Assessing Technology Adoption at a University of Technology: A Case Study of Electronic Response Systems

Onalenna P. Tsumake
Central University of Technology
Department of Innovation in Learning and Teaching
Bloemfontein, South Africa
otsumake@cut.ac.za

Arthur J. Swart
Central University of Technology
Department of Electrical, Electronic and Computer
Bloemfontein, South Africa
aswart@cut.ac.za

***Abstract*— Technology adoption is defined as accepting and using a new technology in order to improve delivery, service or performance. One such new technology is an electronic responsive system, called clickers. One of the advantages of clickers is to help passive students become more actively engaged with course material during classroom time while helping academics to monitor student learning. Despite the advantages of using clickers in education, some academics fail to adopt this new technology into their teaching practice. The purpose of the paper is to establish factors that may influence academics to adopt the use of clickers at universities of technology. A non-experimental research design incorporating a descriptive case study with quantitative data is used with convenient sampling. Sixty academics from a specific university completed a questionnaire that was structured using the four main constructs of Venkatesh's Unified Theory of Acceptance and Use of Technology model. Statistical results suggest that there is a strong relationship between Performance Expectancy, Effort Expectancy and Facilitating Conditions towards the use of clickers. Social influence has a moderate relationship in this regard. The results also indicate that age; experience or gender play no significant role in the adoption of such a system. Based on these results, there is a need to create awareness among all academics, irrespective of their age, experience or gender, of the importance of adopting clickers in their teaching practice to further student learning.**

***Keywords*—Unified Theory of Acceptance and Use of Technology, UTAUT, clickers, usability**

I. INTRODUCTION

Universities have embraced the use of emerging technologies as a way to improve quality education and to create more opportunities in the teaching and learning environment [1]. This may lead to improved student engagement with course content, enabling individual students to become actively involved in the teaching and learning process.

There are other technologies that enable interactivity amongst students through immediate formative feedback. This immediate feedback can achieve higher engagement and positive student responses to assessments [2]. Interactivity and effective feedback also doubles how quickly students learn and it is one of the best ways to improve student learning [3]. Its technology tools like electronic responsive systems (also called clickers) that provide this type of feedback, thereby enhancing student participation and engagement in the classroom environment [4].

Previous research has shown that clickers enhance students' motivational levels for learning through leveraged classroom participation [5]. Despite such advantages associated with using clickers in a classroom, some academics fail to adopt these emerging technologies into their teaching practice [4].

The research question thus arises "what may influence an academic to adopt clickers in his or her teaching practice?" Technology adoption models may be used to answer this question [6]. Technology adoption describes the adoption or acceptance of a new product or innovation, according to the demographic and psychological characteristics of a defined group of people. Technology adoption includes a number of different theory models [7]. Some of these include the UTAUT model (Unified Theory of Acceptance and Use of Technology) [8], TAM (Technology Acceptance Model), TRA (Theory of Planned Behaviour), TTF (Task Technology Fit) and TPB (Theory of Planned Behaviour) [9]. The UTAUT model is selected for this paper from various theoretical models as a result of its ability to be adapted to diverse studies and capable to help one understand complex technologies, such as clickers.

The purpose of the paper is to establish factors that may influence academics to adopt the use of clickers at universities of technology. A non-experimental research design incorporating a descriptive case study with quantitative data is used with convenient sampling. The paper will firstly review the UTAUT model and the importance of student engagement by using an ERS (Electronic Response System that is also termed "clickers"). Secondly, the research methodology is given along with the results and the conclusions.

II. LITERATURE REVIEW

The UTAUT model is composed of eight models and theories (TRA, TAM, MM, TPB, C-TAM-TPB, MPCU, IDT, and SCT) [8]. The UTAUT is a technology acceptance model formulated by Venkatesh [8] and others in "User acceptance of information technology: Toward a unified view". The UTAUT aims to explain user intentions to use an information system and subsequent usage behaviour. The theory holds that there are four key constructs: Performance Expectancy, Effort Expectancy, Social Influence, and Facilitating Conditions [8]. The purpose of conveying the UTAUT model was to incorporate the uneven theory and research on the individual acceptance of information technology into a unified theoretical model. This model has been used in a variation of settings to ascertain the use of technology and Facilitating Conditions and behaviours.

