Usage of Internet of Things in Iraqi Higher Education: An Extension of Information System Success Model

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ABSTRACT

The usage of Internet of things (IoT) in higher education is still emerging especially in developing countries. The purpose of this study is to examine the information and the system and service quality on the Usage of IoT (UIoT) among students and academic staff and non-academic staff. The study, based on Information System Success model (ISS), proposes that Information Quality (IQ), System Quality (SYSQ), and Service Quality (SQ) have a positive impact on UIoT. The research further proposes that IoT awareness acts as a moderator. The data were collected with a use of a questionnaire. Stratified random sampling was used and the data collected from a sample of 423 participants completed a process of validation and pilot testing. The data analysis was conducted using Smart PLS 4. The findings of the study indicate that SQ, IQ, and SYSQ do have positive effects on UIoT. IoT awareness moderated the effect of IQ only on UIoT. To increase the UIoT, it is advised to focus on enhancing the awareness about the IoT and provide reliable information.

Keywords-information system success; service quality; IoT; higher education; information quality; system quality

I. INTRODUCTION

The Internet of Things (IoT) affects education, business, and public sectors [1, 2]. At 6% of the global economy, IoT is gaining popularity among consumers, businesses, and governments. IoT devices have become more common, according to recent data. IoT devices increased from 15.4 billion in 2015 to 26.7 billion in 2019 and the projections predict 75 billion IoT devices by 2025 [3], while numerous industries have implemented IoT [4]. IoT is a network of Internet-connected sensors and embedded technologies that gather and share data [5]. Multiple layers and components of the IoT depend on sensors and networking technologies to collect and analyze data [6]. A $330.6 billion market in 2021 and $875 billion by 2025 illustrate the IoT's widespread use [7]. However, IoT integration in Higher Education (HE) is still under progress but offers many potential benefits [8]. IoT in education is still new, and few research publications have examined its usage in HE [9]. HE must accept and incorporate new technology to integrate human-machine interactions, services, and information. Universities have improved teaching, learning, and operations by using IoT technologies. This integration needs academic, non-academic, and student skill development [10]. IoT can solve problems with course delivery, educational quality, teacher leadership, and education structure [11]. The incorporation of the IoT, meanwhile, encounters obstacles in the realms of information exchange and cooperation [12].

The significant capacity of the IoT to bring about transformation in academic and research institutions, particularly in the realm of new educational solutions is acknowledged [13]. The effective implementation of this initiative in the public sphere is contingent upon its acceptability [14]. The UIoT area has challenges such as a lack of comprehensive literature on UIoT technologies and the presence of ambiguity around developing technologies [15].

From a geographical perspective, the UIoT is mostly seen in countries characterized by modern infrastructure, while developing nations are still in the process of investigating its possibilities [16]. According to the literature review in [17] the primary contributors to research on the IoT are China, the USA, and the UK.

This study examines UIoT stakeholders' perspectives, unlike prior studies that focused on students or academic staff [18]. According to [19], little research has been conducted on IoT usage from multiple theoretical perspectives, thus this study analyzes the UIoT across students, academic staff, and non-academic staff.

In the domain of literature on technology use, there is a wide array of models, theories, and frameworks. The current research chooses to employ the Information System Success (ISS) model [20], which encompasses the dimensions of SYSQ, IQ, and SQ. These dimensions together impact the intention to use, user satisfaction, and the net benefits obtained from the use of IS. This study proposes a predictive framework for the UIoT in HE by utilizing the ISS, as well as analyzing existing models. The framework includes SYSQ, IQ, SQ, and IoT awareness as a moderator. Figure 1 visually represents the conceptual framework.

