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User Acceptance of Internet of Things in Higher Education Institutions of Pakistan: A Case Study

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Abstract
In the present digital era, the Internet of Things is gaining increasing popularity in different speheres of everyday life and professional aspects. Internet of Things is an emerging concept that enables the information sharing among people and physical devices by utilizing the digital devices and functions of web connectivity. Similarly, after the outbreak of COVID-19, higher education institutions have transferred their teaching environment from physical to online space. This calls for transferring traditional classroom approaches to the smart classroom styles. While this has been possible with advanced available technologies, it comes with greater challenges including the smart classroom design and management, lack of IoT infrastructure, limited digital resources, old and inappropriate teaching methods, etc. Accordingly, IoT seems to be a favorable choice for HEIs to facilitate smooth learning of students. The purpose of this paper is to assess the acceptance of IoT by HEIs in Pakistan. Initially, a conceptual framework is proposed. Subsequently, survey-based research is conducted with students and teachers to verify the proposed model and statistically analyze the readiness of stakeholder towards IoT adoption. The results of the study show that Technology awareness, IoT efficacy, Performance Expectancy, Price value trade-off, and Social Influence are important affecting factors in this regard.

Keywords: Internet of Things; Higher education institutes; Smart Education; Digitalization; Smart Classroom.

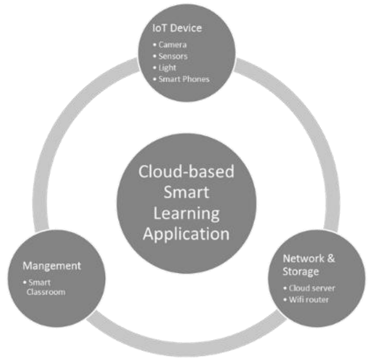
Introduction

Internet of things (IoT) is one of the most cutting-edge technologies of current era which uses functionalities of smart devices. IoT enables the communication and transfer of data and information among devices as well as people in a similar fashion. The basic concept underlying the paradigm of IoT is that the everyday objects can be configured and categorized for sensing, processing capability, and interconnectivity that helps them to be recognized over the internet and accomplish specific task.

Adoption of IoT in Pakistan Higher Education Institutes changed the perspective of learning for students and teachers. Universities is large platform for researchers; unfortunately, they are facing problems due to the lack of IoT infrastructure, lack of collaboration among students and teachers, they need highly interactive learning environment with different facilities like applications (e.g. IoT based cloud integrated smart classroom (Revathi et al. 2020) as shown in Figure 1), Fully equipped Lab with IoT devices, High Speed WLAN, availability of related research material according to the requirement. If HEIs will design and development such an environment, then it will improve the learning skills among them. The concept of digital campus enhance the real value and experience for students, teachers adding better IT services to the HEIs of Pakistan (Aldowah et al. 2017).

Recently, IoT has got enormous attention more than 50 billion smart devices had connected to form the digital pervasive environment (Tripathi et al. 2020). It is currently being adopted in almost every field including the healthcare, home management, industrial applications, as well as education and research sectors. Given the ubiquitous availability of internet and computer systems, education sector has been adopting the concepts of online education, distance learning and smart education since decades to different levels. Recently, especially after the outbreak of Covid-19 pandemic worldwide, transformation of educational institutions from physical environment to the smart learning environment has been a necessity for smooth conduct of academic activities. Online education, and the recent notion of smart education, is the source for students to learn and acquire immersive skills through novel teaching methods, virtual lectures, smart board techniques, interactive contents, on demand training sessions, and so on (Gul et al. 2017).

Figure 1.
IoT cloud based infrastructure



Whilst, adopting smart learning paradigm has been a great opportunity for higher education institutions (HEIs) of Pakistan and is believed to empower future of education, it nevertheless comes with greater challenges such as lack of IoT infrastructure, limited availability of technical resources, inappropriateness of existing teaching methods, lack of human skills, lack of teachers' and students' readiness, and the like (Gul et al. 2017; Elsaadany and Soliman 2017; Noreen & Hafeez 2016; Tenhunen et al. 2017; Journal & Special 2017; Aldowah et al. 2017). In such realm, IoT enables the concept of virtual classes with smart equipment and learning methods. It enhances educational infrastructure and facilitates the education at the doorstep (anytime and anywhere) using applications such as automated attendance system and smart and content-based learning. Thus, it overcomes the challenges like resource scarcity, security, privacy, and interoperability of different stakeholders and their digital devices. Furthermore, IoT empowers Higher Education Institutions (HEIs) to make more knowledgeable decisions regarding students' learning involvements, security, learning efficiency, creativity, and many other facets of the education. Consequently, it brings an array of advantages and reduces the risks.

