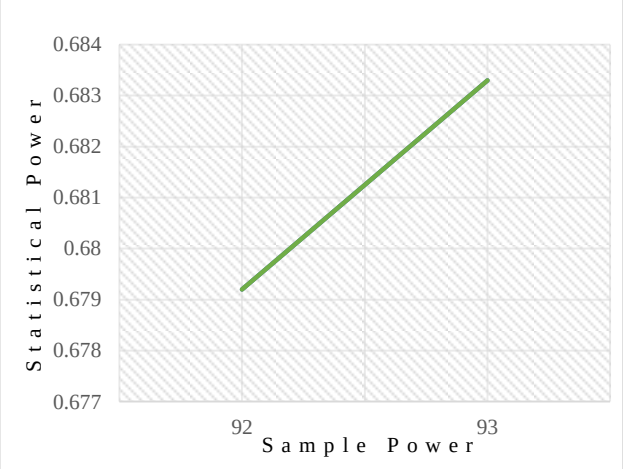

Figure 1. Result of the inverse square root method

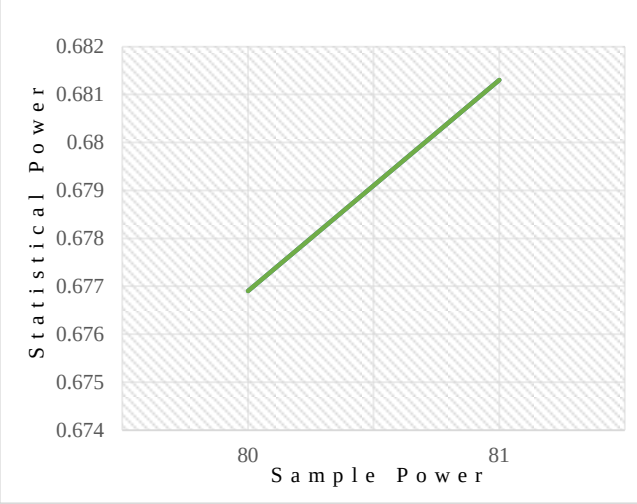

Figure 2. Result of the Gamma-exponential method

Table 1 presents the demographic characteristics of the respondents participated in this study.

Table 1. Demographic Characteristics of the Respondents

	Frequency	**Percentage (%)**
Sex		
Male	54	65.9%
Female	28	34.1%
Age		
18 – 19 years old	27	32.9%
20 – 21 years old	52	63.5%
22 – 24 years old	2	2.4%
25 years old and above	1	1.2%

As shown in the table, respondents were composed of 65.9% of males and 34.1% of females. In the higher learning institution for this study, the number of male students is greater than the number of female students as supported by [19].

Research Instrument

A survey questionnaire was used as the instrument for this study. Ensuring that the instrument used produces results that can answer the research problems is essential for a research study. Thus, the researchers conducted a literature review to understand the constructs needed for the instrument.

The instrument has two parts. The first part contains the demographic profile of the respondents, and the second part enumerates the items for the four-construct used in this study: perceived ease of use, perceived usefulness, attitude towards using, and intention to use. The contents of the instrument were based on [4]. However, the researchers modified the instrument to suit the context of this study.

Reliability and Validity Measurements

Table 2 presents the reliability and convergent validity measures. Reliability is concerned with an instrument's ability to measure consistently. Internal consistency describes the extent to which all the items in a test measure the same construct [20]. Composite reliability and Cronbach's alpha are measures of internal consistency with an acceptable coefficient of 0.70 and above for both. As can be seen, the coefficients of CR and CA are above 0.70. Thus, the latent variables are reliable.

Validity is concerned with the extent to which an instrument measures what it is intended to measure [20]. An instrument has good convergent validity if the items associated with each latent variable are understood by the respondents in the same way as they were intended by the designers of the instruments [21]. The measures for discriminant validity are loading and average variance extracted (AVE). The p-values for each load must be equal to or less than.05, and each load must have a value of 0.5 or above [22]. The AVEs must be greater than or equal to 0.5 [23]. As can be seen, the factor loading for each latent variable and its AVE have values above 0.5 and satisfy the accepted validity.