Aditya and Permadi [10] used the UTAUT model to assess the use of a virtual classroom in supporting teaching and learning in Higher education. The UTAUT model may help to determine the cause of underutilization of a specific technology.

Figure I shows the original UTAUT model with an additional construct to be used in this study, being digital inclusion. This additional construct may have an impact upon the behavioural intention of people to adopt a new technology or innovation [11]. This adapted model may provide a sound theoretical framework for analysing the technology acceptance of ERS by academics. The following defines the UTAUT model constructs:

- PE - Performance Expectancy is defined as the degree to which an individual believes that using the system will help him or her to improve their job performance [12].
- EE - Effort Expectancy is defined as the degree of ease associated with the use of the system [13].
- SI - Social Influence is defined as the degree to which an individual perceives the importance from other individuals about a system and believes he or she should use it [6].
- FC - Facilitating Conditions refers to the extent to which an individual perceives that technical and support structures are in place to help new users with the system [11].
- DI - Digital Inclusion is defined as the ability of an instructor and groups to access and use information and communication technologies in the system [14].

Each of these constructs may influence the behavioral intention (BI) of academics to use a technology or a system, which may also be linked to their age, experience and gender (these are seen as variables). All the constructs may influence the BI of a user and also contribute to user behavior (UB). The technology or system under review in this paper is an ERS.

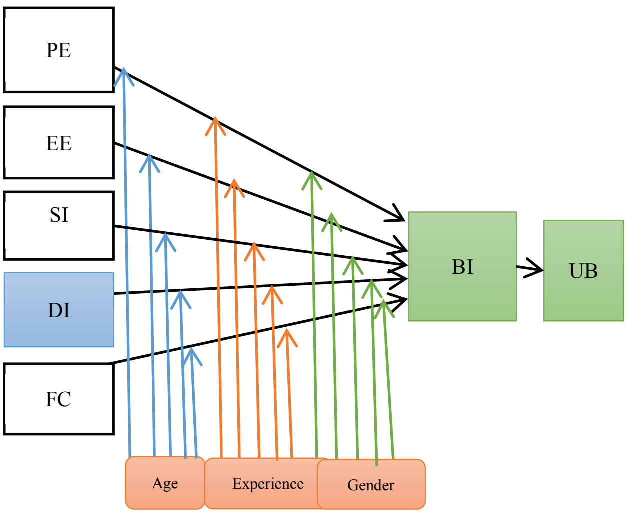

Fig. I The UTAUT Model Extended

E-learning, or electronic learning, is one platform that students may use to enhance their skills through online learning [15]. These include clickers, Blackboard, WebCT and Web 2.0 technologies. These emerging technologies have brought about flexibility and innovation in delivering and communicating information between academics and students. The effective use of these technologies have shown to improve student engagement with course content, to enable reflective practice and to help students to be successful in their academic studies [16] [17] [18]. According to [19] it is reported that clickers increase student engagement and student attendance when they are part of a classroom session.

Kuh [20] defines student's engagement as the time and effort students devote to activities linked to desired outcomes of education. ***All*** students need to be engaged with the course content inside and outside of the classroom. Engaging ***all*** students inside the classroom may easily be achieved by using an ERS. According to [21], some individuals tend to be shy and reserved, resulting in their voice not being heard in workshops or classrooms. However, it is vital that the voice of ***all*** individuals be heard to encourage agency, which refers to the capacity of individuals to act independently and to make their own free choices using clickers [21]. Clickers is one of the known as electronic responsive systems (ERS), are one of the emerging technologies that have grown to be popular in recent years mainly because of the value of engaging ***all*** students during lecture times [22].

