Conceptual Framework for the Adoption of Computer-aided architectural Design (CAAD) in the Teaching and Learning of Architecture

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Abstract

Digital technologies are changing the way we live, think, learn, and conduct businesses across the world. In fact, information and communication technologies have completely changed the way architects practice their profession, and thus it is imperative that architectural educators embrace this change intelligently in other to enhance the quality of products they unleash unto the labour market. In view of the important role architects play in the construction industry, new and innovative teaching approaches are needed in the delivery of curriculum that reflects both contemporary and future trends in information management in the construction industry. This paper aims at developing a conceptual framework for understanding the adoption of Computer –aided architectural design (CAAD) in the teaching and learning of architecture in the Schools of Architecture. It relies on extensive review of literature, the precepts of the unified theory of acceptance and use of technology to develop a conceptual framework for understanding the key issues, challenges, and prospects of the adoption CAAD technologies in the delivery of architecture curriculum content in the Schools of Architecture in the developing countries. The proposed framework is expected to firstly, extend understanding on innovative and sustainable pedagogies for producing information technology compliant professionals in architecture profession in particular, and construction industry in general; and secondly provide the basis for empirical research on this subject.

Keywords: Acceptance, innovation, technology, adoption, Computer Aided Architectural design, Framework

1 INTRODUCTION

The aim of this research is to study the use of Computer Aided Architectural design (CAAD) in architectural education. The exchange and collaboration within the domain of computer aided architectural design education and research, with due respect to the pedagogical and administrative approaches in the different schools and countries, can be regarded as a core activity. Many theories abound that deals with the use of innovative technology in industry, business, and education. These theories are found in the information system research (ISR) domain; therefore, the objective of this paper is to evaluate these theories with a view of adopting the relevant sections to suit the aim of this research work.

2 METHODOLOGY

The methodological approach followed here is qualitative. The paper relies on the review of secondary data on use and acceptance of information technology. Many theories abound that elucidates the use of innovative technology in industry, business, and education. These theories are found in the information system research (ISR) domain, an evaluation of these theories is presented here with a view of adopting them to suit the aim of this research work.

3 RESULTS

The results of the review of secondary data on use and acceptance of information technology are hereby presented:

3.1 DISCUSSIONS ON THEORITICAL FRAMEWORK

The aim of this research is to study the conceptual framework for the adoption of Computer Aided Architectural design (CAAD) in teaching and learning of architecture. Many theories abound that elucidates the use of innovative technology in industry, business, and education. These theories are found in the information system research (ISR) domain, an evaluation of these theories is presented here with a view of adopting them to suit the aim of this research work.

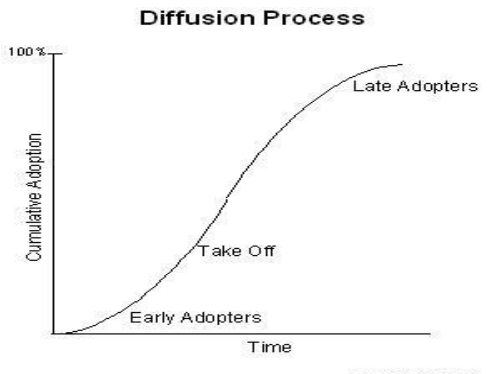
3.2 THE STAKE HOLDERS THEORY

Several views of Stakeholder Theory are presented in the literature. However, a key distinction can be drawn between the tenets of Stakeholder Theory and the conventional input-output model of the organization which see organizations as turning investor, supplier, and employee inputs into customer outputs (Donaldson et al, 1995). The main dependent factor in Stakeholder Theory is organization performance and in our context is the quality of research and graduates produced by a university which is based on the quality of teaching and learning delivered by the institution. The main independent factor in Stakeholder Theory is stakeholder's interests which in the context of our study is the management of an institution and its desire for an enhanced ranking position and rating, the faculty and staff of an institution and their need for an improved infrastructure that will be a platform for career advancement and the students and their parents/sponsors whose need is to get quality education that will conform with best practices around the world. Stakeholder theory argues that every stakeholder participating in the activities of an organization do so to obtain benefits and that the priority of the interests of all legitimate stakeholders is not self-evident.

