Modeling the Adoption of Internet of Things in Educational Institutions by Teachers: A Conceptual Framework

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Abstract: The Internet of Things (IoT) is an ecosystem where objects (or things), equipped with sensors, communicate with each other and computers or mobile devices, often autonomously, without the need for user interaction, through a variety of networking solutions, especially wireless ones. This paper proposes a model to understand the behavioral intention to use and attitude of college teachers towards IoT adoption in the field of education. The study proposes the use of Technology Acceptance Model (TAM) to analyze the IoT acceptance in the field of education. The study uses three variables - perceived usefulness, perceived ease of use and attitude to predict the IoT acceptance level of teachers. Intention to use, which is considered an adequate proxy for consumer acceptance, is adopted as the dependent variable. A conceptual frame and hypotheses are proposed along with the proposed research framework.

Keywords — Attitude, Internet of Things (IoT), Perceived ease of use, Perceived usefulness, Technology Acceptance Model (TAM)

I. INTRODUCTION

The Internet of Things (IoT) is an ecosystem where objects (or things), equipped with sensors, communicate with each other and computers or mobile devices, often autonomously, without the need for user interaction, through a variety of networking solutions, especially wireless ones [1]. The Internet of Things (IoT) has a major potential and has already started to improve the human life in all sectors: smart cities, smart environment, smart water, smart metering, security and emergency, retail, logistics, industrial control, agriculture, home automation and eHealth [2]. IoT is the next major step in the evolution of digital technology affecting industries and infrastructures [3]. IoT has also permeated to the field or teaching, learning and education institutes' administration. It is argued that the area of the IoT can transform the educational environment [4]. The implementation of IoT technology in campuses can reduce operational costs, improve security, and offer tools for researchers, academics, students and staff [5]. Though a well-designed physical campus with completely integrated technology is fundamental for building an IoT environment, the important factor for such learning transitions in the field of education is the general attitude of the teaching community towards engaging in use of such technology [6]. Therefore it is important to understand behaviour intention of the teaching community to use such an advanced technology such as IoT before its actual implementation in our educational institutions. An attempt to understand their attitude and concerns will help to address them effectively so that a smooth transition can be made to this new world order.

A variety of models have been developed to explain consumers' acceptance of a new technology including that of adoption of ICT technologies by educators. However, Technology acceptance model (TAM) proposed by [7] is the most widely referenced adoption model in IT/IS research. This study uses the original TAM proposed by Davis to analyse the acceptance level of teachers towards the use of IoT enabled technology in the field of teaching and learning.

II. REVIEW OF LITERATURE

A. Internet of Things (IoT):

The term internet of things (IoT) was coined in 1999 by Ashton of MIT. He defined IoT as an ecosystem where objects (or things), equipped with sensors, communicate with each other and computers or mobile devices, often autonomously, without the need for user interaction, through a variety of networking solutions, especially wireless ones [1]. IoT may be understood as "a network of items – each embedded with sensors – which are connected to the internet" [8]. IoT is also defined as "IoT is seamless connected network of embedded objects/devices with identifiers, in which M2M communication without any human intervention is possible using standard and inter-operable communication protocol." Phones, tablets and PCs were excluded from this definition [9].

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On the most basic level, the IoT involves fitting objects with a microchip and a communications antenna [10]. Using radio frequency identification (RFID), every real object in the analogue world could have a unique identifying number, like an IP address [11]. Constant connectivity, remote control ability, data sharing, and so on which were the features of regular internet is thus extended to physical objects. Thus IoT inter connect things with the help of internet. These objects have set of connected physical features; have the ability to be located and to send/receive messages.

