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The Feasibility of using Internet of Things in Higher Education Institutions

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Abstract
The Internet of Things (IoT) is a modern phenomenon that is used in a variety of industries, including intelligent transportation, smart cities, healthcare, games, and education. The use of IoT applications to enhance the quality of higher education has become a crucial subject in the discipline of teaching research. The objective of this research is to find out whether educational institutions could incorporate higher education and the Internet of Things by utilizing the technological acceptance model. For the purpose of achieving this, the University of Mosul was chosen to identify the position of faculty members in this field. The study proposes a model consisting of factors adopted from the TAM Theories. A quantitative approach has been used in this study; the questionnaire has collected data from the research sample, and a random sample of 99 participants was selected. Data analysis was carried out using SPSS 26 and Smart Partial Least Squares (SmartPLS4) packages. According to the findings of this research, the perception of benefit is influenced by ease of use. In contrast, self-efficacy and facilitation conditions are unchanged and do not affect behavioral intention to adopt the Internet of Things. The study suggested the need to hold workshops and training courses for academic staff in the field of Internet of Things applications.

Keywords: Adoption, TAM model, Internet of things IoT, Higher education institutions.

1. Introduction

One of the technologies is the Internet of Things, which has been widely used in recent times and has contributed to a change in contemporary life; it can be used in many areas, such as education, health, etc. [1]. The Internet of Things is defined as a set of Things (devices) that have the ability to connect to the Internet in order to create communication and data transmission between them or between them and between humans to execute a set of commands according to predefined rules [2]. The Internet of things contributes to addressing many of the problems facing educational institutions, both in the field of university administration and in the educational process itself. Also, it contributes to reducing costs and improving performance. The adoption of IoT technology in educational institutions has financial, psychological, and behavioral considerations. Many studies have discussed the adoption of the Internet of things in the higher education sector in developed countries. Still, as far as the researcher is aware, there is no study of the Iraqi environment, and the University of Mosul in particular tested the adoption of the Internet of things by proposing a hypothetical model of TAM theory factors.

This study contributes to increasing the awareness of teachers at the University of Mosul about the Internet of Things and its applications in the field of education, as well as the most critical factors that affect its adoption and use, which will enable the university administration to enhance the positive aspects and attempt to overcome the negative factors.

The study included five main axes: the first of which discusses the most important studies related to the current study, The second axis presents the theoretical background and the concept of TAM theory, as well as presenting the dimensions of the hypothetical model of the current study. The third axis reviews the conceptual model and research hypotheses; the fourth axis presents the research methodology and data collection demographic characteristics of the study sample, as well as the data analysis and results of descriptive statistics for the dimensions of the study. The fifth axis deals with the most important conclusions and future studies.

2. Literature Review

2.1 IoT

The idea of integrating gadgets with integrated sensors, which enable them to connect at the same time via an Internet interface, is what the Internet of Things is built on [4]. IoT connections require an extensive network to facilitate communication between objects, machines, and inside-out sensors, whereas standard Internet services enable communication and information sharing, thereby connecting individuals [5]. IoT is conceptually described as the process of combining network resources, brainpower, and smart things that communicate with consumers on their own [6]. In terms of technical construction, it consists of three parts: hardware, infrastructure, application, and services [7]. The Internet of Things (IoT), as a result, is a vast web made of actual items like machines and sensors that provide standard communication between them and in distant databases [8]. Additionally, IoT gives customers access to remote management and control of their electrical equipment, including security and lighting systems, heating systems, and other similar systems, via their computers and mobile devices [9]. IoT may therefore do more than offer Internet services; it can also interact remotely with machines and other objects. There are multiple indications that the Internet of Things will change a number of businesses, including higher education, especially universities [10]. Now, universities have an opportunity to lead the technical development and innovation models for the IoT and to build the leaders of the IoT into the future.