In the mid-1980s, the first generation of clickers emerged when several scientists came up with a prototype of a new teaching tool called a Classroom Communication System (CCS). Figure II demonstrates the CCS that was first tested in a physics classroom. This CCS is an ERS that consists of a device used by students in conjunction with an electronic USB transceiver connected to a personal computer. It is a system used to collect information from students in a contact setting and to provide immediate feedback on their responses [5]. This is achieved by using an interactive PowerPoint presentation that may be developed using the TurningPoint Software.

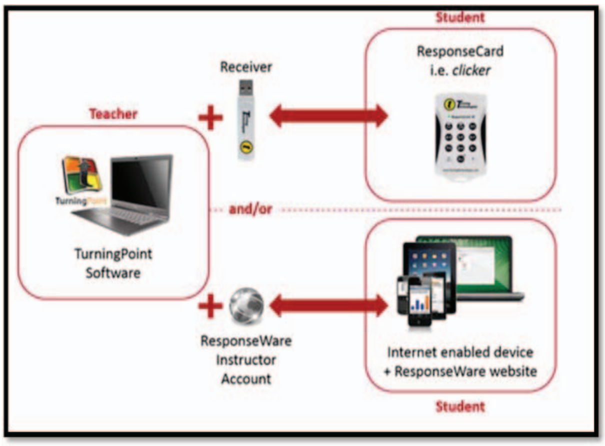

Fig. II The Electronic Responsive System (Clickers)

ERS have shown many advantages over the non-technical methods for collecting anonymous feedback with the ability to display responses immediately. Some of the advantages are as follows:

- It leads to active learning; this enables participants to be involved in discussions and to move away from passive learning [23].
- Fulfilment of learning; this results when participants learn from his or her own misconceptions, as their viewpoints are shared and analysed by others in a secluded way [4].
- Participants tend to take ownership over the decisions

they make which allows them to participate by choice [24].

- Participants are helped to act independently and make their own free choices [25].

III. RESEARCH METHODOLOGY

A non-experimental research design incorporating a descriptive case study with quantitative data is used with convenient sampling. A non-experimental research design is where there is some doubt as to which variable to take as independent [26], thereby resulting in no manipulation of any variables as done in this study.

A descriptive case study is one that is focused and detailed in proposition and questions about a phenomenon and is carefully scrutinized and articulated at the outset [27]. The focused question in this regard is which factors may influence academics to adopt the use of clickers at a university of technology?

Convenient sampling is defined as a type of non-probability sampling that involves the sample being drawn from a part of the population that is nearby. It is a type of sampling mostly useful for pilot testing [27]. In this study, the target population are academics from the Central University of Technology (CUT) where the sample is drawn from those who voluntarily attended an ERS workshop.

A questionnaire was used as the data collection instrument. Four questions were posed per construct and a link to the online questionnaire was sent to the academics after they had attended the workshop. Questions were formulated using the constructs of the UTAUT model. The profile of the participants was also obtained, which included their number of years in academia and their highest academic qualification (and if they possess a teaching qualification). Descriptive statistics is used for data analysis and is a term that helps describe, show or summarize data in a meaningful way [28].

IV. FINDINGS AND ANALYSIS

Table I displays the demographic profile of the sample, being academics who voltunarily attended an ERS workshop at CUT. The profile indicates that the majority of academics are female (52.6%) with the largest number belonging to the age group of 20 to 39 years of age (42.1%). This suggests that the results will not be biased towards a specific gender or age group, as the sample is almost equally representative of both genders and the given number of age groups (except for above 50 years of age). The results indicate a relevance to the hypothesis of the study regarding the influence of gender o age on the adoption of an ERS. In this case, the alsmost equal representation adds to the reliability of the final results as gender bias is reduced.

