

EFFICIENCY ENHANCEMENT ON HIGHER EDUCATION
INSTITUTIONS IN SHANGHAI, CHINA THROUGH UTAUT
INTERNET OF THINGS (IOT) MODEL

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through UTAUT Internet of Things (IoT) Model

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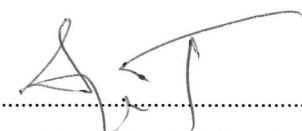

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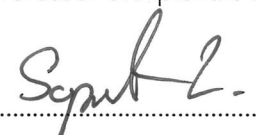
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Abstract

This study investigates how the Internet of Things (IoT) can enhance efficiency in Chinese higher education institutions and examines student acceptance of IoT through the Unified Theory of Acceptance and Use of Technology (UTAUT). Using a mixed-methods design, quantitative data were collected via a survey of 408 university students, and qualitative insights were obtained from semi-structured interviews with seven tutors. Regression and frequency analyses were used to analyse the benefits and challenges of IoT adoption and to evaluate the UTAUT relationships, while thematic analysis was used to identify key IoT application areas and to inform adoption options for universities. The study evaluates and contextualises the UTAUT constructs, performance expectancy, effort expectancy, social influence, and facilitating conditions, in an IoT-based higher education setting. Results indicate that performance expectancy shows a positive association with students' intention to use IoT, whereas social influence, effort expectancy, and facilitating conditions do not demonstrate positive effects in this sample. Reported benefits include personalised curriculum support and improved institutional efficiency, while major challenges involve reliable internet connectivity and security/safety concerns. Identified application areas include smart classrooms, smart campuses, and assistive uses supporting daily life and learning for individuals with disabilities. Overall, the findings suggest that universities should

prioritise IoT initiatives with clear, demonstrable learning and efficiency gains (to strengthen performance expectancy) and implement connectivity and security safeguards as baseline conditions for scalable adoption, rather than relying on social influence or ease-of-use messaging to drive intention.

Keywords: Internet of Things (IoT); Unified Theory of Acceptance and Use of Technology (UTAUT); higher education; technology acceptance; smart campus; efficiency; mixed methods

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Chapter 1

Introduction

Rationale of the study

IoT is although offering a virtual access to education for students from every geographical location but at the same time presenting challenges in terms of concerted effort, communication, and face to face partnership between students and teachers (Shaikh et al., 2021). One possible solution is to utilise smart pieces of instruction in learning environment and IoT is found to be the most limitless mediator in facilitating interactive understanding (Park et al., 2017). However, in IoT's educational system, the possibility of cooperation between physical and virtual objects is expected at an abnormal position of probability. It is because IoT applications, though like other digital technologies but contain physical structures, which can elicit different responses of enthusiastic and cognitive users (Qureshi et al., 2021). Therefore, it is important to understand how educational technologies gain user acceptance at scale. To address this need, this study adopts the Unified Theory of Acceptance and Use of Technology (UTAUT) as its core theoretical framework to explain students' acceptance of IoT in China's higher education context.

The use of IoT based tools in educational practices is in early stage and so, there are very limited and dispersed papers focused on IoT usage in higher education by measuring its overall consequential impact. Thus, there is a need of providing a descriptive study together with a statistical methodology to provide supplementary support in these research phenomena. Also, further progress is required by institutions to adapt IoT in their current practices. The outcomes of IoT systems applications, its facilities, related software and applications can be influenced by students, academics and researchers (Aldowah et al., 2017). The concept of IoT is evolving increasingly and becoming an indisputably emerging topic which is creating concern and awareness around the globe (Ramlowat & Pattanayak, 2019). Also, there are many signs of changes that will bring by IoT in educational institutions,

specifically in higher universities. The educational institutes are increasingly adopting IoT based educational models and so, it will ultimately build a workforce in future, which will be serving IoT based service industry. Also, undoubtedly the historical stage wherein we are immersed is creating significant changes for humanity. Such technical period is characterised with new difficulties for the users which are arising from Big Data, from automatic decision making (robots and artificial intelligence), from high risks to privacy and security (cybersecurity) and from greater ambiguity and reduced visibility (Liu et al., 2015; Dai, 2019; Çiftçi, 2016). Besides this, it is likely that only a selected population group will benefit and such digital division exists due to differences between population who can access internet and those who cannot connect to the advanced educational technologies from their home (Sulaiman & Halamy, 2021). Thus, it is imperative to study IoT in education from a digital inequality perspective.

In addition, the characteristics of higher educational institutes and studies are more favourable and open to innovation and so, required technological incorporation into both research and teaching (Chandio et al., 2016). Also, IoT in higher education has possibility to impact clearly on how educational systems are redeveloped and re-imagined from a traditional pattern to one which is flexible, adaptable, scalable and more adaptive to rapid and dynamic alterations (Dwivedi et al., 2017). Moreover, in the design of learning and educational logistics management, facilities should be responsive to the students learning needs. The scholars believed that IoT to integrate in higher education need to achieve favourable attitude of users (van Deursen et al., 2021; Songsom, Nilsook & Wannapiroon, 2019; Tan et al., 2018). Accordingly, income and educational differences should be taken into consideration, which must not produce inequalities and ultimately, a rejection to IoT implementation in education. It is because people with high income and education might show a more favourable attitude towards using IoT and they might be first to obtain necessary skills and make diverse utilisation of IoT in education (Chopdar et al., 2018). Therefore, this study is focused on determining the potential of accepting IoT among Chinese students of higher universities. For this reason, the proposed

UTAUT model will be considered as a measuring device. Overall, this study is necessary to reveal methods that can be used by higher educational institutes of China to benefit from IoT applications.

Background of the Study

At the start of twenty first century, the development in higher education has been witnessed with the changes in civilisation. It is because the universities started to utilise different learning applications and strategies in order to improve the educational practices (Satu et al., 2018). Educational institutions are increasingly using modern techniques, like IoT (internet of things) to provide an interactive and transformed experience of learning to the students. The introduction of IoT in the field of education is giving rise to several applications for providing communication channels to students globally, improve safety of students and support disabled pupils. IoT in education has made the learning process more agile and improved the overall quality of education (Bagheri & Movahed, 2016). In addition, IoT has helped in making education more interactive, facilitates physical objectives to communicate with sensors and controllers to spread information without involving human beings. Also, IoT in higher education has offered a new way of imparting education and an atmosphere wherein people can learn skills and knowledge online (Banica, Burtescu, & Enescu, 2017).

According to Romero-Rodríguez et al. (2020), education is considered as most essential macro activities of human lives and thus, IoT implementation in educational practices has become a key requirement for today's societies, whether in developed or developing nations. IoT is an emerging technology but making a big footprint in the virtual world as well as have the capacity to replace the traditional education practice with highly interactive, flexible and scalable process using its sensors, competent tools, strong technology and actuators (Abbasy & Quesada, 2017; Bagheri & Movahed, 2016). IoT can be considered as a collective network of technology and connected devices that makes things more efficient and easier by using more reliable connectivity, embedded processing and sensors in current technology. This will allow

making it possible to build an intelligent e-learning system according to the needs of students and capabilities of educator in a highly effective and interactive manner (Mishra et al., 2020). Thus, IoT is reforming the practices of education institutions.

Particularly, China is dominating in the process of integrating technical applications in education field. Although the education market is highly competitive, the market is young, as parents are willing to adopt digital innovation which could support schools and their children to ensure better education. It is because the Chinese people are increasingly judged on the basis of their pupils' success, as they consider education as a prime way of achieving better position in life. Consequently, the Chinese families tend to spend additional on education of their child as compared to other aspects of their life (Feijóo et al., 2021). By leveraging on the readiness of the Chinese parents and students to accept innovation in education, the online learners in the nation have reached to 142 billion even before pandemic and reached to 308 billion in 2022 (Statista, 2022). Overall, the social environment of China comprises of a young and wide market, eager for technological innovations which enable rapid commercialisation of novelties, specifically if they offer an advantage in educational opportunities. In addition to above, the Chinese government strongly support technological solutions as an investor and even as a customer of digital technologies and offer an access to key data for institutions with favourable conditions. Moreover, the government carries out several experiments on development at the local level as well as on new policies and practices. If such developments are found satisfactory, these are further extended across the nation. Such encouragement from the government along with distributed responsibility is creating an atmosphere where regional and local governments are competing to offer best outcomes possible within the planned top-down policies in China. The same process has occurred pre and post-COVID-19 pandemic period (Feijóo et al., 2021). Therefore, within administrative guidelines, the local authorities in China are allowed to make decisions for offering best technical support for higher education.

In addition, reforms in the Chinese education system have started to move from passive and abstruse learning to more elective and balanced learning, which is

offering not just essential knowledge but even problem-solving and digital learning skills. In this regard, IoT is enabling institutions to change their operations radically and enhance learning capabilities of students in different ways (Yu, 2020). It is enhancing learning experience of students by offering various features of interactive learning. Accordingly, many educational institutions and universities have removed their traditional way of imparting education that are being replaced by technologies such as use laptops and tablets and online student portals. Such use of technology is supporting students to learn at their pace from where they are comfortable and get the same learning experience at both college and home which leads to increased convenience for both students and university authorities (Mishra et al., 2020). However, teachers remain doubtful as to whether new online education will have desired effect on students' learning, as the system is not free from challenges, including big data development threat, privacy issue and information protection among others (Geetha, Vinayachandra & Prasad, 2021). Even the market growth of online education is estimated to slow down in upcoming years by 17.5%. However, if IoT is adopted effectively by the students, then the Chinese universities will have wide platform to provide the best higher education in most innovative manner (Feijóo et al., 2021). This makes it interesting to study the benefits and challenges of using IoT in higher education.

In the above context, the purpose of conducting this research is to look into possibility among the Chinese students to accept IoT in their higher education. Particularly, UTAUT model is considered as a key model to test the potential of accepting new technology (Shaikh et al., 2021). Venkatesh, Thong & Xu (2012) proposed the model to explain the users' predisposition and behaviour to use any given technology. The key factors of the particular model have been taken from eight distinct theoretical models that develop the main dimensions of mode, such as social influence, facilitating conditions, effort expectancy and performance expectancy. The model is decided to be used in this study to adapt its key constructs to IoT. Particularly, the model is used here to analyse the Chinese students' acceptance of IoT in educational system and their usage-based confidence

issues, by evaluating benefits and challenges of adopting digital technologies in education. Moreover, this research intends to discuss the application areas of IoT in higher education institutions in China.

Significance of study

The vision of IoT is grounded on an assumption that definite advances in information, communication technology and microelectronics observed in recent times will undergo into predictable future (Agarwal & Pati, 2016). IoT applications though being already leveraged in the sectors like customer service and healthcare but schools and universities have recently started integrating these applications into their operations. Due to this, ways in education institutions can be benefitted by IoT might be manifest but others are not as apparent (Aldowah et al., 2017). Therefore, investigating IoT applications in the context of higher education in this study will support educational institutes to determine the way in which they could shape the next generation learning. Also, the universities future is not just about employing and using the available technology, rather about their level of adaptation to changing needs of future of work, economy and future knowledge worker (Lent, 2018). In this regard, this study provides overview of IoT in higher education, determine emerging trends and explore possible impact of IoT on future education by exploring its likely challenges for the sector. Also, China was already leading in educational technology before the outbreak of pandemic and was the first nation experienced extensive quarantine and digital schooling (Feijóo et al., 2021). Therefore, evaluating here the Chinese experience of IoT applications in education field can provide relevant insights for other developed and developing nations to adopt their educational system in both hybrid and blended situations.

Moreover, the results of this study are assisting education sector, specifically policy makers in higher education sector to determine factors considered by students while accepting any new technology for their education purpose and ultimately, to improve learning for next generation. Also, the study is contributing to literature and knowledge by highlighting educational challenges of why not every student pursuing

higher education could harness the potentials of IoT and online learning benefits. The results here are offering insights to clarify the mindset of students toward needed educational technologies for their online learning. In this way, the results will assist practitioners, including IoT developers, educational institutes, marketers and other academic professionals to consider the mind-set of students while defining strategies and products for introducing IoT in education. Overall, this study is offering insights on IoT in university education, illustrating students' perspectives on adapting IoT as their learning tool and thus supporting institutions seeking practices and trends for skills and developments into work-based learning.

Significance of using SWOT and TOWS in this study

In addition to the theoretical contribution of applying the Unified Theory of Acceptance and Use of Technology (UTAUT) to IoT adoption in higher education, this study also offers practical value by translating empirical findings into actionable recommendations for universities. To achieve this, the study employs SWOT analysis and the TOWS matrix as complementary strategic tools. SWOT is used to synthesise key internal and external factors influencing IoT adoption (strengths, weaknesses, opportunities, and threats) based on the literature review and the study's empirical results. Building on this diagnosis, the TOWS matrix then converts the SWOT factors into structured strategy options (SO, WO, ST, and WT), which directly support the study's objective of proposing "full options" for IoT adoption in Chinese higher education institutions. As a result, the recommendations are not presented as generic suggestions; instead, they are explicitly grounded in identified benefits and challenges, contextual constraints (e.g., connectivity and security), and feasible implementation pathways for universities.

Table 1.1 SWOT analysis for IoT adoption in Chinese higher education

Strengths (Internal)	Weaknesses (Internal)
S1. Potential to enhance learning efficiency through smart learning environments (e.g., smart classrooms/smart campuses).	W1. Inconsistent network connectivity and infrastructure readiness can hinder stable use.
S2. Supports personalised learning and more responsive learning logistics.	W2. Data privacy and security management capacity may be insufficient for large-scale deployment.
S3. Clear perceived value can drive student acceptance (aligned with performance-related expectations).	W3. Uneven digital literacy and support resources may reduce adoption effectiveness.
Opportunities (External)	Threats (External)
O1. Rapid growth of IoT ecosystems and “smart campus” solutions creates scalable implementation opportunities.	T1. Rising cybersecurity risks and potential data breaches may reduce trust and willingness to adopt.
O2. Increasing demand for digital/IoT-related skills in the future workforce strengthens the relevance of IoT-based education.	T2. Digital inequality (access differences) may widen learning gaps if adoption is not inclusive.
O3. Technological advances (AI/automation/Big Data) enable richer learning analytics and campus services.	T3. Compliance pressures and public concerns over surveillance/privacy may constrain implementation.

Note. The SWOT analysis synthesises internal and external factors affecting IoT adoption in Chinese higher education. Items were derived from the literature review (Chapter 2) and the study’s empirical findings (Chapters 3–4) to support the development of practical adoption options.

Table 1.2 TOWS matrix: strategy options derived from SWOT

	Opportunities (O)	Threats (T)
Strengths (S)	SO strategies (use strengths to seize opportunities) SO1. Prioritise high-impact IoT use cases (e.g., smart classrooms and smart campus services) that deliver visible learning/efficiency gains to strengthen perceived value and accelerate adoption. SO2. Integrate IoT initiatives with employability-oriented digital skills development to align education outcomes with market demand.	ST strategies (use strengths to reduce threats). ST1. Embed privacy-by-design and security-by-design in IoT-enabled learning environments to protect trust and reduce cybersecurity concerns. \nST2. Set clear governance for data collection and usage transparency to address surveillance/privacy concerns.
Weaknesses (W)	WO strategies (overcome weaknesses by using opportunities). WO1. Phase implementation starting from infrastructure-ready sites; invest in connectivity upgrades and technical support before scaling. WO2. Provide user support and digital literacy training (students and staff) to reduce uneven readiness and improve adoption outcomes.	WT strategies (minimise weaknesses and avoid threats). WT1. Establish minimum security and compliance requirements (access control, data minimisation, incident response) before deploying campus-wide services. WT2. Adopt inclusive access measures (device support, on-campus access points, alternatives for low-access users) to prevent widening the digital divide.

Note. The TOWS matrix translates SWOT findings into actionable strategy options (SO, WO, ST, WT), supporting the study’s objective of proposing “full options” for IoT adoption grounded in identified contextual factors.

Research Question, Aim and Objectives

Research Questions

How to design the full options for adopting IoT in Higher education institutions?

Research Objectives

This research aims to investigate how IoT technology enhances the efficiency of Chinese higher educational institutions by conceptualizing the UTAUT model to measure the students' acceptance of new technology in their learning and development. The following objectives are developed in line with this aim:

1. To analyse the challenges and benefits of adopting IoT in higher education institutions in China
2. To analyse the application areas of IoT in higher education institutions in China
3. To design full options for adopting IoT in higher education institutions in China
4. To evaluate and design the UTAUT model

Research Framework

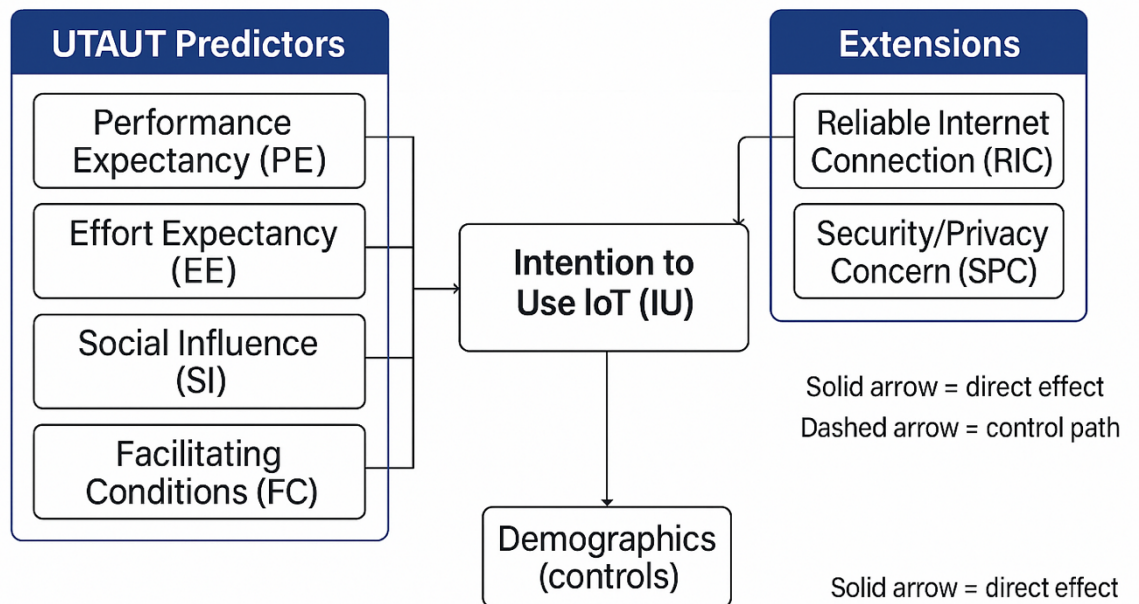


Figure 1.1 Conceptual model: UTAUT predictors and extensions for intention to use IoT.