2.2 IoT in Education Institutions

IoT in education has been intertwined since 1999 when the Massachusetts Institute of Technology's Auto-ID Centre initially put forth the idea [7]. The educational sector has seen a significant upheaval thanks to IoT [11]. Administrators and academics in educational institutions are pushed to modify their ways of thinking about instructing and educating the new student generations in the era of rapid technological advancement. Additionally, there is more pressure on educational institutions to modernize their teaching strategies and adapt to market technological changes[12]. In summary, educational institutions should refocus their strategy to improve education, learning, and research operations through IoT. Additionally, IoT can encourage learners to engage in active listening and discussion with instructors, giving instructors the best opportunity to understand and connect with learners [13]. IoT, for instance, can offer an interactive teaching English program that caters to student peculiarities and develops their creative faculties. The Internet of Things has recently become one of the most familiar and popular expressions in various sectors, especially the education sector, through which we can use Internet of Things solutions to automate and monitor everything. The Internet of Things has a major role in improving the quality of the educational process in general, and through it, the educational environment becomes more intelligent and more connected.

In this field, the study in [33] aims to review the factors influencing the acceptance of the Internet of Things in the field of education among bachelor's students in Jordanian universities. The purpose of this study is to propose a hypothetical research model based on the UTAUT theory to test students' acceptance of Internet of Things technologies. In the study[33], a questionnaire was administered to 300 university students from various Jordanian universities, and PLS was used to analyze the data collected. The study concluded that the proposed model for adopting Internet of Things technology in education among Jordanian university students is accepted.

Another study of IoT adoption in higher education in Romania [34] also identifies and describes the most important benefits and challenges related to the adoption of IoT in higher education. In order to analyze the impact of IoT adoption in the education environment, the authors propose an assessment model based on six hypotheses, including their definitions and descriptions. They are validated against the Romanian higher education system, as well as a set of survey data. Structural equation modeling (SEM) is used in the study to validate the suggested model as well as to determine how the adoption of the IoT relates to intra- and extra-university connectivity, attracting additional resources, teaching and learning activities, data security and integrity as well as education policies.

In general, the Internet of Things provides many tools through which buildings and classrooms can be monitored; student attendance can be taken automatically, and this data can be analyzed and sent to the departments and colleges in universities. The Internet of Things also enables professors to access many educational materials and create interactive content with students directly using smartphones. The Internet of Things helps education work more efficiently, enhances the security of educational institutions, and monitors emergency incidents such as fires.

3. Conceptual Model and Research Hypothesis

3.1 Technology Acceptance Model (TAM)

Technology acceptance theory (TAM) is one of the most reliable and widely used theories in testing individuals' intention to adopt a new technological innovation [36]. This theory was developed by Davis in 1989. This theory aims to explain the behavior of beneficiaries towards new technical innovations, test their behavior, and predict their intention to adopt these innovations.

This model is based on two important variables: Perceived Usefulness and Ease of Use. This theory posits that individuals' acceptance of information systems is achieved through two main variables: perceived usefulness and perceived ease of use [37]. TAM theory links the two variables (perceived usefulness and ease of use) to the intention to adopt and use new technical innovations, as it assumes that an innovation that is easy to use and individuals feel that using this technology can contribute to improving their performance. Therefore, they will adopt this technology [38].

One well-known model that aids in simulating how people adopt and use new technology is the Theoretical Background Technology Acceptance Model (TAM) [14]. From the consumer perspective, The model relies on the factors that have an impact on behavioral intent to apply new technologies [15]. Researchers typically employ this model to explain these actions and to identify the elements influencing the acceptance of technology; TAM is one of the most significant theories that describe how people behave toward new technology. The TAM model's two fundamental components and most crucial characteristics are perceived utility and ease of use. The researchers in [16] identified perceived usefulness as the user's perception that making use of a given program or system's capabilities will develop. The maturity of a person's expectations that utilizing a system or program would be simple and easy is referred to as ease of use[17,18].

3.2 Conceptual Model and Hypotheses Development

Depending on the aforementioned, the conceptual model was proposed by the researcher, as shown in **Figure 1**. The elements of the hypothetical research model that influence the intention to use the Internet of Things will be covered in the sections that follow. The model includes five dimensions (perceived usefulness (PU) and facilitating conditions (FC), self-efficacy (SE), and ease of use (EU). Behavioral intention (BI) refers to an individual's expected or planned future behavior to use and adopt a particular technology. It represents the expectation that an individual may adopt a certain behavior in a specific situation [34]. Individuals' intentions toward their use of the Internet of Things are affected by many factors, including those related to the nature of the system and the users' ability to use it easily and conveniently. It is also affected by the level of benefits that the user achieves from using these technologies [35].

