Intention to use Internet of Things (IoT) in higher education online learning – the effect of technology readiness

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Abstract

Purpose – This study examines higher education students' technology readiness level in explaining adoption intention toward educational Internet of Things (IoT) needed for online learning.

Design/methodology/approach – Quantitative deductive research approach is used to check the theory of technology readiness index toward IoT in education. An online administrated questionnaire is distributed through convenience sampling to reach generation(Z) students. The questionnaire is developed using Google form, placing the link on various universities' social media platforms so to be accessible to the respondents. Path coefficient analysis of SEM is used to test the hypotheses.

Findings – Results show that the individual's level of technological optimism, discomfort and insecurity impact adoption intentions toward IoT products and services for online learning; the mental motivator, innovativeness, is insignificant.

Practical implications – This study helps guide practitioners (education institutions, IoT-developers, marketers and other professionals in the field) to consider students' mindset when designing products and strategies for promoting online learning and introducing educational IoT. This research provides insights on IoT in higher education; it provides perspectives for IoT adoption intention pro-online learning, aiding institutions looking for trends and practices for skills and work-based learning developments.

Originality/value – This study contributes to knowledge and literature by shedding light on the educational challenge of why not all students could harness the potentials of online learning and IoT of the twenty-first century. It provides insights to clarify students' mindset toward educational IoT needed for online learning.

Keywords Adoption, Higher education, IoT, Online learning, Technology-acceptance

Paper type Research paper

1. Introduction

The Internet of Things (IoT) is changing the dynamics in many business fields (Belanche *et al.*, 2020; Robinson *et al.*, 2020). IoT reflects the network of connected products, devices and other objects that collect and exchange real-time data by inserted sensors and software; they are considered smart devices interconnected with cloud services, providing users with perceived ease and convenience to engage in the required tasks (Tsourela and Nerantzaki, 2020). It is claimed that IoT has changed traditional way of businesses and people's personal operation, performance and lifestyle; it grips constant technology advancement and datafication to make society more efficient, comfortable and reliable (Karadal and Abubakar, 2021).

In higher education context, IoT has led to many benefits, expanding instructional approaches and learning opportunities from rising effectiveness of online courses to integrated mobile technology and efficient teaching methods (Basiyr, 2021). IoT provides students with better access to learning materials, key resources tracking and real-time or archived communication with other learners and instructors. It allows students to use mobile IoT devices to automate education tasks, such as attending lectures, note-taking, research, etc. (Rahmani *et al.*, 2021). Education IoT is: *"not about the technology; it's about sharing*

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knowledge and information, communicating efficiently, building learning communities and creating a culture of professionalism" (Thomas, 2021, p. 1).

Online learning has become a common practice in education globally, especially during Covid-19 pandemic. During this period, many higher education entities worldwide discontinued in-person instruction to mitigate the virus spread; education entities turned to IoT to facilitate the shift to remote learning (Gardner and Matviak, 2020). New digital technologies made the courses reachable to students (Jacobson *et al.*, 2020). Video conferencing platforms, like Zoom and other technologies (Moodle, C-Pen, Google-Classroom, etc.), became main tools for education (Al-Emran *et al.*, 2020). Online learning provided support to students in overcoming many barriers, such as geographic unreachability, physical disabilities, health and time-restraints (Luo *et al.*, 2019). With IoT, online learning became a tool for continuous learning (Jacobson *et al.*, 2020).

When physical restriction was removed, many people returned back to the traditional form of education. Scholars reported that not all students could harness the potentials of online learning and IoT (Rasheed *et al.*, 2020). The current penetration rate of IoT in education among individuals is still relatively low even though it provides many benefits (Rahmani *et al.*, 2021). Many studies show that IoT has positive influence on education performance, yet students hold mix or negative feelings toward technology in education; and more studies are needed to understand the reasons why (Rasheed *et al.*, 2020). To address this challenge, there is a need for more research to aid in better understanding students' perspective toward IoT in education; to know how to promote acceptance and usage of these technologies as they have the power to make a positive difference to the individuals' personal growth as well as society development (Ahmad *et al.*, 2021).