Chapter 2

Literature review

Introduction

This chapter discusses available literature on the chosen topic provided by previous scholars. The purpose of completing this chapter is to gain deep insights and understanding on IoT use and acceptance in higher education by evaluating the opinions of different scholars. Also, the focus here is given on determining key gap in the existing literature to develop a conceptual model for this study and add new literature on the subject. Moreover, literature review is done to derive survey questions of this study and devise a hypothesis based on chosen variables to perform empirical testing. The most relevant literary data for this chapter has been extracted online by accessing scholarly journals and articles on Google Scholars and Science Hub.

IoT in Higher Education

According to Stoyanov (2017), the traditional knowledge-transfer model is shifting to an active self-directed, collaborative model, as technology is disrupting today's higher educational institutions. It is forcing many educational institutes and universities to rethink about their process of learning and teaching. The technical influence on education can be seen in several aspects, i.e., from engagement of students in content creation and learning to supporting teachers in giving personalised content and enhancing student performances (Bagarukayo & Kalema, 2015). IoT is considered as a subcategory of internet technology supporting education in distinct manners. Also, IoT solutions are allowing educational institutions to obtain wide data from wearable devices and sensors more easily and carry out meaningful actions on the basis of such data. The system even facilitates students to access learning materials and needed information anytime from anywhere using QR code,

embedded sensors and other technologies (McRae, Ellis & Ken, 2018). Thus, in this way, IoT helps in enhancing the learning capabilities of students.

According to Mishra et al. (2020), IoT in the educational sector has many contributions and brings correct meanings for the concept of smart education and smart learning. It is making the process of learning more interactive and interesting. IoT can even improve efficiency and accuracy to prevent errors that can be committed easily and thus, support learners in saving their valuable time. Aldowah et al. (2017) asserted that the key purpose of utilising IoT in education is developing an environment which support acquisition of knowledge in an effective, natural, and novel manner consistent with the expectations and needs of learners. The authors even claimed that higher education institutions are beginning to leverage cloud computing and RFID (radio frequency identification) through IoT technologies, able to manage and analyse Big Data. As per Zhiqiang & Junming (2011), application of IoT in higher education lies in three aspects: educational middleware development, current teaching platforms integration, and progressive evaluation of students. This is offering increased convenience to students and even making the overall process of teaching effective for professors and instructors. In this regard, authors claimed that the flow in technology and connected devices means that professors can concentrate on learning, which is useful for students than performing routine activities. Particularly, university students today are shifting away from textbooks to laptops and tablets, which is allowing students to learn at their convenience and have identical experience of learning in both homes and classrooms (Aldowah, Ghazal & Muniandy, 2015; Ghazal, Samsudin & Aldowah, 2015). Therefore, IoT in higher education is increasing satisfaction and progression rates and allowing instructors to deliver one-to-one instruction along with persistent assessments of students.

Application Areas of IoT in Higher Education

The following are some scenarios where IoT technology can be utilised in learning applications:

1. Smart classroom

As per Bajracharya, Blackford & Chelladurai (2018), IoT enabled classrooms can be utilised for evaluating and tracking effectiveness and performance of students. IoT devices in classrooms allow automatic monitoring of students' attendance. Also, using smartwatches, the safety of students can be monitored. According to Gligoric et al. (2015), IoT enabled smart classroom allow measuring students' interest level by monitoring their behaviour using microphones and cameras. Even IoT wrist bands utilised in such classes facilitate monitoring safety of students. Also, smart classroom system allows analysing impact of distinct parameters in physical environment, such as environmental noise, temperature and CO₂ level on the focus of students. Thus, it facilitates determining if optimised environment is presented for maximising ability of students to concentrate on a lecture provided in any given time. As per Bajracharya, Blackford & Chelladurai (2018), it ensures smooth running of facilities and enhance the extent of personalised active learning. Similarly, Aldowah et al. (2017) stated that textbook images and words and blackboard are too short for communicating and understanding concept. It results in conflicts of perception and creates confusions in the classes. Here, IoT applications, specifically smart board can be used to make information exchange and learning interactive, interesting and easy. Also, complex formulas in maths can be quickly solved by seeing tutorial videos and info graphics.

In smart classroom system, a flipped classroom (FP) model has also been introduced to facilitate students attend lectures at home, while complete homework in classroom with the support of group mates and instructors and participate in several activities and seminars held in the classes. In this model, the tutor prepares video lessons to share with students and then students prepare themselves on particular concept before participating in the classes. Accordingly, it facilitates tutor to use class time in measuring knowledge gained by students from videos (Moraros et al., 2015). This reflects a significant difference of FP from traditional classroom

model, i.e., FP provides students with an opportunity to learn their subject at any place and any time. Even they can pause video or replay it several times, if miss something (Zhamanov et al., 2017). The authors' statistical analysis also revealed that IoT based FP help students to achieve better results than traditional classrooms, i.e., FP students in average got 74.24% than students educated through traditional approach, i.e., 54.73% in average. Therefore, IoT implementation in universities as a part of smart classroom helps students and instructors to make learning easy and automate.

2. Artificial intelligence (AI) and big data

According to Chen, Chen & Lin (2020), AI enabling the development of robots to improve students' overall learning experience. Timms (2016) asserted that robots or cobots (college robots) work along with teachers and are being applied to teach routine tasks to students, including pronunciation and spelling, and adjust to their abilities. In this regard, Alam (2021) by gathering data on students has found that AI systems detect students learning shortcomings and allow them to address those weaknesses early in their education period. The authors even claimed that students in the conventional education system are mostly treated similarly but the same teaching practices cannot allow everyone to achieve the best performance. On the other side, AI allows tailoring teaching practice for each student based on their complementary skills, strengths, and personality and thus, improves their learning process and performance. Besides this, AI systems forecast each student's career path by collecting and studying big data that allow customizing the university course according to student's needs (Avella et al., 2016). Chen, Chen & Lin (2020) supported this by asserting that AI-based learning, as produces critical data from students can effectively find students' insights and predict critical competencies that can be pursued by them and ultimately, enable universities to act proactively. Thus, considering individual career paths and ability through AI, universities support students in improving skills applicable in real work situations and obtaining better grades.

By criticising above, Oravec (2022) discussed some negative impacts of AI, such as academic integrity degradation and cheating by utilising paper mill and paper churning services facilitated through AI. Also, AI implementation lacks appreciating the teacher's importance in education and so, creates negative and significant impact on the relationship between students and teachers as well as in between education and students. Consequently, the AI process exacerbating learn infixation process, as making teachers mere facilitators of education rather than someone with the proficiency of teaching others (Guilherme, 2019). Despite this, studies have mostly confirmed the benefits of implementing AI in education and so, its positive effects outweigh the negative effects. Overall, students using machine learning of AI are able to have rich learning experience.

3. Adjusting disability

Disabled face problems in learning and often technical advances have failed to support students with disability. Nevertheless, IoT proved beneficial for them, as hearing-impaired students can use laptops and connected gloves to convert sign-language into written form. This makes it possible for them to learn, perform and behave like other students (Alnahdi & Liu, 2017). Hollier & Abou-Zahra (2018) supported this by claiming that IoT offers a constructive way for disabled to get significant achievements. Moreover, Chin, Callaghan & Allouch (2019) claimed that all students are not same and so, specific ways of dealing with their learning, i.e., personalised learning can draw best out of their capabilities. For example, students with dyslexia are intellectually high or equivalent than their companions, still typical techniques of learning are not adequate for them to show their talent. Furthermore, it is impossible to teach them through textbooks and in such case, the tools like speech to-content programming allow them to use their voices for finishing composed assignments. Thus, IoT applications in such way implemented in different areas of education business model to benefit any students with smart and easy learning.

Moreover, disabled are usually not comfortable in certain learning environment, say well-lighted and low vs high room temperature, etc. and IoT

enables room adjustments for them as per their comfort zone (Hollier & Abou-Zahra, 2018). However, Abou-Zahra, Brewer & Cooper (2017) criticised that IoT systems currently tend to be closed with APIs (Application Programming Interface) and proprietary standards, which makes it difficult for customised assistive technologies to give access to disabled students. Furthermore, IoT systems might expose sensitive information to disabled than for others and so, application of particular tool specifically comes with privacy concerns for disabled. Also, safety and security concerns are high for disabled people, specifically in areas of commerce and healthcare where highly sensitive interactions usually occur. Nevertheless, Haouel, Ghorbel & Bargaoui (2016) found that IoT can monitor usage of devices easily in educational settings and so, allow teachers to analyse child-to-child effectiveness in utilising resources, like laptops, tablets, etc. Moreover, sensors which indicate occupancy and movement give useful information on how the labs, library, classroom and other learning materials have been utilised by the disabled students. Thus, if in case these indicators fail to offer positive analysis then alternative equipment or methods can be utilised to facilitate learning to the students.

Benefits of IoT in Higher Education

1. Personalised curriculum

One key advantage of IoT in education is that it facilitates unique and personalised interaction with students. It supports them to not just get academic topics and personal recommendations but also to resolve their learning difficulties by sending signals to administrators, when they struggle academically (Pervez, ur Rehman & Alandjani, 2018). Also, Govindarajan & Srivastava (2020) stated that IoT supports administrators to comprehend needs of students and provide them learning experience accordingly. Thus, IoT is benefiting students to have on their desk the personalised curriculum. As per Ramlowat & Pattanayak (2019), personalisation is possible through smart wearables allowing enough data collection to know the users' preferences and habits. Specifically, in education, such Big Data techniques offer a means for controllable, planned and quality training and learning

opportunities to the students. The key objective is to facilitate individualised solutions creation by considering students' characteristics to support them in defining their personalised curriculum and overcome difficulties and limitations throughout the process of learning. In this regard, Moreira, Ferreira & Cardoso (2017) claimed that teachers should not assume that each student begin at same time and practically follows the same course at same rate. Furthermore, the significant differences identified through data collection from sources, such as unstructured data from sensors and institutional databases is disrupting the current learning model to make it more personalised. The teachers using personalised learning can observe the students and find where they face difficulty in areas within the program, spend most of their time, learning styles they prefer, sections recommended to peers and particular time in a day they can learn best. Thus, IoT is facilitating personalised learning for students by determining adjustments needed in their curriculum sections.

By criticising the above literature, Tawalbeh et al. (2020) argued that student data collection and use in past couple of years has become more controversial. It is because the effectiveness of data-driven learning analytics to enhance learning of student competes with concerns about safeguarding privacy of students. Thus, difficulty in using student data is challenging the personalised learning. Bulger (2016) supported this by claiming that even without using the new technologies of data-driven learning, it is essential to realise that every environment of teaching in some manner is personalised. It is because interpersonal interactions on daily basis involve a range of personalisation, as people respond to the shifting moods of each other by reading their facial expressions. Similarly, teachers in classroom rely on these interpersonal cues along with their knowledge about how student learn, expertise on subject and knowledge about each student, to determine needs of individual and ultimately, adjust their lessons in response to students' behaviours. Also, teachers by walking around the classroom to monitor how students are working on assignment, provide personalised learning, as check on those challenging or struggling on completing the given work. Thus, personalisation in classes is not completely

dependent on technology, rather on comprehending the learning needs of students. Accordingly, below hypothesis is developed-

H1: Performance Expectancy creates positive effect on Chinese students' intention to use IoT in higher education.

2. Enhance efficiency

According to Bhide & Wagh (2015), it is essential to improve young people skills to prepare them for future. In this regard, capacities like, self-direction, learning proficiency along with basic reasoning can be enormously improve using IoT. In this regard, Houghton Mifflin Harcourt Team in their investigation uncovered that student who utilise tablets for learning Math can improve their score by 20%. It is because IoT applications provide individual interactive experiments to upgrade the student's efficiency. Even by utilising the technology in smart classroom, the learning process can become more interesting and enhance both teachers and students' productivity (Mehmood et al., 2017). Alhaboobi, Yousif & Shawkat (2019) suggested that smart objects can be utilised in classrooms to enhance learning and teaching. The authors even discussed that IoT enable virtual and remote learning for students, optimise campus and classroom environment, add in students' safety and healthy as well as save resources and energy. However, Tawalbeh et al. (2020) faculty and students require dealing with various privacy and security challenges, due to wide data flow between them and thus, put their security at risk. Another challenge is that implementing IoT applications require using different devices and so, huge investment by universities and even students individually. Moreover, effective administration of such devices requires a lot of efficiency and accuracy (Bagheri & Movahed, 2016). Despite this, authors found role of IoT in enhancing the effectiveness of education system, greater flexibility and in creating further revenue stream and business opportunities for students. For instance, research in Columbia showed improvement in learners through incorporating IoT. Moreover, IoT enhances and eases the education quality (Pai, 2017; Niyato et al., 2016; Tan et al., 2018). Therefore, IoT in education support, boost and inspires lifelong study of students. Accordingly, below hypothesis is developed-

H2: Effort Expectancy creates positive effect on Chinese students' intention to use IoT in higher education.

3. Social Influence

As per Ramlowat & Pattanayak (2019), IoT facilitates global networking among the students, guardians, teachers and mentors through connected devices. The blurb sheets as converted into IoT empowered sheets, 'canny', which resulted in emergence of advanced highlighters. This is allowing students to communicate easily with their peers and tutor from their respective places. Moreover, Hasan & Akter (2020) believe that it is possible to enhance learning process using the interactive boards and virtual posters, which enable users to easily recognise, receive and share the data. Gomez et al. (2013) also provided one more benefit of IoT in education, i.e., it offers more wide position to any ideas, while motivating students to think and dissect their inventive arrangements. In this regard, Pervez, Rehman & Alandjani (2011) claimed that applications utilise in current e-learning environment, such as Apple's iPods, smart phones, PCs or tablet are integrated with 5G, 4G telecommunication networks and Wi-Fi allow students to access learning materials and support or collaborative in fieldwork without any restrictions on location and time. As per Algozani & Aleryani (2018), students using mobile devices cooperate with their friends on projects and access different Social Influence sites to achieve progress in their academic programs. The networking sites even allow instructors to share knowledge with students. Also, facilitate students to interact with other teachers at different locations to know and learn about their distinct perspectives on subjects (Mealha, Divitini & Rehm, 2018). Thus, IoT enabled the use of Social Influence and mobile applications in higher education and so, facilitating students to collaborate with wide network for their learning and enhance skills. Accordingly, below hypothesis is developed-

H3: Social Influence creates positive effect on Chinese students' intention to use IoT in higher education.

Challenges of IoT in Higher Education

1. Security and privacy

Recently, IoT has been subject to cybersecurity threats and privacy concerns in education system. Even though IoT devices simplified learning and teaching methods, some serious questions arise in front of IoT device deployment, such as accountability, security, and privacy (Bhide & Wagh, 2015). According to Hasan & Akter (2020), implementing effective cyber security practices is difficult for many institutions when striving to share relevant information to the students. When cybersecurity practices are compromised, it creates an opportunity for hackers to leak sensitive student data such as names, email addresses and phone numbers of students, which increases cybersecurity concerns in institutions. In this regard, Tawalbeh et al. (2020) claimed that cybersecurity and privacy is a significant issues increasing in education centres because people governing the system do not spend enough time and resources securing huge volumes of information. At the same time, when IoT software are weak, students' data is vulnerable to malware attacks as IoT devices are extremely unguarded. Consequently, the sophisticated security of IoTs in education system requires serious awareness of devices that can protect students and institutions from being a victim of malware attacks (Ramlowat & Pattanayak, 2019). Also, the coming years will notice tremendous growth in number of IoT connections, however, increasing security awareness and IoT privacy is paramount in the education system to mitigate threats concerning security and privacy. Thus, educational institutions by providing insightful information on data security will be able to support students in analysing the possibilities of their devices getting exposed to various threats.

In the above context, Hollier & Abou-Zahra (2018) claimed that security and privacy are major challenge in education system due to the increased communication and complexity of IoT technology. The growing number of cyber malfunctions and internet attacks are posing the biggest threat to students' privacy in the education system. Similarly, Guilherme (2019) found educational systems as the largest source of data breaches and external attacks due to poorly secured

communication. Data storage is also directly linked to IoT security issues in education because schools, colleges and universities have a large amount of student and other data that needs to be stored and organised in IoT devices. Inadequate and outdated software can make data unstable and easy to get exposed (Moreira, Ferreira & Cardoso 2017). Therefore, it can be said that before adopting IoT devices for learning and teaching purposes, institutions need to check for technology solutions that not only secure IoT devices but also provide network visibility to learn and maintain effective communication between teachers and students. Accordingly, below hypothesis is developed-

H4: Security and privacy creates positive effect on Chinese students' intention to use IoT in higher education.

2. Reliable internet connection

For effective implementation of IoT devices in the education system, educational institutions must have reliable internet connection that connects digital devices to empower collaboration and communication within a classroom (Zhamanov et al., 2017). However, Alnahdi & Liu, (2017), found that IoT devices are equipped with major connectivity challenges such as interoperability, maintainability, signalling, bandwidth, and power consumption. Interoperability is a prime issue in education system because students need easy-to-connect and easy-to-use devices for understanding lessons taught in the class. Nevertheless, unreliable internet connections and interoperability challenges results in the inability to connect devices that can work together in a desired manner. In this regard, Pervez, Rehman & Alandjani (2011) argued that smart devices used for educational purposes are designed in a way that can notify potential issues to the user before shutting down. Despite this, self-management and maintainability challenges often lead to network failure while installing IoT devices in institutions (Govindarajan & Srivastava, 2020). Therefore, maintainability is a vital requirement for smart devices that reflects the reliability of internet connections in any work setting.

According to Cardoso et al. (2022), the internet connections and functions of IoT devices are often disrupted due to failing nodes and tired batteries that offer

limited energy resources and lower operational quality. Consequently, supervising effectiveness of IoT devices is significant to manage the subsystems implemented for teaching and learning. As per Bagarukayo & Kalema (2015), signalling is an important parameter for detecting reliability of internet connections in bidirectional IoT devices. However, Alam (2021) suggests that non-reliable connectivity has disabled collection and routing of relevant information between multiple smart devices that not only results in signal loss but also disturbs the network mesh required to exchange information across the institution. In this context, Akter et al. (2018) proclaimed that to ensure reliable network settings, institutions must consider Wi-Fi standards and high bandwidth signals necessary to transfer data from one point to another. Failure to adopt high bandwidths and Wi-Fi signals increases the chances of signal loss causing networks to lose its range and reliability in the teaching process. Similarly, Aldowah, Ghazal & Muniandy (2015) highlighted power consumption as a significant challenge in IoT connectivity. The devices connected in IoT enabled smart education system should determine best timetable to operate them, so that higher efficiency in power consumption is offered to the students. However, standard Wi-Fi connections and Bluetooth range causes maximum battery damage resulting in high power consumption (Timms 2016). In this regard, Chen, Chen & Lin (2020) believe that by designing battery-friendly network systems that operate on less energy, institutions can deliver the best teaching experience to the students. Nevertheless, a standard base supporting interoperability, maintenance, and less power consumption in IoT devices requires years of innovation and testing to provide a solution for reliable internet connections in IoT devices. Thus, it can be said that operations of IoT devices greatly depends on reliable internet connections, therefore institutions should install high bandwidth connections and WiFi signals to offer a great learning experience to the students. Accordingly, the below hypothesis is developed-

H5: Reliable internet connection positively affects Chinese students' intention to use IoT in higher education.