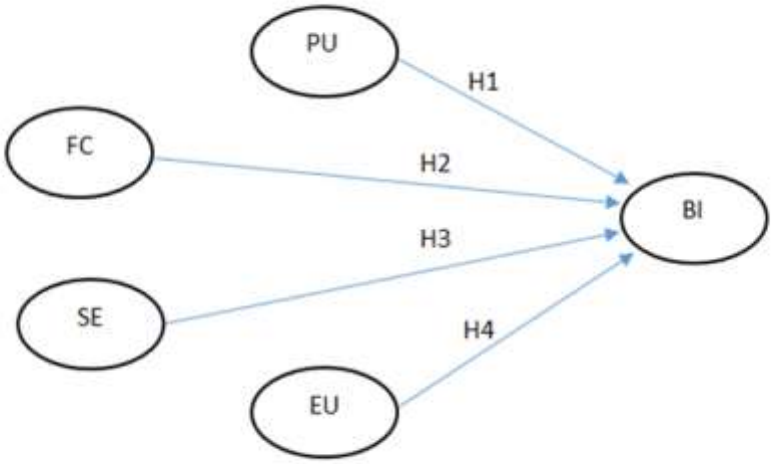

Figure 1. Conceptual model

The study's hypothetical model represents the factors that affect the intention to adopt IoT technology based on the Technical Acceptance Model (TAM). The factors are (Perceived usefulness, Facilitating conditions, Self,-efficacy, and Ease of use). These factors were adopted according to previous studies that adopted the same factors, as shown in **Table 3**. The factors and hypotheses for each of them were explained. The variables mentioned above will be linked to relationships that clarify their impact on the behavioral intention to adopt the Internet of Things, as follows, respectively:

3.2.1 Perceived usefulness and behavioral intention of IoT

The definition of perceived usefulness as the extent to which a person thinks that using technology will help to improve his or her ability to succeed at work [19]. Research reveals that perceived utility influences individuals' behavioral intention to use modern technology [20]. In light of this, the following hypothesis can be put forward:

H1: PU has a positive influence of users BI of IoT.

3.2.2 Facilitating conditions and behavioral intention of IoT

Facilitation conditions are one of the variables that indicate an individual's belief in the existence of both organizational and technical infrastructure that enables the utilization of technology [21]. Some studies have proven that the facilitation of the conditions has tremendous effects on an individual's behavioral intentions [22,23]. Depending on the preceding, we suggest the following hypothesis:

H2: FC has a positive influence on the BI of IoT.

3.2.3 Self -efficacy and behavioral intention of IoT

Self-efficacy generally means the ability of an individual to perform a particular job [18]. The adoption of information technology by users is significantly influenced by self-efficacy [19]. Despite how crucial self-efficacy is in understanding the behavior of individuals, few studies have paid attention to this [24]. Therefore, the hypothesis that follows can be put forward:

H3: SE has a positive influence on the BI of IoT.

3.2.4 Ease of use and behavioral intention of IoT

The degree to which a user anticipates that new technology will enable them to complete their tasks quickly is defined as perceived usability [25]. Numerous research indicate that perceived ease of use influences the behavioral intent of several individuals to adopt information technology [26,27]. The following hypothesis is put out in light of the aforementioned:

H4: EU has a positive influence on users BI of IoT.

4.Research methodology

This section presents the answers of the individuals surveyed regarding the study variables, as well as testing the study hypotheses.

4.1 Research Design

The most recent study relied on the quantitative approach as the main approach. The survey method and the scale were developed based on a set of scales used in a group of previous research and shown in **Table 1** to be suitable for the language of the research participants; the scale was translated into Arabic, Using a pentagonal Likert scale.

Table 1. Research construct

Construct	Items
Behavioral intention (BI)	3
Perceived usefulness (PU)	3
Perceived ease of use (EU)	3
Facilitating conditions (FC)	3
Self-efficacy (SE)	3

4.2 Data Collection

The research data were gathered using an electronic questionnaire distributed to a random sample of the academic staff at the College of Administration at Mosul University through official social media, and the number of participants was 99.