Researches show that the inadequate level of students' readiness concerning IoT (the given nature of innovation in the education) is one of the important reasons for such discrepancy; yet there are insufficient insights in the matter (Sunny *et al.*, 2019; Khalifeh *et al.*, 2020). To this end, scholars in the field of advanced technology adoption, such as online learning, IoT education, AI adoption domain, have suggested that the technology readiness index (TRI) is a suitable framework to study the motives of students' behaviors; but, still unexplored in education context (Basol *et al.*, 2018; Khalifeh *et al.*, 2020).

To address this research gap, this study applies the technology readiness index (TRI) theory in explaining the motives of adoption intention of IoT education products and services. This focus considers both the managerial and academic importance to understand the role of TRI on understanding of students' decisions to develop intention to adopt educational IoT needed for online learning. Unlike various technology acceptance models found in literature that focus on product features as motivations, TRI focuses on individuals' positive and negative mental readiness toward innovations so to use technologies as a means to achieve certain goals (Parasuraman, 2000). This research objective is twofold: to know the mentality of higher education students toward educational IoT; and how their state-of-mind accelerates adoption intentions. This research can help practitioners (higher education institutions, IoT developers, marketers and other professionals in the field) to acknowledge the successful introduction of these education innovations among students so to aid them in higher education skills and work-based learning.

The research's goal is to develop and test a model, explaining individuals' intention to use IoT education products and applications needed for online learning, focusing on consumers' positive (optimism and innovativeness) and negative (discomfort and insecurity) mental readiness toward these educational technologies and innovations. The following sections in this paper is organized as follows: section 2 provides the literature review; section 3 presents research methodology; section 4 presents the research analysis; section 5 presents the discussion of the findings, clarifying the managerial and theoretical implications as well as the research limitations and future directions.

2. Literature

Researches show that higher education students are significant consumers to various advanced technology that aid in skill development and work-based learning. They seek to use and learn cutting-edge technology during their academic experience (Khalifeh *et al.*, 2020). In addition, *"mobile and other personal technologies have become a major source of learning, addressing the issues related to the schedules, environments, and locations"* allowing them to acquire various (Ahmad *et al.*, 2021, p. 4). Nevertheless, Al-Emran *et al.* (2020) highlight that adoption of IoT and its usages in developing states are still in their initial steps. More studies are needed to encourage this innovation. Online learning is a strategy that is expected to transform ordinary learning into a learning philosophy that can be adapted, shared, reusable and sustainable (Rasheed *et al.*, 2020). Many studies show that educational and learning technologies and innovations are integral to students' personal development and their performance in the course work; technology skills and usage is required for the future labor market (Ahmad *et al.*, 2021). In research, many students agree that IoT can improve learning (Rodney, 2020); it provides: *"prompt feedback from their instructor, collaboration and communication with classmates, and allow the student better control of course activities"* (Elliott *et al.*, 2008, p. 12). Based on previous research, online learning and IoT acceptance is influenced by many factors. However, some important factors have not been determined and discussed previously (Al-Emran *et al.*, 2020); therefore, further investigation is needed (Rahmani *et al.*, 2021). The following sections illustrate the researches and literature regarding technology in higher education and students' technology readiness.

2.1 IoT and higher education

Research has long-established that digitalization has altered the strategies, provision and tools of education; it has improved the education process, learning quality and student performance (Ahmad *et al.*, 2021). Zhu and He (2012) explain that smart education and learning is: *"to create intelligent environments by using smart technologies, so that smart pedagogies can be facilitated to provide personalized learning services and empower learners"* (p. 2). Researches assume that advanced technology role is irrevocable in supporting the change in the learning process. Literature considers digitalization in education as an emerging concept; research should focus more on content and learners' perspectives as there is limited study on it than its technologies, although the technological infrastructure is advanced and intelligent (Ahmad *et al.*, 2021).