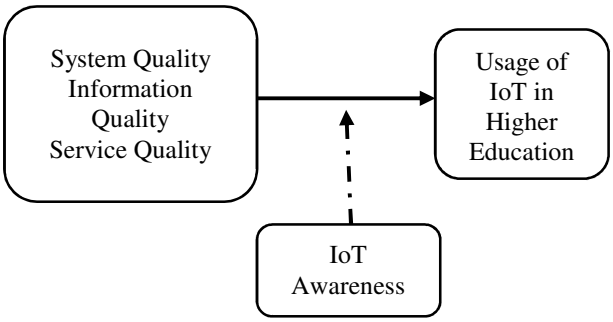

Fig. 1. Conceptual framework.

A. System Quality and UIoT

SYSQ is a component of ISS proposed to have a direct impact on both the intention to use and the actual utilization of technology. Authors in [21] revealed a significant influence of SYSQ on utility value and authors in [22] demonstrated that SYSQ produces positive outcomes in terms of both utility and hedonic value. Authors in [23] found that in the public sector of Pakistan, the use of SYSQ had a notable impact on the PEOU in relation to the implementation of IoT technology. In contrast, the impact of SYSQ on the use of systems in e-learning applications was shown to be inconspicuous across different settings [24]. As a result, the following hypothesis is formulated:

H1: SYSQ has a positive impact on UIoT among stakeholders in HE.

B. Information Quality

Research on the effects of IQ has repeatedly shown a favorable correlation with utility and hedonic values [22]. The influence of IQ on PU and PEOU has been seen in several settings [23, 25]. Within the field of HE, many studies have explored the relationship between IQ and UIoT. Notably, authors in [26] conducted an investigation in this relationship and found evidence supporting a positive influence of IQ on the UIoT technology. Consequently, the following hypothesis is proposed:

H2: IQ has a positive impact on UIoT among stakeholders in HE.

C. Service Quality and UIoT

The concept of SQ has been the subject of substantial research in terms of its influence on utility and hedonic values [22]. Furthermore, previous research has shown a correlation between SQ, PEOU, and PU [27]. Authors in [26], provided empirical data about the impact of SQ on end user satisfaction and UIoT. Similarly, authors in [23] revealed the significance of SQ in relation to PEOU and PU. Authors in [28] shown that deficiencies in service delivery have a significant impact on the effectiveness of UIoT. Consequently, the following hypothesis is formulated.

H3: SQ has a positive impact on UIoT among stakeholders in the HE.

D. The Role of IoT Awareness as a Moderator

The level of understanding among users regarding the increasing security and privacy risks associated with the IoT has gained attention. The impact of IoT awareness on UIoT has been examined in different contexts, revealing its direct effects [6]. Furthermore, the awareness of the IoT has been found to have an impact on individual long-term intentions to use IoT, [29]. Despite the numerous studies on awareness's direct influence, its moderating function has gotten less attention [30]. It has been shown that awareness moderates the association between brand credibility and purchase intention [30] and mediates the relationship between psychological characteristics and purchase intentions [31]. This research suggests that IoTA moderates SQ, IQ, and SYSQ on UIoT. The following hypotheses are proposed:

H4: IoTA moderates the effect of SQ on UIoT.

H5: IoTA moderates the effect of IQ on UIoT.

H6: IoTA moderates the effect of SQ on UIoT.

II. RESEARCH METHODOLOGY

An explanatory research design is used in this study, which falls under the category of hypotheses testing studies. This design utilizes relevant theories and historical empirical evidence to propose and support relationships. The study includes 80 HEIs in Iraq, consisting of 35 public universities and 45 private colleges and universities [32]. The educational institutions in Iraq are spread across different locations and accommodate a significant number of students and staff, totaling 336,395 individuals. This figure represents approximately 42% of the combined student and staff population in Iraq, including both academic and non-academic personnel.

