Analysis of Recent Studies Undertaken for Assessing Acceptance of Technology among Teachers using TAM

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ABSTRACT

Although there is an increase in availability and support for technology integrated teaching and learning methods , teachers' acceptance of technology into their teaching activities seems very low. The study aims at probing recent usage of the Technology Acceptance Model (TAM), in assessing acceptance of technology among teachers from among the research publications with a focus on behavior intentions of teachers towards technology adoption and usage, published in peer reviewed journals and conference proceedings 2005 onwards. The analysis projects TAM as a robust model which can be used in assessing technology acceptance among teachers, in the educational vertical, just as it has been used in various business verticals. The review provides evidences that TAM can predict actual usage by using both subjective and objective measures.

Keywords : TAM, intention to use IT, ICT in education , teacher's use of technology, IT adoption, technology acceptance, Qualitative Analysis , TAM studies, IT as a teaching tool

1. INTRODUCTION

In the developed countries research work in the area of Information Technology deployment in teaching practices is plenty compared to developing countries like India. The reason could be the very fact that technology as tool for teaching is just being introduced in many developing countries. Also there are only very few research studies involving meta-analysis of other studies which had a focus on the application of technology in education. These studies have concluded that there are identifiable benefits by the use of technology as a tool in teaching , such as a) enhancement of instructional effectiveness; b) reduction in time to reach instructional objectives; c) knowledge enhancement and performance improvement in students ; and d) enhance "soft skills" (applicable to many areas of business). Even though studies indicate so many advantages of using ICT in teaching and learning process, the real conviction among teachers to use technology for teaching seems doubtful even in the most developed countries like US and some European countries. Although introduction of new teaching and learning practices can promote modern thinking and learning skills among students, there seems to be a gap between these benefits and the actual use by teachers. In this context, to further investigate and predict the teacher's acceptance of technology as a teaching tool, the researchers have attempted to use the most widely applied theoretical model in Information Systems field, the Technology Acceptance Model (TAM).

TAM came in to existence as Davis (1989) posed the question, "What causes people to accept or reject information technology?" Davis explored the prospect that beliefs influence attitudes that indicate intentions and generate behaviors relative to technology acceptance, by building upon the work done on social psychology theory in general and Theory of Reasoned Action (TRA) in particular.

As TAM is an intention-based model that was developed specifically for explaining and predicting user acceptance of computer technology, it is most widely used for explaining factors affecting user acceptance and to provide explanations of usage behavior of adopting these new technologies. TAM is among the first few models to include psychological factors that affect technology acceptance.

TAM can be termed a mature model as it has been validated in different contexts. TAM was conceptualized under conditions more similar to the business and organizational settings and hence has been applied in a variety of businesses including manufacturing, accounting, financial services, and investment banking firms. TAM has undergone extensive revisions over the years resulting in multiple extended, improved and adapted versions. With the increasing deployment of Information and Communications Technologies (ICTs) this model has been used by researchers as an effective model for evaluating the acceptance of ICTs not only in business but also in areas like education, health-care, governance etc. In education , TAM is one theoretical model that has been used by the usability experts mainly , i) to check for acceptance of computer based teaching methods among students and teachers , ii) to gauge acceptance of partial e-learning implementations in Universities and Institutions, and iii) to assess and predict Web-based ERP-simulated technology in classroom environments.

2. RESEARCH USING TAM - PROGRESS AND FOCUS AREAS

Over the years Information Systems researchers have been developing several models to explore and comprehend the factors affecting the acceptance of computer technology in organizations. The theoretical models developed to study user acceptance, adoption, and usage behavior include the (i) Theory of Reasoned Action (TRA) (e.g., Fishbein & Ajzen,

1975; Ajzen & Fishbein, 1980), (ii) the Technology Acceptance Model(TAM) (e.g., Davis, 1989; Davis et al., 1989), (iii) the Theory of Planned Behavior (TPB) (e.g., Ajzen, 1991; Mathieson, 1991), (iv) the Model of PC Utilization (Thompson, Higgins & Howell, 1991), (v) the Decomposed Theory of Planned Behavior (DTPB) (e.g., Taylor & Todd, 1995a), and (vi) Innovation Diffusion Theory (IDT) (e.g., Brancheau & Wetherbe, 1990; Rogers, 1995;Agarwal & Prasad, 1997) etc.