Duran-Sanchez *et al.* (2017) research elaborate that digitalization help students' education to become impactful; and IoT (physical objects with embedded sensors that gather and exchange data in real time) plays a significant role in this development (Rodney, 2020). IoT solutions for education have enhanced the quality of education across the world. According to Al-Emran *et al.* (2020), IoT allows the education process to become contextual, personalized and transparent; it allows students to gain education that allow them to learn flexibly, in any place and at any time and work collaboratively. This allows students and practitioners to handle effectively various environment difficulties and obstacles in learning (Luo *et al.*, 2019). Many educational platforms are recently surfacing due to IoT-enabled devices (smart technology and the artificial intelligence embodied in it), allowing education to be convenient, easy to use and safe in platforms for the teachers and students (Rasheed *et al.*, 2020). Ahmad *et al.* (2021) explain that IoT provides: *"retrieving learning content, communication, evaluation, and expression in the process of technology-enhanced learning"* (p. 4). Thus, IoT in education is a service-oriented and learner-centric educational paradigm and is focused on both technology and learners (Rodney, 2020).

According to Digiteum research (2020), COVID-19 triggered many IoT to create education enhancement; it acted as promising solutions deployed in higher education around the world.

For example, *EdModo* is a connected platform that helps teachers and students share guidance, suggestions, news, instructions, opinions, learning materials, keep track of students' progress, and improve the efficiency of education inside and beyond the classroom; *C-Pen* is a portable scanner, allowing students to share anything they write online or save it as a picture (to ensure lessons or lecture-notes will not be lost); *Locorobo* is an application that helps programming students learn and provides connected coding platform and a lesson library; *Magicard* is a multiple-purpose card for online-students to use; it acts as a payment cards, attendance cards and health data cards, etc.

Potential discrepancies between IoT and adoption exist among research (Karadal and Abubakar, 2021). Debates claim that though IoT's primary aim is to make life easier and simple for people, there may be other objections that could delay its adoption (Tsourela and Nerantzaki, 2020). Past researches have focused on the design and usage of IoT or IoT outlooks among organizations and practitioners; little attention has been devoted to understanding the acceptance of IoT from individuals' mentality (Rahmani *et al.*, 2021), specifically students in the education context (Rodney, 2020). Ahmad *et al.* (2021) state that IoT needs further research to grasp the factors that determine its acceptance so to apply this knowledge on students' skill-development and learning.

2.2 Technology acceptance

Researches claim that technology acceptance reflects a person's psychological condition regarding his/her intention to adopt and use a technology (Flavián *et al.*, 2022). Most of the studies in technology adoption are based on the behavioral intention of an individual. Theories have claimed that individual's developing adoption is a process that begins with the individual being aware of the technology and then making full use of it (Ahmad *et al.*, 2021). The adoption process is well documented by researchers; studies show that individual's adoption of technology is not a sudden process, but occurs over time and involves a several actions (Rogers, 2003; Flavián *et al.*, 2022). The growth of information and communications technologies and digital transformation of tasks created a deep-instilled effect on individuals, society, business and education, leading to growing online learning, making IoT in education an unavoidable phenomenon (Al-Emran *et al.*, 2020).

Numerous models and theories are presented to examine constructs that influence technology and innovations adoption (Belanche *et al.*, 2020), in particular in the education context (Khalifeh *et al.*, 2020). According to past theories, such as the theory of reasoned actions, diffusion of innovation, technology acceptance model and unified theory of acceptance and use of technology, many variables are identified (Flavián *et al.*, 2022). Nevertheless, scholars have indicated that adoption to technology involves individual's mental-readiness more than factors associated with the specified technology (Wong, 2016). Mental-readiness prepares individuals for any situation, giving them the focus to self-manage and develop confidence to approach and use technology regardless of its features, function and ease-of-use (Kaplan and Haenlein, 2020). Research shows that individuals who are mentally ready to use technology are more likely to try it (Parasuraman, 2000). Thus, this study seeks to assess individuals' adoption toward IoT education products and services by using the technology readiness index (TRI) over the other existing theories.