The results also show that many of the academics hold a senior lecturer position (42.1%) while 47.4% of the academics reported being in academia for 6-10 years. This indicates that there is a good spread between younger and older academics, which should also reduce bias with regard to the results when considering the influence of experience on the adoption of ERS. Age and experience are part of the variables in Figure I which is fairly equally represented by the academics in this study. The faculty most represented was the Faculty of Engineering (31.6%). This suggests that more academics in the engineering field are using ERS in their classrooms.

TABLE I: DEMOGRAPHIC PROFILE

	Frequency	Valid Percent
Gender		
Male	27	47.4
Female	30	52.6
Total	57	100.0
Age group		
20-39 years old	24	42.1
40-49 years old	20	35.1
50 and above	13	22.8
Total	57	100.0
Position		
Assistant lecturer	1	1.8
Junior lecturer	13	22.8
Senior lecturer	24	42.1
Academic support	14	24.6
Professor	5	8.8
Total	57	100.0
Experience		
Less than 1 year	1	1.8
2-5 years	14	24.6
6-10 years	27	47.4
11-15 years	15	26.3
Total	57	100.0
Faculty		
Academic Support	6	10.5
Humanities	7	12.3
Health	17	29.8
Engineering	18	31.6
Management Sciences	9	15.8
Total	57	100.0

Table II shows the reliability and normality test results. The standard deviation indicates a number used to tell how measurements are spread from the average (mean), or expected value. The kurtosis indicates if a distribution is flatter than a normal curve with the same mean and standard deviation [29]. If the kurtosis is greater than 3, then the dataset has heavier tails than a normal distribution. The Cronbach alpha is used to measure the internal consistency; that is how closely related are a set of items in a group. It is also used to measure the scale of reliability [30].

The scale reliability was conducted on seven constructs including their items to measure the internal consistency of each construct. The results demonstrate that some constructs (Behavioral Intention, User behavior and Digital Inclusion) are not internally consistent, as their Cronbach Alphas are below 0.6. This value should be above 0.6 to ensure internal consistency [31]. It was attempted to improve those constructs by deleting items that had a poor contribution to the scale. This measure assisted to improve the construct Behavioral Intention and User behavior (see the right-hand column). No further improvement was possible for Digital Inclusion. Consequently, Performance Expectancy, Effort Expectancy, Social Influence, Facilitating Conditions, Behavioral Intention and User Behavior were found internally consistent in their measurement. This is a typical measure based on the correlations between different items on the same test. It refers to the degree to which test items measure the same construct [31]. This means that it measures whether several items on the table that propose to measure the same constructs produced similar scores.

TABLE II: RELIABILITY AND NORMALITY TEST

						Non-Improved Cronbach Alpha		Improved Cronbach Alpha	
Constructs	**Mean**	**Standard Deviation**	**Skewness**	**Kurtosis**		**Cronbach's Alpha**	**No items**	**Cronbach's Alpha**	**No items**
Performance Expectancy	4.09	0.55	0.21	-0.47		0.843	4		
Effort Expectancy	4.02	0.52	0.38	-0.24		0.700	4		
Social Influence	3.73	0.59	-0.63	1.88		0.615	4		
Facilitating Conditions	3.91	0.49	-0.24	0.92		0.601	4		
Behavioral Intention	3.44	0.57	0.06	0.55		0.241	4	0.766	3
User Behavior	3.24	0.67	-1.41	1.98		0.552	4	0.658	3
Digital Inclusion	3.21	0.64	0.61	0.19		0.323	4		

Table III represents the multicollinearity of the five independent constructs (Performance Expectancy, Effort Expectancy, Social Influence, Facilitating Condition, and Digital Inclusion). This multicollinearity test was conducted to assess if there is a similar correlation between the independent constructs. Multicollinearity was assessed by examining Tolerance and Variance Inflation Factor (VIF). The value of the Tolerance should be above 0.1 and the value of VIF is expected to be below 10. The results indicate that there is no multicollinearity issue found in all presented constructs as the value of the Tolerance for each one is above 0.1 and VIF is below 10. This means that all the independent constructs are distinct enough to be considered as different entities.