5. Data analysis and results

The data analysis process was divided into three parts, the first one was a description of the demographic characteristics of the participants, the second part represented the test of the measurement model, and finally the third part was devoted to testing the hypotheses [28]. The analysis was performed using Smart-PLS 4 software. SmartPLS is one of the prominent software applications for Partial Least Squares. The software has gained popularity since its launch in 2005, not only because it is freely available to academics and researchers but also because it has a friendly user interface and advanced reporting features [32].

5.1 Sample demographic

Table 2 shows that there is a convergence between the ratios of males and females in the research sample. In terms of age groups, it is clear that the largest group is 31-40, with a percentage of 57.6%, which indicates that young people are the majority in the research sample. In terms of experience, they scored the category 11-20 with the largest percentage of 36.4%.

Table 2. The demographic of the sample

Category	Item	Frequency	Percentage
Gender	Male	48	48.5
	Female	51	51.5
Age	20-30	15	15.2
	31-40	57	57.6
	41-50	19	19.2
	Greater than 50	8	8.1
Experience	1-5	26	26.3
	6-10	24	24.2
	11-20	36	36.4
	21-30	9	9.1
	31-40	4	4

5.2 Description of the study variables

The analytical survey method was used to collect the opinions of the study sample represented by academic staff at the University of Mosul. The questionnaire form represents the main tool in collecting data from the study sample (99 lecturers), and clarity and simplicity were taken into account in the wording of its paragraphs, which contributes to enhancing the ability of the study sample to diagnose and measure the factors affecting their intention to adopt the Internet of Things and responding to the questionnaire items through a five-way Likert scale. The questionnaire form included three axes. The first related to the personal information of the study sample and included (gender, age, and experience). The second axis dealt with questions related to the factors affecting the intention to adopt the Internet of Things and included 15 questions related to the five hypotheses of the study. **Table 3** shows the questions related to the hypotheses and sources adopted in preparing the questionnaire and its structural construction.

Table 3. Structural construction of the questionnaire and approved sources

Variables	Questions	Source
Demographic	1-3	
Behavioral intention (BI)	BI1, BI2, BI3	**[34]**
Perceived usefulness (PU)	PU1, PU2, PU3	**[19]**
Ease of use (EU)	EU1, EU2, EU3	**[26, 27]**
Facilitating conditions (FC)	FC1, FC2, FC3	**[22,23]**
Self-efficacy (SE)	SE1, SE2, SE3	**[24]**

The research variables of the questionnaire included questions related to the five research hypotheses shown in **Table 4**. The total number of questions in the questionnaire was twenty. The first three questions were related to personal data, while the rest of the questions were divided into the five research variables. 5 Likert scale was used to measure the variables.

Table 4. Descriptive Statistics

Var.	S. Agree		Agree		Neutral		Disagree		S. Disagree		Mean	Stdv.
	Count	%	Count	%	Count	%	Count	%	Count	%		
					Behavioral intention (BI)							
BI1	43	43.4	31	31.3	22	22.2	1	1.0	2	2.0	4.13	0.933
BI2	29	29.3	58	58.6	11	11.1	0	0	1	1.0	4.15	0.691
BI3	29	29.3	56	56.6	11	11.1	2	2.0	1	1.0	4.11	0.754
					Perceived usefulness (PU)							
PU1	27	27.3	59	59.6	10	10.1	3	3.0	0	0	4.11	0.698
PU2	16	16.2	62	62.6	20	20.2	1	1.0	0	0	3.94	0.636
PU3	20	20.2	56	56.6	16	16.2	5	5.1	2	2.0	3.88	0.860
					Ease of use (EU)							
EU1	30	30.1	47	47.5	14	14.1	8	8.1	0	0	4.00	0.881
EU2	43	43.4	49	49.5	6	6.1	1	1.0	0	0	4.35	0.644
EU3	33	33.3	47	47.5	14	14.1	5	5.1	0	0	4.09	0.822
					Facilitating conditions (FC)							
FC1	23	23.2	54	54.5	19	19.2	3	3.0	0	0	3.98	0.742
FC2	19	19.2	50	50.5	21	21.2	8	8.1	1	1.0	3.79	0.884
FC3	24	24.2	50	50.5	22	22.2	3	3.3	0	0	3.96	0.768
					Self-efficacy (SE)							
SE1	8	8.1	49	49.5	25	25.3	14	14.1	3	3.0	3.45	0.940
SE2	14	14.1	53	53.5	22	22.2	9	9.1	1	1.0	3.71	0.860
SE3	16	16.2	54	54.5	20	20.2	8	8.1	1	1.0	3.77	0.855