2.3 Technology readiness index

In the context of education, research claim that self-efficacy is considered a significant factor that influence the students' technology readiness; self-efficacy is the individual personal judgment of his/her ability to prosper in a particular task (Khalifeh *et al.*, 2020). According to Parasuraman (2000), personality dimensions affect people's tendency to use new technologies. TRI differs from other well-known technology acceptance models as it seeks to assess the beliefs people hold about the innovation (Flavián *et al.*, 2022). TRI is a multidimensional psychographic model, segmenting individuals upon their underlying positive and negative beliefs toward the technology; four beliefs define technology readiness: optimism and innovativeness are contributors to technology readiness; discomfort and insecurity are contributors to technology dismissal/inhibitors (Parasuraman and Colby, 2015). TRI assumes that individuals can concurrently hold both positive and negative beliefs (Parasuraman, 2000).

Optimism is: *"positive view of technology and belief that it offers people increased control, flexibility, and efficiency"* (Parasuraman and Colby, 2015, p. 60). Kaplan and Haenlein (2020) say that optimists are accepting to new technologies as they distinguish the products as functional, exciting and trustworthy. *Innovativeness* reflects: *"technology pioneer and thought leaders"* (Parasuraman and Colby, 2015, p. 60). According to Rodriguez-Ricardo *et al.* (2018), innovators have positive impression toward technology; they are open-minded and courageous to try new things. Flavián *et al.* (2022) mention that innovators exhibit willingness to use technologies. *Discomfort* is: *"perceived lack of control over technology and feeling of being overwhelmed by it"* (Parasuraman and Colby, 2015, p. 60). Parasuraman (2000) explains that lacking capability or control to deal with technologies result in rejection. Al-Emran *et al.* (2020) explain that individuals facing uneasiness, stress and/or awkwardness with technologies would not accept their regular usage; they feel averse toward the technology. *Insecurity* is: *"skepticism about its ability to work properly and concerns about its potential harmful consequences"* (Parasuraman and Colby, 2015, p. 60). Kaplan and Haenlein (2020) explain that doubtful individuals usually refuse new products; high-level of technology insecurity leads individuals to avoid usage.

3. Research design

Based on the literature review, the proposed research model (Figure 1) emerged, postulating four hypotheses. This study sought to assess TRI on students' tendency to use IoT educational products and services associated with online learning, checking the TRI theory is valid in IoT education context. The research question was: *"what enablers and inhibitors define higher-education students' adoption intention of educational IoT products and services for online-learning?"*

This study used *quantitative descriptive approach*. The data collection was at a single point in time, during March and April 2022, succeeding a *cross-sectional study*. This study's managerial and theoretical concerns were to describe how higher education students perceive educational IoT and their adoption intention. The research pursued objective data to apply the *positivist approach*: *"law-like generalizations similar to those produced by the physical and*

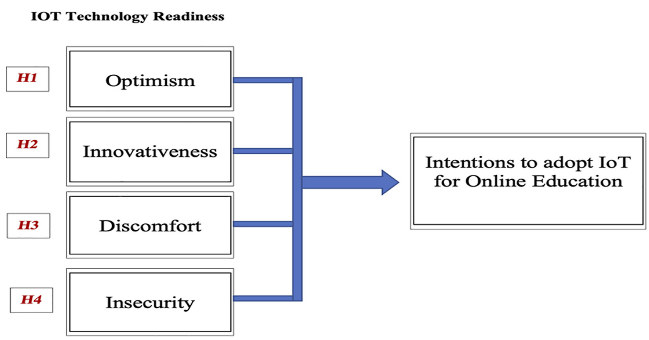

Figure 1. Proposed research model

natural scientists" (Saunders *et al.*, 2009, p. 15). The tool used to collect data was *administrated questionnaire*; the questionnaire was created on Google form. The form link was placed on various universities' social media platforms so site-visitors had access for participation. *Convenience sampling* was applied.