The classical TAM proposed by Davis (1985) has three major factors, the Perceived Ease of Use, the Perceived Usefulness and the Attitude towards using Technology. He hypothised that the attitude of the user will be determining usage or rejection of an IS, and the attitude is dependent upon two variables, the perceived ease of use and the perceived usefulness. TAM was developed under contract with IBM Canada Ltd. in the mid-1980s where it was used to evaluate and predict usage for a variety of then-emerging PC-based applications in order to guide investments in new product development (Davis & Venkatesh, 1996). Most Information Systems studies have replicated TAM or used TAM instrument expansively to examine a range of issues in the area of user acceptance (e.g., Mathieson, 1991; Moore & Benbasat, 1991; Trevino & Webster, 1992; Adams, Nelson & Todd, 1992; Segars & Grover, 1993; Chin & Gopal, 1993; Sjazna, 1994; Igbaria et al., 1997).

Most IS researchers have used TAM and TRA as a theoretical base to conduct research on the factors that affect the user acceptance of IT (Igbaria, 1992), and have come forward with suggestions for modifications in TAM by giving theoretical models based on the specific scenario under which the studies were carried out. Ajzen and Fishbein formulated the TRA after trying to estimate the discrepancy between attitude and behavior. TRA was related to voluntary behavior. Later on behavior appeared not to be 100% voluntary and under control, and this resulted in the addition of perceived behavioral control. With this addition the theory was called the Theory of Planned Behavior (TPB), which could explain the relationship between behavioral intention and actual behavior.

In the Theory of Reasoned Action (TRA), Fishbein and Ajzen suggested that the attitude of a person towards a behavior can be measured by taking the sum of the product of all Salient Beliefs (B_i) about the consequences of performing that behavior and an evaluation (E_i) of these consequences. They further defined, the Subject Norms (SN) associated with a behavior , to be determined by considering the sum of the product of a person's normative belief's (nB_i) , that is perceived expectation of others and his motivation to comply (M_i). Thus TRA expressed, Behavioral Intention (BI)

as $\quad BI = \sum B_i E_i + \sum nB_i M_i$

TAM is highly praised for its parsimony and predictive power which make it easy to apply in different situations. But this has led to some reservations as well. As Venkatesh (2000) points out that while TAM's strength is parsimony, it is also a major constraint of the model. As per findings and

conclusions of Venkatesh, while TAM has proven to be very powerful in predicting technology acceptance, it does not help understand and explain acceptance in ways that can lead and guide for further development. TAM can be used to understand information system characteristics, impact, usefulness and ease of use but does not go beyond that thereby placing a limitation on the ability to meaningfully design interventions to promote acceptance. According to Vernon (2002), "IT implementation is arduous because computer systems are complex entities". The complexity of computer systems accounts for the varying degrees of acceptance and use that people have of information systems. Apart from the built in complexities of information technology, it is also changing so rapidly that people have to not only handle the changes but also the incompatibilities that different versions and models pose, thus further complicating its usage.

3. TAM STRUCTURE AND VARIABLES

The classical TAM proposed by Davis (1985) has usage of a system as a behavior taking TRA as a base. He took Attitude (A) as a major factor but ignored the Subjective Norms as it was considered to be the most mystifying part of TRA ; instead chose two major factors, the Perceived Ease of Use (PEOU) and the Perceived Usefulness (PU).

Perceived Ease of Use (PEOU/E) - This refers to the degree to which a person believes that using a particular technology will be free of effort. Users believe that a given application is useful, but they may, at the same time, believe that the technology is too hard to use. The performance benefits of usage are outweighed by the effort of using the application (Davis and Arbor, 1989).

Perceived Usefulness (PU/U) - Usefulness is a factor which has been theorized as influencing attitudes towards IS/IT and ICT use. Perceived usefulness is defined as the degree to which a person believes that using a particular technology will enhance his or her job performance. People tend to use or not use an application to the extent they believe it will help them perform their job better (Davis et al., 1989). This means the user has a perception of how useful the technology is in performing his job tasks. This includes decreasing the time for doing the job, more efficiency and accuracy. Now the question is usefulness to whom? Venkatesh and Davis (2000) define perceived usefulness specifically as the extent to which the object of adoption is thought to enhance the individual's performance on the job. Others, however, define perceived usefulness as subjective utility to the citizen or consumer, depending on the context.