3. Lack of experience of using IoT in education

As per Almaiah et al. (2022), a psychological construct defined as experience can be considered as an inner motive that comprises fulfillment and fun. The extant scholars who combined perceived experience with the Technology Acceptance Model revealed that individuals when have good experience of using any technology then ultimately, adopt it in their real life. This means, the on-time experience can significantly anticipate the perceived ease of use and perceived usefulness (Tsybulsky & Sinai, 2022). In this regard, Kassab, DeFranco & Laplante (2020) have claimed that people when believe that it is easy to use certain technology then their presumption allow them to make freely use of the technology without putting much work or thought. Also, it occurs anytime when an experienced user regularly interacts with the technology that create a welcoming and comfortable atmosphere. However, Momani & Abualkishik (2014) by investigating the adoption level of mobile users for MMS have found a significant impact of ease of use but no direct and significant impact of perceived experience on users' adoption of MMS. Thus, the authors confirmed previous experience as least frequent variables from their study. On the other side, Allen & Seaman (2013) described holistic experience with the cognitive absorption concept that can be seen best by its manifestation in the degree of involvement of user with video games and internet. The existing studies have confirmed positive outcomes on technology adaptation and use through such type of engagement (Agarwal & Karahanna, 2000; Saadé & Bahli, 2005). Therefore, behaviour of a personal toward new IT is shaped through holistic experiences.

In addition, Marks and Al-Ali (2022) have revealed that one of the important challenges in adopting IoT in higher education is lack of availability of critical IT competencies and skills among the staff. The authors found that IT staff when does not have previous experience of using technology in education and teaching purpose then prefer more English-based curricula, traditional education systems and operations. In the same way, many IT directors and managers sometimes do not have high technical or educational experience to establish an overall digital transformation plan and vision and thus, fail to integrated IoT in students' education.

Similarly, Alhasan et al. (2023) provided that limited e-learning experience of students may influence their self-confidence and ability of utilising IoT in smart classroom. The finding is supported by Alhasan et al. (2023), who confirmed that perceived ease of use (PEoU) of any technology play an important role in positively influencing users' behaviour to use the technology regularly. But Ashraf et al. (2014) have only partially supported the finding as their study produced no significant impact of PEoU on the regular use of any technology in the education. The authors even provided that many technologies have been integrated into the education field in recent years but not all of them have implemented with proper planning. Due to this, students may experience difficulties in using such technologies in their routine learning. Therefore, such type of challenging experiences may create complexities of adopting IoT in education. Accordingly, below hypothesis is developed-

H6: Lack of experience of using IoT in education creates positive effect on Chinese students' intention to use IoT in higher education.

UTAUT Model

The UTAUT (unified theory of acceptance and use of technology) model is used in this study, as it is key methodological framework to know the intention of using certain technology. Venkatesh, Thong & Xu (2012), proposed the model for explaining user's predisposition and behaviour of using any technology. The authors proved that the model can explain around 70% of technology usage and so, its basic structure was applied by many scholars as a useful tool to evaluate several emerging technologies adaptation level by users. The main elements of UTAUT have been extracted from eight distinct theoretical frameworks which support in model's central construction: effort expectancy, performance expectancy, social influence and facilitating conditions (Romero-Rodríguez et al., 2020). In this study, these constructs will be adapted to IoT in higher education. For instance, UTAUT will be used for investigating students' acceptance of using diverse applications including tablet computers, web-based technologies and smart watch, etc. Thus, all the dimensions

of UTAUT are properly contextualised for the research model of this study with the central topic.

1. Performance expectancy

Performance expectancy (PE) is similar to relative advantage of Innovation Diffusion Theory (IDT) and TAM's (Technology Acceptance Model) perceived usefulness (Martins & Oliveira, 2014). As per Lee & Shin (2019), PE is considered as user expectations about degree to which utilising any technology will provide them benefits. Here, in the IoT in education context, PE is referred to an extent to which using IoT technologies perceive by students will enhance their academic performance and productivity. This means, students will accept using technology in their studies when feel that it will result in improvement of their overall performance. For instance, Almetere, Kelana & Mansor (2020) assumed that students with Dyslexia will use interactive and smart objects if they their visual and auditory skills will be enhanced. Some past scholars found that PE always create positive impacts in defining use behaviour of IoT in distinct contexts of study (Madigan et al., 2016; Guest et al., 2018; Bharati & Srikanth, 2018). Moreover, the scholars focusing on online services in their study have found that PE is the strong indicator in predicting online services use by students (Mou et al., 2016; Lin et al., 2014). However, Shaqrah & Almars (2022) by collecting data from Taibah university students and by quantitatively examined them using PLS-SEM software have found weak effect of PE on adoption of IoT by students. Similarly, Nizar et al. (2019) have found no significant relationship between PE and intention to use IoT by university students. In this context, Shaikh et al. (2019) also found believing that value of IoT in education is subjective and determined through the way in which customers want to adapt with IoT. Consequently, those who do not foresee or value any advantages from physical hardware use in education are most probably consider IoT as possibly destructive and superfluous. Accordingly, it can be assumed that desires of users about value of IoT capabilities acknowledgement in their study will influence its wide level of integration in higher education institutions of China. Therefore, the following hypothesis is developed to be tested in this study:

H6: Performance Expectancy creates positive effect on Chinese students' intention to use IoT in higher education.

2. Effort expectancy

Effort Expectancy (EE) is defined as an extent to which a person believes that using any given technology is effortless (Venkatesh, Thong & Xu, 2012). Accordingly, EE in this study is considered as a degree to which Chinese students feel using IoT is free of effort. Some previous scholars confirmed strong relationship between use behaviour and EE (Guest et al. 2018; Bharati & Srikanth, 2018; Nur, Faslih & Nur, 2017). The direct relationship between these two variables has also proven in the research of Lin et al. (2014) and Shang and Wu (2017). The authors asserted that EE or perceived ease of use is the key determinant of users' satisfaction in using any mobile application and online service. Similarly, Lee & Shin (2019) have found that the more effort spends by a user in using IoT, the less possible they will adopt and use the particular technology. Thus, existing literature is extensively indicating that when a person considers using any given technology as easy and effortless then their likelihood of using the technology

is usually high. However, some scholars criticised by showing insignificant relationship between use behaviour and EE of IoT (Madigan et al., 2016; Paulo et al., 2018; Maillet, Mathieu & Sicotte, 2015). Similarly, Yusof, Qazi & Inayat (2017) have collected data from 132 students, where 46 were belonging from Sultan Zainal Abidin University and 86 from Sultan Idris Education University of Malaysia and found that EE effect is more on female students than their male counterparts in the universities. Thus, inconsistent findings available on the variables call here to carry out further investigation on the issue by testing following hypothesis:

H7: Effort Expectancy creates positive effect on Chinese students' intention to use IoT in higher education.

3. Social influence

Venkatesh, Thong & Xu (2012) referred Social Influence as perception of an individual that a group of people important to him/her think he/she should not or should perform certain behaviour. In this regard, Nizar et al. (2019) asserted that

superiors and peers are the groups closely associated to social influence in the context of IoT in education. By referring to this, SI in the following study is considered as a degree to which Chinese students perceives pressure from their teachers and peers in the learning environment influence their use of IoT applications and tools in higher education. Moreover, previous scholars found both positive and negative relationship between use behaviour and SI of proposed technology. For instance, drawing on UTAUT model, Hamari & Koivisto (2015); Nur, Faslih & Nur (2017); Maillet, Mathieu & Sicotte (2015) have found positive impact of colleagues and friends influence on a student's decision of using IoT in education. Similarly, Abdullah and Ward (2016) through their meta-analysis findings have concluded that 27 out of 32 researches referred in the study confirmed SI relationship in determining any given technology use. Bharati & Srikanth (2018) and Paulo et al. (2018) however, found no positive relationship between SI and use behaviour of IoT. The participants of authors study revealed that students' perception of using IoT in education is influenced by the decision of another person. Similarly, Yusof, Qazi & Inayat (2017) have confirmed no significant impact of SI on students' behavioural intention of using IoT in education by testing participants results through structural equation modelling, as the results reflected R² value = 0.004. The authors even asserted that the adoption process of certain technology take place when harmony between several factors together influence human behaviour. But it is complex practice that comprises social factors directly affect whether the subject (students and teachers) interacts with IoT. Despite this, Shaqrah & Almars (2022) claimed that IoT integrated smart education system will support iLearning by influencing students to learn advanced technologies. Also, it will help iSocial by offering a safe environment for professors and students to communicate with each other. Accordingly, the authors support key role of SI in increasing acceptance of IoT by students. Based on these literary findings, this research hypothesised that:

H8: Social Influence creates positive effect on Chinese students' intention to use IoT in higher education.

4. Facilitating conditions

According to Venkatesh, Thong & Xu (2012), Facilitating Conditions (FC) is perception of individual towards needed technical infrastructure to support the use of current technology. In the context of this study, FC is referred to perceived level of students towards IoT tools and applications assistance to support their use behaviour of advance technology in education. Lin et al. (2014) have extended TRA (Theory of Reasoned Action) model to perceive the m-commerce service use. The authors confirmed that perceived risk is the main factor in influencing m-commerce uses and their findings revealed positive relationship between the variables. In this regard, Shang & Wu (2017) also asserted that perceived value creates strong influence on satisfaction of customers while using m-shopping with β value for the construct in their study was generated as 0.997. In both the studies, perceived value and perceived risk bring equal meaning to FC determinant. Some previous scholars have also found significant relationship between the given variables (Paulo et al., 2018; Guest et al., 2018; Madigan et al., 2016). On the other side, Bharati & Srikanth (2018) found insignificant relationship of FC with Electronic Patient Record (EPR) use. Thus, given the inconsistent findings available on the particular determinant, further investigation is needed. Accordingly, the following hypothesis is developed to be tested in this study:

H9: Facilitating conditions creates positive effect on Chinese students' intention to use IoT in higher education.

Research Gap

Despite the growing global interest in the Internet of Things (IoT) within educational environments, existing research has largely concentrated on its technical functionalities or its implementation in Western contexts. Numerous studies have explored the potential of IoT to improve learning outcomes, administrative efficiency, and institutional decision-making processes (Gupta et al., 2021; Chen et al., 2021). However, there is limited empirical evidence concerning how these technologies are

perceived and adopted by end-users, particularly students, within the specific sociocultural and institutional framework of Chinese higher education.

Most notably, while the Unified Theory of Acceptance and Use of Technology (UTAUT) has been widely applied in studies assessing technology adoption in various domains, its application in the context of IoT adoption among students in China remains scarce. Prior research in China has either focused on infrastructural readiness or managerial perspectives (Zhou & Li, 2020), often overlooking student-centric viewpoints which are crucial to the successful integration of IoT in learning environments.

This research therefore seeks to fill this critical gap by applying a conceptualized UTAUT model to examine the factors influencing student acceptance of IoT in Chinese universities. By focusing on this underexplored demographic and contextual setting, the study contributes not only to the theoretical development of UTAUT in educational technology but also provides practical insights for institutional leaders aiming to deploy IoT-driven strategies effectively.

Chapter 3

Research Methodology

Introduction

Research refers to a process of resolving a particular issue by searching, observing and examining the information available from various sources (Saunders, Lewis & Thornhill, 2009). The methodology of the research is a process of selecting the correct research methods and techniques to find out the solution of the problem (Bryman, 2003). Considering the nature of the study that seeks to assess the link between various variables, a scientific technique has been employed for the data collected via survey method. Further, in the case of qualitative data, interview method was used and the collected data were analysed using the thematic analysis method. Thus, the present research has been designed as mixed method research design and in line with the same; pragmatism philosophy and abductive approach have been adopted and justified. Apart from this, since the nature of the research requires insights from the students; hence, primary data have been collected from the students of different universities. These all methods have been selected and justified by referring to Saunders' research onion.

Research Framework

Research Philosophy

The research philosophy refers to a system of thoughts of the researcher, by following which reliable and new knowledge about the object of the research is obtained (Chawla & Sodhi, 2011). A set of assumptions made by the researcher at various points assists the researcher to answer the research question and applied methods. Thus, consistent and correctly established assumptions enable the researcher to select the right data collection and analysis methods (Crossan, 2003). There are mainly three types of philosophies namely positivism, interpretivism and pragmatism philosophy. In the case of positivism philosophy, objectives findings are

derived wherein the scientific tools are preferred by the researcher. However, this philosophy lacks the rich view of realities and differences in the individual experiences (Bryman, 2003). Yet, in the present case, the analysis of the experience of Internet of things by Chinese students will demand both generalised findings as well as different individual experience. Owing to this, pragmatism philosophy involving both quantitative data to justify existing conditions of uses and acceptance of internet of things and qualitative data to analyse the students' perceptions about area of implementation. The pragmatism philosophy includes an empathic stance with the use of existing knowledge of the researcher and exploring existing studies on the same topic (Saunders, Lewis & Thornhill, 2009). Also, the pragmatic philosophy incorporates the operational decisions based on 'what will work best' to find out the answers of the research questions and enables the researcher to conduct the research in an innovative way (Wilson, 2014). Likewise, in the current case, to understand some facts in its original form whereas making interpretation of some qualitative information is required. Moreover, the pragmatism philosophy focuses the research question and merges various methods according to differently set objectives (Saunders, 2014). At this point, challenges and benefits have been examined by using positivism philosophy whereas application areas of IoT and intention of the students require interpretation of the researcher. Therefore, pragmatism philosophy has been considered appropriate for the issue under consideration.

Research Approach

The selection of right research approach is essential as it drives the overall success and quality of the ultimate outcomes and conclusion. The research approach is segregated into three types, deductive which is suitable for quantitative research, inductive that is preferred for qualitative research and abductive which provides a mixed stance (Bell, Bryman & Harley, 2022). The abductive research approach focuses on in-depth exploration of secondary data as well as critical examination of collected primary data. Thus, this approach tends to allow for the creativity and intuition to understand generalisable and specifics of the observed phenomenon (Bryman, 2016). The current research demands both objective as well

as subjective approaches; thus, the investigation requires research initiation from specific investigation and exploring the literature review to testing the existing theories (Reyes, 2004). At this point, interview of first 10 students provide specific information about application areas. Also, beginning the research with the literature provides an idea to formulate correct survey strategy to test the existing theories. This also assisted the researcher to develop new theory based on what Chinese students feel and perceive about implementing IoT in their study (Saunders, Lewis & Thornhill, 2009). In this relevance, being an active part of the research, the researcher carried out the interviews to understand the respondents more precisely. The gained knowledge by this could be applied in scientific verification (Bryman, 2003). Thus, both deductive and inductive approaches applied together and accordingly, using abductive approach is correct and justifiable.

Research design

There are mainly three types of research design namely qualitative, quantitative and mixed method research design (Saunders, 2014). The mixed method research design combines both qualitative as well as quantitative research design (Creswell & Creswell, 2005). In this context, Saunders, Lewis & Thornhill (2009) asserted that the mixed method research design tends to enhance confidence, reliability and validity by addressing the limitations linked with sources of the data or sample. Likewise, the mixed method research design assists in a more effective way to find out the benefits and challenges affecting the perception of the Chinese students to accept artificial intelligence and internet of things in their study. This is due to the fact that qualitative design facilitates to explore the untapped issues by interacting with participants (Bryman, 2003). In a similar vein, this design has been used to understand overall perception of Chinese students about artificial intelligence and advanced technology in their study. Apart from this, quantitative investigation has been conducted to examine the gathered data from large sample whereas deep and detailed insights accumulated via the interview assisted the researcher to uncover the real perceptions and intentions of students (Bell, Bryman & Harley, 2022). Thus, the issue linked with both data collection method is set off by

each other and mixed method research design is found significant for the issue under consideration.

Research strategy

According to Kapur (2018), the research strategy refers to an action plan which is completed by following required steps and gives an idea to the researcher's thoughts to carry out the research comprehensively. On this note, interview, survey, observation, grounded theory and experiments are major research strategies. The interview method is generally preferred where the researcher access small sample to extract the detailed information. Also, the interview design provides insights of untapped issue by interacting with participants directly. However, the interview method is costly and time consuming as the researcher needs to set up and ensure overall plan for collecting the data (Creswell & Creswell, 2005). According to Saunders & Thornhill (2011), survey research strategy is used to overcome the shortcomings of interview method and approaching a large sample size. The survey research strategy helps to quantify the outcomes by which overall credibility and generalisability can be increased. At this point, the perceptions of students about application areas of IoT in higher education demands deep insights directly from students. For this purpose, interview strategy is suitable. Yet, the benefits, challenges associated with the uses and implementation of IoT demands the collection of data from more people so that different benefits and challenges could be uncovered. Further, the analysis of the views and past experience of the students is essential to know the actual benefits and challenges of IoT. At this point, Bryman (2003) stated that survey strategy helps to get insights from large sample and experiences of individuals. Therefore, in line with the mixed method research design, survey and interview research strategy have been used and found appropriate for the current research.

Research Sample and Procedure

Data collection methods

The data collection is a prominent part of the research process wherein the researcher gets sufficient evidences for the research. For conducting an empirical research two types of data are used namely primary and secondary (Ghauri, Grønhaug & Strange, 2020). The primary data is first hand data directly collected by the researcher by approaching participants. The primary data is significant to examine the personal views and perceptions of individuals and provides accurate information to address research problem (Flick, 2015). Another method is secondary data collection which is collected from existing sources. However, the secondary data is available based on the objectives of other people. Yet, the research under consideration aims to examine and evaluate the perceptions of Chinese students about adopting and implementing the internet of things. This reflects that the insights from Chinese students are necessary to accomplish the set aim and objectives of the study. At the similar stance, the detailed discussion with Chinese students provides valid and realistic information required for the current study. Thus, primary data have been collected through the application of interview and survey method.