The sub-sample size is determined by calculating the percentage of each group relative to the total population. The percentage of academic staff is 7.4%, students are 85.8%, and non-academic staff are 6.8%. Based on [33], the sample size is 384. However, due to the anticipated low response rate, the sample size was doubled [34] to 768. The data were collected with the use of a questionnaire. The questionnaire was adopted from several sources as shown in Table I. This study involved the participation of UIoT experts who were invited to validate the questionnaire. The experts made significant comments, resulting in the inclusion of an additional item related to UIoT and trust. The measurement was translated into Arabic using a back-to-back translation. A pilot study was conducted by collecting 32 responses from students, academic, and non-academic staff. However, valid and complete responses accounted to 30. Table I displays the outcomes of the reliability analysis. All variables demonstrate a Cronbach's Alpha (CA) greater than 0.70, indicating reliable measurements for the variables.

TABLE I. SAMPLE SIZE AND CA OF THE PILOT STUDY

Variable	No. of items	No. after validation	CA	Source
UIoT	5	6	0.768	[35]. Item 6 was added based on validation.
SQ	5	5	0.886	[26]
IQ	5	5	0.804	1-4 from [23] and 5 from [27, 36].
SYSQ	5	5	0.916	1-3 from [26] and 4-5 from [27, 36].
IoT awareness	5	5	0.800	1-3 from [29] and 4-5 from [37].

A total of 449 responses were collected, resulting in a response rate of 58.4%. As a result of missing value and outlier analyses, 26 responses were removed. Therefore, a total of 423 responses that were complete and reliable were used for the subsequent data analysis. The computed values of Skewness and Kurtosis were less than 1, indicating that the data followed a normal distribution. In addition, the data had no multicollinearity issues because tolerance was greater than 0.20 and variation inflation factor was less than 5.

III. FINDINGS

A. Background Information

The questionnaire and a summary of the responses can be seen in the Appendix. Out of the total respondents, 266 individuals (62.9%) identified as males, while 157 individuals (37.1%) identified as females. The highest counts of 269 respondents (63.6%) were between the ages of 18 and 28 year old. In terms of education, 148 individuals (35.0%) possessed a bachelor's degree. The majority of the respondents, 336 or 79.4%, identified themselves as students. The academic staff accounted for 11.1% (47) and the non-academic staff accounted for 9.5% (40), the highest percentage of 32.9% or 139 are using the internet for 5-10 years. In terms of usage IoT by universities, 87 or 20.6% reported that they are using the IoT while 244 or 57.7% are not sure. At the individual level, 184 or 43.5% are using the IoT while 209 or 49.4% are intending to use.

B. Measurement Model Assessment

Authors in [38] recommended removing items with factor loadings below 0.70. The evaluation of the measurement model revealed that certain items exhibited low factor loadings, falling below this threshold. Following this assessment, two items, namely SYSQ1 from the variable SYSQ and item IoTA5 from IoT awareness (IoTA), were excluded due to their factor loadings being below 0.70. After eliminating these items with insufficient factor loadings, the CA and Composite Reliability (CR) were scrutinized. Both CA and CR exceeded 0.70, indicating satisfactory reliability of the variables. A threshold of 0.70 or higher is considered acceptable for CA and CR [38]. Convergent validity was assessed by examining the average variance extracted (AVE), with a value above 0.50 deemed acceptable. The calculated AVE surpassed 0.50, signifying that the items were capable of explaining over 50% of the variation within the measured variable. Table II shows the evaluation result of the measurement model.

TABLE II. MEASUREMENT ASSESSMENT

Variable	CA	CR	AVE
IoTA	0.884	0.932	0.738
IQ	0.909	0.908	0.737
SQ	0.889	0.891	0.694
SYSQ	0.930	0.930	0.827
UIoT	0.914	0.915	0.815

For assessing the discriminant validity of the study, the method suggested in [39] involves assessing the correlation between variables using the heterotrait-monotrait ratio of correlations (HTMT). The correlation between variables determined by HTMT should not exceed 0.85. The outcomes of the HTMT analysis are presented in Table III. The results indicate that the inter-variable correlations are below 0.85, affirming the attainment of discriminant validity.