Donaldson et al (1995) offer four central thesis related to stakeholder theory. It posited that Stakeholder Theory is descriptive in that it offers a model of the organization. It went further to state that Stakeholder Theory is instrumental in offering a framework for investigating the links between conventional firm performance and the practice of stakeholder management. Furthermore it said that although Stakeholder Theory is descriptive and instrumental, it is more fundamentally normative. The paper concluded by positing that Stakeholder Theory is managerial in context, that it recommends attitudes, structures, and practices and requires that simultaneous attention be given to the interests of all legitimate stakeholders.

3.3 THE INNOVATION DIFFUSSION THEORY

In the Diffusion of Innovation theory, an innovation is seen as being communicated within a particular social system through certain channels over time (Rogers, 1995). Individuals are perceived as possessing different levels of willingness to adopt innovations and according to Rogers (1995), it is generally observed that the portion of the population adopting an innovation is approximately normally distributed over time. Diffusion of Innovation theory provides an important viewpoint on one of the most challenging topics in the IT field, which is the improvement of technology assessment, adoption and implementation. Diffusion theory provides quantitative and qualitative tools for assessing the probable rate of diffusion of a technology, and also identifies numerous factors that facilitate or hinder technology adoption and implementation. Innovation diffusion as a borrowed theory in architecture provides the advantage of a rich cumulative tradition. However care must be taken to ensure that the context to which the theory is being applied matches with that in which the theory was developed, or on the other hand, to tailor the theory to account for contextual differences. Diffusion theory was developed in the context that adopters make independent decisions to accept or reject an innovation based on the utility they expect to accrue to them from their independent use of the technology. However, the adoption of a technology may be encouraged by management (Leonard-Barton and Deschamps, (1988) or even mandated (Moore and Benbasat, (1991). Furthermore according to Markus (1987), the decision to adopt a technology by individuals and organizations may depend on the dynamics of community wide levels of adoption because of network externalities; the above context captures the position of CAAD in education which has been adopted as a result of prevalence of CAAD in architectural practice. According to Fichman (1992) a well-established generalization of adoption of innovation by individuals has been synthesized from the work of several scholars and they are that (a) Innovations possess certain characteristics (i.e., relative advantage, compatibility, complexity, trialability and observability) which, as perceived by adopters, determine the ultimate rate and pattern of adoption; (b) Some potential adopters are more innovative than others, and can be identified as such by their personal characteristics ("cosmopolitanism," level of education, etc.); (c) The adoption decision unfolds as a series of stages (flowing from knowledge of the innovation through persuasion, decision, implementation and confirmation) and adopters are predisposed towards different kinds of influence (e.g., mass market communication versus word-of-mouth) at different stages; (d) The actions of certain kinds of individuals (opinion leaders and change agents) can accelerate adoption, especially when potential adopters view such individuals as being similar to themselves; and (e) The diffusion process usually starts out slowly among pioneering adopters, reaches "take-off" as a growing community of adopters is established and the effects of peer influence kick-in, and levels-off as the population of potential adopters becomes exhausted, thus leading to an "S-shaped" cumulative adoption curve.



Source: Rogers (1995)

Figure 1. Schematic Diagram of Diffusion of Innovation Theory (Rogers, 1995)

Scholars have focused on extending diffusion theory to adoption of innovations by individuals subject to strong managerial influences (Leonard-Barton and Deschamps 1988) or by organizations as a whole (Kwon and Zmud 1987; Robertson and Gatignon 1986; Rogers 1983) and also adoption of special classes of technologies, i.e., those that involve marked adopter interdependencies (Katz and Shapiro 1986; Markus 1987) or that impose an exceptional knowledge burden on would-be adopters (Attewell 1992; Cohen and Levinthal 1990), the learning and adoption of CAAD in education can be classified under this context.

Cohen and Levinthal (1990) developed the idea that an organization's innovative capability is a function of its absorptive capacity, where absorptive capacity is defined as the organization's ability to recognize the value of new information, assimilate it, and apply it to productive ends. They went on to state that an analogous notion of absorptive capacity also exists for individuals. Furthermore they argued that absorptive capacity is developed over time through prior investments in learning in areas that are closely related to the innovation at hand. According to Fichman (1992) Information technology diffusion research can diverge from classical diffusion assumptions due to characteristics of the technology (user interdependencies, knowledge barriers) or the locus of adoption (individual versus organizational). Moore and Benbasat (1991) posited that there are many parallels between Technology Acceptance Model(TAM), Theory of Reasoned Action (TRA) and Diffusion Theory. This can be exemplified in TAM's perceived usefulness and perceived ease of use which are basically the same as diffusion theory's relative advantage and complexity.