Table 4 shows the frequency distributions, percentages, arithmetic means, and standard deviations for the Internet of Things adoption indicators, as follows:

1. Behavioral intention (BI): Table 4 indicates that the behavioral intention to adopt the Internet of Things, which is represented by the variables (BI1 - BI3), gave a percentage of agreement of the amount 87.9%, and this is reinforced by the value of the arithmetic mean (4.15), which is significant, and with a standard deviation (0.691) of the highest percentage of the variables that contributed to achieving the positivity of this dimension is the variable BI2, which It indicates that I intend to use the Internet of Things in my work. The individuals surveyed in BI1 and BI3 indicated that the Internet of Things would achieve all expectations with successive standard deviation percentages (BI1 = 0.933, BI3= 0.754).

2. Perceived usefulness (PU): Table 4 indicates that the perceived usefulness variable, represented by the variables (PU1, PU2, PU3), produced an agreement percentage of 78.8%, and this reinforces the value of the arithmetic mean of (4.11), and a standard deviation of (0.698).

The highest percentage of sub-variables that contributed to achieving the positivity of this dimension is represented by the variable PU 2, which indicates that using the Internet of Things will increase productivity.

3. Ease of use (EU): Table 4 indicates that there is no perceived ease of use represented by the variables (EU1, EU2, EU3), and this resulted in a percentage of agreement amounting to (93%) in EU2 that showed there is a difficulties in applying IoT in education, and this is reinforced by the value of the arithmetic mean, which is (4.35) and with a standard deviation (0.644).

4. Facilitating conditions (FC): in **Table 4,** the result show that the facilitating conditions represented by the variables (FC1, FC2, FC3), the result showed the agreement amount to FC1 (77.7%), which indicates the necessary resources (technology) are not available to apply the Internet of Things in education. There is a difficulties in applying the IoT, with the value of the arithmetic mean of (3.98), and a standard deviation of (0.742).

5. Self-efficacy (SE): The self-efficacy results in Table 4 represented by the variables (SE1, SE2, and SE3), and the results showed the agreements amount to (70.7%) in SE3 that indicates the necessary knowledge to use the Internet of Things application in education.

5.3 Measurement model

To figure out the model's quality, the measurement model is used to conform with the data obtained from the field [29]. In order to achieve this, the PLS Algorithm method was used in SmartPLS 4 software, and it relied on convergent and discriminate validity, as well as reliability.

Table 5 reveals the loadings of the indicators on their latent variables ranging between 0.717 and 0.873. All of them passed the threshold of 0.70 recommended by [30] Since it is evident that the average variance extracted (AVE) ranged between 0.603 and 0.705. It exceeded the cut-off score of 0.50 recommended by [29], and It turns out that the range of the combined reliability within 0.820 and 0.878 and exceeded the threshold of 0.70. Based on these results, the study model has an appropriate quality for the current research.

Table 5. Convergent validity and reliability

Variable	Items	Loading	Composite Reliability	AVE
	BI1	0.752		0.655
BI	BI2	0.863	0.850	
	BI3	0.808		
	EU1	0.858		0.705
EU	EU2	0.824	0.878	
	EU3	0.836		
	FC1	0.717		0.635
FC	FC2	0.793	0.838	
	FC3	0.873		
	PU1	0.807		0.603
PU	PU2	0.771	0.820	
	PU3	0.750		
	SE1	0.818		0.667
SE	SE2	0.821	0.857	
	SE3	0.811		

For testing of discriminate validity, the results of **Table 6** showed that the diameter values, which represent the AVE's square root, are higher than the degree to which that variable correlates with other variables.