Table 2. Convergent Validity and Reliability Measures

Construct	No. of Items	Factor Loading	AVE	CR	CA
Perceived Ease of Use	3	.83 - .86	0.72	0.89	0.81
Perceived Usefulness	4	.71 - .87	0.64	0.88	0.81
Attitude toward Using	5	.68 - .83	0.61	0.88	0.84
Intention to Use	5	.73 - .82	0.58	0.87	0.82

All item loadings are significant at .001 (p<.001). AVE=average variance extracted; CR=composite reliability; CA=Cronbach's alpha

Table 3 presents the discriminant validity measures. An instrument has good discriminant validity if the items in each latent variable are not confused by the respondents with the items in other latent variables [21]. The measure for discriminant validity is the square root of the AVE coefficient. The square root of the AVE of every latent construct should be greater than any of the correlations involving the said construct [24]. As can be seen, the square root of the AVE of each latent construct is greater than any of the correlations involving the construct. Thus, the items have discriminant validity.

Table 3. Discriminant Validity Measures

	Perceived Ease of Use	Perceived Usefulness	Attitude Toward Using	Intention to Use
Perceived Ease of Use	**0.850**			
Perceived Usefulness	0.584	**0.801**		
Attitude toward Using	0.756	0.520	**0.779**	
Intention to Use	0.710	0.554	0.773	**0.761**

Diagonal elements are the square root of AVE of constructs while the off-diagonal elements are the correlation between constructs.

Data Gathering Procedures

In the conduct of data gathering, the researchers performed the following activities: reviewed related literature and studies; constructed the instrument; analyzed the validity and reliability of the research instrument; sought approval to conduct the data gathering; collected and analyzed the responses; interpreted the result; and wrote the research report.

In the conduct of the literature review, the researchers read and analyzed research articles, conference proceedings, and books relevant to this study. The essential information was collected and organized. It is necessary to conduct this activity to have a better understanding of the topic under investigation. After the review of related literature and studies, the instrument has been constructed. The researchers ensures that the instrument answers the research problem. To ensure its quality, the researchers sought the expertise of other professionals to review its contents. The feedback given by other researchers was considered for the improvement of the instrument. Afterwards, the reliability analysis was performed. It ensures consistency of items in the instrument.

The researchers then sought approval for the conduct of the study. When the approval was given, the researchers used Google Forms to disseminate the instrument because the conduct of the study happened at the time of the community lockdown because of the pandemic. In the Google Form, essential information was added to ensure that the respondents understood the goal of this study. The researchers also entertained queries from the respondents through instant messaging platforms and short message services to provide additional input. The researchers ensured research ethical considerations. Moreover, they ensured the respondents that the data collected would be treated with the utmost confidentiality and anonymity.

When the period for the data gathering was over, the researchers collected them and performed the appropriate data analysis techniques. Afterwards, the researchers interpreted the results and findings of this study. Lastly, the research report has been written.

Data Analysis

Partial least squares–structural equation modelling (PLS-SEM) using WarpPLS 7.0 was employed to estimate the parameters of the structural model. This statistical test follows three (3) steps: model specification, outer model evaluation, and inner model evaluation [25]. In the model specification, the logical path model is created. Outer model evaluation involves testing for the reliability and validity of the model constructs, while inner model evaluation involves the analysis of the paths of the structural model [26]. A mediation analysis was also conducted.

Model Fit and Quality Indices

Table 4 presents the model fit and quality indices of the PLS structural model. When assessing the model fit with the data, the coefficients of average path coefficient (APC), average r-squared (ARS), and average adjusted r-squared (AARS) must have p-values equal to or lower than.05 [27]. The average block variance inflation factor (AVIF) and average full collinearity VIF (AFVIF) must be equal to or lower than 3.3 [23]. As can be seen, the coefficients of APC, ARS, and AARS have p-values less than.001 and the AVIF and AFVIF are lower than 3.3. Thus, the model fits the data.

The Tenenhaus goodness of fit (GoF) is an index of the explanatory power of the structural model [28]. The explanatory power is small if the coefficient is greater than or equal to 0.1, medium if it is greater than or equal to 0.25, and large if it is greater than or equal to 0.36 [29]. As can be seen, the Tenenhaus GoF is 0.592, indicating that the explanatory power of the structural model is large.

