STUDENTS BEHAVIOUR TOWARD VOICE ASSISTANT TECHNOLOGY IN THE UAE

دراسة سلوك الطلاب تجاه تقنية المساعد الصوتي في دولة الإمارات العربية المتحدة

by

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Abstract

Recently, voice assistant's technology has become a universal learning assistant approach for students to such an extent that they can no longer use their hands to study. The aim of this research is to investigate higher education students' behaviour towards artificial intelligence voice assistants in the United Arab Emirates, such as Siri, Alexa, Google and Cortana etc. This research has three main objectives. First, to review most commonly adopted external variables for adoption and acceptance of voice assistant studies in the TAM. In order to carry out a systematic analysis, the quantitative study technique is based of 42 papers published in the past 10 years. The independent variables of TAM, which includes: (Subjective norms (SN), Enjoyment (ENJ), Facilitating Conditions (FC), Trust (TR), and Security (SR)), were defined as the most commonly used. Second, to generate a conceptual framework by applying TAM model with most commonly adopted external variables. Third, to conduct a current conceptual framework by employing the PLS-SEM procedure, which is appropriate for the context of our research. A questionnaire survey was used to gather data from four universities in the United Arab Emirates which have adopted the voice assistant system. The overall number of students that were involved in this research were 300 students. Based on the study's findings, the results indicate that there was a significant influence of enjoyment and trust on students' perceived usefulness of using voice assistant technology. In addition to that, trust and facilitating conditions have positively impacted the students' perceived ease of use of voice assistant systems. Moreover, perceived usefulness and perceived ease of use has contributed to grow the students' behavior intention to use voice assistant technology.

Keywords

Voice Assistant System; University students; United Arab Emirates; Technology Acceptance Model (TAM); Technology Adoption; Subjective norms; Enjoyment; Facilitating conditions; Trust; Security; Structure equation modeling (SEM); Artificial Intelligence (AI); Technology Acceptance.

ملخص

في الآونة الأخيرة ، أصبحت تقنية المساعد الصوتي أسلوبًا عالميًا و مبتكرة لمساعدة الطلبة على التعلم، بحيث انه يجعل الطلاب ينجزون اعمالهم دون إستخدام أيديهم. و يهدف البحث إلى التحقق من سلوكيات الطلبة الجامعيين تجاه تقنية المساعد الصوتي في دولة الإمارات العربية المتحدة ، مثل سيري و أليكسا و جوجل وكورتانا والخ. الغرض من البحث هو ثلاثة اهداف: أولاً، مراجعة المتغيرات المستقلة الأكثر شيوعًا في نموذج قبول التكنولوجيا حول دراسة اعتماد المساعد الصوتي وقبوله. تم إجراء تحليل منهجي باستخدام تقنية البحث الكمي على 42 ورقة بحثية نُشرت في السنوات العشر الماضية. و قد تم اكتشاف العوامل الخارجية لـنموذج قبول التكنولوجيا ، والتي تشمل : (التأثير الاجتماعي، التمتع ، وتسهيل الظروف ، والثقة ، والأمن) على أنها الأكثر استخدامًا. ثانيًا ، بناء نموذج جديد من خلال تطبيق نموذج قبول التكنولوجيا مع المتغيرات الخارجية الأكثر شيوعًا. ثالثًا، تحقق من نموذج قبول التكنولوجيا باستخدام نمذجة المعادلة البنائية لدراسة فرضيات البحث، وهو إجراء مناسب لسياق البحث. تم استخدام استبيان لجمع البيانات من أربع جامعات مختلفة في دولة الإمارات العربية المتحدة و التي قامت بتطبيق نظام المساعد الصوتي. بلغ العدد الإجمالي للمشاركين في هذا البحث 300 طالب وطالبة. بناءً على نتائج الدراسة ، تشير النتائج إلى وجود تأثير إيجابي على عامل المتعة و عامل الثقة في استخدام المساعد الصوتي على فائدة الطلاب المتوقعة لاستخدام تقنية المساعد الصوتي. بالإضافة إلى ذلك ، أثرت عامل الثقة وعامل تسهيل الظروف بشكل إيجابي على سهولة إدراك الطلاب لاستخدام أنظمة المساعد الصوتي. وقد ساهمت الاستفادة المدركة سهولة الاستخدام المدركة في تنمية النية السلوكية للطلاب لاستخدام تقنية المساعد الصوتي.

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Chapter 1: Introduction

1.1 Brief Overview

The advent of voice-assisted technology is one of the most significant examples of artificial intelligence advancement in recent years. This research focuses on investigating higher education students' behavior towards artificial intelligence voice assistants in the United Arab Emirates, such as Siri, Alexa, Google, and Cortana, etc. In addition to that, the research will comprehend students' acceptance of voice assistant technology. This research was designed to present a set of variables founded on current hypotheses, and based on the variables we can determine the impact of the relationships between the primary constructs of TAM and external variables of using voice assistant technology. The Technology Acceptance Model (TAM) served as the research's conceptual framework, and it proved to be effective in achieving the objectives of this research.

1.2 Problem statement

Recently, Voice assistants have become popular around the world and offer many advantages for students. However, students in the UAE are rarely heard using the voice assistant system as an EdTech consultant. Moreover, the student's behavior at universities in the United Arab Emirates was not adequately discussed in the studies. This research will investigate and review students' behaviors toward the use of voice assistant technology in higher education at four well-known universities in the United Arab Emirates. The research aimed to determine the most commonly adopted external variables in the voice assistant system of the Technology Acceptance Model (TAM). This research analyzed five external variables (Subjective norms (SN), Enjoyment (ENJ), Facilitating Conditions (FC), Trust (TR), and Security (SR)) which will have an effect on students'

intention of use toward voice assistant technology. Additionally, Universities that have effectively adopted voice assistant systems were selected as participants of this research.

1.3 The Purpose of Research

The objectives of this research are addressed in the following below:

- The purpose of this quantitative study is to explore students' behavior and acceptance towards artificial intelligence voice assistant technology in the United Arab Emirates.
- This research will identify the most commonly adopted external variables of the Technology Acceptance Model (TAM) that influences the acceptance of the voice assistant technology. The constructs of TAM include such as Perceived ease of use, Perceived usefulness, Attitude towards use, Behavioral intention to use, and Actual usage of the voice assistant system. Other variables that were generated from the current studies have been included in the conceptual framework of the research, and these variables are (Subjective norms (SN), Enjoyment (ENJ), Facilitating Conditions (FC), Trust (TR), and Security (SR)).
- Another objective of this research is to motivate higher education students to apply the technology as part of their education learning system.
- To begin supporting and developing the idea of incorporating AI voice assistant system in the education system in the United Arab Emirates.
- To investigate the variables influencing voice assistant's system adoption in the published studies.
- Building TAM model for voice assistant technology system.
- Verifying the developed model using a Structural Equation Model (SEM).

1.4 Research Questions

The research objective will be met by answering the following research questions:

1 What are the aspects that influence the adoption of voice assistant technology?

2 To what degree can the most commonly adopted external variables of the Technology Acceptance Model (TAM) influence the acceptance of the voice assistant technology?

3 How is the voice assistant technology acceptance affected by the most commonly adopted external variables of the Technology Acceptance Model (TAM)?

1.5 Research structure

The following section provide the research's chapters:

Chapter one (Introduction): Introduces the research by including a summary of the research. The description of the problem is given. The methodology of the study was explained. The purpose of research as well as the research questions are explicitly specified. Following that, the research structure is then clarified.

Chapter two (Literature Review): In the present section, the concept of using voice assistant technology was explained in the introduction. The research addressed the terminology and definitions of the voice assistant technology and how can the voice assistant work as a learning assistant in the educational field. The section also discusses the approach of the technology adoption model (Technology Acceptance Model) including the constructs. Lastly, the chapter came to a conclusion with defining the data sources used in the research as well as the criteria of research.

Chapter three (Conceptual Framework & Hypotheses): This section represent the approach that is used to test the most commonly adopted external variables of voice assistant system adoption in the technology acceptance model (TAM). In addition, the chapter examines the conceptual framework and hypothesis that has represented as the conceptual platform for conducting this analysis. Description of each factors were presented in this section.

Chapter four (Methodology): The approach used in the research is discussed in this chapter. The section also examines the methodology of the research and methods of data collection is described. The participants in the research are mentioned. A research instrument is developed. Furthermore, the questionnaire design is thoroughly clarified.

Chapter five (Findings & Discussion): The findings of the study are introduced in this section. This chapter provides an summary of the analysis of the questionnaire responses. The various analytical methods that can adapt to the conceptual framework for this research to the obtained data are provided and the model of research is developed and the hypotheses of research is tested.

Chapter six (Conclusion): The research conclusion is defined in this section. The limitation of the research is granted. Moreover, the potential studies on future research can be conducted.