Table 6. Discriminant validity

	BI	EU	FC	PU	SE
BI	**0.809**				
EU	0.567	**0.840**			
FC	0.547	0.658	**0.797**		
PU	0.576	0.653	0.672	**0.776**	
SE	0.430	0.510	0.674	0.602	**0.816**

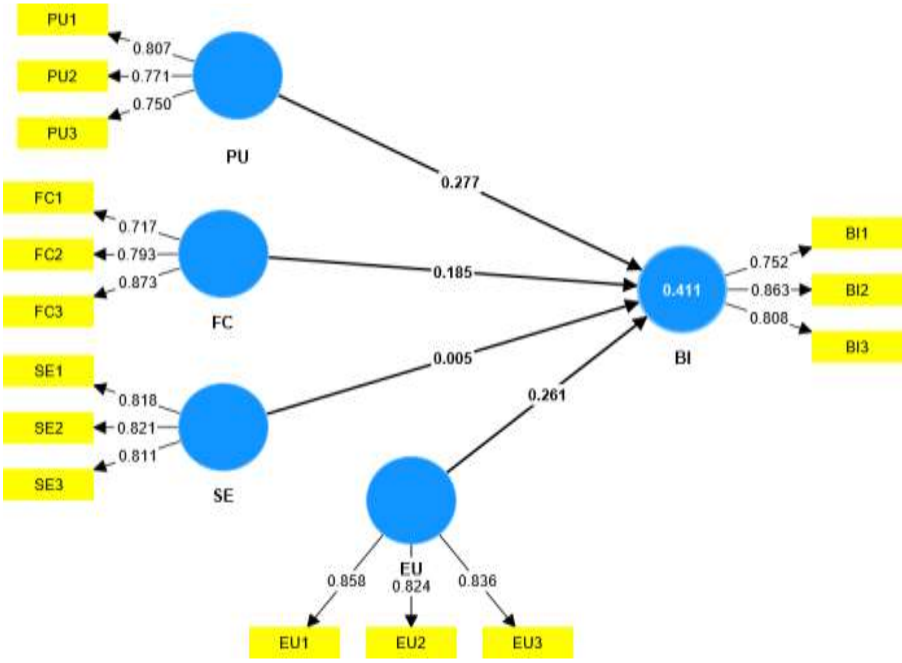

Figure 2. PLS Algorithm

5.4 Structural model

Figure 3 and **Table 7** show that perceived benefit significantly affects behavioral intention (B = 0.286, t = 1.971, P = 0.049), so hypothesis H1 is acceptable. The results also revealed that facilitating conditions do not affect behavioral intention (B = 0.187, t = 1.245, P = 0.213), so H2 is rejected. Self-efficacy has minimal impact on people's intentions to use the Internet of Things in education (B = -0.004, t = 0.030, P = 0.967), and based on that hypothesis, H3 is rejected. Finally, It was discovered that research participants' behavioral intentions are unaffected by perceived ease of use (B = 0.260, t = 1.899, P = 0.058), which means that H4 is rejected.