The population were *generation(Z)*. Generation(Z), known as zoomers or gen-Z (born mid-to-late 1990s), are the first generation to grow-up with access to the Internet and portable digital technology from a young age. They are digital natives – the new generation of technology-savvy students currently in and/or entering higher education programs (Rodney, 2020). Frand (2000) explained that when it comes to gen-z, staying connected is a central part of their lives; he found that they possess necessary skills to use innovations inspired by the Internet; so, IoT is a relevant option for their consumption.

This study's questionnaire contained several scales that were taken from past studies and adapted to suit the context of IoT in higher education. The TRI scales were taken from Parasuraman (2000), and the adoption intention scale was taken from Sundar and Kalyanaraman (2004). These scales were 5-point-Likert-scales (with 1 representing "strongly disagree" and 5 representing "strongly agree"). The questionnaire was originally created in English, and then back-translated to Arabic by linguistic experts so to give respondents a preference in language option. A pilot test with 50 respondents was conducted to confirm that there were no problems with the items in the scale. Once the questionnaire was finalized, the researcher gained institutional ethical permission to use the survey for the research.

The questionnaire final version contained five sections. *Section one* had a paragraph that informed respondents of the study's purpose, confirmation that the replies were anonymous and confidential, verification assuring that they can withdrawal from the study at any-time and relevant questionnaire instructions. This section gave the respondents insights so that they make informed judgment about whether they wished to participate. This section clarified the informed consent for the survey instrument. The section was developed according to the ethical consideration practices set by American Association of Public Opinion Research and according the researcher's attendant institution. *Section two* contained filtered questions to select and eliminate respondents who were either fit or unfit for the study: *did you partake in online learning before; did you use IoT during online learning?* Those who answer yes were asked to complete the questionnaire, while others were issued an apology and explanation on why they discontinued. *Section three* contained scales that assessed TRI (mental enablers and inhibitors). In this section, it contains 36-item-scale to measure*: "people's propensity to embrace and use new technologies for accomplishing goals in home life and at work"* (Parasuraman, 2000, p. 308) *Section four* assessed intentions toward IoT education products and services for online learning (a three-item-scale). *Section Five* asked socio-demographic questions to gain a profile of the respondents.

4. Research results

Of the 600 questionnaires distributed, 400 were returned back from the targeted population complete (response rate of 67%). The collected data was analyzed through IBM-SPSS-19 (for the conduction of the frequency, validity and reliability analyses) and IBM-Amos-18 (for the hypothesis testing through pathway analysis).

4.1 Frequency analysis

Frequency analysis was conducted to portray the participants in this research. According to Table 1, the respondents were diverse in socio-demographic backgrounds and in their opinions toward online learning and IoT usage.

Item	Category	Frequency	%	Item	Category	Frequency	%
Age	Under 20	100	25.000	Average household income	2,000 – less than 5,000	70	17.000
	20–24	205	51.250		5,000 – less than 10,000	144	36.000
	Above 24	95	23.750		Over 10,000	186	46.500
Gender	Female	289	72.25	Study major	Business	104	26.000
	Male	111	27.750		Medicine	1	0.300
Residence	Cairo	172	43.000		Agriculture	30	7.500
	Alexandria	145	36.000		Engineering	102	25.500
	Other	83	20.750		Language	107	26.800
					Media	23	5.800
					Law	20	5.000
					Other	4	1.050
What form of study is preferred?	Online Learning	126	31.500	What benefits did you enjoy through online learning?	Added flexibility	360	90.000
	Hybrid Learning	180	45.000		Self-pace learning	107	26.800
	In-person Learning	104	26.000		Time management	16	4.000
					Virtual communication	104	26.000
					Available materials	86	21.500
					New technical skills	239	59.000
					Sustainable learning	13	3.000