3.4 THE THEORY OF REASONED ACTION (TRA)

This theory was drawn from social psychology and it is a very influential and fundamental theory of human behavior. Wide range of behaviours has been predicted using TRA (Sheppard et al. 1988). An application of TRA to individual acceptance of technology was done by Davis et al. (1989) and it was found that the variance explained to a large extent was consistent with studies that have previously employed TRA in the context of other behaviours. TRA has attitude toward behaviour and subjective norm as its core constructs. Attitude toward behavior is defined as an individual's positive or negative feelings (evaluative affect) towards performing the target behavior (Fishbein and Ajzen , 1975), while subjective norm is a person's perception that most people who are important to him think he should or should not perform the behaviour in question (Fishbein and Ajzen , 1975)

3.5 MOTIVATIONAL MODEL (MM)

General motivation theory has been supported by a significant body of research in psychology as an explanation for behaviour. Several studies have examined the theory and adapted it for specific contexts. An excellent review of the fundamental tenets of this theoretical base was presented by Vallerand (1997). Davis et al. (1992) and Venkatesh and Speier (1999) within the domain of information systems research applied motivational theory to understand new technology adoption and use. The core constructs of MM are extrinsic motivation and intrinsic motivation. Davis et al. (1992) defined extrinsic motivation as the perception that users will want to perform an activity "because it is perceived to be instrumental in achieving valued outcomes that are distinct from the activity itself, such as improved job performance, pay, or promotions". He went on to define intrinsic motivation as the perception that users will want to perform an activity "for no apparent reinforcement other than the process of performing the activity per se"

3.6 MODEL OF PC UTILIZATION (MPCU)

The model of PC Utilization (MPCU) theory was to a large extent derived from Triandis' (1977) theory of human behaviour, this model presents a competing perspective to that proposed by TRA and TPB. Triandis' model was adapted and refined by Thompson et al. (1991) in an information system context and then used to predict PC utilization. The model by its nature is particularly suited to individual acceptance and use of a range of information technology. Usage behavior rather than intention was sought to be predicted by Thompson et al. (1991). The core constructs are Job fit, complexity, long-term Consequences, Affect Toward use, Social factors and facilitating conditions. Each of the constructs were defined by Thompson et al. (1991) as follows; Job-fit: "the extent to which an

individual believes that using (a Technology) can enhance the performance of his or her job", Complexity: "the degree to which an innovation is perceived as relatively difficult to understand and use" this was based on Rogers and Shoemaker (1971), Long-term Consequences: "Outcomes that have a pay-off in the future", Affect Towards Use: "feelings of joy,elation, or pleasure, or depression, disgust, displeasure, or hate associated by an individual with a particular act" this was based on Triandis' (1977) , Social factors: "the individual's internalization of the reference group's subjective culture, and specific interpersonal agreements that the individual has made with others, in specific social situations" this was derived from Triandis' (1977), Facilitating conditions: Objective factors in the environment that observers agree make an act easy to accomplish. For example, provision of support for users of CAAD like training, adequate computer systems and constant power supply may be one type of facilitating condition that can influence system utilization".

3.7 SOCIAL COGNITIVE THEORY (SCT)

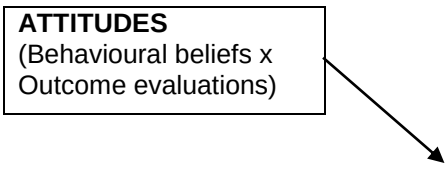
The social cognitive theory is one of the most powerful theory of human behaviour . SCT was extended and applied to the context of computer utilization (Compeau and Higgins 1995b, Compeau et al. 1999). The theory was used by Compeau and Higgins (1995b) to study computer use where usage was an independent variable but the models nature and the underlying theory allows it to be extended to acceptance and use of information technology in general. The core constructs are outcome expectations- performance: it is defined as the performance-related consequences of the behavior and it deals with job related outcomes, outcome expectations-personal: it is defined as the personal consequences of the behavior and it deals with the individual esteem and sense of accomplishment, self-efficacy: this is the judgment of one's ability to use a technology (e.g. computer) to accomplish a particular job or task , affect: This is an individual's liking for a particular behavior (e.g. computer use) and anxiety: This is evoking anxious or emotional reactions when it comes to performing a behavior (e.g., using a computer).