In order to collect data from interview, semi-structured interview of participants has been carried out to find out why Chinese students decide to adopt and prefer the internet of things. Questions were asked about their opinion regarding uses and implementation of artificial intelligence and other technology in higher education. These questions have directed the researcher to accumulate deep insights by areas of implementing the IoT (Saunders & Thornhill, 2011). In this context, Dearnley (2005) asserted that semi-structured interview enables the researcher to follow a systematic framework which contributes for the trustworthiness and objectivity of the research. This is also effective to make the outcomes more fruitful by justifying the significance of the questions asked by respondents while interview is going on. On the other side, survey has been conducted to access the data from Chinese students and to carrying out a

comparative study. Flick (2015) stated that interview method provides richer view of constructs being studied and in-depth insights assisted to understand the respondents' perceptions effectively. The interview method and survey method enabled to collect large amount of data for the present research (Bryman, 2003). The survey method is also imperative to derive valid, generalised and applicable findings. This is due to the fact that insights from the students are missing in the present literature; thus, the large sample inclusion from majority of participants is necessary. On this note, Saunders, Lewis and Thornhill (2009) believed that survey method is cost and time effective as it allows the participants to provide data as per their convenient. Further, the online survey tends to save huge cost and amount by directly sending the questionnaire link to the respondents which resists the direct interaction of the researcher with large number of students (Andrews, Nonnecke & Preece, 2007). Also, Chinese people are technology friendly and prefer the social media frequently; therefore, collecting the data via online survey has been considered more feasible.

Sample design

The target population for this study consists of university students currently enrolled in higher education institutions across Shanghai, China. The focus on Shanghai was determined by the city's leading role in educational modernization and smart campus initiatives supported by both local and national policies. In this study, the sample size has been determined based on the specific objectives, ensuring that the data collected is both representative and comprehensive. Given an estimated population size of approximately 50,000 students in the target context, the minimum sample size for the questionnaire survey was estimated using Yamane's simplified formula for finite populations:

$$n = \frac{N}{1 + N(e^2)}$$

where N is the population size and e is the acceptable margin of error. Using a conventional precision level of 5% ($e=0.05$), the required sample size is approx 397.

$$n = \frac{50000}{1 + 50000(0.05^2)} \approx 397$$

To account for potential non-response, incomplete questionnaires, and data screening, the target sample size was increased; therefore, 408 valid student responses were retained for analysis.

To account for potential non-response, incomplete questionnaires, and data screening, the target sample size was increased. A total of 501 student questionnaires were collected, of which 408 were retained as valid responses after data screening and cleaning. This final valid sample size exceeds the estimated minimum requirement (≈ 397), supporting adequate statistical power for the planned analyses. To ensure comparable representation across institutions during data collection, questionnaires were distributed across five participating universities with approximately 100 respondents per institution: Shanghai Industrial and Commercial Polytechnic ($n = 104$), Shanghai Zhongqiao Vocational and Technical University ($n = 99$), Shanghai Jiaotong Vocational and Technical College ($n = 98$), NYU Shanghai ($n = 103$), and University E (anonymous, by request) ($n = 97$). The final number of valid responses per institution may vary slightly due to incomplete items and exclusions during data cleaning.

Quantitative analyses were performed to summarise response patterns and test the proposed relationships. Descriptive statistics were first computed to summarise central tendency and dispersion (mean, median, mode, and standard deviation). Frequency analysis was then used to report response distributions for key items. Finally, regression analysis was conducted to examine the effects of UTAUT factors on students' intention to use IoT in higher education.

According to Flick (2015), the right sampling design selection is prominent in research, which enhances the reliability and validity of the findings. The right

sampling design enables the researcher to reach right conclusion or outcome. The sampling design refers to the procedure of finding the individual unit of the population which offers rich insights for the research. Creswell & Creswell (2005) asserted that a correct sample size helps to find a representative population and collect data to achieve aim and objectives of the research. In this context, two sampling designs namely probabilistic and non-probabilistic techniques, are employed. The sampling design is chosen based on the availability of time, nature of research, and availability of resources. Saunders, Lewis & Thornhill (2009) stated that in probability sampling, every respondent gets a fair and equal chance of the selection and this design is significant in the case where the researcher has fewer specifications about the population. For instance, the current research is based on the experience and perception of the students; hence, all the students need to be provided equal chance of being part of the study. This helps the researcher to complete the study ethically where different students can offer their views and opinions. On the other side, Vehovar, Toepoel & Steinmetz (2016). asserted that non-probability sampling design is selected where the criteria of respondents are specific like people of a specific experience or specific demographic profile are approached.

In continuance to above, since the present study aims to analyse the benefits, challenges and perceptions of students in terms of IoT; hence, consideration of different students' viewpoints is necessary. Owing to this, a non-probability sampling approach with approximately balanced representation across universities was adopted for the survey, while tutors were recruited based on availability for interviews. This sampling design is suitable for both types of participants including tutors and students for interview and survey respectively. It is because all tutors have knowledge about the processes and aspects which can help students learned in a better way. Therefore, all teachers of university had chances to be part of the study. However, researcher selected any seven tutors based on easy availability. The Chinese context has been selected and the non-probability sampling design is not feasible because students from different universities were approached.

Further, the different universities students might experience positive returns whereas other might found it less effective. Owing to this, approaching students from different universities is justifiable. In this relevance, Creswell & Creswell (2005) asserted that simple random sampling technique provides more ethical insights because all participants have equal chance of being selected. Furthermore, Saunders & Thornhill (2011) stated that the non-probability sampling is generally preferred in the cases where it is not possible for the researcher to approach people randomly due to lack of time and resources. Yet, the possibility of unwanted effects and biases exist in the case of non-probability sampling techniques. Considering this, simple random sampling technique has been used to avoid biases and collect required data.

A total of 408 students were selected for the survey, while 7 tutors participated in interviews. The rationale for this sample distribution is as follows: To analyse the challenges and benefits of adopting IoT in higher education institutions in China

A survey was conducted among 408 students to capture a broad range of perspectives on the benefits and challenges associated with IoT in education. In addition, 7 tutors were interviewed to provide expert insights into how IoT affects teaching and administrative processes.

The main research instrument used in this study was a structured questionnaire consisting of two parts. The first part collected demographic data such as age, gender, academic level, and field of study. The second part included 30 items measured on a 5-point Likert scale (1 = strongly disagree to 5 = strongly agree). These items were adapted from validated UTAUT constructs: Performance Expectancy, Effort Expectancy, Social Influence, Facilitating Conditions, and Behavioural Intention to Use IoT.

To ensure content and face validity, the questionnaire was reviewed by seven academic experts with specialization in digital education, IoT systems, and educational technology. The selected experts were affiliated with universities and research centers in Shanghai, and their expertise ensured that the questionnaire was suitable for the cultural and educational context of Chinese higher education.

The seven appointed experts included:

1. **Dr.Wang Minghao** – Associate Professor, Educational Technology, East China Normal University; expert in digital pedagogy and smart classrooms.
2. **Prof.Li Yunfei** – Professor, Education Policy and Digital Innovation, Shanghai Jiao Tong University; specialized in large-scale educational transformation.
3. **Dr.Zhang Qiaoling** – Assistant Professor, Instructional Technology, Fudan University; focused on adaptive digital learning systems.
4. **Dr.Chen Lei** – Senior Lecturer, IoT Systems and Applications, Shanghai University; background in device integration in education.
5. **Dr.Sun Xiaoxue** – Lecturer, Digital Education and User Experience, Shanghai Normal University; expert in e-learning interface design.
6. **Dr.Xu Weiguang** – Researcher, Shanghai Institute of Educational Sciences; conducts policy impact studies and educational innovation analysis.
7. **Dr.Huang Yifan** – Senior Fellow, China Digital Education Lab (CDEL); research interests include UTAUT model applications and IoT-based learning.

These experts were selected through academic networks and professional affiliations. Each reviewed the instrument for clarity, relevance, and technical appropriateness. Their feedback led to minor revisions in wording and item flow to improve respondent comprehension.

The selection of 408 students ensures statistical representativeness, allowing for generalizable conclusions, while tutor interviews add depth and expert validation to the findings.

To analyse the application areas of IoT in higher education institutions in China

The 7 tutor interviews played a crucial role in identifying the key application areas of IoT in higher education, as tutors are more familiar with its pedagogical and administrative uses.

The 408-student survey supplemented this by gathering feedback on students' experiences with IoT applications, ensuring that the research reflects both theoretical and practical perspectives.

To design full options for adopting IoT in higher education institutions in China

This objective required a mixed-method approach, incorporating both quantitative data from students and qualitative insights from tutors.

The 7 tutor interviews provided expert opinions on how IoT can be integrated into educational settings, while the 408-student survey offered empirical data to assess the feasibility and acceptance of different IoT adoption strategies.

Quantitative techniques such as regression analysis and frequency analysis were applied to validate the effectiveness of the proposed framework.

To evaluate and design the UTAUT model

The 408-student survey was the primary data source for this objective, as the UTAUT model is designed to assess users' behavioural intentions toward adopting new technology.

Regression analysis was conducted to examine the impact of key UTAUT variables—such as performance expectancy, effort expectancy, social influence, and facilitating conditions—on students' intention to adopt IoT.

This sample size allocation ensures that each research objective is adequately addressed with an appropriate mix of qualitative and quantitative data. The combination of wide-scale student participation and expert input from tutors enhances both the reliability and depth of the research findings, making them more robust and applicable to the broader academic community.

Time Horizon

According to Armstrong (2001), the time horizon reflects the time period in which the researcher is interested in studying the population. The researcher determines the time horizon based on the research objectives and type of investigation. There are mainly two types of time horizons namely cross-sectional and longitudinal. The cross-sectional method of time horizon is employed when the

data is collected for one time only. On the other side, Weikum et al. (2011) stated that the longitudinal time horizon implies data collection more than once. In the case of a longitudinal time horizon, the data collection may last a few months and years. Generally, Rindfleisch et al. (2008) stated that a cross-sectional time horizon is applied in the case of lack of time and other resources. Yet, the research purpose and efficacy of collecting the required data at first stance also support a cross-sectional time horizon. Likewise, the present study aims to investigate the application areas and perceptions of students regarding IoT implementation. On this note, the data collection at the first attempt is possible for the researcher because the targeted respondents are fixed and easily approachable. Further, the cross-sectional time horizon is quick and enables the researcher to complete the research on time (Rindfleisch et al., 2005). Also, the cross-sectional time horizon seems to provide data for a specific point of time which is suitable in the present research as it is based on the perceptions and viewpoints of the students. Therefore, the cross-sectional time horizon was applied to the issue under consideration and thus data was collected by the researcher at one specific point of time.

Selection of Key Informants

The selection of key informants is necessary to be described to collect the data because the overall findings of the research depend on the same (Taherdoost, 2016). The population for the present research is Chinese students studying in different universities of Shanghai, China. This is due to the fact that the aim of the study demands opinions, views and insights of the students only to understand their intentions to use internet of things and efficiency of the same to improve learning. In this context, their intentions, efficiency of technology, advantages and challenges could be analysed by collecting the data from them only. Due to this, the students of different universities are correct population for the current research. Apart from this, application area related data can be provided by the tutors only since they better know where IoT can be applied. The number of students in the China is great; yet, it is not practically feasible for the researcher to approach all the students. In this regard, Flick (2015) asserted that targeting overall population is not worth as it

demands huge time and resources. At this point, the correct number of sample size provides an effective idea about the whole population and enables the researcher to accomplish the set aim of the research. In this relevance, seven tutors have been chosen for interview and around 408 have been chosen for the survey. At this point, the limitation of sample size in the case of interview has been overcome by the chosen sample in the case of survey. Thus, the sample size in both cases is complementary to methods of data collection. Therefore, the chosen sample size is correct and justifiable.

Response rate and data Collection Procedure

According to Taherdoost (2016), an issue of poor response rate exists in every research due to lack of time on the part of respondents, less interest and less effective understanding of the research topic. Owing to this, every researcher tends to focus to extract maximum responses by assuring the provision of time, resources and correctness of questionnaire. Likewise, in the present issue, the researcher has provided enough time of a week to complete the questionnaire. Also, 500 questionnaires have been distributed among the students targeting 408 complete responses. Thus, the researcher has addressed the issue of poor response proactively and maintained the quality of the findings.

The data collection process is important in every research because it evidences the data reliability (Andrews, Nonnecke & Preece, 2007; Saunders, Lewis & Thornhill, 2007). In this relevance, Skype interview of initial 10 participants have been conducted. The rationale behind selecting Skype interview is to save time while ensuring face-to-face interaction to note down and evaluate the expressions of the students. Also, the Skype interview is feasible to avoid one-to-one interaction in the prevailing adverse conditions of Covid-19 in China. An interview of around an hour has been carried out with each respondent via Skype. The interviewer has used both Chinese and English language to deal with the Chinese students to make the data collection process easy. The transcript of interview has been recorded during the video-conferencing which has been later translated into English language. Thus, the interview has been conducted by the researcher systematically. On the other side, a

performance-based, informational and self-reported survey has been conducted. For conducting the survey, a link of online questionnaire has been sent to the students on their personal contacts. The research purpose was explained to the students prior to the data collection and email addresses of students were taken with their consent. For this purpose, the researcher has provided sufficient time, free expressions, autonomy and confidentiality to respondents. By using self-reported survey, the researcher has assured adequate record-keeping and received consistent and enough required data from the participants. The data collection was easy because the researcher alone was involved in the process of collecting the data. Moreover, the online link of questionnaire facilitates easy tracking to participants and allows them to fill up the same as per their convenience. Thus, the interview and survey has been conducted and data have been collected comprehensively.

Design of Questionnaire

The appropriate design of questionnaire is imperative in any research (Bell, Bryman & Harley, 2022). Total two questionnaires have been prepared for the present issue; i.e. one for interview and another for survey. In the case of the interview, a few questions have been prepared with the help of a literature review. Further questions have been framed based on the discussion with Chinese students. Thus, the interview does not have a particular number of questions because it was a semi-structured interview wherein the researcher got detailed information from students while discussing the issue. On another side, the questionnaire for the survey consists of two sections i.e., the demographic profile and the main section. The demographic profile contains age, gender, income, nationality, and occupation. The main sector covers the questions justifying the benefits and challenges of using the Internet of Things in education. For this purpose, the Likert scale has been used, which is a popular scale used by many studies carried out on a similar topic (Venkatesh et al. 2011; Bhattacharjee, 2001). The scale helps to assess the level of agreement of participants.

To ensure content and face validity, the questionnaire items were reviewed by seven academic experts with relevant expertise in digital education, IoT systems,

and educational technology. Content validity was assessed using the Item–Objective Congruence (IOC) index, which evaluates the relevance of each item to the research objectives. Based on the experts’ feedback, minor revisions were made to improve item clarity, wording, and flow before the main data collection.

Measuring the Variables

Personalised Curriculum

According to Mikić et al. (2022), personalised curriculum refers to personalisation of learning based on the students’ behaviour and performance in the class. For example, test marks of students provide an idea to teachers regarding shift into the teaching pattern. On this note, Cardenas et al. (2022) adopted four-point Likert scale by selecting four measures of personalised curriculum.

Table 3.1 Measuring Personalised Curriculum

I like the course design	Five-point Likert Scale ranging from “Strongly agree” (1) to Strongly disagree (5)
I like the course content designed by using the technology	
I am satisfied by learning in the course	
I am satisfied with overall experience in the course	

Increase in efficiency

According to Nyagorme (2018), e-learning increases efficiency of students by allowing them to maintain course materials in an effective manner, keep up to date information and view and review in-class activities as many times as student requires. The measurement scale for learning efficiency has been adopted from the study of Lei et al. (2017) and Debeer et al. (2021), which is as below-

Table 3.2 Measuring increase in efficiency

The use of IoT gives flexibility in learning	Five-point Likert Scale ranging from “Strongly agree” (1) to Strongly disagree (5)
IoT caters the specific learning needs and of style students	
IoT enables engaging and active learning activities	
The use of IoT saves instruction time in learning	

Social Influence

According to Rennie & Morrison (2013), networking refers to chain of people and communication which help individual to interact with others. In this regard, the measures adopted by Richardson (2001), have been used in the present research to assess the impact of IoT or artificial intelligence on the Social Influence.

Table 3.3 Social Influence

I feel web-based education is effective medium for social interaction	Five-point Likert Scale ranging from “Strongly agree” (1) to Strongly disagree (5)
I feel comfortable conversing in online classes	
I feel comfortable to introduce myself in the digital class	
I feel comfortable to participate in the course discussion	
I feel comfortable to interact with others in the course	
I find instructor of teacher facilitating the discussion in the course	
The online classes facilitate to make	

distinct individual impression of course participants	
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Security and privacy issues

Security and privacy concerns have been largely mentioned by authors as key challenges for students while adopting IoT based applications and e-learning platforms (Bahramnezhad et al., 2016; Goi & Ng, 2008).

Table 3.4 Security and privacy concern

University e-learning portal is safe to use	Five-point Likert Scale ranging from “Strongly agree” (1) to Strongly disagree (5)
University e-learning portal is secure to use	
There is proper security and support teams for online portal	
My university prepares proper security systems for e-learning	

Reliable internet connection

Reliable internet connection refers to uninterrupted and good quality of internet that is required by students to use IoT services. The four item measurement scale has been adapted from the study of Musa & Othman (2012) by taking only relevant scales.

Table 3.5 Reliable internet connection

I do not experience while browsing university learning platforms	Five-point Likert Scale ranging from “Strongly agree” (1) to Strongly disagree (5)
I found browsing speed satisfactory	
I think I can rely on the computer network	
There is easy access to internet on campus	

Lack of experience of using IoT in education

According to Saadé & Bahli (2005), individuals' behaviour towards new technology is significantly shaped by holistic experience. Without prior experience of using a technology, the level of user involvement may not increase. Accordingly, to measure this variable, four item measurement scale has been used in this study which is adopted from the research of Saadé & Bahli (2005) and Almaiah et al. (2022) (see below table).

Table 3.6 Lack of experience of using IoT in education

I do not have a lot of experience with using IoT in education	Five-point Likert Scale ranging from “Strongly agree” (1) to Strongly disagree (5)
Despite knowing that IoT in education is simple to use,I have not acquired much experience of using it.	
Despite knowing that IoT in education is helpful, I do not have a lot of experience of using it.	
My behaviour towards using IoT in education is shaped by holistic experience of using it.	

Performance expectancy

According to Attuquayefio & Addo (2014), performance expectancy refers to expectations of an individual towards the performance by using a particular tool. For this purpose, Venkatesh et al. (2011) adopted by four measures which have been adapted to match the requirement of the current research.

Table 3.7 Performance expectancy

I find use of technology in education helpful in my daily life	Five-point Likert Scale ranging from “Strongly agree” (1) to Strongly disagree (5)
Use of technology in education enhances my chances of accomplishing thing which are important to me	
Use of technology in education helps in achieving things more quickly	
Use of technology in education augment my productivity	

Efforts expectancy

The efforts expectancy refers to the willingness of an individual to put efforts to learn about new technology or gadget (Attuquayefio & Addo, 2014). On this note, Venkatesh et al. (2011) suggested four measures as stated below which has been adapted to suit the requirement of the current research.