Chapter 2: Literature Review

2.1 Introduction

Nowadays technology is going forward to satisfy human needs with a simpler lifestyle which enhances the level of human productivity and capabilities with perhaps no effort (Chowdhury 2018). As AI technology is currently rapidly evolving, artificial intelligence's basic concept is that it closely resembles and surpasses how humans comprehend and communicate with the world around them. (Chai, Wang & Xu 2020). Besides, AI's machine intelligence has a high potential to learn on its own and to get guidance from humans (Chowdhury 2018), based on the information they collect (Jennifer & Sofroniev 2020). One of the AI forms is known as the "virtual voice assistant" and is considered as one of the popular and growing applications that rely on artificial intelligence to respond to user requests, answer their questions, and assist them in carrying out tasks(Chowdhury 2018; Sorensen 2019). Some of these examples include Siri, Google Assistant, Cortana, or Alexa, where it enables users to look for different topics, arrange a meeting, or make

a hands-free call at home or car. Therefore, it is not necessary to touch the device (de Barcelos Silva et al. 2020) As a result, the voice assistant provides users with a comfortable way to communicate with the technology because they are hardly ever obliged to enter physically or associate with the device, in return they experience human-like practice and can communicate with the device using voice input (McLean & Osei-Frimpong 2019; Sorensen 2019). Additionally, The natural language systems that "voice assistant" applications depend on, enhances the possibility of natural conversations between users and their devices(de Barcelos Silva et al. 2020). Naturally, these expansions in recent technology have created a tendency to integrate technology into education(Hales et al. 2019). The recent studies show that AI technology will be a significant step forward in the educational sector, as it will allow for immediate improvement in educational quality in the upcoming future. (Chai, Wang & Xu 2020). Since voice assistants are user-friendly, there are plenty of smart devices in homes today that integrate them. Smart speakers have always been one of the regular products with voice assistants technology, and they are only recently becoming available in educational institutions. However, even though voice-controlled assistant are common in certain households, their utilization in the classroom setting and for academic intention remains restricted due to concerns over security issues, personal information collection (Terzopoulos & Satratzemi 2020), or the intention of students to use (Teo & Zhou 2014). According to (Teo & Zhou 2014) literature analysis, they concluded that students' motives for using technology can be understood by their technology acceptance. The adoption of system depends on the ability of someone to use technology for their daily practices. Therefore, Researchers have suggested and developed a structure that would serve as a basis for explaining the use of technology. Based on many research, the TAM is the most commonly used paradigm of technology adoption(Neumann 2018; Sohn & Kwon 2020).

2.2 Voice Assistant Technology

A voice-controlled assistant is a digital element that audibly interacts and responds with the user. You can command any questions to your assistants either via smartphone or smart home devices, and handle numerous activities including planning your schedule, playing music, check the mailbox, shop online, set reminders and making calls, etc. (Easwara Moorthy & Vu 2015; Hoy 2018). Usually, voice assistant technology works when the device is actively paying attention to a phrase that will enable it to function. It captures the voice of the user and passes it to the data center, where it handles and analyzes the information as a request. Based on the request, the system can provide relevant data to the virtual assistant to respond to the user (Hoy 2018). The possibility to have direct interaction with a device several years ago sounds very futuristic, but voice technology is now readily accessible (Hoy 2018). The use of smart voice assistants is nevertheless ready to grow in the following years**.** The size of the business for voice assistants is projected to expand massively in the years ahead (Neiffer 2018). Siri, Google Assistant, Cortana, and Alexa are now the leading market in the voice assistant world(Song 2019) Nowadays, voice assistant technology is widespread and you can find the technology almost in every smartphone and smart device. Due to advanced technology such as advanced intelligence, IOT, and cloud-computing, voice technology has become the next generation of human-computer interaction (Terzopoulos & Satratzemi 2020). These systems rely on learning using artificial intelligence technology (Song 2019) to understand the context of questions, interpret human voices and produce an accurate response (Neiffer 2018). Consequently, voice technology can study user's attitudes to improve the user experience to the next level. (Kessler & Martin 2017). To put it briefly, the more voice-based interactions between the users and the device, the more highly value their interaction is (de

Barcelos Silva et al. 2020). Unfortunately, not many people are interested in using this type of technology. In reality, voice assistant system is being avoided and its potential is being neglected, that people started showing ignorant behavior towards voice assistants despite their capability during tasks (Chowdhury 2018).

2.3 Voice Assistant as a Learning Assistant

Students these days are used to seeing modern technologies in their education system; therefore, instructors must educate students that technologies can be used not only during leisure time; it can also use for academic purposes. By integrating advanced technology throughout daily practices, students can become active in the curriculum, perform productively and enjoy a customized learning process (Hales et al. 2019), as well as support them in developing their abilities in many ways (de Barcelos Silva et al. 2020). Moreover, the educational sector is now focusing more on applying AI technology in learning systems, especially for learners. Thus, it can be used widely to build good experience for students (Barret et al. 2019), gain effective knowledge, and receive information easily (Terzopoulos & Satratzemi 2020). Voice assistants can become a universal learning assistant tool for students to such an extent that they can no longer use their hands to study, now they can only be able to communicate with the smartphone using verbal commands. Studies showed that when students get an assignment, they usually exhibited significant work output and levels of teamwork performance when they communicate with voice-assisted technology rather than students associated with teachers (Sayago 2019; Terzopoulos & Satratzemi 2020). Voice assistant can offer many facilities concerning course-related materials. For example, video recording, student's participation, submission, and score results. As per the research, this would benefit teachers minimize their responsibilities while still serving as a key contributor for students. Even though, voice-controlled assistant are commonly available in various households,

their utilization in education institutions is restricted due to concerns about data privacy. (Terzopoulos & Satratzemi 2020) However, there are few studies in the field of User-Machine Interaction that address the possibilities and difficulties of using voice-assisted technology in the education system(Science, Lleida & Sayago 2019). It is only inevitable that this expansion can embrace technology in education. Teachers need to expand their use of technology in the learning environment, in order to train students for a rapidly evolving and technologically oriented world (Hales et al. 2019).

2.4 The Technology Acceptance Model (TAM)

Fred Davis originally introduced the Technology Acceptance Model (TAM), which is the most well-known approach to technology adoption. Even though the first release was created in 1985, except that the TAM model has still been commonly used but has been continued nowadays (Neumann 2018; Jennifer & Sofroniev 2020). It was originally designed in terms of the reasoned action theory, specifically, to describe the connection between two measurements of perceived usefulness (PU) and perceived ease of use (PEOU)(Alharithi 2019), both indicators are impacted by external factors(Salloum & Shaalan 2018) along with behavioral intention (BI) to implement new technology (Lin & Chen 2015). On top of that, TAM has been proven to be an effective framework for understanding intelligent technology systems such as smartphones and smart devices (Schudzich 2019). Another way to describe TAM is a conceptual theory where it describes user's behavior to decide whether to accept the latest technology or not which then influences users' awareness to use new technologies (Easwara Moorthy & Vu 2015; Moriuchi 2019; Song 2019). By other means, TAM's intent is mostly referred to as analyzing and predicting why technology seems to be highly possible to be used or ignored (Kessler & Martin 2017). The classic TAM is provided by five factors including perceived usefulness, ease of use, behavioral intention to use,

attitude, and actual use toward using the technology (Salloum & Shaalan 2018; Chu, Galetzka & Van Deursen 2019). In Figure 1 demonstrate the classic Technology Acceptance Model together with constructs.

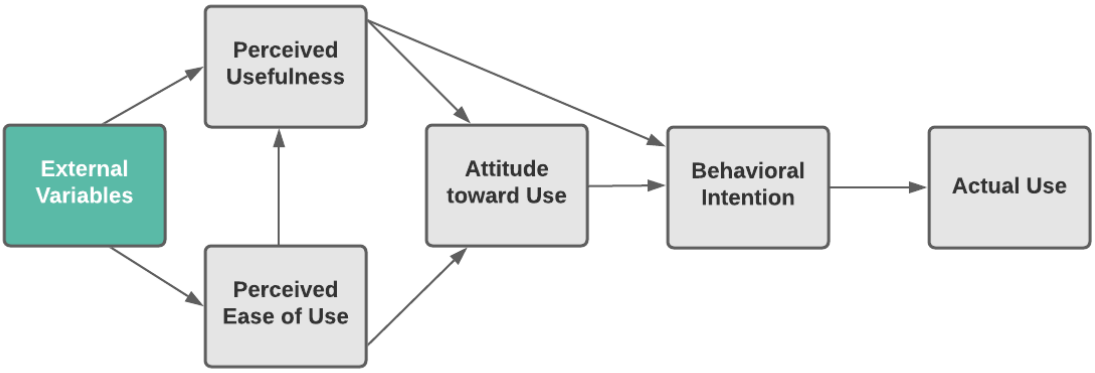

Figure 1. The Technology Acceptance Model (TAM)

Chapter 3: Conceptual Framework and hypothesis

3.1 Brief overview

This research, therefore, suggests a framework that enables researchers in order to have a clearer insight of users' behaviors and user's intention to use voice assistant system. The framework is built upon the constructs of the Technology Acceptance Model (TAM), and it is applied to the context of voice assistants by including external variables. The review shows that the (Subjective norms(SN), Enjoyment (ENJ), Facilitating Conditions (FC), Trust (TR), and Security (SR)) are presumed to be rather widely employed external variables as given in Figure 2. The aim of our study is to establish the conceptual framework, the research's hypothesis, as well as the association between the key constructs of TAM and the most widely employed external variables for the adoption of voice assistant technology.