Table 1. Participants' socio-demographic traits and IoT-behaviors

4.2 Normality testing

Normality tests were applied before further analysis so to determine if the data set was well-modeled by a normal distribution. Several analyses were performed and illustrated in Table 2. According to *Kolmogorov–Smirnov test of normality,* the data was normally distributed if the *P*-value was greater than 0.05. According to *skewness and kurtosis values,* kurtosis value of $\pm$ 1 was considered good for most psychometric uses; skewness reflected a distribution of values deviated from symmetry around the mean; if skewness value was greater than +1 or lower than −1, this indicated substantially skewed distribution. The next normality test was *assumption of multicollinearity,* using variance inflation factor (VIF). This test illustrated if two or more predictors in a model were highly correlated with each other;

Research variables	Descriptive statistics		Skewness		Kurtosis		VIF	Kolmogorov–Smirnov		
	Mean	Std. Deviation	Statistic	Std. Error	Statistic	Std. Error		Statistic	df	Sig
1. Optimism	3.265	1.158	−0.168	0.122	−0.682	0.243	1.936	0.293	400	0.000
2. Innovativeness	3.583	1.073	−0.236	0.122	−0.500	0.243	1.561	0.277	400	0.000
3. Discomfort	3.453	1.121	0.011	0.122	−0.322	0.243	2.047	0.316	400	0.000
4. Insecurity	3.517	0.917	0.457	0.122	−0.796	0.243	1.256	0.285	400	0.000
5. Behavior Intention	3.350	0.997	−0.211	0.122	−0.618	0.243		0.304	400	0.000

Table 2. Testing of normality

if so, this led to problems with clarifying which predictors contributed to variance explained in criterion, and technical issues in calculating multiple regression model. In this study, VIFs were all less than 5, reflecting no problem of multicollinearity between variables.

4.3 Reliability and validity testing

Reliability and validity tests were implemented to assess the quality of the scales used to assess the variables. These tests were basic to confirm that data were sound and the results were accurate. Reliability assessed that the instrument yields the same results over multiple trials. Validity assessed the instrument measures what it was designed to measure (Bryman, 2012). In this study, Kaiser–Meyer–Olkin (KMO), average variance extracted (AVE), Cronbach's alpha (α) and discriminant validity were used to test the reliability and validity. The analyses (Tables 3 and 4) showed values that implied adequate convergent validity, reliability and discriminant validity.

4.4 Confirmatory factor analysis

Confirmatory factor analysis (CFA) verified the factor structure of a set of observed variables. CFA allowed the researcher to test the hypothesis (relationship between observed variables) and their underlying latent constructs existence (Hair *et al.*, 2016). In this study, the analyses showed the minimum discrepancy or chi-square divided by the degrees of freedom (CMIN/DF) was 1.643; the probability of getting as larger discrepancy as with the present sample (p-value) was 0.000; goodness of fit (GFI) was 0.882; adjusted goodness-of-fit index (AGFI) was 0.859; the Bentler–Bonett normed fit index (NFI) was 0.919; Tucker–Lewis index or Bentler–Bonett non-normed fit index (TLI) was 0.962; the comparative fit index (CFI) was 0.966; the root mean square residual (RMR) was 0.013; the root mean square of approximation (RMSEA) was 0.040. Table 5 shows these indicators value in CFA and the recommended values for them.

4.5 Hypotheses testing

SEM path coefficient analysis was used to test the hypotheses. Table 6 shows the testing. The outcomes of the path coefficient showed that optimism, discomfort and insecurity impact significantly students' adoption intentions toward IoT products and services for online learning. Innovativeness did not significantly impact adoption intentions.

5. Conclusion and discussion

IoT has influenced many sectors in the market, and education is one of them. The teaching and learning domain are experiencing significant changes as higher education institutions are offering web-based-courses (online learning) that either replace, supplement and/or complement traditional classroom-based courses (Ahmad *et al.*, 2021). This phenomenon was

Table 3.
Discriminant validity

	1	2	3	4	5
1. Optimism	(0.890)				
2. Innovativeness	0.716**	(0.908)			
3. Discomfort	0.731**	0.737**	(0.927)		
4. Insecurity	0.358**	0.416**	0.405**	(0.874)	
5. Behavior Intention	0.338**	0.350**	0.391**	0.627**	(0.887)