Table 3.8 Effort expectancy

I find it easy to learn how to use technology in education	Five-point Likert Scale ranging from “Strongly agree” (1) to Strongly disagree (5)
I find IoT in education easy to use	
I feel that my interaction with technology in education is understandable and clear	
I find it easy to be skilful of using the technology in education	

Social influence

The social influence refers to perceived motivation of an individual to follow others or their suggestions (Attuquayefio & Addo, 2014). For this purpose, Venkatesh et al. (2011) adopted three measures which define how an individual's actions are led by others to use the technology in the education, in addition to measure of social influence provided by Attuquayefio & Addo (2014). Accordingly, four scale measurement items were adopted to operationalize social influence variable in this study, which are provided as below-

Table 3.9 Social influence

All important people in my network feel that I should use technology in education	Five-point Likert Scale ranging from "Strongly agree" (1) to Strongly disagree (5)
People who have influence on me think that I should use technology in education	
People whose opinion I prefer value that I use technology in education	
People who are important to me think that I should use technology in education	

Facilitating conditions

Facilitating conditions refers to the ease of use towards a particular technology or tool which have been measured by using four statements as follows (Venkatesh et al. 2011)

Table 3.10 Facilitating conditions

I have necessary resources to use technology in education	Five-point Likert Scale ranging from “Strongly agree” (1) to Strongly disagree (5)
I have necessary knowledge to use the technology in education	
Technology in education is compatible with other technologies I use	
I find it easy to get help for others if I face challenges in using technology in education	

Intention to use

The intention to use refers to the willingness of an individual to use particular technology by keeping into mind its associated factors (Attuquayefio & Addo, 2014). Similarly, five measurement items as shown in the below table have been used to measure the intention to use by drawing on the studies of Bhattacharjee (2001) and Venkatesh et al. (2011).

Table 3.11 Intention to use

I intend to continue technology in education	Five-point Likert Scale ranging from “Strongly agree” (1) to Strongly disagree (5)
I will always like to use technology in my daily life	
I will use technology regularly as I do now	
I use IoT when I am learning in class	
I use IoT in order to access personal materials while learning	

Data Analysis Methods

Every research requires specific technique, design and processes to analyse the inputs in a comprehensive way which produces easy-to-understand and effective findings. In this context, various data analysis techniques are used such as qualitative and quantitative. The qualitative techniques include thematic analysis, case study and content analysis (Saunders, Lewis & Thornhill, 2003). These methods are used in the case of information which is typical to be quantified. On the other side, quantitative analysis techniques include regression, correlation and descriptive statistics wherein hypotheses are tested (Bryman, 2016). The qualitative analysis methods are adopted to explore the issue deeply and gaining detailed findings (Bryman, 2003). Therefore, based on the nature of the issue and in line with the mixed method research design, descriptive statistics and regression analysis have been used for quantitative analysis and thematic analysis has been applied for assessing qualitative data.

Qualitative data analysis

In the case of the thematic analysis, various themes have been prepared in such a way as it reflects the purpose of the research. The data gathered via interview has been segregated into various classes and codes and ultimately themes have been framed in line with the objectives of the study. The rationale behind using the thematic analysis method is to evaluate the qualitative information in an in-depth manner so that valid outcomes can be produced (Flick, 2015). At a similar point, it requires an extensive level of involvement of the researcher so that the researcher can interpret multiple facets of a single truth effectively (Saunders & Thornhill, 2011). The thematic analysis method is suitable for the present research as the single truth of the application area of IoT has been influenced by the perceptions and viewpoints of different students.

Quantitative data analysis

In the present study, hypotheses were framed and tested to examine the applicability of existing theories. Survey responses were coded, screened, and cleaned prior to analysis, and the dataset was then analysed using standard quantitative procedures. First, descriptive statistics were calculated due to the relatively large

volume of quantitative data. Descriptive statistics help summarise the key characteristics of a dataset and reveal overall patterns (Mertens, Pugliese, & Recker, 2017). As noted by Saunders, Lewis, and Thornhill (2009), descriptive statistics typically report measures of central tendency (mean, median, and mode) and dispersion (e.g., standard deviation). In this study, descriptive statistics were used to identify common response patterns regarding the benefits and challenges of adopting IoT applications in higher education. In addition, frequency analysis was conducted to report the number and proportion of respondents who agreed or disagreed with each statement. Finally, regression analysis was performed to examine the influence of UTAUT factors on Chinese students' intention to use IoT in higher education and to understand how these factors relate to perceived learning improvement. Accordingly, the quantitative analysis was completed for the survey data. The key variables included in the regression analysis are presented in the table below.

Ethical Consideration

The survey method has been adopted for the purpose of approaching the Chinese students, considering it easy and most economical. Yet, the researcher is required to follow some essential ethical principles to survey by adopting the right practices across the processes of the data collection (Flick, 2015). In this regard, the principles of informed consent, autonomy, and confidentiality have been followed systematically by the researcher. In order to assure the principle of confidentiality, all the data and information gathered from the participants have been kept secure in password protected storage centre. This will avoid loss of data and access to the data by any person other than the researcher. Furthermore, instead of using the names of respondents, some codes have been included to apply statistical tests in the study. All the students were required to sign the informed consent form prior to the survey to have complete information regarding the aim of the study, the places, and data collection purposes. Importantly, the students were provided a right to quit the research process according to their wishes. Thus, the overall research was completed ethically and systematically while the data collection process was kept voluntary.

Chapter 4

Results of Analysis

Introduction

This chapter presents the results and interpretation of the collected data. The findings include the demographic profile of respondents, validity and reliability assessments, correlation analysis, descriptive statistics, and regression analyses. The analysis begins with participants' demographic characteristics, followed by data quality and construct assessments using factor-related procedures. Descriptive statistics are then reported to summarise the overall response patterns. Finally, regression analysis is employed to examine the effects of the selected variables on students' intention to use IoT.

Demographic profile of participants

Table 4.1 Demographic profile of participants (N = 408)

Table 4.1A. Age

Age group	Frequency	Percent	Valid Percent	Cumulative Percent
18–20 years	101	24.8	24.8	24.8
21–25 years	262	64.2	64.2	89.0
26–30 years	45	11.0	11.0	100.0
Total	408	100.0	100.0	100.0

Table 4.1B. Gender

Gender	Frequency	Percent	Valid Percent
Male	192	47.1	47.1
Female	212	52.0	52.0
Prefer not to say	4	1.0	1.0
Total	408	100.0	100.0

Table 4.1C. Education qualification

Education qualification	Frequency	Percent	Valid Percent
Graduation	133	32.6	32.6
Masters	198	48.5	48.5
Diploma/certificate- based course	77	18.9	18.9
Total	408	100.0	100.0

Table 4.1D. Education field

Education field	Frequency	Percent	Valid Percent
Management	87	21.3	21.3
Marketing	198	48.5	48.5
HR	55	13.5	13.5
Finance	22	5.4	5.4
Other	46	11.3	11.3
Total	408	100.0	100.0

The demographic results indicate that the sample includes 212 female respondents (52.0%), 192 male respondents (47.1%), and 4 respondents who preferred not to disclose gender (1.0%). Regarding age, the largest proportion of participants falls within 21–25 years (64.2%), followed by 18–20 years (24.8%) and 26–30 years (11.0%). In terms of education qualification, 48.5% of participants reported pursuing a master’s degree, 32.6% were pursuing graduation, and 18.9%

were enrolled in diploma/certificate-based programmes. For education fields, marketing constitutes the largest group (48.5%), followed by management (21.3%) and HR (13.5%), while smaller proportions were observed in finance (5.4%) and other fields (11.3%).

Reliability and Validity Analysis

Table 4.2 Item communalities (Initial and Extraction) using Principal Component Analysis (Communalities)

Item	Initial	Extraction
I like the course design	1.000	.855
I like the course content designed by using the technology	1.000	.881
I am satisfied by learning in the course	1.000	.830
I am satisfied with overall experience in the course	1.000	.849
The use of IoT gives flexibility in learning	1.000	.867
IoT caters the specific learning needs and of style students	1.000	.956
IoT enables engaging and active learning activities	1.000	.749
The use of IoT saves instruction time in learning	1.000	.622
I feel web-based education is effective medium for social interaction	1.000	.924
I feel comfortable conversing in online classes	1.000	.957
I feel comfortable to introduce myself in the digital class	1.000	.877
I feel comfortable to participate in the course discussion	1.000	.853
I feel comfortable to interact with others in the course	1.000	.823
I find instructor of teacher facilitating the discussion in the course	1.000	.880
The online classes facilitate to make distinct individual impression of course participants	1.000	.957
University e-learning portal is safe to use	1.000	.530

Table 4.2 Item communalities (Initial and Extraction) using Principal Component Analysis (Communalities) (Continued)-

Item	Initial	Extraction
University e-learning portal is secure to use	1.000	.900
There is proper security and support teams for online portal	1.000	.737
My university prepares proper security systems for e-learning	1.000	.889
I do not experience issues while browsing university learning platforms	1.000	.730
I found browsing speed satisfactory	1.000	.773
I think I can rely on the computer network	1.000	.632
There is easy access to internet on campus	1.000	.826
I do not have a lot of experience with using IoT in education	1.000	.965
Despite knowing that IoT in education is simple to use, I have not acquired much experience of using it.	1.000	.566
Despite knowing that IoT in education is helpful, I do not have a lot of experience of using it.	1.000	.965
My behaviour towards using IoT in education is shaped by holistic experience of using it.	1.000	.337
I find use of technology in education helpful in my daily life	1.000	.843
Use of technology in education enhances my chances of accomplishing thing which are important to me	1.000	.853
Use of technology in education helps in achieving things more quickly	1.000	.845
Use of technology in education augment my productivity	1.000	.774
I find it easy to learn how to use technology in education	1.000	.709
I find IoT in education easy to use	1.000	.840
I feel that my interaction with technology in education is understandable and clear	1.000	.610
I find it easy to be skilful of using the technology in education	1.000	.769

Table 4.2 Item communalities (Initial and Extraction) using Principal Component Analysis (Communalities) (Continued)

Item	Initial	Extraction
All important people in my network feel that I should use technology in education	1.000	.905
People who have influence on me think that I should use technology in education	1.000	.903
People whose opinion I prefer value that I use technology in education	1.000	.823
People who are important to me think that I should use technology in education	1.000	.828
I have necessary resources to use technology in education	1.000	.910
I have necessary knowledge to use the technology in education	1.000	.910
Technology in education is compatible with other technologies I use	1.000	.445
I find it easy to get help for others if I face challenges in using technology in education	1.000	.355
I intend to continue technology in education	1.000	.770
I will always like to use technology in my daily life	1.000	.956
I will use technology regularly as I do now	1.000	.681
I use IoT when I am learning in class	1.000	.779
I use IoT in order to access personal materials while learning	1.000	.686

Note. Initial communalities represent the initial estimate of variance for each item (equal to 1.00 under PCA). Extraction communalities indicate the proportion of variance in each item accounted for by the extracted component(s); values above .50 are commonly considered acceptable for retaining items.

Table 4.2 reports item communalities, which indicate how much variance in each item is accounted for by the extracted component(s). Under PCA, initial communalities are set to 1.00. In this study, most items demonstrate extraction communalities above .50, suggesting adequate shared variance for inclusion. However, three items show extraction communalities below .50—LE3 (.337), FC3 (.445), and FC4 (.355), indicating weak shared variance with the extracted component(s). These items were removed to improve measurement quality before proceeding to subsequent analyses.

Descriptive statistics (construct-level)

Table 4.3 Descriptive statistics of study variables (N = 408)

Variable	N	Mean	Std. Deviation
Personalised curriculum	408	2.17	.962
Increase in efficiency	408	1.97	.355
Perceived social interaction (online learning)	408	2.10	.780
Security and privacy concern	408	2.14	.861
Reliable internet connection	408	2.01	.377
Lack of experience of using IoT in education	408	2.12	.868
Performance expectancy	408	2.14	.759
Effort expectancy	408	1.96	.359
Social influence (UTAUT)	408	2.06	.797
Facilitating conditions	408	1.92	.302
Intention to use IoT	408	2.05	.493

Table 4.3 summarises the mean and standard deviation for the study variables. The mean value for personalised curriculum is 2.17 (SD = .962), indicating comparatively larger variability in students' perceptions. Increase in efficiency shows

a mean of 1.97 (SD = .355), suggesting relatively consistent responses. Security and privacy concern (Mean = 2.14, SD = .861) and lack of experience (Mean = 2.12, SD = .868) also show greater dispersion, reflecting differing perceptions across respondents. For UTAUT-related constructs, performance expectancy (Mean = 2.14, SD = .759) shows moderate variation, while effort expectancy (Mean = 1.96, SD = .359) and facilitating conditions (Mean = 1.92, SD = .302) show smaller dispersion. Importantly, the construct labelled Perceived social interaction (online learning) is kept distinct from Social influence (UTAUT) to avoid conceptual overlap in naming.

Reliability (Cronbach's alpha)

Table 4.4 Reliability statistics (Cronbach's alpha)

Construct	Cronbach's Alpha	N of Items
Personalised curriculum	.935	4
Increase in efficiency	.741	4
Perceived social interaction (online learning)	.964	7
Security and privacy concern	.843	4
Reliable internet connection	.767	4
Lack of experience of using IoT in education	.722	3
Performance expectancy	.844	4
Effort expectancy	.741	4
Social influence (UTAUT)	.942	4
Facilitating conditions	.900	2
Intentions to use IoT	.895	5

Table 4.4 reports Cronbach's alpha values to assess internal consistency reliability for each construct. In general, values above .70 indicate acceptable reliability, and values above .80 indicate good reliability. The results show that all

constructs meet or exceed the acceptable threshold, suggesting that the item sets demonstrate adequate internal consistency for further analysis. (Hasan & Akter, 2020).

Correlation analysis

Table 4.5 Pearson correlation matrix

Variable	1	2	3	4	5	6	7	8	9	10
1. Personalised curriculum	1									
2. Increase in efficiency	.256**	1								
3. Perceived social interaction (online learning)	.481**	.327**	1							
4. Security and privacy concern	.388**	.092	.335**	1						
5. Reliable internet connection	.239**	.088**	.348**	.148**	1					
6. Lack of experience of using IoT in education	.070	.111*	.101*	-.112*	.117*	1				
7. Performance expectancy	.422**	.271**	.087**	.259**	.293**	.105*	1			
8. Effort expectancy	.019	.046	.133**	.042	.044	.172**	.092	1		
9. Social influence (UTAUT)	-.119*	.010	-.139**	-.027	.045	.281**	-.099*	.076	1	
10. Facilitating conditions	-.094	-.094	-.052	-.076	-.089	-.037	-.022	.017	.010	1

Note. Pearson correlations are reported. $p < .05$ (*), $p < .01$ (**). $N = 408$ for all correlations.

Table 4.5 presents Pearson correlations among the study variables. Most correlations are below the commonly used threshold of $|r| = .70$, suggesting no evidence of extremely high bivariate overlap among constructs. Multicollinearity diagnostics (e.g., VIF and tolerance) should be assessed within the regression models where applicable.

Research Hypotheses

This section summarises the research hypotheses and presents the hypothesis testing results. In line with the study objectives, hypotheses are grouped into (i) the core UTAUT hypotheses and (ii) additional contextual hypotheses reflecting perceived benefits and challenges of IoT adoption in higher education. The results reported below are based on the regression analyses presented in Section 4.5.2 ($N = 408$).

Table 4.6 UTAUT hypotheses and results ($N = 408$)

Hypothesis	Statement	Result
H1	Performance expectancy has a positive effect on students' intention to use IoT in higher education.	Supported (Sig.=.000; β =.270)
H2	Effort expectancy has a positive effect on students' intention to use IoT in higher education.	Not supported (Sig.=.445; β =.038)
H3	Social influence has a positive effect on students' intention to use IoT in higher education.	Not supported (Sig.=.784; β =-.014)
H4	Facilitating conditions have a positive effect on students' intention to use IoT in higher education.	Not supported (Sig.=.076; β =-.088)

Table 4.7 Additional hypotheses (contextual factors) and results (N = 408)

Hypothesis	Statement	Result
H5	Personalised curriculum has a positive effect on students' intention to use IoT.	Supported (Sig.=.000; β =.374)
H6	Increase in efficiency has a positive effect on students' intention to use IoT.	Supported (Sig.=.000; β =.789)
H7	Perceived social interaction (online learning) has a positive effect on students' intention to use IoT.	Supported (Sig.=.000; β =.303)
H8	Security and privacy concern has an effect on students' intention to use IoT.	Supported (Sig.=.017; β =.118)
H9	Reliable internet connection has a positive effect on students' intention to use IoT.	Supported (Sig.=.000; β =.774)
H10	Lack of experience of using IoT in education has an effect on students' intention to use IoT.	Supported (Sig.=.001; β =.164)

Overall, the UTAUT results indicate that only performance expectancy shows a statistically significant positive association with intention to use IoT, while effort expectancy, social influence, and facilitating conditions are not supported in this sample. In contrast, the contextual variables representing perceived benefits and challenges (personalized curriculum, increase in efficiency, perceived social interaction, security and privacy concern, reliable internet connection, and lack of experience) demonstrate statistically significant associations with intention to use IoT, with varying effect sizes.

Results and Analysis

Frequency analysis

The frequency analysis holds an important place in the quantitative evaluation. This is because that it shows repeated occurrence of responses of the participants that helps in identifying the perception of most of the participants about any aspect (Hériveaux et al., 2021). In this context, the below tables showcase the frequency of responses of the students regarding different variables considered of the present research.

Table 4.8 Like the course design

Response option	Frequency	Percent	Valid Percent
Strongly agree	119	29.2	29.2
Agree	142	34.8	34.8
Neutral	83	20.3	20.3
Disagree	55	13.5	13.5
Strongly disagree	9	2.2	2.2
Total	408	100.0	100.0

Table 4.8 shows that most respondents reported positive perceptions of the course design. Specifically, 34.8% selected Agree and 29.2% selected Strongly agree (total 64.0%). A further 20.3% were Neutral, while 13.5% and 2.2% selected Disagree and Strongly disagree, respectively.

Table 4.9 Like the course content

Response option	Frequency	Percent	Valid Percent
Strongly agree	144	35.3	35.3
Agree	128	31.4	31.4
Neutral	98	24.0	24.0
Disagree	29	7.1	7.1
Strongly disagree	9	2.2	2.2
Total	408	100.0	100.0

As presented in Table 4.9 perceptions of the course content designed using technology were generally positive. 31.4% selected Agree and 35.3% selected Strongly agree (total 66.7%). 24.0% of respondents were Neutral, while 7.1% and 2.2% selected Disagree and Strongly disagree, respectively. The range is from 2.2%-35.3%.