3.8 THE THEORY OF PLANNED BEHAVIOUR.

The Theory of Planned Behaviour (TPB; Ajzen, 1991) started as the The Theory of Reasoned Action in 1980 to predict a person's intention to engage in a behaviour at a specific time and place. This proposes a model on how human action is guided. The key component of TPB is behavioural intent; behavioural intentions are influenced by the attitude about the likelihood that the behaviour will have the expected outcome and the subjective evaluation of the risks and benefits of that outcome. The TPB states that behavioural achievement is a function of both motivation (intention) and ability (behavioural control). It distinguishes between three types of beliefs - behavioural, normative, and control. The TPB comprises of six constructs that collectively represent a person's actual control over the behaviour. Attitudes - This is the extent to which a person has a favorable or unfavorable evaluation of the behaviour of interest. It entails a consideration of the outcomes of performing the behaviour. Behavioural intention - This states that motivational factors influence a given behaviour where the stronger the intention to perform the behaviour, the more likely the behaviour will be performed. Subjective norms - This refers to the belief about whether most people approve or disapprove of the behaviour. It relates to a person's beliefs about whether peers and people of importance to the person think he or she should engage in the behaviour.

Social norms - This refers to the customary codes of behaviour in a group or people or larger cultural context. Social norms are considered normative, or standard, in a group of people. Perceived power - This refers to the perceived presence of factors that may facilitate or impede performance of behaviour. Perceived power contributes to a person's perceived behavioural control over each of those factors.

Perceived behavioural control - This refers to a person's perception of the ease or difficulty of performing the behaviour of interest. Perceived behavioural control varies across situations and actions, which results in a person having varying perceptions of behavioural control depending on the situation. This construct of the theory was added later, and created the shift from the Theory of Reasoned Action to the Theory of Planned Behaviour.



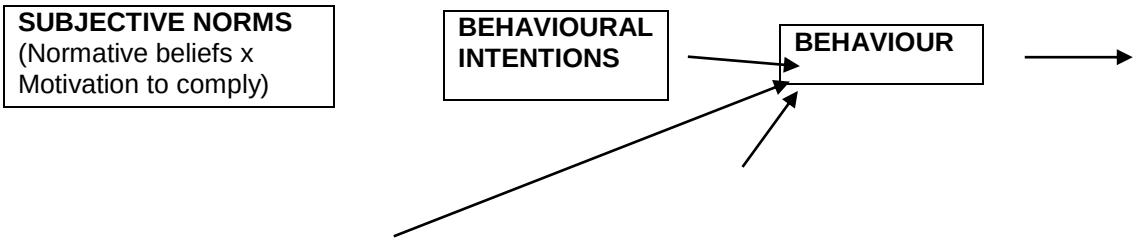


Figure 2. The Theory of Planned Behaviour (Ajzen, 1991)

In practice, there are several limitations of the TPB, which include the following: It assumes that an individual has acquired the opportunities and resources to be successful in performing the desired behaviour, regardless of the intention. It does not account for other variables that factor into behavioural intention and motivation, such as fear, threat, mood, or past experience. While it does consider normative influences, it still does not take into account environmental or economic factors that may influence a person's intention to perform a behaviour. It assumes that behaviour is the result of a linear decision-making process, and does not consider that it can change over time. While the added construct of perceived behavioural control was an important addition to the theory, it doesn't say anything about actual control over behaviour. The time frame between "intent" and "behavioural action" is not addressed by the theory.

3.9 THE TECHNOLOGY ACCEPTANCE MODEL (TAM).

Technology Acceptance Model (TAM) is an adaptation of the Theory of Reasoned Action (TRA) to the field of Information System Research. The major constructs of TAM is perceived usefulness and perceived ease of use. TAM posits that perceived usefulness and perceived ease of use determine an individual's intention to use a system with intention to use serving as a mediator of actual system use. Perceived usefulness is also seen as being directly impacted by perceived ease of use.