3.2 External Factors

3.2.1 Social influence/Subjective norm (SN)

Subjective norms(SN) are described as a "A person's belief about an object may be defined as his subjective probability that the object has a given attribute" (Ajzen & Fishbein 1975), similarly the definition of subjective norm is used to represent social influence (Bloemendaal 2018). In addtion to that, subjective norms are believed to be a major variable in defining users' behavior toward using technology, according to many studies (Basak, Gumussoy & Calisir 2015). This variable will have an impact on how the user will view the technology, their confidence and loyalty, and thus their sense of use (Bloemendaal 2018), usually this variable mostly influenced by views and beliefs from their family members, friends and other groups of society (Neumann 2018). Recently, a research has claimed that subjective norms can impact the adoption of voice assistant technology. In a research undertaken by (Moriuchi 2019; Song 2019), shows that subjective norm had found notable effect on the perceived usefulness (PU) and perceived ease of use (PEU). Accordingly, the following hypothesis has been formed:

H1: Subjective norm (SN) positively influences the perceived usefulness (PU) of voice assistant technology.

H2: Subjective norm (SN) positively influences the perceived ease of use (PEU) of voice assistant technology.

3.2.2 Enjoyment (ENJ)

Enjoyment (ENJ) states the fact of where the behavior of utilizing technology **is viewed to be enjoyable enough** by itself, and that the users would be naturally driven to use a given device as it brings excitement and enjoyment (Agarwal & Karahanna 2000). According to research carried out, that if a device is considered to be fun to use, a user will have positive feelings toward the

technology and be likely to use it. (Basak, Gumussoy & Calisir 2015). The simplicity of starting the system or how effective the voice technology had been in delivering simple responses may influence the enjoyment since the device can perform a wide variety of tasks, the more capabilities the voice technology has, the more enjoyable that would be for the user (Sorensen 2019). Studies have shown that enjoyment is a strong element of the perceived usefulness (PU) and perceived ease of use (PEU) (Chu, Galetzka & Van Deursen 2019; Schudzich 2019). Thusly, the next hypothesis generated:

H3: Enjoyment (ENJ) positively influences the perceived usefulness (PU) of voice assistant technology.

H4: Enjoyment (ENJ) positively influences the perceived ease of use (PEU) of voice assistant technology.

3.2.3 Facilitating conditions (FC)

Facilitating conditions (FC) known as "The degree to which an individual believes that an organizational and technical infrastructure exists to support the use of the system" (Venkatesh et al. 2003).This implies that the factor reassures you more about what potential end-users got to have to use a system, what conditions and facilities need to be provided but also what support they want to accept the new technology (Kessler & Martin 2017). Facilitating conditions shows that attributes such as accessibility and efficiency of smartphones and technologies will impact the usage of Voice Assistant Technology. Researchers have identified that facilitating conditions is a good influence of the perceived usefulness (PU) and perceived ease of use (PEU) in terms of using voice assistant system (Bloemendaal 2018). Consequently, this contributes to the next hypothesis:

H5: Facilitating Conditions (FC) positively influences the perceived usefulness (PU) of voice assistant technology.

H6 Facilitating Conditions (FC) positively influences the perceived ease of use (PEU) of voice assistant technology.

3.2.4 Trust (TR)

Trust in the field of technology is particularly built where a device or piece of technology may assist users in meeting their needs. Studies have found that users should have belief in any technology till they can accept it (Lee & Choi 2017). Trust (TR) best described as "a psychological state comprising the intention to accept vulnerability based upon positive expectations of the intentions or behavior of another" (Rousseau et al. 1998). This indicates that trust is seen as the degree toward which users trust that the voice technology is secure in protecting their personal data and has a good effect on their lives. (Chu, Galetzka & Van Deursen 2019). Trust has proven to be positively affected on perceived usefulness (PU) as well as on perceived ease of use (PEU) in using voice assistant technology (Alharithi 2019; Chu, Galetzka & Van Deursen 2019; Zeng 2020). Thus, the below hypothesis created:

H7: Trust (TR) positively influences the perceived usefulness (PU) of voice assistant technology.

H8: Trust (TR) positively influences the perceived ease of use (PEU) of voice assistant technology.

3.2.5 Security (SE)

Security (SE) refers to "Users' perspectives toward the protection level against the potential threats" when employing voice-controlled solutions (Park et al. 2017). Security is a significant variable in the use of voice-based services, to have a clearer understanding of user's behavior, voice-based technologies need to gather some input and information from consumers such as users' names, ages, gender, questions, voice recording to offer them the best user experience. Since the smart device serves as a users' everyday personal assistant, it often needs the consent of personal details (Cuadra 2018; Chu, Galetzka & Van Deursen 2019). However, to overcome the

possible danger of using voice assistant technology, organizations must successfully build a data structure that can adjust to user's preferences while also providing protection and confidentiality to data collection (Jennifer & Sofroniev 2020). According to the studies, it was found that there is a powerful connection between security (SE) and perceived usefulness (PU) to adopt voice assistant technology (Neumann 2018; Chu, Galetzka & Van Deursen 2019). Therefore, the following hypothesis is founded:

H9: Security (SE) positively influences the perceived usefulness (PU) of voice assistant technology.

3.3 Internal Factors

3.3.1 Perceived Ease of Use (PEU)

The perceived ease of use is basically how easy a user feels toward adopting voice-based technology with less effort and it is considered to be the second primary factor of behavioral intent (Davis 1985). To put it another way, users must have the impression that the technological innovations in their households are simple to operate (Chu, Galetzka & Van Deursen 2019), and the level at which the significant power user expects the aimed technology to be effort-free (Lin & Chen 2015). Technically, users should get an advantage from the technology for future employment, other than that they will be disappointed and probably not be able to use it ahead. Voiced technologies can be confusing for consumers since the functionality of the system is new for some users. There could be dissatisfaction if somehow the technology does not comprehend users' needs and wants, this will definitely reflect on the potential plan of adopting the technology (Sorensen 2019). Some researchers have stated that perceived ease of use (PEU) is the fundamental element that affects the perceived usefulness (PU) and the behavioral intentions (BI) toward virtual

assistant adoption (Moriuchi 2019; Song 2019; Sorensen 2019). For this purpose, the next hypothesis is developed:

H10: Perceived ease of use (PEU) positively influences the Perceived usefulness (PU) of voice assistant technology.

H11: Perceived ease of use (PEU) positively influences the behavioral intention to use (BI) of voice assistant technology.

3.3.2 Perceived Usefulness (PU)

Perceived usefulness (PU) is explained as a level of an individual assumption toward a specific technology which strengthen their efficiency (Davis 1985). Both of Perceived Usefulness (PU) and ease of use (PEU) are known as indicators to indicate user's behavioral intention (BI) in the world of technology acceptance model (TAM). However, Perceived usefulness (PU) is considered to be the most motivational factor in IT adoption than Perceived ease of use (PEU) (Basak, Gumussoy & Calisir 2015; Lin & Chen 2015). In addition, when user intent to use a new technology based of user's behavior, they are proven to be positively influenced by their perceived usefulness (Cacho-Elizondo, Shahidi & Tossan 2012; Chu, Galetzka & Van Deursen 2019). According to recent studies on voice assistant techology, it has explained that there is positively high association between (PU) and behavioral intention (BI) toward using voice assistant system (Sorensen 2019; Chai, Wang & Xu 2020). Therefore, this hypothesis has been established based on this research:

H12: Perceived usefulness (PU) positively influences the behavioral intention to use (BI) of voice assistant technology.

3.3.3 Behavioral Intention to Use (BI)

Behavioral Intention to Use (BI) is a predictor of a user's probability of participating up in a particular behavior and has shown to be a leading indicator of technology use (Ajzen & Fishbein 1980), and this indicates that a user has a productive interaction with a system and is willing to use it again. Users who use voice assistants would have an optimistic behavior if the assistant recognized the user's voice and replies accurately to commanded requests (Sorensen 2019). Numerous researches have shown that there is a strong connection between behavioral intention to use (BI) and Actual Use (AU) regarding the usage of voice assistant technology (Filipe & Afonso 2019). Based on that, the following hypothesis has been introduced:

H13: Behavioral intention to use (BI) positively influences the actual use (AU) of voice assistant technology.