TABLE III. DISCRIMINANT VALIDITY (HTMT CORRELATION)

Variable	IoTA	IQ	SQ	SYSQ	UIoT
IoTA	-				
IQ	0.105				
SQ	0.116	0.819			
SYSQ	0.145	0.596	0.666		
UIoT	0.249	0.716	0.74	0.593	-

C. Structural Model

This research assessed the structural model utilizing R-square, F-square, Q-square, and path coefficient. Recent Smart PLS 4 software upgrades made the Q-square superfluous, eliminating it from the analysis. Figure 2 shows that the independent variables, including the moderator, explain 62.0% of UIoT variation. The F-square effect size showed that all other routes had effect sizes below 0.02 except for the moderating influence of IoTA on the link between SQ, SYSQ, and UIoT. This suggests that moderating effects have little influence on the model, highlighting the need to investigate alternative moderating variables.

D. Hypotheses Testing

The hypotheses of this study were examining based on the output of the structural model. The direct effect of the second order and first order and the moderating effect of IoTA are presented in Table IV.

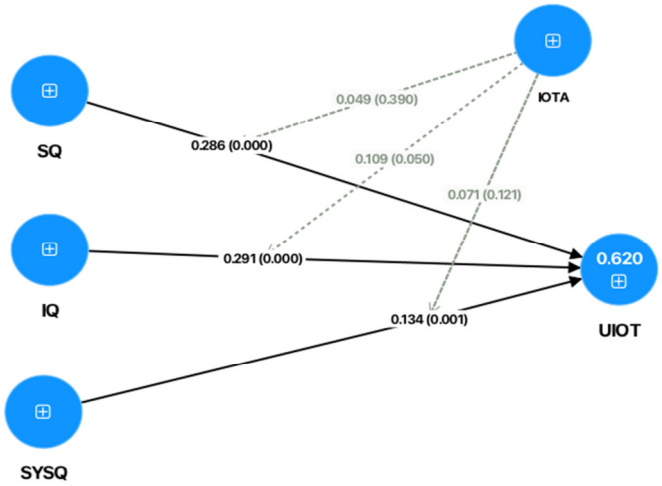

Fig. 2. Structural model.

TABLE IV. RESULTS OF HYPOTHESES TESTING

H	Path	B	Std	T	P
H1	SYSQ → UIoT	0.134	0.041	3.250	0.001
H2	IQ → UIoT	0.291	0.054	5.345	0.000
H3	SQ → UIoT	0.286	0.050	5.777	0.000
H4	IoTA x SYSQ → UIoT	0.071	0.046	1.553	0.121
H5	IoTA x IQ → UIoT	0.109	0.055	1.962	0.050
H6	IoTA x SQ → UIoT	0.049	0.057	0.860	0.390

Regarding the effect of SYSQ on UIoT, the outcomes displayed in Table IV corroborate its significance (B=0.134, T=3.25, P<0.05). The impact of IQ and SQ on UIoT is also established. H2 indicates a positive effect of IQ on UIoT (B=0.291, T=5.345, P<0.05), while H3 is similarly substantiated by the positive and significant relationship between SQ and UIoT (B=0.286, p<0.05). The moderating effect of IoT awareness was examined in this study. For H4, the moderating effect of IoT awareness between SYSQ and UIoT was not supported. The P-value of the moderating effect is 0.121 which is larger than 0.05. Thus, H4 was rejected. For H5, the moderating effect of IoTA was confirmed. IoT awareness moderated the effect of IQ on UIoT. Thus, H5 is supported. For H6, it was rejected because the p-value is above 0.0.5. Thus, IOTA did not moderate the effect of SQ on UIoT.