Note(s): **Correlation is significant at the 0.01 level (2-tailed)

Variables	KMO	AVE%	Cronbach's alpha	Items	Factor loading
Optimism	0.753	85.866	0.868	OPT1	0.826
				OPT2	0.843
				OPT3	0.735
				OPT4	0.779
				OPT5	0.786
				OPT6	0.847
				OPT7	0.843
				OPT8	0.826
				OPT9	0.878
				OPT10	0.871
Innovativeness	0.700	72.720	0.909	INN1	0.747
				INN2	0.799
				INN3	0.847
				INN4	0.843
				INN5	0.771
				INN6	0.846
				INN7	0.742
Discomfort	0.820	64.049	0.846	DIS1	0.847
				DIS2	0.843
				DIS3	0.826
				DIS4	0.878
				DIS5	0.871
				DIS6	0.748
				DIS7	0.747
				DIS8	0.799
				DIS9	0.847
				DIS10	0.843
Insecurity	0.724	76.474	0.897	INS1	0.748
				INS2	0.747
				INS3	0.799
				INS4	0.847
				INS5	0.843
				INS6	0.771
				INS7	0.846
				INS8	0.742
				INS9	0.847
				INS10	0.843
Behavior intention (adoption)	0.729	78.216	0.813	BI1	0.748
				BI2	0.747
				BI3	0.799

Table 4.
Validity and reliability

Measure	Results	Threshold	Measure	Results	Threshold
Chi-square/df	1.643	<2 excellent; < 3 good; < 5 sometimes permissible	TLI	0.962	>0.85
p-value	0.000	>0.05	CFI	0.966	>0.80
GFI	0.882	>0.80	RMR	0.013	<0.09
AGFI	0.859	>0.80	RMSEA	0.040	<0.10
NFI	0.919	>0.80			

Table 5.
Fit indices and thresholds for measurement model

prevalent during the beginning of Covid-19 era. Researches show that IoT provide many benefits to students in their education, such as flexibility, convenience and the opportunity to work collaboratively with other students and lecturers (Al-Emran *et al.*, 2020). Due to IoT technologies, at a fingertip, students can learn at their own pace and have a nearly identical classroom educational experience at their homes (Khalifeh *et al.*, 2020).

Online learning has become popular in many educational institutions worldwide; and throughout this transformation, there has been and will be a need to study students online learning readiness and develop more comprehensive measure toward the encouragement of this educational approach (Khalifeh *et al.*, 2020). Scholars report that not all students could harness the potentials of online learning and IoT (Rasheed *et al.*, 2020). The current penetration rate of IoT in education is still relatively low (especially in developing nations) even though it provides many benefits (Rahmani *et al.*, 2021). Research in the IoT education context is an overriding requirement to try to explain the behavioral intention of students toward online learning, especially when taking into account the psychological attributes (Khalifeh *et al.*, 2020).

This study examines the role of technology readiness in explaining intention to use IoT education products and services for online learning. This study objective is twofold: to know the mentality of higher education students toward educational IoT; and how the state-of-mind accelerates adoption intentions of them. For objective one, the TRI theory explains that individuals' positive and negative mental readiness toward innovations plays a huge role in triggering adoption. A person's overall state-of-mind influences behavior. The mindset toward the preparation of using technology is the calculation of mental enablers and inhibitors that collectively establish a person's tendency to use new technologies (Parasuraman, 2000). This study tests the developed research model based on TRI theory of mental enablers and inhibitors, checking its validation toward IoT education adoption. For objective two, path coefficient analysis of SEM is used to test the research model. Results show that optimism, discomfort and insecurity impact students' adoption intentions toward IoT products and services for online learning. Innovativeness did not impact intentions.