Attitude towards using IT (ATT/A) - TAM asserts that perceived usefulness and ease of use will represent the beliefs and attitudes that lead to acceptance of a new technology (Lederer, Maupin, Sena, & Zhuang, 1999). According to Davis (1995), user's overall attitude toward using a particular system is hypothesized to be a major

determinant of whether or not he actually uses it. Attitude toward using in turn is a function of PU and PEOU.

Behavioral Intention to Use (BI/USE) - Subsequently, intention to use the technology is considered a function of perceived usefulness and attitude toward using the technology. With later developments in TAM, Davis suggested that there can be cases where given a system which was perceived useful , a person might form a strong Behavioral Intention (BI) to use the system without forming an attitude and thus such behavioral intention can determine the actual usage of the technology (Davis et al., 1989).

An additional change that was brought in to TAM was the addition of other factors, termed as **external variables** that might influence the beliefs of a person towards a system. External Variables typically included factors like system characteristics, User Training, the User participation in design and the nature of the implementation process (Venkatesh & Davis, 1989)

The model can be expressed using the four equations (Davis, 1995) 1. $E = \sum \beta_i X_i + \varepsilon$, for i=1,n, 2. $U = \sum \beta_i X_i + \beta_{n+1} E + \varepsilon$, for i=1,n , 3. $A = \beta_1 E + \beta_2 U + \varepsilon$, 4. $USE = \beta_1 A + \varepsilon$
Where $X_{i=}$ design feature I , β_i = Standardized Partial Regression Coefficient , ε = Random error

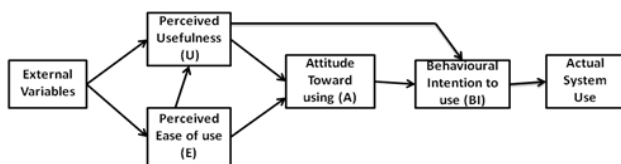Thus the modified TAM looked like this

Figure:1 Technology Acceptance Model (TAM)*
 * Source: Davis, F. D., Bagozzi, R. P., and Warshaw, P. R. "User Acceptance of Computer Technology: A Comparison of Two Theoretical Models," Management Science, 35, 1989, 982-1003.

Venkatesh, et al (2003) proposed Unified Theory of Acceptance and Use of Technology (UTAUT), which was developed by integrating elements across eight models in the field of technology acceptance research. UTAUT posits that performance expectancy, effort expectancy, social influence and facilitating conditions are determinants of behavioral intention or use behavior, and that gender, age, experience and voluntariness of use have moderating effects on the acceptance of technology.

Even though TAM is considered a great success by IS researcher and has various studies and research work undertaken using it , only a few systematic efforts have been seen in the past in tracing its history , to investigate and evaluate its findings , limitations , and future scope [e.g., Gafen and Straub(2000) ; Legris et al (2003), Lee et al (2003)] . In the recent past there were some efforts from researchers to conduct Meta analysis on TAM literature and investigating TAM's findings in various business scenarios.
The study here analyzes publications from the years 2005 on the TAM research and is an attempt to extensively explore usage of TAM by researchers to predict acceptance of

technology in the education vertical. The research objective of the study was to find answers to the questions :

- Was TAM found to be an effective model to assess and predict system usage among teachers?
- What factors were found to have significance in assessing acceptance of technology by teachers?
- What are the major constraints or limitations recorded by the researchers in using TAM to assess acceptance of technology among teachers?
- What kinds of studies are carried out in Indian context and what is the scope for future research ?

4. DATA ANALYSIS AND FINDINGS
4.1 Literature
After conducting a search among the articles published in peer reviewed journals and conference proceedings published between 2005 and early 2011, around 60 empirical studies undertaken by IS researchers to assess technology acceptance in education using TAM were identified. From those a sample of 45 studies which had 'teachers' as subject of the study were analyzed further.

Articles used in the study are taken from various peer reviewed journals though with almost 55% of them appearing in "Computers & Education" and rest in the other journals like : Computers in Human Behavior, Information & Management, Innovation and Creativity in Education , Interacting with Computers , Interdisciplinary Journal of Contemporary Research In Business , International Journal of Instruction , International Journal of Organizational Innovation , Journal of Engineering and Technology Management , Journal of Information Systems Education , Journal of School Psychology Teaching and Teacher Education , The Internet and Higher Education , proceedings of World Conference on Educational Sciences and Crop Protection from Elsevier.