IoT devices have a distinctive identifier associated to at least one name and one IP address. IoT devices have inbuilt computing features and sensors that could sense temperature, light, electromagnetic radiation level and to activate actions having an effect on the physical phenomenon [12]. Objects in an interconnected world interact without human intervention. A number of cute-edging techniques (such as intelligent sensors, wireless communication, networks, data analysis technologies, cloud computing, etc.) have been developed to realise the potential of the IoT with different intelligent systems. IoT is a blending of three visions such as radio frequency identification (RFID), wireless sensors and actuators with near-field communication (NFC). However, technologies for the IoT are still developing and many technical difficulties associated with IoT have to be surpassed. One of the most significant obstacles in IoT is security which involves the sensing infrastructure security, communication network security, application security, and general system security.

The most common devices that use IoT are:

- Wearables that integrate nano electronics and sensors to expand the functionality of clothes, watches, and other body-mounted devices. Eg: Smart watches and smart bands
- Wearable devices to monitor patient health connected to hospital devices.
- Smart homes and buildings – including home networks of smart consumer electronics and appliances like washing machine, as well as buildings automation solutions based on intelligent sensors to monitor and manage heating, ventilation, air conditioning, lighting, security etc.
- Smart manufacturing – providing access to production-plant systems for sharing its capacity, allowing for more flexibility of manufacture and production management,
- Smart cities – monitoring and integrating city's all transport modes, communication, water, electrical power to optimise usage of resources while maximising service quality to its citizens
- smart farming and food security – monitoring, control and treatment (even allowing autonomous interventions) in agriculture – for plant and animal production - on farm and area level to increase food security, lower ecological footprint and decrease costs.

There are however many technical issues faced in the implementation of the IoT technology [13]. Security and privacy issues are the major challenges for consumer acceptance of the IoT technology's user-oriented IoT applications [14]. Notwithstanding these issues, IoT is the next major step in the evolution of ICT industries and infrastructures [3]. Before it was Internet of People and now it is Internet of Things. It has, for example, created and transformed markets for digital content such as music, news, maps and other information. Tomorrow's smart devices should create value by applying connectivity and intelligence to improve the core value proposition of the device: smart cooktops that automatically turn the heat down when a pot boils over; smart toasters that can tell the difference between golden brown and burnt; smart washers that can call for maintenance before the product breaks, mix the exact quantity of detergent needed and use the optimal temperature of water [15]

B. IoT in Education:

Technology in education has played a significant role in connecting and educating the students. Integrating IoT as a new actor in educational environments can facilitate the interaction of people (students and teachers) and (physical and virtual) objects in the academic environment. IoT technology is playing a likely role for the improvement of education at all levels including school, college and university teaching. From student to teacher, classroom to campus, everything can get benefited with this technology [16]. With the help of IoT, we move towards smart classes. For this campus has to be connected to the Internet. Using sensors, RFID, NFC, QR tags and such other IoT technologies, common objects such as windows, doors, projectors, printers, classrooms, labs, parking, and building, etc. can be converted to Smart objects. A Smart Campus can be a collection of multiple smart things in a single system. An intelligent campus may include following - Smart E-learning Application with IoT, Smart IoT-based Classroom, Smart IoT-based LAB Room, IoT Sensors for Notes Sharing, IoT Sensors for Mobiles Devices, IoT-enabled Hotspot for Campus.

In addition to above, a smart campus may have many other smart features like smart parking, smart inventory, smart lighting, and smart tracking of students, goods and equipment using RFID technology. Some of the noted usages of IoT in education are:

- Interactive Whiteboards
- Tablets and Mobile devices
- 3-D Printers
- eBooks
- Student ID Cards
- Temperature Sensors

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- Security Cameras and Video
- Room Temperature Sensors
- Electric Lighting and Maintenance
- Smart HVAC systems
- Attendance Tracking Systems
- Wireless door locks