TABLE III: MULTICOLLINEARITY

Constructs	**Collinearity Statistics**	
	Tolerance	**VIF**
Performance Expectancy	0.383	2.614
Effort Expectancy	0.416	2.402
Social Influence	0.765	1.308
Facilitating Conditions	0.676	1.479
Digital Inclusion	0.815	1.227

A multiple linear regression test was conducted to evaluate the impacts of Performance Expectancy, Effort Expectancy, Social Influence, Digital Inclusion and Facilitating Conditions on Behavioral Intention and on User Behavior. Table IV shows these results, including the standardized coefficients, t-values and p-values. The p-value is the calculated probability of finding the observed or more extreme results when the null hypothesis of the study question is true. The t-value is usually trying to find evidence of a significant difference between population mean and hypothesized value. The t-value measures the size of the difference relative to the variation [32]. Performance Expectancy, Effort Expectancy and Behavioral Intention indicates a strong evidence against the hypothesis (<0.05) so the null hypothesis is rejected. The Social Influence, Digital Inclusion and Facilitating Conditions have a large p-value which indicates weak evidence against the null hypothesis, so the hypothesis is rejected. The results indicate that these constructs explain up to 48.1% of the variance of Behavioral Intention to use an ERS.

The results further reveal that Performance Expectancy (β= 0,301; p<0.05; t= 1,935) and Effort Expectancy (β= 0,471; p<0.005; t= 3,157) have a positive and significant effect on Behavioral Intention. The results further show that Social Influence (β= 0,079; p>0.001; t= 0,722), Digital Inclusion (β= 0,049; p>0.001; t= 0,651), and Facilitating Conditions (β= -0,085 v p>0.001; t= 0,473) have no statistically significant effect on Behavioral Intention. Behavioral Intention (β= 0,394; p<0.005; t= 3,181) has a positive and significant effect on User behavior.

TABLE IV: MULTIPLE REGRESSION ANALYSIS

Predictor	**Unstandardized Coefficients**	**Std. Error**	**Standardized Coefficients**	**t-value**	**p-value**
Performance Expectancy	0,475	0,246	0,301	1,935	0,050
Effort Expectancy	0,784	0,248	0,471	3,157	0,003
Social Influence	0,117	0,162	0,079	0,722	0,474
Digital Inclusion	0,066	0,145	0,049	0,455	0,651
Facilitating Condition	-0,150	0,208	-0,085	-0,722	0,473
Behavioural Intention	0,342	0,107	0,394	3,181	0,002

V. Conclusions

The purpose of the paper was to establish factors that may influence academics to adopt the use of clickers at universities of technology. This study has the potential to contribute to the body of knowledge for the UTAUT model by establishing factors that promotes adoption of ERS for learning, with the addition of the Digital Inclusion construct.

Performance Expectancy, Effort Expectancy, Social Influence, Facilitating Conditions, Behavioral Intention and user behavior were found internally consistent in their measurement, indicating that the questions used in the questionnaire were indeed measuring the intended construct. Digital Inclusion could not be verified, suggesting that its questions need revision.

No multicollinearity issue exists in all presented constructs which means that all the constructs are distinct enough to be considered as different entities. Furthermore, a multiple linear regression test indicates that Performance Expectancy, Effort Expectancy and Behavioral Intention indicates a strong evidence against the hypothesis, leading to the null hypothesis being rejected. Social Influence, Digital Inclusion and Facilitating Conditions have a large p-value which indicates weak evidence against the null hypothesis, so the hypothesis is rejected. The results further indicate that these constructs explain up to 48.1% of the variance of Behavioral Intention to use an ERS.

These results suggest that Behavioral Intention to use an ERS is not really driven by Social Influence, Digital Inclusion, and Facilitating Conditions. However, adoption of an ERS seems to be driven by Performance Expectancy and Effort Expectancy. The results also indicate that age, experience or gender play no significant role in the adoption of such a system.