Table 4. Model Fit and Quality Indices

Indices	Coefficients
APC	0.467, p<0.001
ARS	0.550, p<0.001
AARS	0.542, p<0.001
AVIF	1.529
AFVIF	2.605
Tenenhaus GoF	0.592

IV. RESULTS AND DISCUSSION

Model Results

Figure 3 illustrates the PLS path model with beta coefficients as the path coefficients of the model. As can be seen, the beta coefficients for the paths between perceived ease of use and perceived usefulness (β = 0.65, p = 0.01); perceived ease of use and attitude toward using (β = 0.69, p = 0.01); attitude toward using and intention to use (β = 0.66, p = 0.01); and perceived usefulness and intention to use (β = 0.22, p = 0.02) are significant and positive. These indicate that there are significant positive relationships between perceived ease of use and perceived usefulness; perceived ease of use and attitude toward using; attitude toward using and intention to use; and perceived usefulness and intention to use.

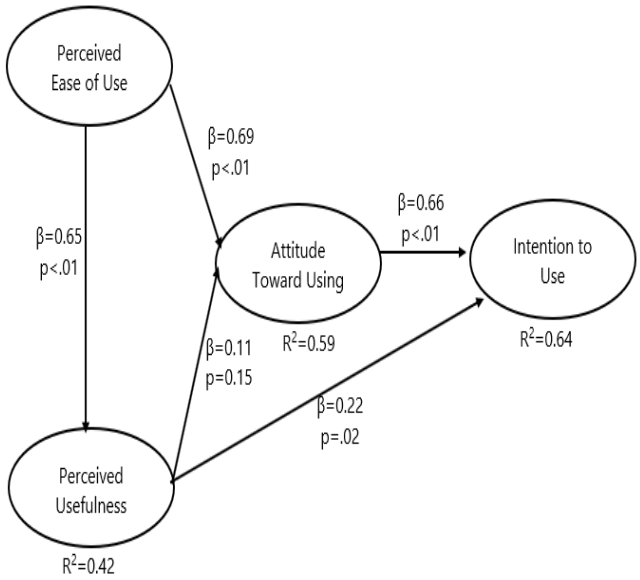

Figure 3. The Technology Acceptance Model with Parameter Estimates

The positive relationship when accepting technology in terms of its usefulness and ease of use is supported by [30]. Researchers also expressed a somewhat strong relationship between usefulness and ease of use [31]. Another study was conducted expressing that perceived usefulness and perceived ease of use are direct and significant predictors of behavioural intentions to use technology. Moreover, perceived usefulness is affected by perceived ease of use and job relevance [32]. This study found that when students positively perceive the usefulness of technology, it can become easy to use for them. This positive relationship denotes easy acceptance and high confidence in the technology.

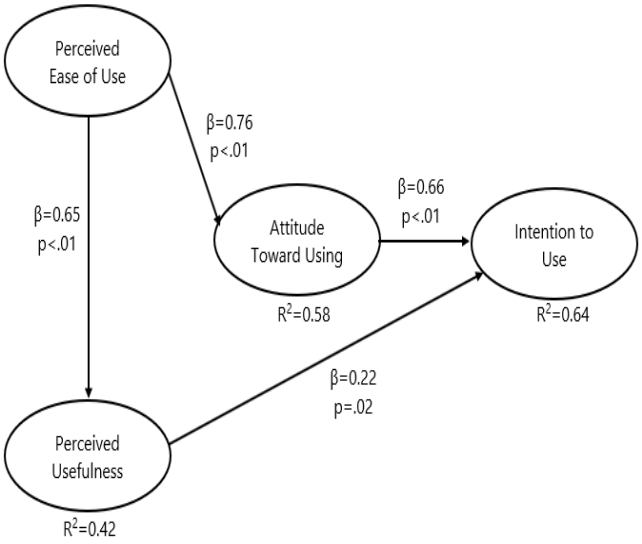

Figure 4. Revised Technology Acceptance Model with Parameter Estimates

However, the analysis reveals that there is no significant relationship between perceived usefulness and attitude toward using (β = 0.11, p = 0.15). The coefficient of determination (r-squared) is also shown in the PLS path model. The R^2 coefficients indicate how much of the total variation in the latent variable can be explained by the latent variables that are hypothesized to affect it [33]. The R^2 coefficients of 0.42, 0.59, and 0.64 reflect the predictive accuracy of the exogenous variable on the endogenous variable.

A study found that attitudes and feelings such as anxiety have no impact on perceived usefulness in the context of e-commerce acceptance by college students [34]. Another study discovered that the perceived usefulness and attitude toward unit dose dispensing using a management information system in a pharmacy installation in one hospital have insignificant effects [34]. Thus, supporting the results of this study.