IV. DISCUSSION

The findings of this study demonstrate statistically significant and positive effects of SYSQ, IQ and SQ, on UIoT. The results underline the significance of SQ as a distinct element that significantly contributes to UIoT. As a result, it is anticipated that enhancing the levels of SYSQ, SQ and IQ would contribute to a rise in UIoT among the stakeholders involved in Iraq's HEI. The aforementioned results are consistent with those in [12, 40, 41], whereby a collective body of evidence substantiates the existence of a positive and statistically significant association between individual variables and the UIoT [42, 43]. Moreover, previous research has also detected the corroborative influence of IQ on UIoT [26]. Similarly, authors in [28] found supporting evidence for the impact of SQ on UIoT.

The examination of the moderating role of IoT awareness indicates that it only moderates the impact of IQ on UIoT. It is worth noting that there is a strong relationship between increased levels of awareness of IoT and a greater positive impact of IQ on the UIoT. Nevertheless, the results suggest that the level of awareness of IoT does not have an impact on the association between SQ and SYSQ and UIoT. The findings of this study align with other research that has examined the role of awareness as a moderating factor. Brand credibility and online purchase intention [30] and social responsibility and IoT service purchase intention in academic libraries [31] were moderated by IoTA in previous research.

V. IMPLICATIONS

This study examined how IQ, SYSQ, and SQ affect UIoT in Iraqi HE. The research also evaluated if IoTA moderates these associations. The research contributes significantly to the literature, since UIoT in HE has received little research until now. Expanding the research, the study examined emerging nations' unique situations, focusing on Iraq. Integration of frameworks like ISS extended the TAM and UTAUT's dominance. The objective of this integration is to develop a more complete model that considers IQ, SQ, and SYSQ and IoT awareness, addressing the lack of holistic research in the existing literature.

This synthesis expanded the existing information on the IoT in HE and confirmed the effectiveness of the ISS framework. This framework accounted for a substantial 62.0% of the variation in the UIoT in the context of HE. The research provides practical insights for decision-makers and stakeholder by identifying the key determinants of UIoT in the HE environment of Iraq. It is worth noting that SYSQ, SQ, and IQ were found to be important for UIoT. These results suggest that educational institutions should emphasize the improvement of these aspects in order to promote increased levels of the UIoT.

Furthermore, the research revealed that the level of awareness about the IoT serves as a moderating variable, impacting the relationship between IQ and the UIoT. Given the circumstances, it is suggested that seminars and public dialogue be organized in order to enhance stakeholders' understanding of IoT technology. The dissemination of positive word-of-mouth, together with excellent communication on the benefits of UIoT, has the potential to enhance the UIoT across all stakeholder groups within HE.

VI. CONCLUSION

This study makes several key contributions to the existing literature by extending the ISS model to explore the adoption of IoT in higher education, particularly within the context of Iraqi institutions. First, the study confirms that system quality, information quality, and service quality significantly impact IoT usage among students, academic staff, and non-academic staff. Second, the inclusion of IoT awareness as a moderating

factor offers a novel perspective, demonstrating that IoT awareness significantly moderates the relationship between information quality and IoT usage. This insight fills a gap in the literature, as previous studies have largely overlooked the moderating role of awareness in technology adoption.

Third, this research addresses the underexplored issue of IoT adoption in developing countries, particularly Iraq, contributing to the limited body of knowledge on technology adoption in regions with infrastructural challenges. By focusing on Iraq, the study sheds light on specific barriers, such as limited awareness and infrastructure, which influence IoT adoption in higher education in such contexts. Fourth, the findings provide practical implications for policymakers and educators, emphasizing the importance of increasing IoT awareness and improving system, information, and service quality to enhance IoT adoption and its effectiveness. These findings provide a foundation for future research to further investigate other moderating factors and explore IoT adoption in different educational environments.

APPENDIX

The questionnaire and the acquired responses are given in this section.