C. Technology Acceptance Modal (TAM):

In the IT/IS literature, a variety of models have been advanced to explain innovation usage [17]. Among them, the TAM, proposed by [7], has evolved as the most popular. TAM suggests that two variables, perceived ease of use and perceived usefulness, are significant determinants of behavioural intention to use a system/technology. Specifically, perceived usefulness is defined as the degree to which one believes that using the technology will enhance his/her performance [18]. Perceived ease of use refers to the degree to which one believes that using the technology will be free of effort. TAM also proposes that perceived ease of use can explain the variance in perceived usefulness. TAM have applied to a wide range of research questions, including adoption of internet banking, online shopping, mobile financial services, mobile advertising, 3G mobile value-added services, online community participation, adoption of e-health [19] and e-learning. Therefore, even if TAM was originally intended to predict IT system use in the workplace, the TAM variables can also be employed to predict consumer acceptance in a variety of settings. TAM can serve as a useful foundation for investigating consumer acceptance of IoT technology, as IoT system is a type of new IT [20].

D. Critical Reviews

The author has identified that researches relating to IoT implementation in education system is scarce. Most of the researches are confined to research relating to the identification of the factors that affect the acceptance of IoT by customers in general. [21] investigated the factors that affect the acceptance of IoT in China. They used TAM variables such as perceived ease of use and perceived usefulness along variables such as trust, social influence, perceived enjoyment, and perceived behavioral control. The study revealed that perceived usefulness, perceived ease of use, perceived enjoyment, social influence, and perceived behavioral control have significant effect on behavioral intention to use the IoT. A similar study was conducted in the USA by [22] using a sample of 2000 customers. Awareness of the technology, usefulness, price, security, privacy was found to be influencing behavioral intent by them. [23] found that the intentions to use IoT services are influenced by perceived privacy risks and personal interest, legislation, data security, and transparency of information use. [24] studied the adoption of a smart fridge in UK. The findings were based on interviews with 35 students. The findings indicate that there are social factors such as cost, technology anxiety, and social influence that influence behavioral intension.

Many studies have attempted to review the literature to find the factors that affect the acceptance of IoT services. [25] in the literature review found that the barriers for effective adoption of IoT are slow technology adoption rate, issues with interoperability, the collection and impactful use of big data, a lack of regulations and privacy concerns, messaging design, consumer perception, and finally, cost of implementation.

III. MODEL FRAMEWORK AND HYPOTHESES DEVELOPMENT

Technology acceptance model studies the effects of each antecedent on the intention to use which constitutes the hypotheses (Figure 1). The researcher proposes to test this model using empirical research. A visual representation of the elements in the TAM is as follows:

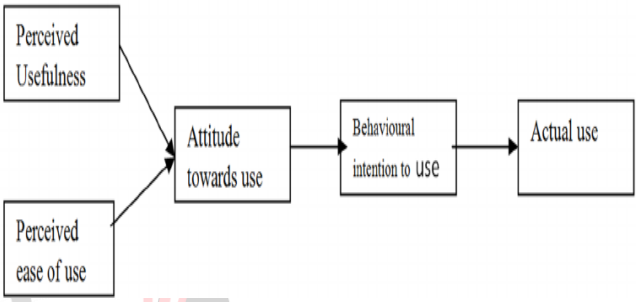

Figure 1: Model testing framework

IV. HYPOTHESIS:

H1. Perceived usefulness (PU) has a positive impact on the behavioral intention (BI) to adopt IoT technologies in the field of education

H2: Perceived usefulness (PU) has a positive impact on the attitude (ATT) to adopt of IoT technologies the field of education

H3: Perceived ease of use (PEOU) has a positive impact on the behavioral intention (BI) to adopt IoT technologies the field of education

H4: Perceived ease of use (PEOU) has a positive impact on the attitude (ATT) to adopt IoT technologies in the field of education

H5. Attitude (ATT) has a positive effect on the BI to adopt IoT in the field of education

V. RESEARCH METHODOLOGY

A. RESEARCH DESIGN:

This research is exploratory and empirical in nature. The objective of exploratory research is the development of hypothesis rather than their testing while empirical research is appropriate when proof is sought to study the affect of

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certain variables on other variables in some way thereby supporting the given hypothesis [26].