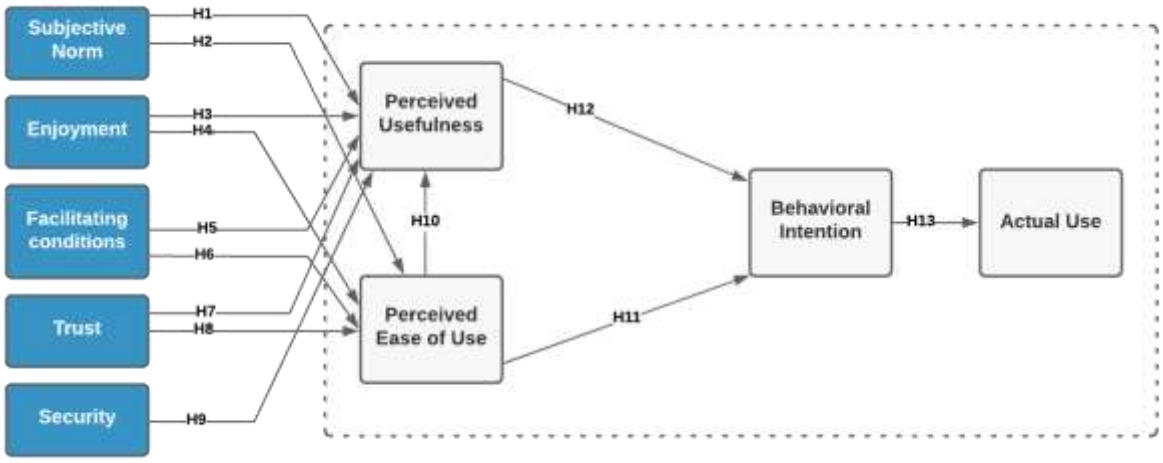

Figure 2: Conceptual Framework

Chapter 4: Methodology

4.1 Introduction

In the following chapter, the approach for investigating the higher education students' behavior towards artificial intelligence voice assistant's technology in the United Arab Emirates has been

described in this chapter. Four universities were selected as participants, all of which have adapted voice assistant technology. The sample of the participants in the research are introduced, and the mechanisms of the students' surveys are thoroughly explained. The hypotheses of analysis were evaluated by structural equation modeling (SEM). The venue for data collection has been also explored in this report as well as the Instruments of collected data. This research proposed a conceptual framework that includes the main factors of Technology Acceptance Model (TAM), namely PEU, PU, BI, and AU of the voice assistant technology, were presented as theories. External variables such as (Subjective Norm, Enjoyment, Facilitating Conditions, Trust, and Security) were also included in the research.

4.2 Sources of the Data

A systematic review was performed to achive the purpose of this study. The study was conducted in accordance to the research topic that targeted specifically around “adoption of voice assistant technology”. This means all relevant studies related to the acceptance of voice assistant system and the TAM conceptual model will be analyzed and included in the research. Most of the studies were collected from an academic database such as (WorldCat, IEEE, Springer, Taylor & Francis, Wiley, ScienceDirect, MDPI), as well as Google Scholar engine. All the data were classified by using several keywords (as shown in Table 1), mostly related to voice assistant and technology acceptance model (TAM). Based on findings, 42 journal articles were found in accordance with research criteria as outlined in Table 2. While analyzing these data, 14 papers excluded from the research due to poor quality researches. In addition, systematic reviews, such as voice assistant studies, which did not provide comprehensive data have been excluded as well. As seen in Table 3, a total of 28 papers that satisfied the selection criteria and were used in the research. Most variables introduced in the research have been combined to specify the external variables that

commonly used and found in the literature. Therefore, the external variables with a correlation to TAM were tested and validated in more than four studies and evaluated by the researchers to guarantee in the correlation amoung the independent variables and TAM. The following parameters are used to ensure accuracy in the research for analysis of data when selecting relevant papers:

- Research related to Acceptance of Voice Assistant Technology
- Research related to Technology Acceptance Model
- All factors must be provided in the research
- Research written in English language.
- Published between 2010 and 2020.

#	Keywords
1	"TAM" AND "voice assistant"
2	"TAM" AND "voice command"
3	"Voice intelligence" AND "TAM"
4	"TAM" AND "AI Virtual Assistant"
5	"TAM" AND "personal digital assistant"
6	"Technology acceptance" AND "voice assistant"
7	"Technology acceptance model" AND "voice assistant"
8	"Artificially Intelligent Virtual Assistant" AND "Students"
9	"Voice Assistants" AND "Users' acceptance" AND "education"

Table 1: Keywords search

Database	No. of Studies
Google Scholar	24
Wiley Online Library	1
ScienceDirect	4
Springer	3
Worldcat	1
Taylor & Francis	2
MDPI	4
IEEE	3
Total	42

Table 2: Results of the initial research papers

#	Author(s)	TAM (Construct)				Variable(External Factors)														
		Perceived usefulness (PU)	Perceived ease of use (PEU)	Behavioral Intention to Use (BI)	Actual Use (AU)															
1	(Schudzich 2019)	PU				Facilitating Conditions	Enjoyment	Autonomy	Security	Openness/Innovativeness										
2	(Moriuchi 2019)	PU	PEU			Average Variance Extracted	Composite Reliability	Consumer Engagement	Localization	Customer Loyalty	Standard Deviation	Subjective Norm								
3	(Song 2019)	PU	PEU	BI		Subjective Norm														
4	(Pal et al. 2020)	PU	PEU	BI		Perceived Complementarity	Compatibility	Privacy Concerns												
5	(Basak, Gumussoy & Calisir 2015)	PU	PEU	BI		Perceived Enjoyment	Subjective Norms	Personal innovativeness	Computer Self-efficacy											
6	(Easwara Moorthy & Vu 2015)	PU	PEU	BI	AU	Social Influence	Facilitating Conditions													
7	(Chu, Galetzka & Van Deursen 2019)	PU	PEU	BI		Security	Enjoyment	Reliability	Internet Skills	Trust	Self-innovativeness	Social Influence	Perceived cost	Attitude toward smart speakers						
8	(Zeng 2020)	PU				Privacy Concerns	Trust	Attitude towards Nozama												
9	(Neumann 2018)	PU		BI		Performance Expectancy	Effort Expectancy	Social Influence	Facilitating Conditions	Technological Anxiety	Perceived Trust	Perceived Cost	Enjoyment	Perceived Control	Perceived Connectedness	Perceived System Reliability	Perceived Security	Compatibility	Economic Benefit	Innovativeness
10	(Cacho-Elizondo, Shahidi & Tossan 2012)	PU	PEU	BI		Perceived enjoyment	Subjective Norms													

21	20	19	18	17	16	15	14	13	12	11
(Sohn & Kwon 2020)	(Filipe & Afonso 2019)	(Wagner, Nimmermann & Schramm-Klein 2019)	(Jennifer & Sofronov 2020)	(Cuadra 2018)	(Chowdhury 2018)	(Kessler & Martin 2017)	(Nasirian, Ahmadian & Lee 2017)	(Bloemendaal 2018)	(Lin & Chen 2015)	(Alharithi 2019)
PU			PU	PU				PU	PU	PU
PEU			PEU					PEU	PEU	PEU
BI	BI	BI		BI	BI	BI	BI	BI	BI	BI
	AU									
Subjective Norms/Social Influence	Performance Expectancy	Performance Expectancy	Prior Technological experience	Perceived enjoyment	Behavioural Beliefs	Performance Expectancy	Information Quality	Autonomy	Self-efficacy	Trust
Perceived Behavioral Control	Effort Expectancy	Effort Expectancy	Social influence	Perceived information control	Normative Beliefs	Effort Expectancy	System Quality	Customer Attitude	User Attitude	Privacy (PR)
Performance Expectancy	Social influence	Hedonic Motivation	Demographics	Anonymity	Control Beliefs	Social Influence	Interaction Quality	Customer Trust	Media Richness	
Effort Expectancy	Facilitating Conditions	Price Value	Awareness	Confidentiality	Subjective Norm	Facilitating Conditions	Trust	Customer Commitment		
Enjoyment	Hedonic Motivation	Habit	Convenience	Perceived privacy risk	Perceived Behavioral Control	Hedonic Motivation	Intention	Product Performance		
Perceived Fee	Price Value	Facilitating Conditions	Risk	Regulatory perceptions	Actual Behavioural Control	Price Value	Personal Innovativeness	Use of personal data		
Technicality	Habit	Social Influence	Trust	Perceived benefits of information disclosure	Behaviour	Habit		Personalization		
Perceived Value		Likeability	Attitude Towards Change	Information Sensitivity				Human-like interaction		
		Humanlike-Fit		Importance of information transparency				Facilitating condition (costs)		
		Animacy		Perceived behavioral control				Facilitating condition (connection)		
		Perceived Sociability						Social Influence		
								Level of innovativeness		
								Personal information		
								Attitude towards Google		