Gender

	Frequency	Percentage
Male	266	62.9
Female	157	37.1
Total	423	100.0

Age

	Frequency	Percentage
18-28 years	269	63.6
29-38 years	78	18.4
39-48 years	60	14.2
49-58 years	10	2.4
Above 58 years	6	1.4
Total	423	100.0

Educational Level

	Frequency	Percentage
High School	126	29.8
Diploma	78	18.4
Bachelor	148	35.0
Master	34	8.0
Ph.D.	37	8.7
Total	423	100.0

Occupation

	Frequency	Percentage
Student	336	79.4
Academic Staff	47	11.1
Non-Academic Staff	40	9.5
Total	423	100.0

How long have you been using internet applications?

	Frequency	Percentage
Less than 5 years	34	8.0
5-10 years	139	32.9
11-15 years	123	29.1
16-20 years	112	26.5
More than 20 years	15	3.5
Total	423	100.0

Does your university employ or intent to use IoT?

	Frequency	Percentage
Yes	87	20.6
No	92	21.7
Not sure	244	57.7
Total	423	100.0

Have you ever used IoT applications?

	Frequency	Percentage
Yes	30	7.1
No	184	43.5
I intend to use	209	49.4
Total	423	100.0

UIOT1: Using the IoT improves my performance in my personal and education-related tasks

	Frequency	Percentage
Strongly disagree	45	10.6
Disagree	37	8.7
Neutral	113	26.7
Agree	112	26.5
Strongly agree	116	27.4
Total	423	100.0

UIOT2: Using the IoT in my personal and education-related tasks increases my productivity

	Frequency	Percentage
Strongly disagree	45	10.6
Disagree	37	8.7
Neutral	117	27.7
Agree	142	33.6
Strongly agree	82	19.4
Total	423	100.0

UIOT3: Using the IoT enhances my effectiveness in my personal and education-related tasks

	Frequency	Percentage
Strongly disagree	41	9.7
Disagree	57	13.5
Neutral	143	33.8
Agree	128	30.3
Strongly agree	54	12.8
Total	423	100.0

UIOT4: : I find the IoT to be useful in my personal and education-related tasks.

	Frequency	Percentage
Strongly disagree	46	10.9
Disagree	45	10.6
Neutral	127	30.0
Agree	137	32.4
Strongly agree	68	16.1
Total	423	100.0

UIOT5: The use of IoT technologies increases the quality of educational processes

	Frequency	Percentage
Strongly disagree	44	10.4
Disagree	57	13.5
Neutral	104	24.6
Agree	152	35.9
Strongly agree	66	15.6
Total	423	100.0

UIOT6: We receive adequate training to use IoT

	Frequency	Percentage
Strongly disagree	44	10.4
Disagree	55	13.0
Neutral	163	38.5
Agree	120	28.4
Strongly agree	41	9.7
Total	423	100.0

SQ1: IoT in universities has up-to-date hardware and software

	Frequency	Percentage
Strongly disagree	42	9.9
Disagree	62	14.7
Neutral	128	30.3
Agree	146	34.5
Strongly agree	45	10.6
Total	423	100.0

SQ2: IoT in universities is dependable

	Frequency	Percentage
Strongly disagree	37	8.7
Disagree	60	14.2
Neutral	116	27.4
Agree	167	39.5
Strongly agree	43	10.2
Total	423	100.0

SQ3: IoT employees in universities give prompt services to users

	Frequency	Percentage
Strongly disagree	29	6.9
Disagree	59	13.9
Neutral	172	40.7
Agree	130	30.7
Strongly agree	33	7.8
Total	423	100.0

SQ4: IoT employees in universities have the knowledge to do their job

	Frequency	Percentage
Strongly disagree	27	6.4
Disagree	64	15.1
Neutral	140	33.1
Agree	144	34.0
Strongly agree	47	11.1
Total	1	0.2

SQ5: IoT in universities have users' best interests at heart

	Frequency	Percentage
Strongly disagree	33	7.8
Disagree	58	13.7
Neutral	153	36.2
Agree	145	34.3
Strongly agree	34	8.0
Total	423	100.0