In this regard, the purpose of this paper is to propose a conceptual framework for investigating the IoT adoption in education sector in developing countries. In doing so, the study attempts to identify key factors that influence the students, and teachers of HEIs towards IoT adoption. In order to achieve this, the study question is framed as "what are the key factors that influence IoT adoption in HEIs"? The proposed framework can assist in investigating and implementing better technology-oriented education and training programs in HEIs and also evaluate and improve existing programs in terms of their IoT related components.

The remainder of this paper is structured as follows. Section 2 presents the conceptual framework and hypothesis development for this study. The research methodology is explained in section 3 and study results are presented in section 4. The paper concludes with an outlook to future research aspects in section 5.

Literature Review

In the current digital age, Internet of things (IoT) is gaining increasing attention as a cutting-edge technology that fucntions with smart devices. The term was first coined by Kevin Ashton, who appraised the concept of connecting the physical devices to networks by using the pervasive sensors. It is now understood as the combination of the internet technology, things (physical devices), and their connectivity that transforms real world into intelligent virtual world with self- bolstering techniques (Muntjir et al. 2017).

According to Gul et al. (2017), role of IoT in education sector is based on four pillars: people, data, process, and internet. Challenges driven IoT based educational framework focuses on learning approaches framed around problem solving, critical thinking and individual project based learning (Tenhunen et al. 2017). As an example, Journal and Special (2017), implemented virtual research office with virtual questions and exercises to support dispersed learners and engaging them in innovative projects by adopting new technology and tools that collect data from on demand resources for learners and tutors. Noreen and Hafeez (2016) have stated that IoT adoption in education requires change in learners' behavior (accomplice's evaluation, unity, and self-reformation) and positive attitude towards smart devices. Accordingly, the awareness of IoT and attitude towards IoT among students, teachers, and administrators is crucial for its successful adoption and implementation in education sector (Elsaadany & Soliman 2017). This is more prevailing in the developing countries as use and adoption of IT therein is in incepting stages in various domains. It is widely acknowledged that the awareness of IoT and its adoption is very slow and much fast from satisfactory levels in many developing countries. To remedy this, it is important to inform and motivate the key stakeholders of education systems to accept and adopt IoT technologies. Accordingly, it becomes crucial to solicit and understand the factors that influence the stakeholders' intentions and acceptance of IoT in HEIs.

Adoption of IoT in Pakistan Higher Education Institutes changed the perspective of learning for students, and teachers. Universities is large platform for researchers; unfortunately, they are facing problems due to the lack of IoT infrastructure, they need highly interactive learning environment with different facilities like applications (IoT based learning application), Fully equipped Lab with IoT devices, High Speed WLAN, and availability of related research material according to the requirement of user. If HEIs of Pakistan will design and development such an environment, then it will improve the learning skills among students and the concept of digital campus will enhance the real value and experience by adding better IT services to the HEIs of Pakistan (Aldowah et al. 2017).

HEIs of Pakistan are still in struggling to implement the IoT infrastructure, HEIs like University of Sindh, Shah Abdul Latif University Khairpur, etc. they are facing the many problems like: lack of resources, lack of digital low cost smart IoT device for smart classroom. Therefore, this research study will focus on the users (students and teachers) acceptance of IoT in HEIs of Pakistan for implementation and adoption of IoT based cloud integrated smart classroom.

Proposed Conceptual Framework and Hypothesis Development

Scientific literature on the topic of technology acceptance and adoption has proposed various theoretical models such as Theory of reasoned action (TRA), Theory of planned behavior (TPB), Technology acceptance model (TAM), and Unified theory of acceptance and use of technology (UTAUT).