Table 4.10 IoT and learning flexibility

Response option	Frequency	Percent	Valid Percent
Strongly agree	43	10.5	10.5
Agree	363	89.0	89.0
Neutral	2	.5	.5
Disagree	0	0	0
Strongly disagree	0	0	0
Total	408	100.0	100.0

Table 4.10 indicates very strong agreement that IoT provides learning flexibility. The majority of respondents selected Agree (89.0%), while 10.5% selected Strongly agree. Only 0.5% selected Neutral.

Table 4.11 IoT and specific needs of students

Response option	Frequency	Percent	Valid Percent
Strongly agree	34	8.3	8.3
Agree	342	83.8	83.8
Neutral	11	2.7	2.7
Disagree	21	5.1	5.1
Strongly Disagree	0	0	0
Total	408	100.0	100.0

Table 4.11 shows that most students perceived IoT as supporting specific learning needs and learning styles. 83.8% selected Agree and 8.3% selected Strongly agree (total 92.1%). 2.7% were Neutral, while 5.1% selected Disagree. The range is from 0%-83.8%.

Table 4.12 Web-based education and social interaction

Response option	Frequency	Percent	Valid Percent
Strongly agree	92	22.5	22.5
Agree	256	62.7	62.7
Neutral	32	7.8	7.8
Disagree	24	5.9	5.9
Strongly disagree	4	1.0	1.0
Total	408	100.0	100.0

According to Table 4.12 web-based education was perceived as effective for social interaction by the majority of respondents. 62.7% selected Agree and 22.5% selected Strongly agree (total 85.2%). 7.8% were Neutral, whereas 5.9% and 1.0% selected Disagree and Strongly disagree, respectively. The range is from 1%-62.7%.

Table 4.13 Online class accelerates comfortable conversing

Response option	Frequency	Percent	Valid Percent
Strongly agree	72	17.6	17.6
Agree	246	60.3	60.3
Neutral	41	10.0	10.0
Disagree	45	11.0	11.0
Strongly disagree	4	1.0	1.0
Total	408	100.0	100.0

Table 4.13 indicates that most respondents felt comfortable conversing in online classes. 60.3% selected Agree and 17.6% selected Strongly agree (total 77.9%). 10.0% were Neutral, while 11.0% and 1.0% selected Disagree and Strongly disagree, respectively. The range is from 1%-60.3%.

Table 4.14 Safety over the e-learning portal of the University

Response option	Frequency	Percent	Valid Percent
Strongly agree	149	36.5	36.5
Agree	131	32.1	32.1
Neutral	90	22.1	22.1
Disagree	30	7.4	7.4
Strongly disagree	8	2.0	2.0
Total	408	100.0	100.0

As shown in Table 4.14 perceptions of the university e-learning portal being safe to use were generally positive. 32.1% selected Agree and 36.5% selected Strongly agree (total 68.6%). 22.1% were Neutral, whereas 7.4% and 2.0% selected Disagree and Strongly disagree, respectively. The range is from 2%-36.5%.

Table 4.15 University e-learning portal is secure to use (I think University e-learning portal is secure to use)

Response option	Frequency	Percent	Valid Percent
Strongly agree	121	29.7	29.7
Agree	138	33.8	33.8
Neutral	84	20.6	20.6
Disagree	58	14.2	14.2
Strongly disagree	7	1.7	1.7
Total	408	100.0	100.0

Table 4.15 indicates that perceptions of the university e-learning portal being secure are generally positive. Specifically, 33.8% of respondents selected Agree and 29.7% selected Strongly agree (total 63.5%). 20.6% of students were Neutral, whereas 14.2% and 1.7% selected Disagree and Strongly disagree, respectively. The range is from 1.7%-33.8%.

Table 4.16 Issues while browsing the university's platform (I do not experience issues while browsing university learning platforms)

Response option	Frequency	Percent	Valid Percent
Strongly agree	40	9.8	9.8
Agree	355	87.0	87.0
Neutral	12	2.9	2.9
Disagree	1	.2	.2
Strongly disagree	0	0	0
Total	408	100.0	100.0

As shown in Table 4.16, most respondents reported that they do not experience issues while browsing university learning platforms. 87.0% selected Agree and 9.8% selected Strongly agree (total 96.8%). 2.9% selected Neutral, while only 0.2% selected Disagree. The range is from 0%-87%.

Table 4.17 Browsing speed (I found browsing speed satisfactory)

Response option	Frequency	Percent	Valid Percent
Strongly agree	39	9.6	9.6
Agree	324	79.4	79.4
Neutral	20	4.9	4.9
Disagree	22	5.4	5.4
Strongly disagree	3	.7	.7
Total	408	100.0	100.0

Table 4.17 shows that most students perceived the browsing speed as satisfactory. 79.4% selected Agree and 9.6% selected Strongly agree (total 89.0%). 4.9% were Neutral, whereas 5.4% and 0.7% selected Disagree and Strongly disagree, respectively. The range is from .7%-79.4%.

Table 4.18 Experience to use IoT (Despite knowing that IoT in education is simple to use, I have not acquired much experience of using it.)

Response option	Frequency	Percent	Valid Percent
Strongly agree	44	10.8	10.8
Agree	318	77.9	77.9
Neutral	23	5.6	5.6
Disagree	20	4.9	4.9
Strongly disagree	3	.7	.7
Total	408	100.0	100.0

Table 4.18 indicates that many respondents reported limited experience of using IoT in education despite perceiving it as simple to use. 77.9% selected Agree and 10.8% selected Strongly agree (total 88.7%). 5.6% were Neutral, while 4.9% and 0.7% selected Disagree and Strongly disagree, respectively. The range is from .7%-77.9%.

Table 4.19 Experience of using IoT (I do not have a lot of experience with using IoT in education)

Response option	Frequency	Percent	Valid Percent
Strongly agree	123	30.1	30.1
Agree	140	34.3	34.3
Neutral	84	20.6	20.6
Disagree	54	13.2	13.2
Strongly disagree	7	1.7	1.7
Total	408	100.0	100.0

As shown in Table 4.19 respondents generally agreed that they do not have extensive experience using IoT in education. 34.3% selected Agree and 30.1%

selected Strongly agree (total 64.4%). 20.6% were Neutral, whereas 13.2% and 1.7% selected Disagree and Strongly disagree, respectively. The range is from 1.7%-34.3%.

Table 4.20 Uses of technology in daily life (I find the use of technology in education helpful in my daily life)

Response option	Frequency	Percent	Valid Percent
Strongly agree	91	22.3	22.3
Agree	231	56.6	56.6
Neutral	43	10.5	10.5
Disagree	36	8.8	8.8
Strongly disagree	7	1.7	1.7
Total	408	100.0	100.0

Table 4.20 shows that most respondents perceived technology use in education as helpful in daily life. 56.6% selected Agree and 22.3% selected Strongly agree (total 78.9%). 10.5% were Neutral, while 8.8% and 1.7% selected Disagree and Strongly disagree, respectively. The range is from 1.7%-56.6%.

Table 4.21 uses of technology and accomplishing things (Use of technology in education enhances my chances of accomplishing thing which are important to me)

Response option	Frequency	Percent	Valid Percent
Strongly agree	107	26.2	26.2
Agree	217	53.2	53.2
Neutral	55	13.5	13.5
Disagree	25	6.1	6.1
Strongly disagree	4	1.0	1.0
Total	408	100.0	100.0

As presented in Table 4.21 most respondents agreed that technology use in education enhances their ability to accomplish important things. 53.2% selected Agree and 26.2% selected Strongly agree. 13.5% were Neutral, whereas 6.1% and 1.0% selected Disagree and Strongly disagree, respectively. The range is from 1%-53.2%. s

Table 4.22 Easy to learn the technology (I find it easy to learn how to use technology in education)

Response option	Frequency	Percent	Valid Percent
Strongly agree	50	12.3	12.3
Agree	356	87.3	87.3
Neutral	2	.5	.5
Disagree	0	0	0
Strongly disagree	0	0	0
Total	408	100.0	100.0

Table 4.22 shows that respondents overwhelmingly found it easy to learn how to use technology in education. 87.3% selected Agree and 12.3% selected Strongly agree, while 0.5% selected Neutral. The range is from 0%-87.3%.

Table 4.23 IoT easy to use in education (I find IoT in education easy to use)

Response option	Frequency	Percent	Valid Percent
Strongly agree	41	10.0	10.0
Agree	350	85.8	85.8
Neutral	8	2.0	2.0
Disagree	9	2.2	2.2
Strongly disagree	0	0	0
Total	408	100.0	100.0

As presented in Table 4.23, most respondents perceived IoT in education as easy to use. 85.8% selected Agree and 10.0% selected Strongly agree. 2.0% were Neutral, while 2.2% selected Disagree. The range is from 0%-85.8%.

Table 4.24 Suggestion of people in the network to use technology (All important people in my network feel that I should use technology in education)

Response option	Frequency	Percent	Valid Percent
Strongly agree	101	24.8	24.8
Agree	251	61.5	61.5
Neutral	28	6.9	6.9
Disagree	24	5.9	5.9
Strongly disagree	4	1.0	1.0
Total	408	100.0	100.0

Table 4.24 indicates that respondents generally perceived supportive expectations from important people in their network regarding technology use in education. 61.5% selected Agree and 24.8% selected Strongly agree. 6.9% were Neutral, whereas 5.9% and 1.0% selected Disagree and Strongly disagree, respectively. The range is from 1%-61.5%.

Table 4.25 Influencing people and use of technology (People who have influence on me think that I should use technology in education)

Response option	Frequency	Percent	Valid Percent
Strongly agree	89	21.8	21.8
Agree	254	62.3	62.3
Neutral	28	6.9	6.9
Disagree	33	8.1	8.1
Strongly disagree	4	1.0	1.0
Total	408	100.0	100.0

As shown in Table 4.25 a majority of respondents indicated that influential people think they should use technology in education. 62.3% selected Agree and 21.8% selected Strongly agree. 6.9% were Neutral, while 8.1% and 1.0% selected Disagree and Strongly Disagree, respectively. The range is from 1%-62.3%.

Table 4.26 Necessary resources and use of technology (I have necessary resources to use technology in education)

Response option	Frequency	Percent	Valid Percent
Strongly agree	37	9.1	9.1
Agree	368	90.2	90.2
Neutral	3	.7	.7
Disagree	0	0	0
Strongly disagree	0	0	0
Total	408	100.0	100.0

Table 4.26 shows that respondents largely reported having the necessary resources to use technology in education. 90.2% selected Agree and 9.1% selected Strongly agree, while 0.7% selected Neutral. 0% selected disagree. The range is from 0%-90.2%.

Table 4.27 Necessary knowledge and use of technology (I have necessary knowledge to use the technology in education)

Response option	Frequency	Percent	Valid Percent
Strongly agree	37	9.1	9.1
Agree	368	90.2	90.2
Neutral	3	.7	.7
Disagree	0	0	0
Strongly disagree	0	0	0
Total	408	100.0	100.0

As presented in Table 4.27, most respondents indicated that they have the necessary knowledge to use technology in education. 90.2% selected Agree and 9.1% selected Strongly agree (total 99.3%). 0.7% selected Neutral. 0% selected disagree. The range is from 0%-90.2%

Table 4.28 Continuing technology in education (I intend to continue technology in education)

Response option	Frequency	Percent	Valid Percent
Strongly agree	28	6.9	6.9
Agree	345	84.6	84.6
Neutral	11	2.7	2.7
Disagree	24	5.9	5.9
Strongly disagree	0	0	0
Total	408	100.0	100.0

Table 4.28 indicates that most respondents intend to continue using technology in education. 84.6% selected Agree and 6.9% selected Strongly agree (total 91.5%). 2.7% were Neutral, while 5.9% selected Disagree. 0% selected strongly disagree. The range is from 0%-84.6%.

Table 4.29 Use of technology in daily life (I will always like to use technology in my daily life)

Response option	Frequency	Percent	Valid Percent
Strongly agree	34	8.3	8.3
Agree	342	83.8	83.8
Neutral	11	2.7	2.7
Disagree	21	5.1	5.1
Strongly disagree	0	0	0
Total	408	100.0	100.0

As shown in Table 4.29, respondents generally reported a strong preference for using technology in daily life. 83.8% selected Agree and 8.3% selected Strongly agree (total 92.1%). 2.7% were Neutral, while 5.1% selected Disagree. 0% selected strongly disagree. The range is from 0%-83.8%.

Regression analysis and hypotheses testing

Relationship between PC and IU

Table 4.30 Model summary (Personalised curriculum → Intention to use IoT)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.374	.140	.138	.458

Predictor: Personalized curriculum

Table 4.31 ANOVA (Personalised curriculum → Intention to use IoT)

Source	Sum of Squares	df	Mean Square	F	Sig.
Regression	13.885	1	13.885	66.214	.000
Residual	85.135	406	.210		
Total	99.020	407			

Dependent variable: Intention to use IoT

Table 4.32 Coefficients (Personalised curriculum → Intention to use IoT)

Predictor	B	Std. Error	R	t	Sig.
(Constant)	1.632	.056	29.087	.000	
Personalised curriculum	.192	.024	.374	8.137	.00

The model indicates a moderate association ($R = .374$) and explains 14.0% of the variance in intention to use IoT ($R^2 = .140$) (Sarstedt et al.2019). The regression is statistically significant (Sig. = .000), and the personalized curriculum shows a positive standardised effect ($\beta = .374$, Sig. = .000). Therefore, H5 (Personalised curriculum has a positive effect on students' intention to use IoT.) is supported.

IE and IU

Table 4.33 Model summary (Increase in efficiency → Intention to use IoT)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.789	.623	.622	.303

Predictor: Increase in efficiency

Table 4.34 ANOVA (Increase in efficiency → Intention to use IoT)

Source	Sum of Squares	df	Mean Square	F	Sig.
Regression	61.644	1	61.644	669.622	.000
Residual	37.376	406	.092		
Total	99.020	407			

Predictor: Increase in efficiency

Table 4.35 Coefficients (Increase in efficiency → Intention to use IoT)

Predictor	B	Std. Error	R	t	Sig.
(Constant)	-.114	.085	-1.342	.180	
Increase in efficiency	1.096	.042	.789	25.877	.000

The model shows a strong association ($R = .789$) and explains 62.3% of the variance in intention ($R^2 = .623$) (Sarstedtet al.2019). The regression is significant (Sig. = .000) with a strong positive effect ($\beta = .789$, Sig. = .000). Therefore, H6 (Increase in efficiency has a positive effect on students' intention to use IoT) is supported.

SN and IU

Table 4.36 Model summary (Social Influence → Intention to use IoT)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.303	.092	.090	.471

Predictor: Social Influence

Table 4.37 ANOVA (Social Influence → Intention to use IoT)

Source	Sum of Squares	df	Mean Square	F	Sig.
Regression	9.100	1	9.100	41.087	.000
Residual	89.920	406	.221		
Total	99.020	407			

Dependent variable: Intention to use IoT

Table 4.38 Coefficients (Social Influence → Intention to use IoT)

Predictor	B	Std. Error	R	t	Sig.
(Constant)	1.646	.067	24.522	.000	
Social Influence	.192	.030	.303	6.410	.000

The model shows a moderate association ($R = .303$) and explains 9.2% of variance ($R^2 = .092$) (Sarstedt et al.2019). The regression is significant (Sig. = .000) with a positive effect ($\beta = .303$, Sig. = .000). Therefore, H7 (Perceived social interaction (online learning) has a positive effect on students' intention to use IoT.) is supported.

SPC and IU

Table 4.39 Model summary (Security and privacy concern → Intention to use IoT)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.118	.014	.012	.490

Predictor: Security and privacy concern

Table 4.40 ANOVA (Security and privacy concern → Intention to use IoT)

Source	Sum of Squares	df	Mean Square	F	Sig.
Regression	1.385	1	1.385	5.761	.017
Residual	97.634	406	.240		
Total	99.020	407			

Dependent variable: Intention to use IoT

Table 4.41 Coefficients (Security and privacy concern → Intention to use IoT)

Predictor	B	Std. Error	R	t	Sig.
(Constant)	1.904	.065	29.261	.000	
Security and privacy concern	.068	.028	.118	2.400	.017

The model indicates a weak association ($R = .118$) and explains 1.4% of variance ($R^2 = .014$) (Sarstedt et al. 2019). The regression is significant (Sig. = .017) with a small positive effect ($\beta = .118$, Sig. = .017). Therefore, H8 (Security and privacy concern has an effect on students' intention to use IoT.) is supported.

RIC and IU

Table 4.42 Model summary (Reliable internet connection → Intention to use IoT)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.774	.599	.598	.313

Predictor: Reliable internet connection

Table 4.43 ANOVA (Reliable internet connection → Intention to use IoT)

Source	Sum of Squares	df	Mean Square	F	Sig.
Regression	59.325	1	59.325	606.793	.000
Residual	39.694	406	.098		
Total	99.020	407			

Dependent variable: Intention to use IoT

Table 4.44 Coefficients (Reliable internet connection → Intention to use IoT)

Predictor	B	Std. Error	R	t	Sig.
(Constant)	.012	.084	.139	.890	
Reliable internet connection	1.013	.041	.774	24.633	.000

The model shows a strong association ($R = .774$) and explains 59.9% of variance ($R^2 = .599$) (Sarstedt et al. 2019). The regression is significant (Sig. = .000) with a strong positive effect ($\beta = .774$, Sig. = .000). Therefore, H9 (Reliable internet connection has a positive effect on students' intention to use IoT.) is supported.

LE and IU

Table 4.45 Model summary (Lack of experience → Intention to use IoT)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.164	.027	.025	.487

Predictor: Lack of experience of using IoT in education

Table 4.46 ANOVA (Lack of experience → Intention to use IoT)

Source	Sum of Squares	df	Mean Square	F	Sig.
Regression	2.679	1	2.679	11.289	.001
Residual	96.341	406	.237		
Total	99.020	407			

Dependent variable: Intention to use IoT

Table 4.47 Coefficients (Lack of experience → Intention to use IoT)

Predictor	B	Std. Error	R	t	Sig.
(Constant)	1.851	.064	29.067	.000	
Lack of experience of using IoT in education	.094	.028	.164	3.360	.001

The model indicates a weak association ($R = .164$) and explains 2.7% of variance ($R^2 = .027$) (Sarstedtet al.2019). The regression is significant (Sig. = .001) with a small positive effect ($\beta = .164$, Sig. = .001). Therefore, H10 (Lack of experience of using IoT in education has an effect on students' intention to use IoT.) is supported.