A limitation of the study was that the questionnaire was given to academics who had been trained to use the clickers, and not to all academics. Distributing the questionnaire to a wider audience may provide more insights. However, there is a need to create awareness among all academics, irrespective of their age, experience or gender, of the importance of adopting clickers in their teaching practice. Literature does suggest that the use of clickers in a classroom environment can improve student engagement and learning.

References

[1] M. Britland, "What is the future of Technology in education.," The Guardian, 2013.

[2] D. J. Evans, P. Zeun and R. A. Stanier, "Motivating student learning using a formative assessment journey," *Journal of Anatomy,* vol. 224, pp. 296-303, 2014.

[3] F. Gouldian, "Create Effective Feedback with Education Technology," 3 May 2018.

[4] J. D. Morrison, "The effects of Electronic Response System on Student learning," in *SholarWorks at WMU*, 2015.

[5] J. E. Caldwell, "Clickers in the Large Classroom: Current Research and Best Practice Tips.," *Life Science Education,* vol. 1, no. 6, pp. 6-20, 2016.

[6] O. O. Durodolu, "Technology Acceptance Model as predictor of using information systemto aquire information literacy skills," *Library Philosophy and Practice,* vol. 97, no. 8, 2016.

[7] D. C. Lee, S.-H. Lin and H.-L. Ma, "Use of a Modified UTAUT Model to Investigate the Prespectives if Internet Access Device Users," *International Journal Of Human-Computer Interaction,* pp. 549-564, 2016.

[8] V. Venkatesh, M. Morris and D. G. Davis, "User Acceptance of Information Technology: Toward a Unified View," pp. 425-478, 2003.

[9] M. Ajzen and M. Fishbein, "Attitude-behaviour relations: A theoretical analysis and review of empirical research," 1975.

[10] B. R. Aditya and A. Permadi, "Implementation of utaut model to understand the use of virtualclassroom principle in higher education," *Journal of Physics,* vol. 978, no. 3, pp. 33-78, 2017.

[11] K. Ghalandari, "The Effect of Performance Expectancy, Effort Expectancy, Social Influence and Facilitating Conditions on Acceptance of E-Banking Services in Iran: The Moderating Role of Age and Gender," *Middle-East Journal of Scientific Research,* vol. 17, no. 5, pp. 801-807, 2012.

[12] H. Y. Wang and S. H. Wang, "User Acceptance of Mobile Internet Based on the Unified Theory of Acceptance and use of Technology: Investigating the Determinats and Gender Differences," *Social Behaviour and Personality,* vol. 49, no. 1, pp. 48-58, 2010.

[13] D. C. Lee, S. H. Lin and H. L. Ma, "Use of a Modified UTAUT Model to Investigate the Prespectives of Internet Access Device Users," *International Journal of Human Computer Interaction,* vol. 33, no. 7, pp. 549-564, 2016.

[14] F. S. Sulma, M. R. Antonio and L. C. Maria, "Digital inclusion in education in Tarija, Plurinational State of Bolivia," *Cepal Review,* pp. 63-80, 04 April 2015.

[15] T. Mikali, "The internet usage of Undergraduate students of Physical Education and Sports College.," *Library of Congress class,* vol. 43, no. 2, pp. 34-78, 2014.

[16] L. Taylor and J. Parsons, "Improving Student Engagement," *Current Issues in Education,* vol. 14, no. 1, 2011.

[17] L. M. Dreyer, "Digital storytelling to engage postgraduates in reflective practice in an emerging economy," *South African Journal of Education,* vol. 37, 2017.

[18] J. Moraros, A. Islam, R. Banow and B. Schindelka, "Flipping for success: evaluating the effectiveness of a novel teaching approach in a graduate level setting," *Article in a Prediocial,* 28 february 2015.

[19] A. Arner, "How do clickers affect student engagement and test performance?," 2018.