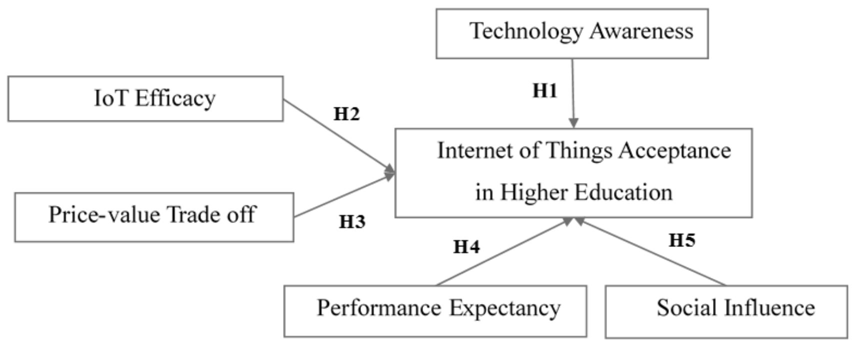
The earlier models TRA (Fishbein & Ajzen, 1977) and its extended version TPB (Ajzen, 1991) has been widely used for the assessment of usage behavior of IT artifacts. These both models suggest that the behavioral intention of users to leverage any particular IT product is modified by their social and personal factors (Madden et al. 1992). The TRA propose that technology adoption is influenced by user's personal attitude and their social norm that is aggregated result of their action within the society. The TPB in contrast propose that in addition to the attitude and subjective norm (given in TRA), the IT adoption is also influenced by the behavioral control and perceived available facilitation (Chuttur, 2009).

The succeeding and one of the most widely used TAM model (Davis, 1989) is based on its earlier models. The main premise of TAM model is to predict the use of IT artifact by its users and illustrate why the users will accept or reject the particular technology. It entails that the users' attitude is determined by two external factors including perceived usefulness (the degree that the user thinks the targeted IT artifact is useful in improving he user performance) and perceived ease of use (the degree that the user thinks the targeted IT artifact is user friendly and easy to use). The earlier version of TAM eliminated the subjective norm factor as essential factor. However, its latter version named as TAM2 again included it as an important factor in determining users' behavioral intentions towards any IT artifact (Venkatesh & Davis, 2000).

The other widely used and highly recognized model for the acceptance of technology artifacts is the UTAUT model which mainly explores the factors towards the user acceptance and use of IT products in organizational contexts (Venkatesh et al. 2012). According to the UTAUT, four factors are of importance for determining the user acceptance of technological artifacts. These factors are effort expectancy (the degree of user friendliness and ease of use), performance expectancy (perceived benefits), social influence (degree of acceptance and perceived usefulness among the social circle), and facilitating conditions (perceived availability of resources and support). UTAUT model is the latest model which has been applied in many studies e.g. Jones and Jo, 2004, Samaradiwakara and Gunawardena, 2014. UTAUT is useful to measure the frequencies whereby data is collected through questionnaires regarding its various constructs.

Considering the above-mentioned existing models of technology adoption, the conceptual model of this study for the adoption of IoT in Higher Education Institutions proposed the Conceptual framework for IoT based cloud integrated smart classroom, it is framed based on five independent constructs. These five factors collectively shape the degree of IoT acceptance in Higher Education (IoTAHE). In other words, IoTAHE is collectively determined by the degree of Technology Awareness (TA), IoT Efficacy (IoTE), Price-Value Tradeoff (PVT), Performance expectancy (PE), and social influence (SI) by the higher education stakeholders including the students, and teachers. Figure 2 shows the proposed for conceptual framework for adoption in HEIs of Pakistan.

Figure 2.
Proposed conceptual framework



Technology Awareness
Technology awareness is defined as the degree of knowledge that the user possess about the usage, features, simplicity, and perceived benefits about the IoT in general. It is believed that higher the awareness, more positive attitude towards IoT adoption will be observed (Abubakar 2013). In this regard, the first hypothesis is constructed as:
H_1: Technology awareness will have positive and significant influence on IoT acceptance in HEIs.

IoT Efficacy
IoT efficacy is second independent variable that influences the acceptance of IoT in Higher education institutes. It is defined as the level of attractiveness and interest that the users feel with using IoT. It is believed that IoT efficacy helps the users to identify, feel confident about, and leverage several benefits of IoT (KASU et al. 2020). Thus, the second hypothesis of the study is framed as:
H_2: IoT efficacy will have positive and significant influence on IoT acceptance in HEIs.