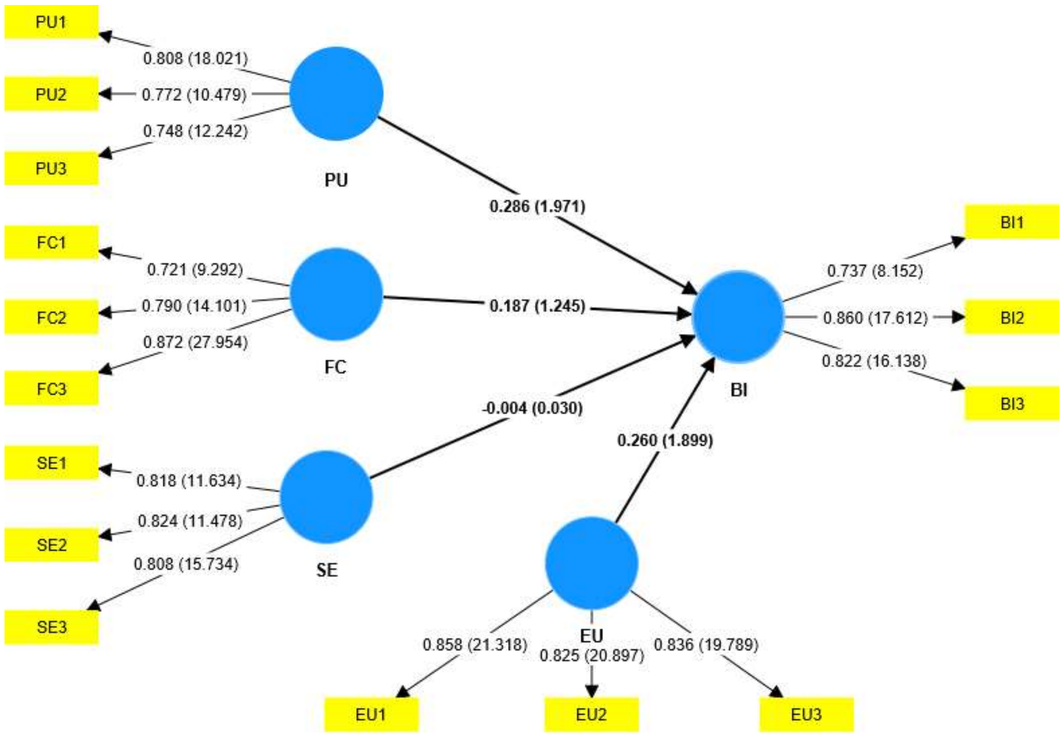

Figure 3. Structural model

Table 7. Hypothesis testing

Path	Beta	STEDV	t	P	Result
Hypo1: PU ➔ BI	0.286	0.145	1.971	0.049	Accepted
Hypo2: FC ➔ BI	0.187	0.150	1.245	0.213	Rejected
Hypo3: SE ➔ BI	-0.004	0.123	0.030	0.967	Rejected
Hypo4: EU ➔ BI	0.260	0.137	1.899	0.058	Rejected

6. Discussion and Limitation

6.1 Discussion

The conclusions collected through the implementation of the study show that the study sample has an awareness of the benefits that the Internet of Things can bring to them by quickly completing tasks with less effort and improving their productivity. This awareness will make it easier for the organization under study to adopt the Internet of Things later.

The current study's objective was to figure out the acceptance of a sample of faculty members to accept the use of the Internet of Things in the educational procedure. The results of hypothesis testing revealed that the perceived benefit significantly influences the behavioral intention of the participants. In the study, this means that people's expectations of benefits from using the Internet of Things will be encouraged to apply these technologies in education.

The outcomes of hypothesis testing showed that the facilities of the conditions do not affect the behavioral intention of the respondents, which means that the low equipment and technical infrastructure do not stand in the way of the participants in implementing IoT in education, which indicates the desire and the subjective ability of individuals to provide and use it.

The analysis's findings indicate that self-efficacy has a negligible effect on behavioral intention, which means that the low capabilities of the teaching staff to deal with Internet of Things technologies will not stand in the way of the respondents' desire to use this technology when the opportunity arises. Finally, it was found from the results of the analysis that the participants' behavioral intentions are unaffected by the ease of use, which means that they have the desire and willingness to adopt the Internet, even if it is difficult.

6.2 Limitation

The study was limited to the University of Mosul, and it is possible that the study will be generalized in the future to include universities in Iraq in general and expand the sample size to include the students with the staff academy. The majority of respondents, according to the research's findings, are familiar with the idea of the Internet of Things, indicating that this idea is widely understood in current society. Because IoT technologies support and enhance the services of the educational process, there are behavioral intentions to integrate them into education in the future. In terms of equipment and tools, the majority of respondents emphasized the significance of having the facilities and conditions needed for the usage of IoT technologies.

7. Conclusion and Future work

This research was completed at the university in Mosul. The intention was to demonstrate how IoT applications were being used in higher education in Iraq. The adoption of IoT literature was reviewed in the study. The TAM model was used as a theoretical adoption model. It was determined that independent TAM elements, including BI, PU, EU, FC, and SE, have an influence on the BI of IoT applications. Academic staff made up the responses. Using SmartPLS 4, analyze the data. The outcomes proved that BI influences how IoT applications are actually used.

For future studies on the topic of adopting Internet of Things technology in education and educational institutions, we recommend conducting more studies on adopting the Internet of Things and presenting more of its actual applications. The study's respondents included academic staff only, so future research should concentrate on academic staff and students in each group independently. The study suggests conducting further future studies that clarify the application of the Internet of Things in the form of actual programs that demonstrate its usefulness.

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Conflicts of Interest

The authors declare no conflict of interest.

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