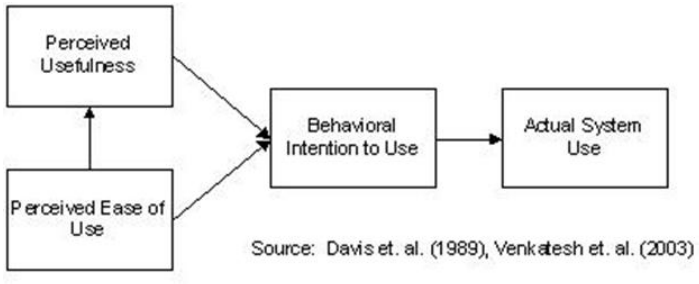


Figure.3 Technology Acceptance Model. Davis et.al. (1989), Venkatesh et.al (2003)

According to Shroff et al (2011) several models have been developed to investigate and understand the factors affecting the acceptance of computer technology. He stated that the theoretical models employed to study user acceptance, adoption, and usage behaviour include the theory of reasoned action (TRA) (Ajzen & Fishbein, 1980; Fishbein & Ajzen, 1975), the theory of planned behaviour (TPB) (Ajzen, 1991; Mathieson, 1991), the technology acceptance model (TAM) (Davis, 1989; Davis,), the decomposed theory of planned behaviour (Taylor & Todd, 1995), and innovation diffusion theory (Agarwal & Prasad, 1997, 1999; Brancheau & Wetherbe, 1990). However, he stated current research has focused on the technology acceptance model (TAM) because the research seeks to understand the relationship between perceptions (such as perceived usefulness and perceived ease of use of technologies) and usage behaviour.

3.10 COMBINED TAM AND TPB (C-TAM-TPB)

The combined theory of technology acceptance model and theory of planned behaviour (C-TAM-TPB) combines the constructs of TPB with perceived usefulness from TAM to produce a hybrid model (Taylor and Todd 1995a). The core constructs of C-TAM- TPB, attitude toward behaviour, subjective norm and perceived behavioural control were adapted from the theory of reasoned action and the theory of planned behavior while the construct of perceived usefulness was adapted from technology acceptance model.

3.11 THE UNIFIED THEORY OF ACCEPTANCE AND USE OF TECHNOLOGY (UTAUT).

A simplified TAM has been developed by researchers by removing the attitude construct found in TRA from the current specification (Venkatesh et. al., 2003). TAM extensions have generally taken one of

three approaches: by introducing factors from related models, by introducing additional or alternative belief factors, and by examining antecedents and moderators of perceived usefulness and perceived ease of use (Wixom and Todd, 2005). The simplified TAM developed by (Venkatesh et. al., 2003) known as The Unified Theory of Acceptance and Use of Technology (UTAUT) posits that four major constructs (performance expectancy, effort expectancy, social influence, and facilitating conditions) are direct determinants of usage intention and behaviour. It went further to add that Gender, age, experience, and voluntariness of use mediate the impact of the four major constructs on usage intention and behaviour. This model encapsulated and expanded the classical TAM and its constructs of Perceived Usefulness and Perceived Ease of Use to give it a wider acceptance in the information system research domain. To better understand UTAUT the definitions of the constructs by (Venkatesh et. al., 2003) are presented thus: Performance expectancy: The degree to which an individual believes that using the system will help him or her to attain gains in job performance , Effort expectancy: The degree of ease associated with the use of the system, Social influence: The degree to which an individual perceives that important others believe he or she should use the new system, Facilitating conditions: The degree to which an individual believes that an organizational and technical infrastructure exists to support use of the system, Voluntariness: The extent to which potential adopters perceive the adoption decision to be non-mandatory . UTAUT was subsequently validated in a longitudinal study found it to account for 70% of the variance in usage intention (Venkatesh et. al., 2003).

The longitudinal field study that yielded the UTAUT model was conducted in an organizational setting in the workplace, however it is yet to be seen how this model will respond in an academic learning environment where computer technology has been adopted as part of the educational curriculum.

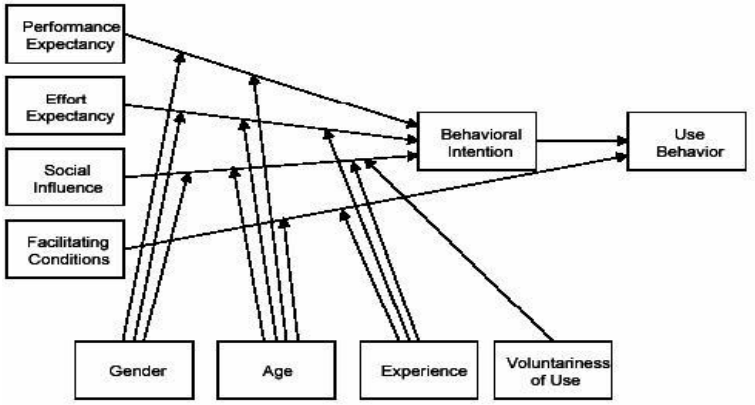


Figure.4 Unified Theory of Acceptance and Use of Technology (UTAUT). Source (Venkatesh et. al., 2003).