22	(Lee & Choi 2017)			BI		Self-Disclosure	Reciprocity	Intimacy	Trust	Interactional Enjoyment	User Satisfaction									
23		PU	PEU			Performance risk	Technology Attitudes	Purchase intention	Fashion involvement											
24	(Chai, Wang & Xu 2020)	PU		BI		AI literacy	Subjective norm	AI anxiety	AI for social good	attitude towards using AI	confidence in learning	AI optimism								
25	(Pal & Patra 2020)	PU	PEU		AU	Technology Characteristics	Individual Characteristics	Task-technology Fit												
26	(Pal, Arpnikanondt, Funilkul & Chutimaskul 2020)	PU	PEU	BI		Subjective Norms/Social Influence	Performance Expectancy	Effort Expectancy	Enjoyment	Perceived Technicality	Perceived Fee	Perceived Value								
27	(Sorensen 2019)	PU	PEU	BI		Age	Gender	Level of Experience	Perceived Enjoyment	Perceived Innovativeness										
28	(Teo & Zhou 2014)	PU	PEU	BI		Attitudes towards using technology	Computer self-efficacy	Subjective norm	Facilitating conditions											

Table 3: List of Researches

4.3 Research Design and Sampling

The aim of this research is to discover higher education students' behaviors regarding the adoption of voice assistant technology among UAE universities. The research will be conduct in a form of quantitative data analysis and the chosen method of data collection will be an online questionnaire. The research target participants will be higher educational students from four well known universities in the UAE, which are Zayed University, Higher Colleges of Technology, The British University and United Arab Emirates University. Based on (Al-Emran & Salloum 2017),

purposive sampling was used to collect the data upon student's willingness to participate in the survey. The sample technique is used when participants have an appeal to the field of research or believe that the study could be beneficial to them. Therefore, the survey is a voluntary act which the participants have the free of will to either complete the survey or to not participate in the study. Moreover, there will be no coercion in the survey's process and the survey will state the fact of no disclosing information that is involved with the participant's name or nationality. Lastly, the overall number of respondents submitted was 300 responses.

4.4 Data Collection Methods

The study's target participants were mostly students between the ages of 18 to 40 and above. This research was based on online questionnaires survey that allowed the students to interact with the survey questions effortlessly, considering there will be no observation nor experiment was required. The study data was collected using Google forms, which was circulated by email and WhatsApp to the students, and this survey was distributed among four top universities in the United Arab Emirates, which are Zayed University, Higher Colleges of Technology, The British University, and United Arab Emirates University. The data conducted in this research from 20/01/2021 till 31/03/2021. As seen in Table 4, a total of 300 students responded to the survey. As indicated by (Krejcie & Morgan 1970), this is viewed as an ideal sample size for a population of 1400 in 302 participants. The sample size in this research is 300, which is near to the required sample size that is acceptable.

University Name	No. of Participants
Zayed University	44
Higher Colleges of Technology	176
The British University in Dubai	14
United Arab Emirates University	66
Total	300

Table 4: Number of participants.

4.5 Pilot research

In this study, the research items were evaluated in a pilot test to see how reliable they were. Consequently, 40 cases were chosen randomly from the sample group for this research. The reliability of the research instrument was assessed using Cronbach's alpha. If a test contains reliability of 0.70 or higher is considered suitable by (Taber 2018). Cronbach's alpha results across all variables in this analysis were above than 0.7, which can be shown in Table 5. Accordingly, the entire variables are dependable and could be employed in the research.

Construct	Cronbach's Alpha	No of Items
PU	0.787	4
PEU	0.837	3
BI	0.862	3
AU	0.854	2
SN	0.894	3
ENJ	0.876	3
FC	0.814	3
TR	0.871	3
SE	0.863	3

Table 5: Construct's Reliability

4.6 Instrument

A research instrument was generated to examine the hypotheses proposed in this paper. The survey consisted of 27 items that were used to assess 9 variables in the survey questionnaire. Moreover, the items have been updated from the previous researches to comply with the needs of the present research. The description of the items along with their resources are mentioned in Table 6.

Study Constructs	Items	Item Description	Reference
Perceived Usefulness (PU)	PU1	I think voice assistant technology can improve my productivity	(Lin & Chen 2015; Pal, Arpnikanondt, Funilkul & Chutimaskul 2020; Pal, Arpnikanondt, Funilkul & Razzaque 2020)
	PU2	I think voice assistant technology can increase my performance	
	PU3	I think voice assistant technology can encourage me to finish my tasks quicker.	
	PU4	I would find using voice assistant technology can be useful	
Perceived Ease of Use (PEU)	PEU1	Learning how to use a voice assistant technology is easy to me	(Teo & Zhou 2014; Sorensen 2019; Jennifer & Sofroniev 2020)
	PEU2	My interaction with a voice assistant technology is clear and understandable	
	PEU3	I find voice assistant technology is easy to use	

Behavioral Intention to Use (BI)	BI1	I intend to use a voice assistant in the future	(Lee & Choi 2017; Chowdhury 2018; Wagner, Nimmermann & Schramm-Klein 2019)
	BI2	I will recommend using voice assistant technology to my friends and family	
	BI3	I will keep myself updated with the latest voice assistant technology	
Actual Use(AU)	AU1	I use the voice assistant technology frequently	(Easwara Moorthy & Vu 2015; Filipe & Afonso 2019; Pal & Patra 2020)
	AU2	I prefer to use the voice assistant technology	
Subjective norm (SN)	SN1	People who are close to me recommend using a voice assistant technology.	(Bloemendaal 2018; Moriuchi 2019; Song 2019)
	SN2	People around me use voice assistant technology	
	SN3	People who are close to me would guide me to use a voice assistant technology.	
Enjoyment (ENJ)	ENJ1	I enjoy interacting with the voice assistant technology.	(Cacho-Elizondo, Shahidi & Tossan 2012; Basak, Gumussoy & Calisir 2015; Chu, Galetzka & Van Deursen 2019)
	ENJ2	The conversation with the voice assistant is interesting.	
	ENJ3	My creativity can be stimulated when using a voice assistant.	
Facilitating conditions (FC)	FC1	I have the knowledge to use voice assistant.	(Easwara Moorthy & Vu 2015; Neumann 2018; Schudzich 2019)
	FC2	I have the required skills to use voice assistant technology.	
	FC3	I can get assistance from others when I get trouble using a voice assistant.	
Trust(TR)	TR1	Voice assistants are trustworthy.	(Neumann 2018; Alharithi 2019; Zeng 2020)
	TR2	I think voice assistants are reliable.	
	TR3	I believe voice assistants are honest.	
Security (SE)	SE1	I am concerned about voice assistant technology on leaking my personal information without my authorization.	(Neumann 2018; Chu, Galetzka & Van Deursen 2019; Schudzich 2019)
	SE2	Using voice assistant might threaten my personal privacy.	
	SE3	I am afraid of voice technology might collect my personal information without me acknowledging.	

Table 6: The Study Constructs and references

4.7 Questionnaire Design

The survey was divided into ten categories and mostly constructs of the research. A Likert scale has been used to evaluate the survey items by using 5 point Likert scale measurement, which includes in five points: “Strongly Agree” = 5, “Agree” = 4, “Neutral” = 3, “Disagree” = 2, and “Strongly Disagree” = 1. The participants' demographic statistics is presented in the first segment. In the second segment, there are four items that reflect the perceived usefulness of the voice assistant technology. In the third segment, there are three items that reflect the perceived ease of use of the voice assistant technology. There are three items in the fourth segment that indicate behavioral intention to use towards the voice assistant technology. The fifth segment contains two items that focus on actual use of the technology. In the sixth segment contains three items which

are related to subjective norms of the voice assistant technology. The seventh segment contains three items that are about the enjoyment of the voice assistant technology. In the eighth segment, it contains three items which describe the facilitating conditions of the voice-controlled assistant. The ninth segment includes three items related to trust of the voice assistant technology. Finally, in the last segment there are three items that are around security towards the voice assistant system.

4.8 Data Analysis

In order to evaluate structural equations, researchers usually employ two methods. One of them is based on covariance technique (CB-SEM) which is more commonly adopted, and the other one is based on variance technique (PLS-SEM). Although both effective approaches have the same fundamental purpose as estimating the correlations between variables and predictors, their analytical concepts differ substantially, and primarily in the way they approach construct measurement models (Sarstedt et al. 2016). PLS-SEM and CB-SEM were both developed at around the same period. Despite that, PLS-SEM has been designed to provide a more flexible structural equation modeling approach in relation to CB-SEM (Hair, Howard & Nitzl 2020). To evaluate the proposed hypotheses in this research, the partial least squares-structural equation modelling (PLS-SEM) were carried out via (SmartPLS) ver. 3.3.3 as pointed out (Wagner, Nimmermann & Schramm-Klein 2019), the entire hypothesis was based on the prevalent assumptions and that were relevant to voice assistant technology. There are two key explanations for this analysis as to why we have chosen PLS-SEM technique. First of all, PLS-SEM performs best than CB-SEM, if the intention of the study is to generate or propose a hypothesis, as this is the case in this study. Secondly, PLS-SEM is furthermore effective approach compared to CB-SEM in a way we can use both measurement and structural models for analyzing and predicting

data, and this is the same situation as in this study (Henseler, Ringle & Sinkovics 2009; Hair, Howard & Nitzl 2020).