The articles chosen have data from across the globe as the studies were undertaken in US , UK and countries like Sweden, Malaysia, Cyprus, China, Taiwan , Turkey , Singapore, Finland and Serbia etc.

4.2 Characteristics of Study Subjects
As shown in the table 1 , from among the 45 studies chosen for analysis , 71% have regular teachers teaching various courses (e.g. Mathematics, Science and English etc.) , 18 % have Student teachers (students getting training to become teachers at teachers' training institutes) as subjects, and 11 % have Pre service teachers (trainee teachers) as subjects of studies.

Table 1 . Characteristics of Subject types and Sample Size in chosen TAM Studies

Subject Types		Sample Size	
Teachers	32	Mean	285
Pre service teachers	5	Standard Deviation	284
Student Teachers	8	Minimum	10
Total	45	Maximum	1540

4.3 Research Methodology Used

The majority of studies in the sample chosen have used questionnaire based survey (85%) for data collection and have quantitative data analysis methods adopted whereas only a few (11%) have structured and semi structured interview methods and the rest 4% are using Delphi Technique ,Focus Group and Telephone Interview for data collection to predict intentions and usage of computer among teachers. Data in most of the studies is analyzed using regression and other descriptive statistics using software like SPSS and SAS , though in some cases usage of Structural Equation Modeling , with Partial Least Square (PLS) using LISREL or AMOS is found.

4.4 Target IT/ICT technology tools used for teaching in the studies

Over 30 different types of Information technology tools used for teaching and learning were the target systems in these articles. These can be classified in six major categories such as :   Computer (Systems) in Classrooms , e-learning , Learning Management Systems , Web2.0 tools , Subject Specific Software Tools and Hardware . From among the sample , it is observed that though more studies have looked at " Computer Usage", in general by teachers i.e. for showing content in the classroom, using computers to assess students thru assignments, preparing presentations and other documents etc. , an increasing trend towards studies of acceptance of e-learning and Distance Learning Technology tools among teachers is also seen in the 2005-10 period . In Learning Management Systems as target systems, Blackboard (WebCT) and Moodle , are the two LMS being researched on. From among the 45 studies analyzed only 3 had Web2.0 tools and subject specific online community building as target systems . As the young generation is spending more and more time on the Internet , there seems to be a lot of efforts from the part of teachers and educationist ,in general , to use ICT as a tool for teaching and learning . So there is a large scope for studies to check the usage pattern of teachers and level of acceptance of the latest tools like Blogs, Wikis , Twitter, Facebook and other Social networking sites as target systems .

Table 2 . Summary of IT/ICT target Systems and Research Methods adopted in TAM Studies

Type of Target System	*Research Method / Model used for data analysis*
Computer Systems in Classrooms (31%)	%T test %Variance Analysis %Descriptive Statistics %Pearson Product Moment Correlation %Discriminant Function Analysis %DTPB Factor Analysis % Path Analysis %Multilevel Modeling %Task Technology Fit %Structured Equation Modeling (SEM) %Social Cognitive Theory
ICT in classroom (29%)	%Confirmatory Factor Analysis, %Variance Analysis % Delphi Technique %Descriptive Statistics %SEM

	% Component Analysis % Interpretive Case Study %Bi-variate Correlation Analysis
Digital learning Environment (8%)	%SEM using LISREL % Variance Analysis %Factor Analysis
e-learning (7%)	%Information Systems Continuance Theory % ANOVA % Regression % E-learning Acceptance Measure (ElAM)
IT (2)	%SEM % Analysis of TAM variables
Learning Management Systems (7%)	%SEM % DeLone & McLean's Information System Success Model %Descriptive Statistics
Subject Specific s/w (2)	% Analysis of TAM variables
Tablet PC usage (2)	%SEM % Analysis of UTAUT variables
Web2.0 / Blogs	%Attitude scale and UTAUT scale

4.5 The variables used to measure acceptance of technology

In most of the studies Perceived Ease of Use (PEOU), Perceived Usefulness (PU), Intentions to use ICT in teaching and learning (IU) and the Attitude towards use (A) variables are used (See Table below). Apart from these , computer self efficacy, facilitating conditions , teacher's personal characteristics and awareness and hands-on-training were the other major variables which were useful in determining teacher's technology usage in the teaching and learning process.