B. INSTRUMENT DESIGN:

The study shall be conducted using survey method using a structured questionnaire to capture the attitude of teachers towards implementation of IoT in educational institutes. The questionnaire shall have two sections. Section 1 composed of questions regarding demographic features of the respondents. The section 2 of the questionnaire consists of 21 scales to measure Perceived Usefulness (PU), Perceived Ease of Use (PEOU), Attitude (ATT) and behavioral intention to use (BI) of the respondents. Davis' scales [7] were adapted to capture these variables though it was slightly modified or reworded to suit the specific context of the study. Google doc is used to share the questionnaire with the respondents. The questionnaire is also accompanied by a video that demonstrates the working of IoT technology and for what they can be used in the field of education. This method has been adopted in other IoT adoption studies to ensure that participants have sufficient information to form an opinion about their use of IoT technology [27].

The following table shows the Questionnaire items for TAM variables:

Variable	Scale Questions
PU1	IoT adoption will enhance my teaching experience
PU2	IoT adoption would help the students understand concepts better
PU3	IoT adoption would improve my overall productivity and efficiency
PU4	IoT adoption will help me be a better teacher.
PU5	IoT adoption would make job easier.
PU6	IoT adoption will be useful in my job.
PU 7	IoT adoption will help teachers to monitor students better
PEOU1	Learning to operate IoT would be simple for me.
PEOU2	IoT could do what I want it to do.
PEOU3	Communication with the IoT would be clear and reasonable
PEOU4	Interaction with IoT will be flexible
PEOU5	Achievement of IoT skills will be less complex
PEOU6	I would find the IoT effortless to use.
ATT1	Using IoT in education is a smart idea
ATT2	IoT in education and Smart devices usage is beneficial.
ATT3	Using IoT in education and smart devices is liked.
ATT4	Using IoT in education and smart devices is essential for me.
ATT5	I look forward to the implementation of use of smart devices
ATT6	I have a generally favourable attitude towards using the IoT technologies
BI1	Assuming that I had access to IoT technology, I intend to use it
BI2	I have an intention to take time to learn how to use IoT

Table 1: Questionnaire items for TAM variables

C. POPULATION, SAMPLING DESIGN AND SAMPLE SIZE:

This study is proposed to be conducted among college teachers in Kerala. Population of the study comprises of all undergraduate and post graduate teachers in Kerala. A multi stage random sampling method is proposed to be used for the study. In the first stage the population is divided district wise. In the next stage teachers are selected from private, aided and Government colleges. The researcher limits the sample size to 200 respondents to limit the scope of the study.

VI. LIMITATION OF STUDY:

The researcher has proposed the use of the original version of TAM. Although previous research has found TAM to be a parsimonious and robust model, TAM only employs very few variables to explain consumer acceptance. However, many studies (eg, [20], [12]) have shown that a user's acceptance towards adoption of ICT including IoT will also be affected by other factors such as the trust, perceived behavioural control, subjective norms, opinions of other important persons, organisational factors, technological factors, environmental factors etc. Thus, the original TAM variables may not adequately and accurately explain important factors influencing teachers and acceptance of IoT technology. Also due to the small sample size, it might be difficult to generalise the result of the study

V. CONCLUSION

The purpose of this paper is to develop a conceptual model of the adoption of IoT services in teaching and learning by teachers. The study uses three variables identified by Davis in TAM model viz perceived usefulness, perceived ease of use and attitude to predict the IoT acceptance level of teachers to predict the behavioral Intention to use the technology. A conceptual frame and hypotheses are proposed along with the proposed research framework. The researcher proposed to conduct the study to find out what the attitude of faculty members towards implementation of IoT to the teaching and learning processes will be. Many studies have proved that perceived usefulness and perceived ease of use is positively related to the behavioral intention to adopt any new technology. Since faculty members are pivotal in the education system of our country, the results of the study will help in the smooth adoption of innovative technologies into the field of education.

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