Chapter 5: Findings and Discussion

5.1 Participant Demographics

In this section, we described the demographics of the sample which includes demographic objects, categories, number of frequency and percentage. The demographic results were analyzed using IBM SPSS Statistics (ver. 27). The participants' full demographic characteristics shown in Table (7). 300 students participated in this survey, 243 (81%) were females and 57 (19%) were males. The majority of students participated were in the age group of 18 and 21 years old with 57%, and 33.3% of the students were categorize in the age group 22 and 26, and the remainder of participants were above 26 years old, with 9.6%. Moreover, most of the students who took part in the research were from Higher Colleges of Technology with 176 students (58.7%), and 124 (41%) of the students were from other universities such as United Arab Emirates University, Zayed University, and The British University. Additionally, there were 240 (80%) of the students with the degree of a bachelor, whereas the rest of students had other types of academic degree (e.g Diploma (6.7%), Doctorate (0.3%), Higher Diploma (6.3%), and Master (6.7%)). 46.7% of the students chosen Google assistant as their voice assistant system, and 44.7% of the students selected Siri. Just 8.6% picked Cortana, Alexa and other types of voice assistant technology.

Demographic object	Category	Frequency	Percent%
Gender	Female	243	81.0%
	Male	57	19.0%
Age	18 - 21	171	57.0%
	22 - 26	100	33.3%
	27 - 30	11	3.7%
	31 - 35	10	3.3%
	36 - 40	4	1.3%
	40+	4	1.3%

University name	Higher Colleges of Technology	176	58.7%
	The British University	14	4.7%
	United Arab Emirates University	66	22.0%
	Zayed University	44	14.7%
Level of Education	Bachelor	240	80.0%
	Diploma	20	6.7%
	Doctorate	1	0.3%
	Higher Diploma	19	6.3%
	Master	20	6.7%
Types of Voice Assistants	Alexa (Amazon)	13	4.3%
	Cortana (Microsoft)	2	0.7%
	Google	140	46.7%
	Others	11	3.7%
	Siri (Apple)	134	44.7%

Table 7: Participant Demographics

5.2 Measurement model data analysis

5.2.1 Convergent validity

In this research, SmartPLS statistic was used to perform structural equation modeling to evaluate the recommended hypotheses. The use of a PLS approach is justified by the fact that the aim of the study is estimation and extend the hypotheses (Wagner, Nimmermann & Schramm-Klein 2019). Defining the validity and reliability of the variables is a must, to test the model of measurement. As reported by (Janadari, Subramaniam Sri Ramalu & Wei 2018), the reliability of the variables can be measured using two standard criteria: (1. Cronbach alpha 2. Composite reliability (CR)) and the validity of the variables can be measured by ((1) convergent validity (2) Discriminant validity). The results are seen in Table 8 which reveal the rate range for Cronbach's alpha is from 0.821to 0.899, all of these values were above 0.7. The results of Table 8 further reveals that the composite reliability (CR) range from 0.894 to 0.937, that is exceeding the threshold of 0.7 (Hair, Howard & Nitzl 2020). These results support variable's reliability and indicate that all constructs are

flawless. As claimed by (Janadari, Subramaniam Sri Ramalu & Wei 2018), convergent validity measurement is built by obtaining the Factor loading and Average Variance Extracted (AVE). According to the outcomes, Table 8 shows all of the factor loadings with value higher than the suggested level of 0.7. Furthermore, the outcomes of Table 8 further indicates that values of Average Variance Extracted (AVE) are from 0.736 to 0.864, which determines that the results exceed the required threshold of 0.5 (Pal & Patra 2020). These outcomes had proven that the requirement for convergent validity has been fulfilled and all constructs are competent.

Variables	Items	Factor loading	Cronbach's Alpha	CR	AVE
Perceived Usefulness	PU1	0.846	0.881	0.918	0.736
	PU2	0.852			
	PU3	0.857			
	PU4	0.877			
Perceived Ease of Use	PEU1	0.905	0.899	0.937	0.832
	PEU2	0.913			
	PEU3	0.919			
Behavioral Intention to Use	BI1	0.911	0.888	0.931	0.818
	BI2	0.939			
	BI3	0.862			
Actual Use	AU1	0.919	0.843	0.927	0.864
	AU2	0.940			
Subjective norm	SN1	0.903	0.884	0.928	0.811
	SN2	0.900			
	SN3	0.899			
Enjoyment	ENJ1	0.923	0.895	0.935	0.827
	ENJ2	0.918			
	ENJ3	0.886			
Facilitating conditions	FC1	0.909	0.821	0.894	0.739
	FC2	0.885			
	FC3	0.779			
Trust	TR1	0.897	0.872	0.921	0.796
	TR2	0.913			
	TR3	0.867			
Security	SE1	0.882	0.870	0.920	0.793
	SE2	0.889			
	SE3	0.901			

Table 8: Convergent validity findings

5.2.2 Discriminant validity

Discriminant validity measures how far one construct varies from different constructs in the study framework (Chin 1998). This type of validity can be assessed by examining the cross loading within the variables through Fornel-Larcker criterion and Heterotrait Monotrait Ratio (HTMT). Primarily, to generate discriminant validity, the loading of the variables should be greater than its loadings of other latent vairables (Janadari, Subramaniam Sri Ramalu & Wei 2018). Another way to attempt the discriminant validity of the variables could be evaluated by the comparison of square root of the Average Variance Extracted (AVE) with the other latent constructs correlations. Typically, the square root of AVE for a given variables must be greater than the variance shared by the variables and other latent variables in the model, and it must be higher than the recommended value of 0.5. (Fornell & Larcker 1981). The cross loadings are seen in Table 9. A detailed overview of the loadings and cross loadings values which indicates that each variable's item loadings are greater than the fillings of the associated variables (Al-Emran 2021). The Fornell-larcker criterion analysis is observed in Table 10. Obviously the square root of AVE components are shown in bold diagonal values are greater than off-load diagonal values (i.e. the correlations among the latent variables) in all columns and rows (Fornell & Larcker 1981). As seen in the table, the values of the square root of AVE, is greater than the implied value of 0.5, ranging between 0.858 and 0.929. This explicitly indicates that entier variables have more variation than with other latent variables in the model which implying discriminate validity.

5.2.3 Heterotrait-Monotrait Ratio of Correlations (HTMT)

The Heterotrait Monotrait ratio (HTMT) is introduced as a modern technique for assessing discriminant validity based on significant variation of structural equation modeling. Researchers have used a Monte Carlo model to show the effectiveness of HTMT by comparing its results of the Fornell-Larcker criterion and the cross loadings measurement (Henseler, Ringle & Sarstedt 2015). For the purpose of obtaining discriminant validity, the HTMT result must be from confidence threshold between (-1 and 1) (Janadari, Subramaniam Sri Ramalu & Wei 2018). If the value of HTMT is beyond the threshold, then it reveals that there are lack of discriminant validity. Many researchers have indicated that 0.85 is used as the predefined threshold. Whereas other researchers recommended that 0.90 is used as the predefined threshold (Pal & Patra 2020; Yusoff et al. 2020).

	AU	BI	ENJ	FC	PEU	PU	SE	SN	TR
AU1	**0.919**	0.684	0.562	0.531	0.564	0.573	0.360	0.698	0.595
AU2	**0.940**	0.793	0.692	0.610	0.656	0.730	0.440	0.694	0.678
BI1	0.694	**0.911**	0.661	0.662	0.758	0.746	0.440	0.598	0.643
BI2	0.747	**0.939**	0.697	0.711	0.795	0.769	0.366	0.645	0.694
BI3	0.726	**0.862**	0.670	0.624	0.633	0.703	0.360	0.667	0.650
ENJ1	0.653	0.714	**0.923**	0.710	0.682	0.677	0.419	0.602	0.633
ENJ2	0.546	0.657	**0.918**	0.647	0.610	0.651	0.399	0.506	0.597
ENJ3	0.653	0.666	**0.886**	0.682	0.514	0.670	0.448	0.669	0.663
FC1	0.519	0.657	0.695	**0.909**	0.735	0.596	0.356	0.537	0.579
FC2	0.525	0.631	0.661	**0.885**	0.671	0.562	0.447	0.552	0.555
FC3	0.549	0.612	0.568	**0.779**	0.612	0.563	0.403	0.611	0.695
PEU1	0.579	0.730	0.585	0.718	**0.905**	0.643	0.377	0.495	0.537
PEU2	0.641	0.735	0.617	0.714	**0.913**	0.653	0.351	0.574	0.651
PEU3	0.585	0.745	0.618	0.715	**0.919**	0.705	0.400	0.515	0.633
PU1	0.612	0.658	0.641	0.589	0.600	**0.846**	0.389	0.512	0.591
PU2	0.577	0.658	0.611	0.566	0.577	**0.852**	0.412	0.484	0.559
PU3	0.581	0.717	0.581	0.530	0.606	**0.857**	0.324	0.516	0.570
PU4	0.651	0.765	0.677	0.604	0.716	**0.877**	0.412	0.565	0.604
SE1	0.500	0.423	0.388	0.438	0.424	0.412	**0.882**	0.380	0.444
SE2	0.328	0.361	0.411	0.439	0.327	0.362	**0.889**	0.336	0.362
SE3	0.323	0.360	0.439	0.372	0.347	0.418	**0.901**	0.307	0.377
SN1	0.692	0.644	0.578	0.566	0.490	0.554	0.346	**0.903**	0.587
SN2	0.650	0.659	0.595	0.659	0.582	0.530	0.329	**0.900**	0.617
SN3	0.681	0.596	0.581	0.547	0.488	0.556	0.361	**0.899**	0.599