Revised Model

Figure 4 illustrates the revised PLS path model with the insignificant path removed. As can be seen, the beta coefficients for the paths between perceived ease of use and perceived usefulness (β = 0.65, p = 0.01); perceived ease of use and attitude toward using (β = 0.76 p = 0.01); attitude toward using and intention to use (β = 0.66, p = 0.01); and perceived usefulness and intention to use (β = 0.22, p = 0.02) are significant and positive. These indicate that there are significant positive relationships between perceived ease of use and perceived usefulness, perceived ease of use and attitude toward using; attitude toward using and intention to use; and perceived usefulness and intention to use.

The R^2 coefficients of 0.42, 0.58, and 0.64 indicate that 42% of the variation in perceived usefulness can be explained by perceived ease of use, 58% of the variation in attitude toward using can be explained by perceived ease

of use, and 64% of the variation in intention to use can be explained by perceived ease of use, perceived usefulness, and attitude toward using.

Using the revised mobile, mobile application may be design and develop but the results on the acceptance of the students may be considered to produce a more applicable, acceptable, and appropriate application for the intended beneficiaries. Moreover, the results of the assessment can be a basis for other future mobile application development projects.

Direct and Indirect Effects

Table 5 presents the direct and indirect effects of the revised PLS path model. Analysis of the data indicates that perceived ease of use positively affects perceived usefulness ($\beta = 0.65$, $p < 0.01$) with a large effect size (Cohen's $f^2 = 0.42$); perceived ease of use positively affects attitude towards using ($\beta = 0.76$, $p < 0.01$) with a large effect size (Cohen's $f^2 = 0.58$); perceived usefulness positively affects intention to use ($\beta = 0.22$, $p = 0.02$) with a small to medium effect size (Cohen's $f^2 = 0.13$); and attitude towards using positively affects intention to use ($\beta = 0.66$, $p < 0.01$) with a large effect size (Cohen's $f^2 = 0.51$).

The analysis also indicates that the indirect effect of perceived ease of use on intention to use with attitude toward using as a mediator is statistically insignificant ($\beta = 0.14$, $p = 0.03$) while the indirect effect of perceived ease of use on intention to use with perceived usefulness as the mediator is statistically significant ($\beta = 0.50$, $p < 0.001$) with large effect size (Cohen's $f^2 = 0.36$). This suggests that perceived usefulness mediates the effect of perceived ease of use on the intention to use.

Table 5. Direct and Indirect Effects

	β	SE	p-value	f^2
Direct Effects				
PEU → PU	0.65	0.09	<.01	0.42
PEU → ATU	0.76	0.09	<.01	0.58
PU → IU	0.22	0.10	.02	0.13
ATU → IU	0.66	0.09	<.01	0.51
Indirect Effects				
PEU → PU → IU	0.14	0.08	.03	0.10
PEU → ATU → IU	0.50	0.07	<.001	0.36

PEU=perceived ease of use; PU=perceived usefulness; ATU=attitude towards using; IU=intention to use; f^2 is [25] effect size: 0.02=small, 0.15=medium, 0.35=large; SE=standard error; β=standardized path coefficient.

V. CONCLUSION AND FUTURE SCOPE

This study aims to identify the relationship between the ease of use, perceived usefulness, attitudes towards and the intention to use electronic learning modules using mobile applications. The study involved 82 respondents, and based on the analysis of the measure of sufficiency, which is one of the requirements for PLS-SEM, the total number of respondents was found to be sufficient for this study. The respondents were composed of 65.9% males and 34.1% females. An instrument based on [6] was utilized for this study, but modifications were made to suit the context of the current study. WarpPLS 7.0 was used to perform partial least squares-structural equation modeling (PLS-SEM). An analysis of validity and reliability was performed to ensure the suitability of the instrument for this study.

Results show that there are significant positive relationships between perceived ease of use and perceived usefulness; perceived ease of use and attitude toward using; attitude toward using and intention to use; and perceived usefulness and intention to use. However, the analysis reveals that there is no significant relationship between perceived usefulness and the attitude toward using it. A revised TAM model was made based on parameter estimates.

Based on the results, application developers may use the findings of this study as a basis for the development of a mobile application to integrate electronic learning modules. Furthermore, future studies may be conducted to test the revised model presented in this study.

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