4.0 CONCLUSION

The conclusions of this study based on the review of secondary data on use and acceptance of information technology is here presented here

4.1 THE CONCEPTUAL FRAMEWORK.

According to Shroff et al (2011), considerable discussions emanating from academic debate and research surround the emergence of technology acceptance (Davis, 1993; Gao, 2005; Gong, Xu & Yu, 2004).Research indicates that, although institutions have made large investments in educational technology, many technologies have been underutilized or abandoned completely, due to limited user acceptance (Liu, Liao & Pratt, 2009; Park, 2009; Teo, 2009). There are many theories and models developed in IS research domain, however TAM through literature review has been adjudged as the most popular. Despite TAM's popularity and usefulness many researchers according to Kripanont (2006) still want to investigate whether TAM should be revised, extended or modified to account for rapid changes in both technologies and their environments. The paper went further to state that previous research studied what determinants might be significant in affecting behaviour intention and actual behaviour in specific context including technology, individual and organizational. Scholars have questioned whether there are only determinants such as perceived usefulness, perceived ease of use, subjective norm, perceived behavioural control and moderators such as age, gender, experience, voluntariness to determine behaviour intention and actual behaviour. Perhaps according to Kripanont (2006) there could be other determinants and moderators that play important roles. Studies have shown that most of this research on TAM was conducted, developed, modified and extended in the USA and it is wondered whether it can be used in other regions like Africa and especially in Nigeria. Researchers have previously studied different technologies in order to develop or extend models or theories of technology acceptance and usage. Examples of technology under investigation in previous research are: software packages (Davies, F.D, Bagozzi and Warshaw 1989; Venkatesh and Davis 1996), microcomputers (Igbaria, Guimares and Davis 1996) email (Gefen and

Sraub 1997; Szajna 1996), telemedicine technology (Hu, P.J. et. al.1999), World Wide Web (Agarwal and Karahanna 2000) and Internet (Kripanont. N 2006).

For the purpose of this study the software packages used to investigate TAM by (Davies, F.D, Bagozzi and Warshaw 1989; Venkatesh and Davis 1996) is described as social systems (word processing, excel etc) in architectural education (Achten 1996). This study investigated the use of a professional system in architectural education (Achten 1996) using the Unified Theory of Acceptance and Use of Technology (UTAUT) by Venkatesh et. al., 2003 as the theoretical base. CAAD use is prevalent in architectural education and the locus of adoption is organizational. Leonard-Barton and Deschamps (1988) suggests that because each individual was adopting in the context of a coordinated technology implementation effort, managerial influences were expected and this implies that the social influence construct will play an important part in determining behavioural intention to use the system. This research operationalized the social influence construct to suit the objectives of this study. Kelman (1958) distinguished between three different processes of social influence that affect individual behaviour: compliance, identification, and internalization. He defined these processes as follows; Compliance: when an individual adopts the induced behaviour not because she believes in its content but with the expectation of gaining rewards or avoiding punishments. Identification: when an individual accepts influence because she wants to establish or maintain a satisfying self-defining relationship to another person or group. Internalization: when an individual accepts influence because it is congruent with her value system. He stated further that by distinguishing between these processes, one could ascertain if usage behaviour is caused by the influence of referents on one's intent or by one's own attitude. Kelman observes that each of the above three processes is characterized by a distinctive set of antecedent conditions corresponding to a characteristic pattern of internal responses (thoughts and feelings) in which the individual engages while adopting the induced behaviour. Similarly, he posited that each of the three processes is characterized by a distinctive set of consequent conditions, involving a particular qualitative variation in the subsequent history of the induced response. For instance, behaviour induced through compliance tends to be performed under surveillance by the influencing agent (For example: CAAD course examinations by students and compliance to e-learning by faculties to enhance promotion status). In contrast, behaviour induced through identification tends to be performed under salience of one's relationship with the agent; and behaviour induced through internalization tends to be performed under conditions of the relevance of the issue, regardless of surveillance or salience.