TR1	0.651	0.689	0.611	0.610	0.599	0.603	0.352	0.673	**0.897**
TR2	0.655	0.690	0.632	0.635	0.635	0.658	0.441	0.561	**0.913**
TR3	0.526	0.575	0.613	0.649	0.544	0.545	0.394	0.555	**0.867**

Table 9: Cross Loading findings

In Table 11 reveals the values of Heterotrait Monotrait ratio of the correlations (HTMT) are between 0.437 to 0.922. As a result, the findings were compared to the threshold values, 4 of the 36 correlations (AU and BI; BI and PEU; BI and PU; FC and PEU) were failed to meet this condition with value of 0.85 and exceeded the recommaned value of 0.90. In spite of the fact that the remnant of the correlations met the predefined threshold of 0.85, the discriminant validity condition was not met. From my perspective the reason of HTMT values were greater than 0.9 in this study, it is evident that the results of the data responses were not accurate enough.

	AU	**BI**	**ENJ**	**FC**	**PEU**	**PU**	**SE**	**SN**	**TR**
AU	**0.929**								
BI	0.799	**0.905**							
ENJ	0.679	0.748	**0.909**						
FC	0.616	0.737	0.748	**0.860**					
PEU	0.660	0.808	0.666	0.785	**0.912**				
PU	0.707	0.818	0.732	0.667	0.732	**0.858**			
SE	0.433	0.429	0.463	0.466	0.413	0.448	**0.891**		
SN	0.748	0.703	0.650	0.657	0.579	0.607	0.383	**0.901**	
TR	0.688	0.732	0.693	0.706	0.666	0.678	0.444	0.668	**0.892**

Table 10: Fornell-larcker criterion analysis

	AU	**BI**	**ENJ**	**FC**	**PEU**	**PU**	**SE**	**SN**	**TR**
AU									
BI	**0.919**								
ENJ	0.776	0.838							
FC	0.741	0.864	0.871						
PEU	0.754	**0.902**	0.738	**0.912**					
PU	0.811	**0.922**	0.824	0.785	0.818				
SE	0.500	0.488	0.526	0.556	0.465	0.509			
SN	0.868	0.794	0.732	0.774	0.648	0.686	0.437		
TR	0.794	0.829	0.786	0.841	0.749	0.769	0.507	0.760	

Table 11: Heterotrait-Monotrait Ratio (HTMT)

5.3 Structural model data analysis

5.3.1 Coefficient of determination -$R2$

The coefficient of determination (R2) is the utmost widely utilized indicator for measuring the structural model (Hair Jr et al. 2016). It is a predictor of all endogenous variables in-sample measurement. This assumes that the predictive potential is only measured for the data set used in evaluating the outcomes and that (R2) cannot be deduced from the population (Hair, Howard & Nitzl 2020). (Chin 1998) stated that the (R2) values above 0.67 are categorized as "High", whereas values between 0.33 and 0.67 are categorized as "Moderate", and if the values between 0.19 to 0.33, they are categorized as "Weak", and lastly if the values of (R2) below 0.19 are unsuitable. As specified in the Table 12, the values of (R2) for the Actual Use (AU), Perceived Ease of Use (PEU), and Perceived Usefulness (PU) are discovered to be within the range of 0.33 and 0.67, which means that the predictive power of the variables are categorized as “Moderate”. On the contrary, the values of (R2) for the Behavioral Intention to Use (BI) is discovered to be above 0.67, which implies that the predictive power of the variable is considered as “High”.

Constructs	R2	Results
Actual Use (AU)	0.638	Moderate
Behavioral Intention to Use (BI)	0.763	High
Perceived Ease of Use (PEU)	0.645	Moderate
Perceived Usefulness (PU)	0.667	Moderate

Table 12: Coefficient of determination ($R2$) results

5.3.2 Predictive relevance (Q2)

Researchers use the R2 values not simply to calculate prediction performance, rather than to measure the Stone Geisser’s ($Q2$), which is descriptive of the paradigm's predictive relevance (Geisser, 1974; Stone, 1974).Which implies that if PLS-SEM shows predictive relevance, therefore it is obvious that the measurement point of the indicators of endogenous variables and

individual element endogenous variables are predictable in the measurement model. The values of ($Q2$) for a distinct endogenous latent variable must be above zero which specify the path model of the PLS has predictive relevance for this distinct variable. A predictive power measurement is preferred to use PLS for predicting. The Blindfolding technique is the recommended method for determining predictive relevance (Hair Jr et al. 2016). As can be observed in Table 13, the resulting variables were considerable: Actual Use ($Q2$ = 0.541), Behavioral Intention to Use ($Q2$ = 0.618), Perceived Ease of Use ($Q2$ = 0.529), and Perceived Usefulness ($Q2$ = 0.48), which means the ($Q2$) values are (> 0), this confirms that the statement of this model of study is capable of predicting appropriately.

Variable	SSO	SSE	Q^2 (=1-SSE/SSO)
Actual Use	600	275.496	0.541
Behavioral Intention to Use	900	343.778	0.618
Enjoyment	900	900	
Facilitating conditions	900	900	
Perceived Ease of Use	900	424.275	0.529
Perceived Usefulness	1200	624.392	0.48
Security	900	900	
Subjective norm	900	900	
Trust	900	900	

Table 13: Construct cross-validated redundancy

5.3.3 Hypothesis testing (Path coefficient)

The assessment of structural model is performed by using a 5000 re-sample bootstrapping procedure to measure the t-value, standard beta (β values), and R-squared (R2 values) (Hair Jr et al. 2016). In Table 14 and Figure 3 shows the result of path coefficients for the proposed hypotheses in the conceptual model. According to the data analysis there are 8 out of 13 hypotheses (H3, H6, H7, H8, H10, H11, H12, and H13) were supported in this research. Except for H1, H2, H4, H5, and H9, that were not accepted by the empirical data. Accordingly, the findings demonstrated that Subjective Norm has insignificant positive influenced on Perceived usefulness

(β = 0.090, t = 1.387) and on Perceived ease of use (β = 0.017, t = 0.315) of voice assistant technology. Wherefore, H1 and H2 were rejected. Therefore, based on the results, the Enjoyment has positively influences Perceived usefulness of voice assistant technology (β = 0.350, t = 5.780). Thus, H3 was accepted. Further, the findings shows that Enjoyment was determined to be insignificant effect on Perceived ease of use (0.104, t = 1.127) and Facilitating conditions has insignificant effect on Perceived usefulness of voice assistant technology (β = -0.109, t = 0.248). This means that H4 and H5 were rejected. Next, the results shows that Facilitating conditions has significantly influenced Perceived ease of use of voice assistant system (β = 0.567 , t = 8.124). Hence, H6 is accepted. Another finding indicates that Trust was significantly influenced on Perceived usefulness (β = 0.155, t = 2.574). and Perceived ease of use (β = 0.183, t = 2.397) of using voice assistant technology. Hence, H7 and H8 were accepted. Following outcomes reveals that Security has an insignificant positive correlations with Perceived usefulness of using voice assistant system (β = 0.068, t = 1.553). Which indicates the rejection of H9. The findings also points out that Perceived ease of use has positively high association with Perceived usefulness (β = 0.401 , t = 6.051) and Behavioral intention to use (β = 0.450, t = 9.614) of using voice assistant. Which means that H10 and H11 are accepted. In addtion, Perceived usefulness has a strong connection with Behavioral intention to use (β = 0.488, t = 10.772). Hance, H12 is accepted. Lastly, Behavioral intention to use was positively affected with Atual Use (β = 0.799, t = 29.279) to adopt voice assistant technology. Eventually, H13 is accepted.