[20] G. D. Kuh, "What student affairs professional need to know about student enagement," *Journal of college student development,* vol. 50, pp. 683-706, 2009.

[21] A. J. Swart and L. Meda, "Can you teach an old dog new tricks? A case study of using an electronic responsive system in an academic development workshop," *Works Transaction on Engineering and Technology Education,* vol. 17, 2019.

[22] V. Lithuania, "Web 2.0 Technologies and Applications in the Best Practice Networks and Communities," *Informatics in Education,* vol. 9, no. 2, pp. 185-197, 2010.

[23] A. J. Swart, "Using Web2.0 technology to improve student academic success among senior engineering students- a case study from a telecommunications module!," *Southern African Telecommunication Networkd and Application Conference,* pp. 237-242, 2015.

[24] V. I. Osubor and S. C. Chiemeke, "A technology Based Teaching Method for Providing Access to Sustainable Quality Education.," *African Journal of Computinhg & ICT,* vol. 8, pp. 127-132, 2015.

[25] A. M. Dantas, S. A. Gauci and D. A. Williams, "Promoting student centered active learning in lectures with a personale response system," *Advanced Physiology Education,* vol. 33, no. 2, pp. 60-71, 2009.

[26] M. B. Hurbert, "Causal Inferences in Noneperimental Research," The Seeman Printery, Durham, 1964.

[27] R. V. Labaree, "Organising your social Sciences Research Paper: Types of Reasearch Design," USC Libraries, 2009.

[28] H. Pizarro, "What is the importance of descriptive staticstics," *Article in a Periodical,* 20 February 2015.

[29] P. Mukul , "Links to all tutorial articles," *Risk Education Prep,* pp. 23-32, 02 December 2012.

[30] C. Goforth, "Using and Interpreting Cronbach's Alpha," *Research Data Services and Sciences,* pp. 19-22, 16 November 2015.

[31] K. Malhotra, "Professor Naresh Malhotra - CMEE," *Indian Institute of Management, Lukenow,* vol. 11, no. 54, p. 54, 07 March 2012.

[32] J. Frost, "Cross Validates," *how to Interpret p values and coefficients in the Regression analysis,* vol. 9, no. 1, pp. 23-24, 2018.

[33] H.-Y. Wang and S.-H. Wang, "User Acceptance of Mobile Internet Based on the Unified Theory of Acceptance and use of Technology: Investigating the Determinants and Gender Differences," *Social Behaviour and Personality,* pp. 415-426, 2010.

[34] L. Damodaran, T. Gilbertson and W. Olphert, "The Vision, the challenges and the way forward," *International Journal on Advances in internet Technology,* 2015.

[35] "Technology Acceptance Model as predictor of using information system to acquire information literacy skills," *Library Philosophy and Practice,* 2016.

[36] Y. Ramma, A. Bholoa and M. Watts, "Teaching and learning physics using technology: Making a case for the affective domain," 29 June 2017.

[37] V. Lithuania, "Web 2.0 Technologies and Applications in the Best Practice Networks and Communities," *Informatics in Education,* pp. 185-197, 2010.

[38] G. C. Moore and I. Benbasat, "Development of an Instrument to Measure the Perceptions of Adopting and Information Technology Innovation," Informs PubsOnline, 1991.

[39] J. Dunlosk, K. A. Rawson, E. J. Marsh, M. J. Nathan and D. T. Willigham, "Improving Students Learning with Effective Learning Techniques:Promising Directions from Congnitive and Educational Psychology," *Psychology Science,*vol. 9, no 2*,* pp. 4-58, 2013.

[40] A. M. Fishbein and I. Ajzen, "Belief, attitude, intention and behaviour: An introduction to theory and research: An introductionto theory and research," in *Reading MA Addison Wesley*, 1975.

[41] B. D. Friedman, "Webc-Tc An administrative tool," *Journal of Technology in Human Services*,vol. 10, no. 2, pp. 119-122, 2007.