Applying this to use of a new information system, the social influence processes determine the individual user's commitment, or more specifically, psychological attachment (O'Reily 1986), to the use of any new information technology. Kelman suggested that users who perceive use of the information system to be congruent with their values are likely to be internalized -- committed and enthusiastic -- in their system use. However, individuals who perceive such use merely as a means to obtain rewards and avoid punishments are likely to be compliant -- pro forma and uninvested -- in their system use (Klein et.al. 1996). In contrast to the traditional conception of use in terms of use and non-use, this conception suggests that use of an information system needs to be viewed as a continuum (Malhotra 1999). This continuum defines the range from avoidance of use (nonuse) to meager and unenthusiastic use (compliant use) to skilled, enthusiastic and consistent use (committed use). The continuum of use is influenced by users' commitment to the use of the information system: a function of the perceived fit of the system use to the users' values.

The conceptual framework of this study replaces social influence construct in Unified Theory of Acceptance and Use of Technology (UTAUT) with psychological attachment borrowed from (O'Reily 1986) and extends the model to include sustainability of use which will be dependent on utilities derived from performance expectancy in actual usage of the CAAD system. According to Venkatesh et al, (2003) experience was found as a moderator of acceptance and use of technology. It posited that gender and age moderate's performance expectancy in the behavioral intention to use technology and that this moderation is stronger for men and younger users. It further revealed that gender, age and experience are moderators for effort expectancy in the behavioral intention to use technology. Rogers (1995) posited that one of the predictors of technology acceptance is observability which is operationalized in this study as awareness. Rogers (1995) was supported by works done by other scholars on technology acceptance (Nambisan et al, 1999), Charbaji and Mikdashi, (2003), Ilesanmi, F. (2012), Rehman et al, (2012), Wan, et al, (2012), Oye et al, 2013 which posits that awareness is a moderator of behavioral intention to accept the use of technology.

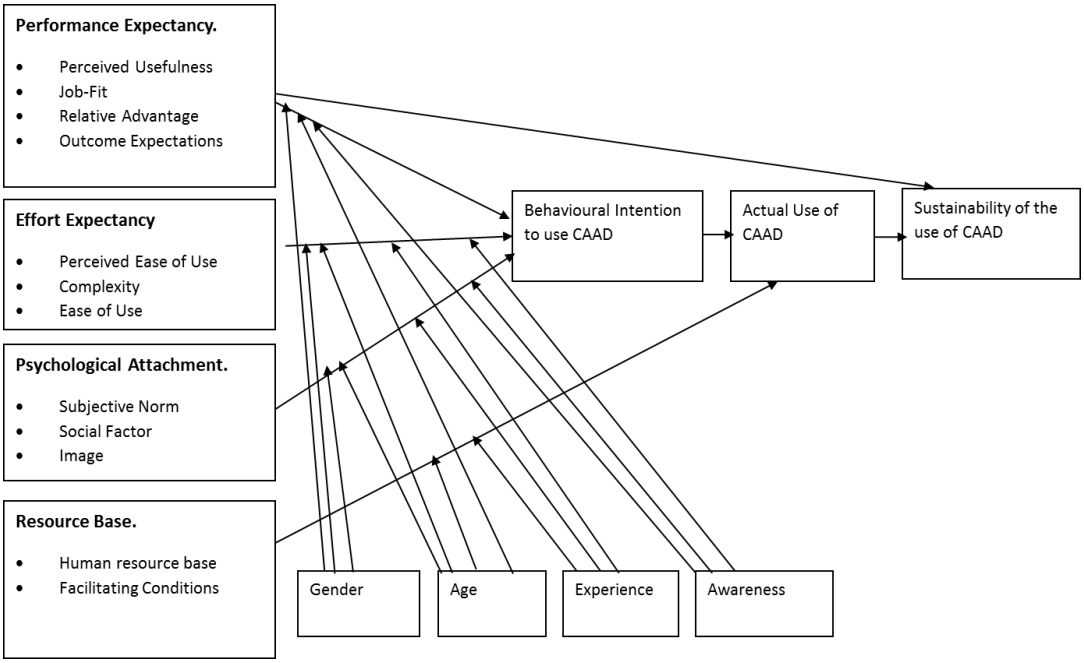


Figure 5 Conceptual Framework for the Study of CAAD in Education

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