Table 3. Variables considered for analysis in the studies

Most Common Variables	% of Studies
Perceived ease of use	47%
Perceived usefulness	56%
Intentions to use	47%
Attitude towards use	71%

Other Variables considered as external variables include:

* Computer Self Efficacy
* Social Influence
* Facilitating Conditions
* teachers' educational beliefs
* Personal innovativeness in the domain of information technology
* Teachers' personal characteristics (gender, age, computer at home, and computer experience)
* Curriculum alignment
* Professional development
* Teacher skill (technology competency and integration)
* Teacher morale
* Negative factors like lack of equipment, lack of institutional support, disbelief of ICT benefits, lack of confidence, and lack of time
* ICT plan
* ICT support
* ICT training
* Principal's perspective and perceptions on technology
* Learning needs of students in specific subject areas
* Performance Expectancy
* Effort Expectancy and
* Subjective Norm

5. DISCUSSION

There has been extensive use of TAM   in determining teacher's technology acceptance level in teaching, as evident from the preceding review . The recent increase in the use of TAM in education sector is seen with many TAM

relationships being validated and proportions of variance in the dependent variable   intention to use or actual use explained. In almost all studies the relationship between Perceived Usefulness and Intention to use is found to be significant, suggesting that to improve use and acceptance, the IT tools for teaching must be perceived as 'useful'. But in addition to the noticeable potency of TAM in education studies, there are some challenges which need to be looked at. These are addressed in the next section along with   a discussion on possible future directions of TAM research in education.

5.1. Strengths of the Studies

The reviewed studies on an average show , (1) reasonably high R^2 values, (2) frequently large effect sizes for relationships between study variables, and (3) some consistently significant relationships among the TAM variables. There is strong evidence to conclude that the perceived usefulness of technology will have some impact on whether teachers' accept and subsequently use technology for teaching or not . Though the perceived ease to use may not be as likely to affect acceptance, but it does appears to correlate with usefulness, thus perhaps reflecting the notion that IT is difficult to use thus cannot possibly be perceived as useful [Marios Pittalis, Constantinos Christou, 2011]. The implication is that design, training, and informational sessions must focus on ensuring that ICT tools are (or, at least, are perceived to be capable of) improving learning among students and is not difficult to use. The consistently significant relationship between facilitating conditions and acceptance suggests that, regardless of how useful and easy to use the technology is, steps will need to be taken to ensure that teachers feel confident in their ability to use it (self-efficacy). They are to be made to feel that using these IT tool is under their control (controllability), with all barriers removed and sufficient support provided (facilitating conditions) [Rong-Ji Chen (2010),Timothy Teo (2009), Claudia Smarkola(2008)] .

Almost every study used well validated questionnaire , with items from previous studies, something that has been discussed as a major benefit of the penetration of TAM. Studies also tend to report the psychometric properties of scale items, which were usually reasonable and did not differ substantially between studies. There were, however some specific studies , for example the study with a focus on educational ideology, a factor though not related to technology but can have major influence on the decisions of a teacher to adopt certain tools, in terms of educational applications [Kiraz,E. & Ozdemir D., 2006], or the measure of the attitude construct using a "perceived enjoyment" scale in another study on teachers' decisions to adopt teaching blogs [Hui-Min Lai, Chin-Pin Chen,2010], reflecting a common misunderstanding of attitude theory. Finally, almost every study added variables to TAM in an attempt to better understand the background of acceptance or teacher's IT use behavior. This "added variables approach", represents the growth of the discipline in its incorporation of multiple theories and multiple sources of causality to account for the complexity of human intentions to use technology [Rong-Ji Chen , 2010].

5.2. Challenges

There were also a number of challenges faced by the body of reviewed studies. As mentioned above, tests of expanded models allowed researchers to test potentially important relationships not specified in the original TAM , such as the effect of subjective norm [Will Wai-kit Ma, Robert Anderssonw & Karl-Oslear Streithw , 2005]. At the same time, the variety in model specification—so great that not a single study tested the same model—greatly limits quantitative or qualitative comparison across studies. Perhaps the lack of standardization is due to the variation in TAM research, generally, seen in the variations between TAM, TAM2, and UTAUT, or in early influential work testing direct relationships between PU and PEOU on one hand, and actual use on the other [Adams DA, Nelson RR, Todd PA ,1992]. Indeed, some scholars have criticized TAM research for adding variables haphazardly, leading to a progressively less coherent theory [Benbasat I, Barki H. Quo vadis,2007] . Even the language used in the reviewed studies is not always standardized, with the terms adoption and acceptance used interchangeably and incorrectly. Standardization of the models tested need not be in conflict with the addition of new variables and relationships: researchers can test a standard TAM for comparison, and can separately test expanded models as well.