PE and IU

Table 4.48 Model summary (Performance expectancy → Intention to use IoT)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
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1	.270	.073	.071	.476
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Predictor: Performance expectancy

Table 4.49 ANOVA (Performance expectancy → Intention to use IoT)

Source	Sum of Squares	df	Mean Square	F	Sig.
Regression	7.207	1	7.207	31.871	.000
Residual	91.812	406	.226		
Total	99.020	407			

Dependent variable: Intention to use IoT

Table 4.50 Coefficients (Performance expectancy → Intention to use IoT)

Predictor	B	Std. Error	R	t	Sig.
(Constant)	1.673	.071	23.683	.000	
Performance expectancy	.175	.031	.270	5.645	.000

The model shows a weak-to-moderate association ($R = .270$) and explains 7.3% of variance ($R^2 = .073$) (Sarstedt et al.2019). The regression is significant (Sig. = .000) with a positive effect ($\beta = .270$, Sig. = .000). Therefore, H1(Performance expectancy has a positive effect on students' intention to use IoT in higher education.) is supported.

EE and IU

Table 4.51 Model summary (Effort expectancy → Intention to use IoT)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.038	.001	-.001	.493

Predictor: Effort expectancy

Table 4.52 ANOVA (Effort expectancy → Intention to use IoT)

Source	Sum of Squares	df	Mean Square	F	Sig.
Regression	.143	1	.143	.586	.445
Residual	98.877	406	.244		
Total	99.020	407			

Dependent variable: Intention to use IoT

Table 4.53 Coefficients (Effort expectancy → Intention to use IoT)

Predictor	B	Std. Error	R	t	Sig.
(Constant)	1.947	.136	14.314	.000	
Effort expectancy	.052	.068	.038	.765	.445

The model indicates a negligible association ($R = .038$) and explains 0.1% of variance ($R^2 = .001$) (Sarstedt et al.2019). The regression is not significant ($\text{Sig.} = .445$) and the effect is non-significant ($\beta = .038$, $\text{Sig.} = .445$). Therefore, H2 (Effort expectancy has a positive effect on students' intention to use IoT in higher education.) is not supported.

SI and IU

Table 4.54 Model summary (Social influence (UTAUT) → Intention to use IoT)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.014	.000	-.002	.494

Predictor: Social influence

Table 4.55 ANOVA (Social influence (UTAUT) → Intention to use IoT)

Source	Sum of Squares	df	Mean Square	F	Sig.
Regression	.018	1	.018	.075	.784
Residual	99.001	406	.244		
Total	99.020	407			

Dependent variable: Intention to use IoT

Table 4.56 Coefficients (Social influence (UTAUT) → Intention to use IoT)

Predictor	B	Std. Error	R	t	Sig.
(Constant)	2.066	.068	30.484	.000	
Social influence	-.008	.031	-.014	-.274	.784

The model shows a negligible association ($R = .014$) and explains virtually no variance ($R^2 = .000$) (Sarstedt et al. 2019). The regression is not significant ($\text{Sig.} = .784$) and the effect is non-significant ($\beta = -.014$, $\text{Sig.} = .784$). Therefore, H3 (Social influence has a positive effect on students' intention to use IoT in higher education.) is not supported.

FC and IU

Table 4.57 Model summary (Facilitating conditions → Intention to use IoT)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.088	.008	.005	.492

Predictor: Facilitating conditions

Table 4.58 ANOVA (Facilitating conditions → Intention to use IoT)

Source	Sum of Squares	df	Mean Square	F	Sig.
Regression	.765	1	.765	3.162	.076
Residual	98.254	406	.242		
Total	99.020	407			

Dependent variable: Intention to use IoT

Table 4.59 Coefficients (Facilitating conditions → Intention to use IoT)

Predictor	B	Std. Error	R	t	Sig.
(Constant)	2.324	.157	14.844	.000	
Facilitating conditions	-.143	.081	-.088	-1.778	.076

The model indicates a weak association ($R = .088$) and explains 0.8% of variance ($R^2 = .008$) (Sarstedt et al. 2019). The regression is not significant ($\text{Sig.} = .076$) and the effect is non-significant ($\beta = -.088$, $\text{Sig.} = .076$). Therefore, H4 (Facilitating conditions have a positive effect on students' intention to use IoT in higher education.) is not supported.

Qualitative analysis

This section presents the qualitative findings based on thematic analysis of the interview data. The analysis generated four themes describing key application areas and perceived values of IoT adoption in higher education.

Table 4.60 Formulation of themes (thematic analysis)

Codes (examples)	Category	Theme (final)
Effective learning; personalised learning; improved learning experience; campus monitoring; safety/security	IoT for campus and learning support	Theme 1: IoT for campus monitoring and learning enhancement
Smart classroom; creative classroom; openness in classroom; better explanation; classroom automation (e.g., note-taking, schedule checking)	IoT-enabled learning environment	Theme 2: IoT-enabled smart and creative classrooms
Improve efficiency; enhancing security; managing large amounts of data; AI-supported prediction and risk reduction	IoT for management and security	Theme 3: AI-IoT integration for management and security
Home automation; assistance for people with disabilities; improving quality of life; independent living support	IoT for accessibility and daily-life support	Theme 4: IoT support for people with disabilities and daily-life assistance

Theme 1: IoT for campus monitoring and learning enhancement

Participants highlighted IoT as a practical solution for improving campus monitoring and supporting learning activities. The interview data suggest that IoT-enabled devices could enhance engagement and performance while also improving

safety and operational control in campus spaces. One participant noted that IoT “can be used to monitor and control the security of the campus, dormitories, and other facilities” and that it can enhance classroom experiences through smart devices such as projectors and interactive tools. Overall, this theme indicates that campus monitoring and learning support represent a key application area for IoT in higher education.

Theme 2: IoT-enabled smart and creative classrooms

The interviews also emphasised the classroom as a major setting for IoT adoption, particularly in enabling smart and creative learning practices. Participants described IoT as useful for automating routine learning tasks and improving classroom interaction. As one respondent explained, IoT could support “note-taking, schedule checking, and research tasks that students perform in the classroom using these mobile IoT devices,” which can be automated. This theme suggests that IoT-enabled classrooms can provide more flexible and engaging learning environments while improving teaching and learning efficiency

Theme 3: Combination of artificial intelligence and IoT drives effective management and security

A third theme concerns the integration of IoT with artificial intelligence for improving operational management and security. Participants noted that AI-enabled IoT systems can support risk reduction, security monitoring, and more effective decision-making through prediction and advanced analytics. As one respondent explained, “using AI with IoT in combination [can] provide better support and, at times, avoid major accidents.” In addition, participants referred to the broad applicability of AI-IoT solutions across domains (e.g., healthcare, education, and domestic settings), suggesting perceived potential for improving efficiency, management capability, and security in higher education.

Theme 4: IoT incorporation reduced issues and improves the life of disabled people

The final theme focuses on IoT applications that support people with disabilities and improve daily-life independence. Participants described how

connected devices can assist with everyday tasks and reduce reliance on caregivers. One participant stated that “speakers, refrigerators, phones, lighting, alarm systems, and more devices can all be connected,” making independent living more feasible for individuals with physical impairments. This theme indicates that accessibility-oriented IoT applications can extend the value of IoT beyond the classroom, contributing to inclusive learning and improved quality of life.

Across the four themes, the qualitative results identify key application areas for IoT adoption in higher education, including campus monitoring, smart/creative classrooms, management and security enhancement through AI-IoT integration, and accessibility support for people with disabilities. These themes complement the quantitative findings by illustrating how IoT may be implemented in practice and by highlighting adoption priorities linked to learning value, operational efficiency, and inclusive support.

Chapter 5

Discussion, Conclusion, and Recommendations

Introduction

This discussion chapter presents a detailed discussion of analysed findings with the literature to find out similarities and differences between the outcomes and existing work of authors. The thematic discussion covers all important aspects based on the objectives of the study. It is significant to draw a realistic and correct conclusion based on the literature and analysed findings.

Abbreviations used in this study include: SD = standard deviation; IOC = Item-Objective Congruence (item-level content validity index); IoT = Internet of Things; UTAUT = Unified Theory of Acceptance and Use of Technology; PE = performance expectancy; EE = effort expectancy; SI = social influence; FC = facilitating conditions; IU = intention to use.

Discussion

Benefits of IoT and intention to use IoT

The frequency analysis disclosed that the IoT provides several benefits to students and these benefits tend to create a positive impact on the intention of the students to use IoT. These benefits are flexibility, comfortable conversing in online classes, and improving chances of accomplishing things, increasing the efficiency of learning and resolving issues, technology being helpful in daily life, and cater specific needs. Likewise, the regression analysis disclosed that personalised curriculum and increase in efficiency have significant and positive relationships with the intention to use IoT. These findings are consistent with existing literature which revealed that IoT provides a personalised curriculum in education including personal interaction, customised courses, analysing needs and requirements for improving learning by big data analysis, data-driven learning, and so forth (Moreira, Ferreira & Cardoso, 2017; Ramlowat & Pattanayak, 2019; Bagheri & Movahed, 2016; Govindarajan & Srivastava, 2020). Apart from these, the IoT also leads to increasing the efficiency of learning by

students. This is done by self-direction technique, constant monitoring, remote and virtual learning, providing ease of use, and others (Bhide & Wagh, 2015; Mehmood et al., 2017; Alhaboobi, Yousif & Shawkat, 2019). In general parlance, the use of IoT or the inclusion of advanced technology enables students to access resources easily and to resolve queries rapidly which in turn provides time-effective advantages to the students. Further, personal attention and scheduling drives focus on individual learning and improvements. These ultimately enable the students to rely on IoT and enhance their interest to use the same. Thus, the greater the benefits provided by IoT, the higher will be the intention of the students to use IoT.

Challenges in the implementation of IoT and intention to use IoT

The regression, frequency, and descriptive statistics disclosed that there is a positive and significant association between the reliable internet connection and intention to use IoT. This shows that the intention to use IoT by students depends on a good and reliable internet connection to a great extent. These insights are consistent with existing literature which discloses that a reliable internet connection is crucial for the students to connect the device easily and assures learning systematically. Further, a less effective internet connection may lead to losing important information and issues in the interaction between teachers and students (Alam, 2021; Bagarukayo & Kalema, 2015). Importantly, the literature has highlighted several other challenges associated with the poor internet connection. These are losing range and reliability in the teaching process, high power consumption, battery damages, and so forth (Timms, 2016; Chen, Chen & Lin, 2020; Aldowah, Ghazal & Muniandy, 2015; Akter, 2020). In general parlance, the slow speed of the internet leads to creating an adverse influence on the intention of the students. This is because the disruption in the internet-speed leads to affecting the interaction adversely. Further, if the students would not find it useful and time-effective to download required material and interact effectively, indeed they tend not to prefer this technology. These justify that a reliable internet connection is prominent for students to determine the uses of IoT.

In the context of security and privacy concerns, the regression analysis indicates a statistically significant but weak positive association with intention to use IoT (Sig. = .017; β = .118). This suggests that students' intention is related to how they perceive security and privacy in the IoT-enabled learning environment, although the effect size is relatively small. In addition, descriptive statistics and frequency analysis show that many respondents reported positive perceptions of the university learning platform's safety and security and did not experience major issues while browsing the portal. This pattern is consistent with prior studies emphasising that stronger perceptions of data security and privacy protection can increase users' willingness to adopt educational technologies, whereas poor protection can reduce trust and hinder adoption (Guilherme, 2019; Hollier & Abou-Zahra, 2018). Moreover, the literature highlights institutional responsibility for ensuring data security and privacy for learners (Moreira, Ferreira & Cardoso, 2017; Bagheri & Movahed, 2016). Overall, while security and privacy concern shows a significant relationship with intention in this study, their influence appears weaker than core utility-related factors such as perceived efficiency gains and reliable connectivity.

Application areas of IoT

The insights revealed that there are various areas of IoT in higher education wherein smart classrooms, campuses, universities, schools, and even the domestic life of the disabled are prominent. In this context, the IoT could be implemented in the classroom to make it creative and innovative by adopting different tools such as an innovative board, tools for preparing notes, and so forth. Further, the security and safety of campus could be assured by adopting various technologies and installing several systems with the help of IoT. Apart from these, disabled people's life is a great area for the application of the IoT. This is because that IoT enables disabled people to be independent and to perform their duties and work conveniently. Automotive tools and machines help them to complete tasks without the assistance and support of others. Moreover, the implementation of IoT along with AI (Artificial Intelligence) seems effective in various fields and the use of this combination is rising continuously.

The above findings are consistent with the literature that revealed that a flipped classroom model, smart watches and gadgets, smart boards, tutorial and info graphics are some of the techniques that assure that a smart classroom could be a great application area for IoT (Aldowah et al., 2017; Bajracharya, Blackford & Chelladurai, 2018; Gligoric et al., 2015; Moraros et al., 2015). However, some findings of the literature are contradictory to primary insights. At this point by contradicting primary findings, literature revealed that AI implementation in educational institutions lacks appreciation of the prominence of the teachers and create complications between teachers and students (Guilherme, 2019; Oravec, 2022). This raises the question that *'whether the application of AI with IoT is not justifiable for different areas?'* Answering the same, literature revealed that robots or cobots, tailoring teaching practices, forecasting the career of students by big data analysis, customisation of university courses are some of the most aspects that justify the effectiveness of the using the combination of IoT and AI (Chen, Chen & Lin, 2020; Avella et al. 2016; Timms, 2016; Alam, 2021). These justify that using AI and IoT is significant for various areas mainly in the field of education. In practice also, IoT is being implemented in almost all the fields such as healthcare, education, corporations, and so forth. Especially in China, where technological advancement is rising constantly, it is worth saying that in every field, people are adopting and implementing the technology. In a nutshell, it is quite significant to implement the IoT because the advanced technology provides time-effective and other advantages which make the increasing implementation of IoT worthwhile.

Chinese students' intention to use IoT in higher education and UTAUT model

Based on the regression results, the UTAUT model is partially supported in this study. Specifically, performance expectancy shows a significant positive association with intention to use IoT, whereas effort expectancy, social influence, and facilitating conditions are not supported in the current sample.

Performance expectancy and intention to use IoT.

The descriptive statistics suggest that students perceive IoT as beneficial for improving performance and learning efficiency. The regression results further confirm a statistically significant positive relationship between performance expectancy and intention to use IoT (Sig. = .000; β = .270). This finding supports studies reporting that IoT-enabled learning tools can enhance students' academic productivity and performance (Lee & Shin, 2019; Almetere, Kelana & Mansor, 2020; Madigan et al., 2016; Guest et al. 2018; Bharati & Srikanth, 2018). Although some studies have reported insignificant links in certain contexts (Nizar et al., 2019; Shaqrah & Almars, 2022; Shaikh et al., 2019), the overall evidence in this study indicates that perceived performance gains are a key driver of Chinese students' intention to use IoT in higher education.

Effort expectancy and intention to use IoT.

The regression analysis shows that effort expectancy has an insignificant relationship with intention to use IoT (Sig. = .445; β = .038), indicating that ease-of-use considerations do not significantly shape intention in this sample. This pattern is consistent with studies that also found a weak or insignificant link between effort expectancy and behavioural intention in technology adoption contexts (Madigan et al., 2016; Paulo et al., 2018; Maillet, Mathieu & Sicotte, 2015; Guest et al., 2018; Bharati & Srikanth, 2018; Nur, Faslih & Nur, 2017). At the descriptive level, however, students still reported generally positive perceptions about learning technology and using IoT being easy, suggesting that perceived ease may be relatively uniform across respondents and therefore less predictive of intention in the regression results. Studies have similarly argued that when users are already familiar with digital tools, ease-of-use may become a "baseline expectation" rather than a differentiating factor (Lin et al., 2014; Shang & Wu, 2017; Lee & Shin, 2019; Yusof, Qazi & Inayat, 2017).

Social influence and intention to use IoT.

The regression results indicate that social influence (UTAUT) is not a significant predictor of intention to use IoT (Sig. = .784; β = -.014). This implies that perceived pressure or encouragement from important others does not uniquely

explain students' intention in the current sample. While some prior studies have reported a positive influence of social norms on adoption intention (Hamari & Koivisto, 2015; Nur, Faslih & Nur, 2017; Maillet, Mathieu & Sicotte, 2015), other studies similarly found no significant impact (Yusof, Qazi & Inayat, 2017; Bharati & Srikanth, 2018; Paulo et al., 2018). One possible explanation is that students' adoption intention may rely more on perceived learning value and practical benefits than on others' opinions, particularly when the technology relates to personal learning routines and preferences. It is also important to distinguish between item-level frequency patterns (which show many respondents agreeing that others encourage technology use) and regression results, where social influence does not emerge as a unique predictor of intention when examined as a model relationship.

Facilitating conditions and intention to use IoT.

Facilitating conditions show a weak and statistically insignificant association with intention to use IoT (Sig. = .076; β = -.088). This suggests that the availability of resources and support does not significantly predict intention in this sample. The literature reports mixed findings regarding facilitating conditions, with results varying by context, user group, and technology maturity (Bharati & Srikanth, 2018; Paulo et al., 2018; Guest et al., 2018; Madigan et al., 2016). In the present study, descriptive findings indicate generally positive perceptions of access to resources and knowledge, which may reduce variability and weaken predictive power. Overall, the results suggest that perceived performance gains (performance expectancy) are more influential than facilitating conditions in shaping Chinese students' intention to adopt IoT for higher education learning.

Effort expectancy and Intention to use IoT

The regression analysis revealed an insignificant, weak but positive relationship between IoT and effort expectancy, suggesting that ease-of-use considerations did not significantly shape intention in this sample. On this note, regression analysis has shown a weak and insignificant relationship, and literature has also revealed an insignificant link between the considered variables (Madigan et al., 2016; Paulo et al., 2018; Maillet, Mathieu & Sicotte, 2015; Guest et al., 2018; Bharati &

Srikanth, 2018; Nur, Faslih & Nur, 2017). Nevertheless, the descriptive findings exposed that IoT tends to save the efforts of the students. These discoveries are consistent with the literature, which showcases that higher adoption of advanced technology drives ease of use and resolves issues with limited efforts (Lin et al., 2014; Shang & Wu, 2017; Lee & Shin, 2019; Yusof, Qazi & Inayat, 2017). This may be because automotive technology provides various easy tricks and solutions that make it easy for students to find out solutions. Further, IoT helps students to interact with tutors and friends quickly, which is substantial to save the efforts of the students. Therefore, based on regression, descriptive it can be ascertained that the use and implementation of IoT in education saves efforts of the students. Yet, literature findings have justified insignificant relationship. At this point, the literature and primary insights have similar findings that security and privacy concern tend not matter to a great extent in the use of IoT by students.