Various theoretical implications can be concluded. This study concluded that innovativeness as a mental enabler is insignificant to the adoption intention of educational IoT. This conclusion implies that digital transformation is a common and necessary practice in almost every sector in the market nowadays. Therefore, by default, many individuals are compelled to participate in the usage of various technologies, not just the technology pioneer and thought leader. According to Basiyr (2021), the advance of online technology has heralded new changes in education. Meola (2022) illustrates that technology has played a key role in changing the dynamics of delivery and pedagogy behind education; the Internet has deeply rooted itself into the learning process for everyone. Therefore, practitioners should not develop new technologies for just the early-adaptors, but for the majority of people since it is a usual behavior during post-pandemic setting. Moreover, this study's outcomes imply that students are optimistic toward IoT; they have confidence that IoT can make learning more

Table 6.
SEM analysis for the research variables

Hypotheses	Estimate	*p*	Hypothesis supported
1. Optimism → BI	0.277	***	Supported
2. Innovativeness → BI	0.128	0.776	Not Supported
3. Discomfort → BI	0.339	***	Supported
4. Insecurity → BI	0.433	***	Supported

Note(s): BI reflects Behavior Intention
*** Reflects Hypothesis is significant

positive, suitable, accessible, interesting and pleasurable during post-pandemic setting. According to Rasheed *et al.* (2020), many educational platforms are recently surfacing due to IoT-enabled devices (smart technology and the artificial intelligence embodied in it), allowing education to be convenient, easy to use and safe in platforms for teachers and students. Kaplan and Haenlein (2020) show that the sense of optimism is vital so people can develop desires for technology usage; people need to think that the new technology leads to efficiency and progression in their lives.

Regarding mental inhibitors, this study conclusions found that the biggest challenge for the adoption intention of IoT in the educational context is the change of mentality required to step out of one's comfort zone. This study's conclusions imply that for students to develop IoT education adoption intention, they should hold self-efficacy because the feeling of inadequacy or insecurity (not being good enough) leads to their anxiety about their ability to handle digital products for online learning situations. They have to cope with evolving technological tools being applied in education. It is vital for students to be able to adapt and to adjust themselves in the wave of technology even if it's stressful at first. Parasuraman (2000) clarifies that people have to fight the overwhelming feeling that technology brings in order to grow and learn more about themselves and their world. Tsourela and Nerantzaki (2020) explain that new ideas and technologies (such as IoT) lead to people being hesitant or skeptical to adopt; but by time people become accustomed and generate greater output and value with IoT (Al-Emran *et al.*, 2020). Therefore, IoT practitioners (developers, marketers, higher education institutions and other professionals in the field) should promote to the students' motivational communications that encourage them to overcome their resistance and engage in IoT consumption.

This study contributes in knowledge and literature to clarify students' mindset in develop adoption intention toward IoT education products and services for online learning. IoT adoption is unavoidable in the education sector. The applications of IoT in education are numerous, and the implications for this disruption are tremendous. This study helps practitioners and policymakers (IoT developers, marketers, higher education institutions and other experts in the field) to consider the students outlook when designing products and strategies for the successful introduction of IoT education products in the market. IoT is a contemporary method of teaching and learning, which can address and resolve many issues related to effective education. IoT is: *"not limited to smart learning, tutoring systems, and social robots; there are many other intelligent technologies, such as virtual facilitator, online-learning environments, learning management systems, and learning analytics, which contribute significantly to the sector"* (Ahmad *et al.*, 2021, p. 8). This research reflects how IoT is viewed by students, and the mental drives for IoT adoption in higher education.

This study has some limitations that need to be considered. The research model developed in this study is based on Parasuraman (2000) framework to assess students' perceived readiness regarding educational IoT. The use of other models or frameworks may lead to different results. So, it is suggested that future studies use other theories (add on variables) for assessing students' readiness; this can increase the validity of the findings and add to the richness of the studies conducted in this area. In this study, the results are obtained from university students in Egypt, which were chosen using convenient sampling. Given the importance of contextual and cultural differences, it is suggested that future studies test the model on a more diverse population of students from different universities, fields and countries based on probability sampling. In addition, future studies can study possible roles of mediating variables, such as age, previous experience, education and cultural values in students' readiness.

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Further reading

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