Finally, looking at Table 3, a few other limitations are obvious. First, certain variables such as actual use have been too infrequently measured (only in 3 studies), precluding tests of several important relationships, such as the one between intention and actual use. Some relationships have been inconsistent (or consistently weak), raising the possibility of moderating effects or other theoretically important differences between studies. Are the effects of PEOU spurious, given their inconsistent predictive power? Perhaps so, but in some studies, the effect of PEOU is as strong as that of PU , if not much stronger [Wong Su Luana, Timothy Teo, 2010]. There are findings which shows how strongly PEOU, or other variables for that matter, relate to attitudes, behavioral intentions, or actual use, depend on factors such as teachers pedagogical-learning evaluation of technology type [Marios Pittalis, Constantonis Christiou, 2011].

Given the nascence of TAM research in education , several future general directions and specific research questions can be suggested. Table 4 provides a non-inclusive list of suggestions, many of which apply to not only in education but TAM research in general.

5.3. Beyond the added variables approach: Context, evolution, and implications for the future

TAM is a well regarded theory of technology acceptance and use that has been widely researched in many areas of IT implementation and has lately become an important theoretical tool for ICT in education research areas. IT Policy makers, Administrators, purchasers, and others involved with IT projects implementation in Schools are routinely advised to use the TAM to aid the design or purchasing process,

training and informational sessions, implementation methods, and other activities. Although TAM did a fair job predicting, and perhaps explaining, teacher/end-user acceptance and use of ICT tools, there is much room for improvement. Aside from a need for standardization, more tests of certain relationships, and better reporting of data, there is also a need to continue exploring new theoretically motivated variables and relationships that can be added to TAM.

Table 4 : TAM research and future directions

General research directions
• Conducting TAM research in the Indian education context where technology as a teaching tool is just being introduced.
• Testing additional variables
• Beliefs elicitation studies to identify how TAM variables are contextualized in teaching and learning contexts and to identify important additional variables
• Testing of TAM and related models on large, representative teachers'/educationists samples
• Longitudinal studies of temporal effects and studies comparing TAM between groups and individuals
Specific research questions
• Under what circumstances do different TAM variables—e.g., ease of use, usefulness, and subjective norms—have the dominant impact on acceptance and use?
• What are individual (e.g., computer experience) or group-level (e.g., subject areas) characteristics that affect relationships in TAM?
• How does TAM fare against other models of acceptance and use of technology in teaching ?

6. CONCLUSION

The study analyses the outcome of a range of studies conducted in recent times , for studying technology adoption issues in education at the user levels. Current research had focus on only TAM studies , not only as TAM is more popular than the rest of the models, but more importantly because the research seeks to understand the relationship between perceptions about technologies (such as perceived usefulness and perceived ease of use) and usage behavior of teachers in adopting technology as a teaching tool. The analysis has clearly indicated TAM as a robust model which can be used very effectively to assess technology acceptance among teachers and can go on to even predicting the actual usage of IT tools in teaching and learning scenario.

A very important finding has been the fact that though there are some studies carried out to assess technology acceptance among users in business verticals in India but there is hardly any study undertaken in Indian education scenario where TAM is used to assess acceptance of technology as a teaching tool . The scope for researchers to conduct studies for identifying salient beliefs about using ICT as a tool for teaching that teachers have in India has at least two reasons. First, this will allow researchers to probe about a wide range of theoretically interesting teachers' beliefs, which could make the theory more robust and relevant in Indian education

context. Second, and equally important, by contextualizing TAM to education, there is the opportunity to develop the "left side of the model." That is, contextualization uncovers the specific and, importantly, actionable meaning and causes of generic variables such as usefulness and ease of use, helps determine who are the "important others" of subjective norms and what are the actual barriers and facilitators to IT use. With the Department of Education, Ministry of Human Resource and Development (MHRD), Government of India developing a National Policy on ICT in Education, the right time to begin uncovering specific, contextualized, and actionable constructs is now.

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