Social influence and intention to use IoT

The primary insights disclosed that social influence has an insignificant, weak, and negative relationship with the intention to use IoT, which justifies that social influence may not have an important role in the intention of Chinese students to use IoT to a great extent. Contrary to this, frequency analysis revealed that social influence plays an important role to motivate students to use IoT. Likewise, the literature has shown a positive impact based on the drawing UTAUT model (Hamari & Koivisto, 2015; Nur, Faslih & Nur, 2017; Maillet, Mathieu & Sicotte, 2015). Thus, it seems that the application of the model from this perspective is less justifiable from the current aspect. Nevertheless, some existing literature findings also disclosed that there is no impact of social influence on the intention of people to use IoT (Yusof, Qazi & Inayat, 2017; Bharati & Srikanth, 2018; Paulo et al., 2018). On this note, it is important to note that in general parlance although suggestions of others make a significant impact on the decision of the people from collectivist culture; however, it could not be an ultimate base for choosing anything for learning. personal viewpoint, choices, and preferences determine the intention of the person. Therefore, social influence pretends not to play any significant role to a great extent to affect the

decision of the students to implement IoT in education. Importantly, the reason behind the differentiation in the findings of the primary insights for the research under consideration and literature may be due to the difference in the selection of the context and participants. For instance, the findings of Bharati & Srikanth (2018) are based on the research conducted for Indian economy. However, the present research has been carried out for Chinese economy. Although the Chinese and Indian economy have similarities in culture and preferences; still, different nations vary in the relevance of the technology adoption, implementation and other aspects. Likewise, the findings of existing literature of Paulo et al. (2018) are based on the analysing the intention of consumers whereas the present research's findings are revealed by assessing the data from the Chinese students. Therefore, it is intrinsic to have differences in the findings of current research and literature.

Facilitating conditions and intention to use IoT

The regression analysis disclosed that the facilitating condition has insignificant, negative and weak link with the intention to use IoT by the Chinese students. This means that the expedited conditions might not play any important role in determining the intention of the students to use IoT. However, descriptive statistics showcases that the expedited conditions are prominent in the implementation of IoT. Nevertheless, literature also revealed mixed findings showing significant and insignificant relationship between facilitating conditions and intention to use (Bharati & Srikanth, 2018; Paulo et al., 2018; Guest et al., 2018; Madigan et al., 2016). This raises the question that 'whether facilitating condition holds any significance to be considered by people to use IoT' In this context based on the findings and literature it can be ascertained that despite expedited conditions, other factors such as efficiency, effectiveness and uses of the IoT implementation might play an effective role. Further, the weak link of facilitating conditions shows that for the present context it may not hold a major place to influence the intention of the students to use IoT. Thus, the aspect of facilitating condition is not clear regarding the use of IoT for the issue under consideration. In this context, the reason behind the differences in the existing literature and insights of the present research may be

the differences in the aspects and scenario considered by the researcher. For example, the present research considers the use of IoT in the context of the education of the Chinese students whereas the scenario of other researchers may vary from educational field. Therefore, it is justifiable to have some differences in the findings of literature and current research.

Conclusion of Findings

This study aimed to examine IoT adoption in Chinese higher education by addressing four objectives: (i) analysing benefits and challenges, (ii) identifying application areas, (iii) proposing adoption options, and (iv) evaluating students' intention to use IoT using the UTAUT framework.

Objective 1: Benefits and challenges of IoT adoption.

The findings indicate that students perceive multiple benefits of IoT-enabled learning, particularly in terms of personalised curriculum support and increased learning efficiency. The quantitative results show that both personalised curriculum (Sig. = .000; β = .374) and increase in efficiency (Sig. = .000; β = .789) have significant positive relationships with intention to use IoT. In terms of challenges, reliable internet connection emerges as a key enabling condition with a strong positive association with intention (Sig. = .000; β = .774), suggesting that connectivity is central to sustained adoption. Security and privacy concern also shows a statistically significant but weak relationship with intention (Sig. = .017; β = .118), indicating that perceived safety and trust matter, although the effect is smaller than value-related drivers

Objective 2: Application areas of IoT in higher education.

The qualitative findings identify four major application areas: (i) IoT for campus monitoring and learning enhancement, (ii) IoT-enabled smart and creative classrooms, (iii) AI-IoT integration for management and security, and (iv) IoT applications supporting people with disabilities and daily-life assistance. These themes suggest that IoT adoption in higher education extends beyond classroom

convenience to include campus operations, security governance, and inclusive support services.

Objective 3: Adoption options for IoT in Chinese universities.

Synthesising quantitative and qualitative results, this study proposes that universities prioritise IoT initiatives that deliver visible learning and efficiency gains (e.g., smart classroom tools and personalised learning support) while treating connectivity and security safeguards as baseline conditions for scalable implementation. The SWOT/TOWS analysis further translates these factors into actionable options, such as phased deployment in infrastructure-ready settings, investment in stable network access, privacy-by-design and security-by-design practices, and targeted user support/training to strengthen implementation capacity. These options aim to convert the identified benefits into practical strategies and to mitigate key constraints affecting adoption.

Objective 4: Evaluation of intention to use IoT through UTAUT.

The UTAUT evaluation shows that the model is partially supported in this context. Among UTAUT predictors, performance expectancy is supported as a significant positive determinant of intention to use IoT (Sig. = .000; β = .270). In contrast, effort expectancy, social influence, and facilitating conditions are not supported in the regression results (Sig. = .445, .784, and .076, respectively). Overall, the findings suggest that students' intention is driven more strongly by perceived learning value and practical outcomes than by social pressure, ease-of-use perceptions, or perceived support conditions in this sample.

Limitations and Scope for Further Research

The present study has been conducted using a mixed-methods approach; however, several limitations should be acknowledged. First, the quantitative analysis relies primarily on simple regression models (one predictor at a time), which does not control for potential confounding factors. Future studies may apply multiple regression or SEM to test the UTAUT model and contextual predictors simultaneously and to provide more robust estimates. Second, the survey data are

based on self-reported responses, which may introduce common method bias and limit causal interpretation. Longitudinal designs and the inclusion of behavioural usage indicators (e.g., actual platform logs) could strengthen future evidence. Third, the sample is drawn from a limited number of institutions within the Chinese higher education context, which may constrain the generalisability of the findings to other regions, institution types, or cultural settings. Future research could expand sampling to additional universities, include more diverse student populations, and compare results across countries or educational systems. Fourth, although the qualitative interviews provide contextual insights into application areas and perceived value, the qualitative sample size remains limited. Future studies could incorporate interviews or focus groups with a broader range of stakeholders (e.g., students, administrators, IT staff, and policymakers) to triangulate perspectives on implementation feasibility and governance issues.

Overall, further research is recommended to (i) test the model using more comprehensive analytical approaches, (ii) explore cross-cultural and cross-institutional differences, and (iii) examine how infrastructure readiness, privacy/security governance, and learning design jointly shape IoT adoption outcomes over time.

Managerial Implications

In the context of increasing digitalisation and IoT adoption, the findings of this study provide practical implications for universities and higher education stakeholders in China. First, universities should prioritise IoT initiatives that deliver clear learning value and efficiency gains, such as smart classroom tools and personalised learning support, because perceived performance benefits are a key driver of students' intention to adopt IoT-based learning. Second, institutions should treat reliable internet connectivity as a baseline condition for implementation by investing in campus-wide network stability, bandwidth, and technical maintenance, as connectivity is strongly associated with intention to use. Third, universities should strengthen privacy and security governance through privacy-by-design and security-

by-design practices, including access control, data minimisation, user consent and transparency, and incident response planning. Fourth, institutions may adopt a phased implementation strategy, starting with infrastructure-ready departments or campuses and scaling gradually based on technical readiness and user feedback. Fifth, universities should provide targeted training and support for both students and staff to improve digital competence and to reduce barriers for those with limited prior experience. Sixth, learning design should incorporate IoT tools in ways that enhance engagement and interaction (e.g., interactive learning devices, automated classroom support, and structured online communication activities), aligning with the qualitative themes around smart and creative classrooms. Seventh, universities and policymakers should consider inclusive IoT applications, particularly those supporting accessibility and daily-life assistance for people with disabilities, to ensure that technological advancement does not widen digital inequality. Eighth, collaboration among university management, IT teams, academic staff, and policymakers is recommended to establish implementation standards and evaluation mechanisms, ensuring that IoT adoption is aligned with educational goals, operational capacity, and student well-being.

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Appendices

Appendix A

List of Specialists and Letters of Specialists Invitation
for IOC Verification



Ref.No. MHESI 0643.14/ 79

Bansomdejchaopraya Rajabhat University
1061 Itsaraparb Hirunrujee
Thonburi Bangkok 10600

12 May 2024

Subject: Invitation to validate research instrument

Dear Dr. Huang Yifan

Mr. Shen Qinjie is a graduate student in Doctor of Philosophy Program in Digital Technology Management for Education of Bansomdejchaopraya Rajabhat University. He is undertaking research entitled "Efficiency Enhancement on Higher Education Institutions in Shanghai, China through UTAUT Internet of Things (IoT) Model"

The thesis advisory committee has considered that you are an expert in this topic. Your recommendations would be useful for further improvement of this research instrument.

With your expertise, we would like to ask your permission to validate the attached research instrument. In this regard, we would like to avail ourselves of this opportunity to express our sincere thanks and appreciation for your help.

Yours faithfully,

Assistant Professor Dr. Tanaput Chancharoen
(Vice Dean of Graduate School for Dean of Graduate School)

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Subject: Invitation to validate research instrument

Dear Dr. Wang Minghao

Mr. Shen Qinjie is a graduate student in Doctor of Philosophy Program in Digital Technology Management for Education of Bansomdejchaopraya Rajabhat University. He is undertaking research entitled "Efficiency Enhancement on Higher Education Institutions in Shanghai, China through UTAUT Internet of Things (IoT) Model"

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Yours faithfully,

Assistant Professor Dr. Tanaput Chanchaoren
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Subject: Invitation to validate research instrument

Dear Prof. Li Yunfei

Mr. Shen Qinjie is a graduate student in Doctor of Philosophy Program in Digital Technology Management for Education of Bansomdejchaopraya Rajabhat University. He is undertaking research entitled "Efficiency Enhancement on Higher Education Institutions in Shanghai, China through UTAUT Internet of Things (IoT) Model"

The thesis advisory committee has considered that you are an expert in this topic. Your recommendations would be useful for further improvement of this research instrument.

With your expertise, we would like to ask your permission to validate the attached research instrument. In this regard, we would like to avail ourselves of this opportunity to express our sincere thanks and appreciation for your help.

Yours faithfully,

Assistant Professor Dr. Tanaput Chanchaoren
(Vice Dean of Graduate School for Dean of Graduate School)

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Thonburi Bangkok 10600

12 May 2024

Subject: Invitation to validate research instrument

Dear Dr. Zhang Qiaoling

Mr. Shen Qinjie is a graduate student in Doctor of Philosophy Program in Digital Technology Management for Education of Bansomdejchaopraya Rajabhat University. He is undertaking research entitled "Efficiency Enhancement on Higher Education Institutions in Shanghai, China through UTAUT Internet of Things (IoT) Model"

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Yours faithfully,

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12 May 2024

Subject: Invitation to validate research instrument

Dear Dr. Sun Xiaoxue

Mr. Shen Qinjie is a graduate student in Doctor of Philosophy Program in Digital Technology Management for Education of Bansomdejchaopraya Rajabhat University. He is undertaking research entitled "Efficiency Enhancement on Higher Education Institutions in Shanghai, China through UTAUT Internet of Things (IoT) Model"

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Yours faithfully,

A handwritten signature in blue ink, appearing to read 'Tanaput'.

Assistant Professor Dr. Tanaput Chanchaoren
(Vice Dean of Graduate School for Dean of Graduate School)

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12 May 2024

Subject: Invitation to validate research instrument

Dear Dr. Xu Weiguang

Mr. Shen Qinjie is a graduate student in Doctor of Philosophy Program in Digital Technology Management for Education of Bansomdejchaopraya Rajabhat University. He is undertaking research entitled "Efficiency Enhancement on Higher Education Institutions in Shanghai, China through UTAUT Internet of Things (IoT) Model"

The thesis advisory committee has considered that you are an expert in this topic. Your recommendations would be useful for further improvement of this research instrument.

With your expertise, we would like to ask your permission to validate the attached research instrument. In this regard, we would like to avail ourselves of this opportunity to express our sincere thanks and appreciation for your help.

Yours faithfully,

Assistant Professor Dr. Tanaput Chanchaeroen
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12 May 2024

Subject: Invitation to validate research instrument

Dear Dr. Chen Lei

Mr. Shen Qinjie is a graduate student in Doctor of Philosophy Program in Digital Technology Management for Education of Bansomdejchaopraya Rajabhat University. He is undertaking research entitled "Efficiency Enhancement on Higher Education Institutions in Shanghai, China through UTAUT Internet of Things (IoT) Model"

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Yours faithfully,

A handwritten signature in blue ink, appearing to be 'Tanaput'.

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Appendix B

Research Instrument

Questionnaire for students

Part-1: Demographic profile

1. Age

- 18-20 years
- 21-25 years
- 26-30 years
- More than 30 years

2. Gender

- Male
- Gender
- Prefer not to say

3. Which education qualification are you pursuing?

- Graduation
- Masters
- Certificate based course/ diploma

4. Which education field are you studying in?

- Management
- Marketing
- HR
- Finance
- Other

Part 2: Main research

Please rate your level of agreement to the following statements on a five point Likert scale where 1=Strongly agree; 2=Agree, 3=Neutral, 4=Disagree; 5=Strongly disagree.

5. Personalised curriculum

	1	2	3	4	5
I like the course design					
I like the course content designed by using the technology					
I am satisfied by learning in the course					
I am satisfied with overall experience in the course					

6. Increase in efficiency

	1	2	3	4	5
The use of IoT gives flexibility in learning					
IoT caters the specific learning needs and of style students					
IoT enables engaging and active learning activities					

7. Social networking

	1	2	3	4	5
I feel web-based education is effective medium for social interaction					
I feel comfortable conversing in online classes					
I feel comfortable to introduce myself in the digital class					
I feel comfortable to participate in the course discussion					
I feel comfortable to interact with others in the course					
I find instructor of teacher facilitating the discussion in the course					
The online classes facilitate to make distinct individual impression of course participants					

8. Security and privacy concern

	1	2	3	4	5
University e-learning portal is safe to use					
University e-learning portal is secure to use					
There is proper security and support teams for online portal					

9. Reliable internet connection

	1	2	3	4	5
I do not experience while browsing university learning platforms					
I found browsing speed satisfactory					
I think I can rely on the computer network					
There is easy access to internet on campus					

10. Performance expectancy

	1	2	3	4	5
I find use of technology in education helpful in my daily life					
Use of technology in education enhances my chances of accomplishing thing which are important to me					
Use of technology in education helps in achieving things more quickly					
Use of technology in education augment my productivity					

11. Efforts expectancy

	1	2	3	4	5
I find it easy to learn how to use technology in education					
I find IoT in education easy to use					
I feel that my interaction with technology in education is understandable and clear					
I find it easy to be skilful of using the technology in education					

12. Social influence

	1	2	3	4	5
All important people in my network feel that I should use technology in education					
People who have influence on me think that I should use technology in education					
People whose opinion I prefer value that I use technology in education					

13. Facilitating conditions

	1	2	3	4	5
I have necessary resources to use technology in education					
I have necessary knowledge to use the technology in education					
Technology in education is compatible with other technologies I use					
I find it easy to get help for others if I face challenges in using technology in education					

14. Intention to use IoT

	1	2	3	4	5
I intend to continue technology in education					
I will always like to use technology in my daily life					
I will use technology regularly as I do now					

Appendix C

The Results of the Quality Analysis of Research Instruments

Questions of interviews for tutors

Opening/consent (30–45 sec). Thank you for participating. With your consent, I'll record our conversation for research purposes. You may skip any question or stop at any time.

Q1. Connectivity & access (RIC).

From your day-to-day experience, how reliable is on-campus Internet (coverage, stability, speed/latency) in classrooms and dorms?

Probes: peak-time slowdowns; drop-offs; login/captive-portal friction; where it works best/worst.

Q2. Classroom enablement (PE).

What course activities work best when digital/IoT tools are involved?

Probes: assessment/feedback link (quizzes, polls, submissions); time saved; concrete examples.

Q3. Ease & support (EE, FC).

How easy is it for students to get started and get help when they run into issues?

Probes: onboarding materials; help-desk responsiveness; device compatibility.

Q4. Social/organizational cues (SI).

What signals from instructors, departments, or peers affect students' willingness to use these tools?

Probes: syllabus prompts; modeling by instructors; peer champions.

Q5. Privacy & security (SPC).

How do students react to privacy/security issues? What messages or safeguards make a difference?

Probes: plain-language notices; where policies are shown; examples of concerns resolved.

Q6. Accessibility & inclusion (experience pathway).

What works for students with limited prior experience or with accessibility needs?

Probes: micro-orientations; assistive features; success stories.

Q7. Equity & location.

Do adoption patterns vary by study location (lecture halls, library, dorms) or device access?

Probes: hotspots vs dead zones; shared devices.

Q8. Priorities and KPIs.

If you could change three things to improve everyday use, what would they be?

Probes: specific KPIs (uptime, latency, login success), small pilots you would try next semester.

Closing (15–30 sec). Anything we didn't ask that we should have

Appendix D
Certificate of English



This is to certify that

Shen Qinjie

Achieved BSRU English Proficiency Test (BSRU-TEP) level

C2

Given on 14th September 2024

(Assistant Professor Dr Kulsirin Aphiratvoradej)

Director

Appendix E

The Document for Acceptance Research



ARTICLE ACCEPTANCE CERTIFICATE

Author: Shen Qinjie, Nainapas Injoungjirakit, Sombat Teekasap, Prapai Sridama

Title: Adoption of Campus IoT in Shanghai Higher Education: A Mixed-Methods UTAUT Study with Infrastructure and Privacy Extensions (ID: **ESP-4347**)

Acceptance Date: 15 December 2025

Environment and Social Psychology



ARTS AND SCIENCE PRESS PTE. LTD.

15 December 2025

Researcher Profile

Name-Surname: Shen Qinjie
Birthday: 27th, Jan, 1997
Place of Birth: FUJIAN, CHINA

Educational background:

- Doctor of Philosophy Program in Educational Administration, Bansomdejchaopraya Rajabhat University, in 2022
- Master in Business Innovation, Bangkok University, in 2020
- Bachelor of Business Administration, Entrepreneurship Management, Bangkok University, in 2017

Work experience:

- Raffles International College Bangkok, BBA Lecturer.

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