Price-Value Tradeoff
Price value trade-off is third independent variable of proposed conceptual framework of IOT adoption in HEIs. It refers to the belief of the user that IoT provides enough benefits (value) in return of its cost. As IoT is latest technology and apparently seems to be expensive especially for developing countries, a good balance of price and offered value is necessary to motivate users to invest in such technology (Niyato et al. 2016). In this regard, the study hypothesis is framed as:
H_3: Price-value tradeoff will have positive and significant influence on IoT acceptance in HEIs.

Performance Expectancy
Performance Expectancy is the fourth independent construct of proposed framework. Performance expectancy refers to the belief of the users that the use of IoT will enhance their performance. Specifically, it refers to the notion that adoption of the IoT will enhance learning efficiency of the students. It is the construct adopted from UTAUT model. In this regard, the study hypothesis is framed as:
H_4: Performance expectancy will have positive and significant influence on IoT acceptance in HEIs.

Social Influence
Social Influence is the last independent construct of the proposed framework. It is also adopted from UTAUT model. It refers to the degree of how much the user is socially influenced. It entails that the use of one user can be influenced by the use and adoption of other user in social community (Alshehri et al. 2012). It is defined by the degree that the social circle of a user thinks that the IoT adoption is beneficial and improves the performance. In this regard, the study hypothesis is framed as:
H_5: Social Influence will have positive and significant influence on IoT acceptance in HEIs.

Methods

This study employs quantitative approach through survey questionnaire with students, and teachers of HEIs of Pakistan to evaluate and empirically validate the proposed conceptual framework. The demographic information of participants is shown in Table 1. The questionnaire was frames on the basis of literature review on the topic. The data was collected through Google forms. The questionnaire consisted of 8 section. The first two sections focused on collecting demographic information of the participants. The next five sections focused on the assessment of five independent variables of the study respectively. The last section collected overall perceptions of the participants regarding IoT acceptance in HEIs of Pakistan. In total, the questionnaire was consisted of 27 five-point Likert-type items.

The participants were recruited using convenient sampling in public HEIs of Pakistan particularly in Sindh province institutes (University of Sindh, Jamshoro, Sindh University Campus Larkana, and Shah Abdul Latif University, Khairpur). As a result, 374 participants participated in the study. The collected data was analyzed using statistical software applications SPSS and Smart PLS.

Table1.

Demographic information of study participants

Variables	Category	Frequency	Percentage
Gender	Female	117	31.30%
	Male	257	68.70%
	Total	374	
Age	18---- 21	38	10.20%
	22---- 24	50	13.40%
	25----28	5	15.20%
	29---- 31	61	16.30%
	More than 32	168	44.90%
Education	Bachelor	112	30%
	Master/MPhil	159	42.50%
	PhD	103	27.50%
Profession	Students	263	70%
	Teachers	111	30%
HEIs of Pakistan (Sindh)	University of Sindh, Jamshoro, Sindh	136	37%
	Sindh University Campus Larkana, Sindh	127	34%
	Shah Abdul Latif University Khairpur, Sindh	111	29%

Results

The result obtained from this research study is that the HEIs of Pakistan particularly of Sindh province have no proper IoT infrastructure and there is lack of resources so that they could not fully adopt the IoT technology but they are much aware about it. The descriptive statistics, reliability of instruments, confirmatory factor analysis, and proposed conceptual framework fitness were tested using SPSS, smart PLS. The final results are discussed in detail as following.

Descriptive statistics and reliability measures

The descriptive statistics of the study constructs in terms of their mean and standard deviation are shown in Table 2. The items are listed with the construct abbreviation combined with relative item number.

The composite reliability for the questionnaire was tested through Cronbach's alpha test in SPSS software. Table 3 presents the composite reliability of all constructs and overall reliability of IoT acceptance in HEIs. As shown, the Cronbach's alpha value for all constructs is found to be greater than 0.7 while 0.7 is regarded as threshold to be acceptable as suggested by many researchers (Cronbach, 1951; Peter, 1981).