IQ1: Information provided on the IoT device interface is up to date

	Frequency	Percentage
Strongly disagree	27	6.4
Disagree	60	14.2
Neutral	132	31.2
Agree	164	38.8
Strongly agree	40	9.5
Total	423	100.0

IQ2: Information of the IoT device interface is concise and clear

	Frequency	Percentage
Strongly disagree	31	7.3
Disagree	54	12.8
Neutral	136	32.2
Agree	155	36.6
Strongly agree	47	11.1
Total	423	100.0

IQ3: The content on the IoT device interface is readily usable

	Frequency	Percentage
Strongly disagree	35	8.3
Disagree	52	12.3
Neutral	149	35.2
Agree	127	30.0
Strongly agree	60	14.2
Total	423	100.0

IQ4: The information provided on the IoT device interface is accurate about relevant service

	Frequency	Percentage
Strongly disagree	26	6.1
Disagree	65	15.4
Neutral	132	31.2
Agree	144	34.0
Strongly agree	56	13.2
Total	423	100.0

IQ5: The information provided on IoT device interface is comprehensive

	Frequency	Percentage
Strongly disagree	34	8.0
Disagree	56	13.2
Neutral	153	36.2
Agree	124	29.3
Strongly agree	56	13.2
Total	423	100.0

SYSQ1: The operation of IoT in my university is reliable

	Frequency	Percentage
Strongly disagree	37	8.7
Disagree	65	15.4
Neutral	123	29.1
Agree	143	33.8
Strongly agree	55	13.0
Total	423	100.0

SYSQ2: IoT in my university allows information to be readily accessible to me

	Frequency	Percentage
Strongly disagree	37	8.7
Disagree	41	9.7
Neutral	156	36.9
Agree	139	32.9
Strongly agree	50	11.8
Total	423	100.0

SYSQ3: The IoT system in my university responds fast to my requests

	Frequency	Percentage
Strongly disagree	31	7.3
Disagree	65	15.4
Neutral	123	29.1
Agree	149	35.2
Strongly agree	55	13.0
Total	423	100.0

SYSQ4: The layout of IoT in my university is clear

	Frequency	Percentage
Strongly disagree	34	8.0
Disagree	52	12.3
Neutral	104	24.6
Agree	178	42.1
Strongly agree	55	13.0
Total	423	100.0

SYSQ5: I find that the IoT in my university is easy to use

	Frequency	Percentage
Strongly disagree	37	8.7
Disagree	41	9.7
Neutral	147	34.8
Agree	142	33.6
Strongly agree	56	13.2
Total	423	100.0

IOTA1: My university makes me aware of constantly evolving security/privacy threats and risks of IoT

	Frequency	Percentage
Strongly disagree	4	0.9
Disagree	30	7.1
Neutral	128	30.3
Agree	157	37.1
Strongly agree	104	24.6
Total	423	100.0

IOTA2: My university provides me with basics awareness of security/privacy threats and risks of IoT

	Frequency	Percentage
Strongly disagree	6	1.4
Disagree	49	11.6
Neutral	152	35.9
Agree	142	33.6
Strongly agree	74	17.5
Total	423	100.0

IOTA3: My university provides me with an understanding of what generates security/privacy threats and risks of IoT

	Frequency	Percentage
Strongly disagree	7	1.7
Disagree	41	9.7
Neutral	138	32.6
Agree	165	39.0
Strongly agree	72	17.0
Total	423	100.0

IOTA4: The users have enough information about using the IoT in universities in general

	Frequency	Percentage
Strongly disagree	6	1.4
Disagree	47	11.1
Neutral	103	24.3
Agree	178	42.1
Strongly agree	89	21.0
Total	423	100.0

IOTA5: Awareness of the usage of IoT in universities leads to increased use of IoT

	Frequency	Percentage
Strongly disagree	8	1.9
Disagree	58	13.7
Neutral	167	39.5
Agree	139	32.9
Strongly agree	51	12.1
Total	423	100.0

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