Table 2.
Descriptive statistics of various constructs of proposed conceptual framework

Item	N	Minimum	Maximum	Mean	Std. Deviation
TA1	374	1	5	4.14	.840
TA2	374	1	5	4.47	.749
TA3	374	1	5	4.23	.909
TA4	374	1	5	4.27	.818
IoTE1	374	1	5	4.14	.840
IoTE2	374	1	5	4.47	.749
IoTE3	374	1	5	4.23	.909
IoTE4	374	1	5	4.27	.818
IoTE5	374	1	5	4.24	.794
IoTE6	374	1	2	1.05	.225
IoTE7	374	1	3	1.37	.654
IoTE8	374	1	5	4.15	.891
IoTE9	374	1	5	4.23	.927
PE1	374	1	5	4.32	.810
PE2	374	1	5	4.03	.901
PE3	374	1	5	3.99	1.122
PE4	374	1	5	4.06	.968
SI1	374	1	5	3.52	1.246
SI2	374	1	5	3.91	.944
SI3	374	1	5	4.01	1.005
PVT1	374	1	5	4.32	.810
PVT2	374	1	5	4.03	.901
PVT3	374	1	5	3.99	1.122
IoTAHE1	374	1	5	3.79	1.220
IoTAHE2	374	1	5	3.85	1.324
IoTAHE3	374	1	5	3.76	1.269
IoTAHE4	374	1	5	4.24	.782

Table 3.
Composite reliability measures

Construct	Cronbach's Alpha	Reliability value
IOTAHE	0.831	Good
TA	0.877	Good
IoTE	0.923	Excellent
PE	0.864	Good
PVT	0.859	Good
SI	0.871	Good

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Data appropriateness and factor loading

To measure the adequacy of data used herein, factor analysis was done through Kaiser-Meyer-Olkin measure and Bartlett's Test of Sphericity respectively. Table 4 shows the results of factor analysis.

Table 4.
Data adequacy and appropriateness measures

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.813
Bartlett's Test of Sphericity	Approx. Chi-Square	12167.823
	df	351
	Sig.	0.000

Table 5 shows the factor loading extraction. According to standards of method Kaiser-Meyer-Olkin, Eigen values must be greater than 1. Therefore, strong variance is observed with 44.194690% of initial eigen value, sum of squared loading with 44% and rotation variance with 15%. Weak value could be dropped due the weak loading, hence last component has low variance with .898% which is less than 1, and moreover no extraction and rotation could be extracted. Furthermore, the discriminant validity of all factors is obtained by Fornell-lacker criterion. The results of discriminant validity are shown in Table 6.

Table 5.
Factor loadings (Extraction Method: Principal Component Analysis)

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	11.933	44.195	44.195	11.933	44.195	44.195	4.190	15.517	15.517
2	2.618	9.694	53.889	2.618	9.694	53.889	3.856	14.283	29.800
3	1.758	6.512	60.401	1.758	6.512	60.401	3.817	14.137	43.937
4	1.468	5.437	65.838	1.468	5.437	65.838	3.259	12.069	56.006
5	1.400	5.187	71.024	1.400	5.187	71.024	2.691	9.967	65.973
6	1.034	3.830	74.855	1.034	3.830	74.855	2.398	8.882	74.855
7	.943	3.492	78.347						
8	.790	2.925	81.271						
9	.717	2.657	83.928						
10	.631	2.336	86.264						
11	.590	2.187	88.451						
12	.562	2.081	90.532						
13	.441	1.633	92.166						
14	.357	1.324	93.490						
15	.318	1.177	94.667						
16	.281	1.041	95.708						
17	.262	.969	96.676						
18	.240	.889	97.565						

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
19	.168	.623	98.188						
20	.152	.564	98.752						
21	.100	.369	99.121						
22	.074	.274	99.395						
23	.064	.238	99.633						
24	.063	.235	99.868						
25	.026	.095	99.962						
26	.009	.032	99.995						
27	.001	.005	100.000						

Table 6.
Discriminant validity

	IOTAHE	IOTE	PE	PVT	SI	TA
IOTAHE	0.820					
IoTE	0.353	0.636				
PE	0.522	0.708	0.801			
PVT	0.454	0.749	0.955	0.818		
SI	0.560	0.511	0.752	0.671	0.774	
TA	0.254	0.854	0.548	0.620	0.433	0.722

Model fitness and hypothesis testing
In order to measure the model fitness of proposed conceptual framework, standardized root mean square residuals method was used through SMART PLS application. According to Hooper et al. (2008), standard value for SRMR for a model fitness should be less than 0.08. Here, applying the bootstrap loading and partial least square (PLS) method. Model fitness index was found to be 0.04 which is within acceptable limits (cf. Table 7) and confirms the fitness of model for the assessment of IoT adoption/acceptance in HEIs of Pakistan.

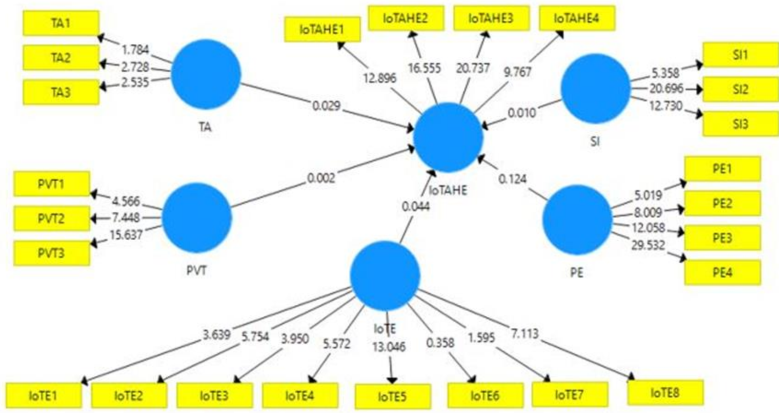
Table 7.
Model fitness

	Saturated model fornell-lacker criterion	Estimated Model
SRMR	0 to 1 (0.08) Highest acceptable	0.044
result		**0.044**

Discussion
The finding of this research is that technology awareness, belief towards the use of technology, social influence, low cost of smart device can increase the performance of students and teachers of HEIs of Pakistan. As shown in Figure 3, individual hypothesis H1, H2, H3, H4, and H5 constructed in section 2 are validated on the sample data. The results show that TA, IoTE, PVT, and SI have positive significant influence on the adoption and acceptance of IoT in HEIs. The p

values of these constructs are found to be 0.029, 0.044, 0.002, and 0.010 respectively which are acceptable according to the standard significance level of less than or equal to 0.05 as suggested in Ioannidis (2018). These hypotheses H1, H2, H3, and H5 are hereby accepted and the hypothesis H4 is rejected as its p value is 0.124 which is greater than the standard significance level. This shows that PE has not much significant influence in the acceptance of IoT in HEIs.
As the results have been obtained from proposed IoT framework, the findings suggest that the Higher Education Institutes should develop some cost-free infrastructure for students and teachers because 1) this should be beneficial for the policy maker to move institutes towards adoption IoT in the form of smart classroom, campus, and institute in place of old traditional methods, 2) this would beneficial for the faculty members or teachers to convey importance of IoT to the students, 3) IoT as smart learning paradigm will be useful for the students, 4) teachers would be enabled to encourage the students to adopt smart learning paradigm more effectively, and 5) administrators would be able to frame a policy to implement IoT in HEIs of Pakistan.

Figure 3.
Hypothesis testing results using smart PLS



Conclusion

This study has proposed the conceptual framework that enlightens the important factors that might influence the adoption and acceptance of IoT in higher education institutions. The model is based on prominent UTAUT model and thus encompasses five constructs of technology awareness, IoT efficacy, price value tradeoff, performance expectancy and social influence. Accordingly, the present work proposed five hypotheses which were later empirically tested and verified with sample data of 374 participants (students, teachers, and administrators of HEIs). The data was collected through questionnaire with 27 items of five point Likert type scale and was analyzed through statistical software applications SPSS and Smart PLS. As a result, the four factors of technology awareness, IoT efficacy, price value tradeoff, and social influence were found to be significant in determining the adoption and acceptance of IoT in HEIs. The proposed model should assist the teachers, HEI administrators, and other stakeholders involved in education systems in understanding the IoT in HEIs and thereby planning and implementing the future improvement plans accordingly. The model should also help to understand relative weaknesses and strengths of particular institutions and regions and address them accordingly. The model is tested with the data from Pakistan and should be applicable to all other developing countries. However, the testing with more empirical data from other regions is also necessary to determine the generalizability and conclusiveness of the proposed model and establish its reliability and validity at a larger extent.

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