5.4 Discussion

The current research found that, there were eight hypotheses accepted as established in Table 14, and the suggested hypotheses that were supported in this study are H3, H6, H7, H8, H10, H11, H12, and H13. The research findings showed that there is insignificant impact with subjective

norm on perceived usefulness and perceived ease of use of voice assistant, and H1 and H2 were therefore rejected. However, this result contradicts with the results found in the prior research (Chu, Galetzka & Van Deursen 2019; Moriuchi 2019; Song 2019), which supported the relationship of subjective norm on perceived usefulness and perceived ease of use. This might be caused by the people surrounding the students, who find the technology hard to use or who are not familiar with voice assistant technology. Therefore, the students in the universities are not using voice assistant technology as part of their learning system. Furthermore, the outcomes revealed that the enjoyment has a positive influence on the perceived usefulness of voice assistant, in which H3 were supported in this study. This result cooperate the findings that was found in previous research by (Chu, Galetzka & Van Deursen 2019), which indicated that the enjoyment has a positive influence on the perceived usefulness. This indicates that students find the voice assistant technology useful and enjoyable to interact with. For example: playing music while studying. Despite the fact that there is previous study supported the correlation between enjoyment and the perceived ease of use of voice assistant (Park et al. 2018; Chu, Galetzka & Van Deursen 2019), the results pointed out that enjoyment has insignificant influence relationship with the perceived ease of use of voice assistant, and H4 were rejected. This shows that students find the voice assistant technology hard to use due to complexity. Therefore, students cannot find any enjoyment while using the system in their learning process. Similarly, the results of this study did not show any significant impact between facilitating conditions and perceived usefulness. Hence, H5 were rejected. This result opposes with the results found in a previous research (Bloemendaal 2018), which supported the association within facilitating conditions and perceived usefulness of voice assistant system. This shows that students have less knowledge and skills towards voice assistant technology and they find the system useless. The results also revealed that facilitating conditions

has been positively impacted by perceived ease of use of voice assistant, supporting H6. The results also found in past studies by (Teo & Zhou 2014), which pointed out that facilitating conditions has a positive impact relationship with the perceived ease of use of voice assistant. This indicates that students find the technology is simple to use by getting assistance from others. The results also found that trust has been positively influenced by the perceived usefulness and perceived ease of use of voice assistant technology, which lead to support both hypotheses (H7 and H8). This result confirms the results found in previous studies by (Alharithi 2019; Chu, Galetzka & Van Deursen 2019), which supported the correlation of trust on perceived usefulness and perceived ease of use of voice assistant. This shows that students find the voice assistant technology trustworthy and reliable to use. For example, the technology can be useful and reliable while searching and gathering information for an assignment. Further, security have no immediate impact on perceived usefulness of voice assistant technology. Therefore, H9 were rejected in the research. While the outcomes of the literature by (Chu, Galetzka & Van Deursen 2019) had supported the hypotheses. This might be caused by having students concerned over leaking personal information without their authorization and might threaten their personal privacy. The results also discovered that there is significant influence with perceived ease of use on the perceived usefulness and the behavioral intention to use of voice assistant technology, which supported both hypotheses (H10 and H11). In fact, they were supported in prior researches by (Song 2019), which supported the correlation with perceived ease of use on the perceived usefulness and the behavioral intention to use to adopt the technology. For hypotheses H10, this indicates that as far as the voice assistant technology is engaged less in the learning process, the higher the advantage of getting the attention of students to realize how useful the voice assistant technology. For hypotheses H11, this shows that students' behavioral intention to use voice assistant technology is increased for students who think that the

system is easy to use. Nonetheless, the observational findings showed that perceived usefulness have significant influence relations with the behavioral intention to use to voice assistant technology. Which means H12 supported the hypotheses. This result comes along with the prior study by (Song 2019), which indicates that there is substantial influence between perceived usefulness and behavioral intention to use to adopt the technology. This shows that students' behavioral intention is increased for students who find the technology useful in their learning process.

Hypothesis	Relationship	Std. Beta	Std. Error	t-value	p-value	Direction	Decision
H1	SN > PU	0.090	0.065	1.387	0.166	Positive	Not Supported
H2	SN > PEU	0.017	0.055	0.315	0.753	Positive	Not Supported
H3	ENJ > PU	0.350	0.061	5.780	0.000	Positive	Supported**
H4	ENJ > PEU	0.104	0.092	1.127	0.260	Positive	Not Supported
H5	FC > PU	-0.109	0.094	1.156	0.248	Negative	Not Supported
H6	FC > PEU	0.567	0.070	8.124	0.000	Positive	Supported**
H7	TR > PU	0.155	0.060	2.574	0.010	Positive	Supported*
H8	TR > PEU	0.183	0.076	2.397	0.017	Positive	Supported*
H9	SE > PU	0.068	0.044	1.553	0.121	Positive	Not Supported
H10	PEU > PU	0.401	0.066	6.051	0.000	Positive	Supported**
H11	PEU > BI	0.450	0.047	9.614	0.000	Positive	Supported**
H12	PU > BI	0.488	0.045	10.772	0.000	Positive	Supported**
H13	BI > AU	0.799	0.027	29.279	0.000	Positive	Supported**

Table 14: path coefficient of the research hypothesis

Finally, the results demonstrated that behavioral intention to use has a strong influence on the actual use to adopt voice assistant technology. Hence, H13 was supported in the research. This is compatible with the earlier research by ((Filipe & Afonso 2019), which stated that behavioral intention to use has a major association with the actual use to adopt the technology. This indicates that students' actual use is increased and ready to adopt the technology in their learning system.

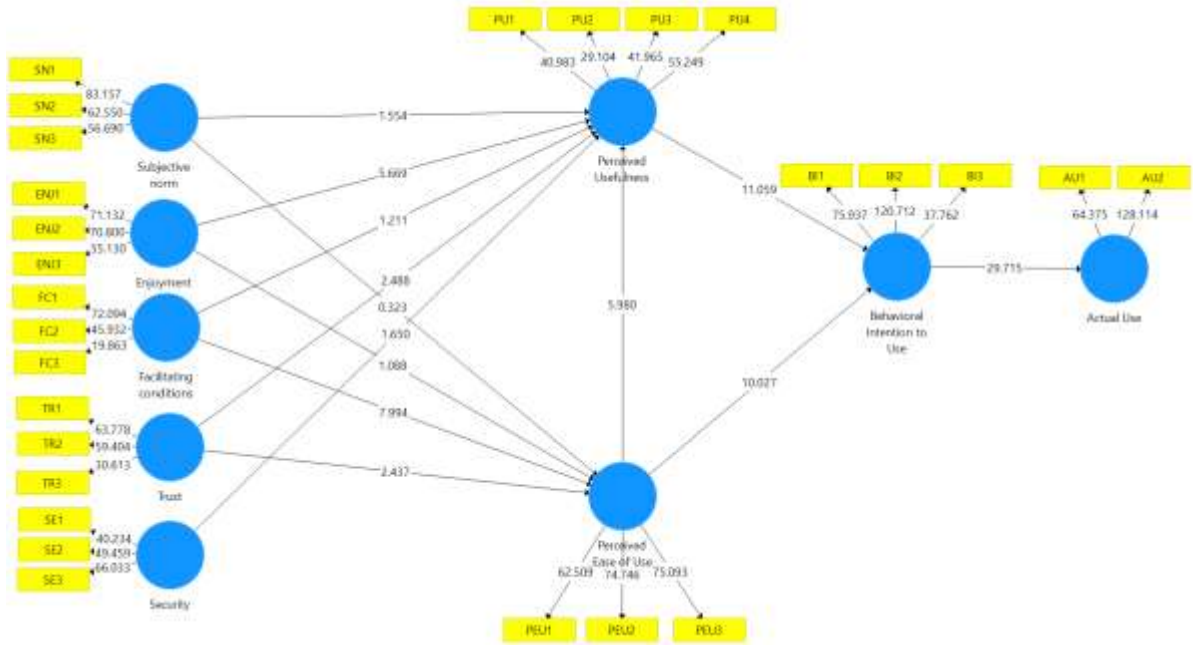

Figure 3: Path coefficient results (PLS algorithm)

Chapter 6: Conclusion

6.1 Theoretical contributions

To conclude, this research has three main objectives. First, to review most commonly adopted external variables for adoption and acceptance of voice assistant studies in the TAM. In order to carry out a systematic analysis, the quantitative study technique is based of 42 papers published in the past 10 years. The independent variables of TAM, which includes: (Subjective norms (SN), Enjoyment (ENJ), Facilitating Conditions (FC), Trust (TR), and Security (SR)), were defined as the most commonly used. Second, to generate a conceptual framework by applying TAM model with most commonly adopted external variables. Third, to conduct a current conceptual framework by employing the PLS-SEM procedure, which is appropriate for the context of our research. A questionnaire survey was used to gather data from four universities in the United Arab Emirates which have adopted the voice assistant system. The overall number of students that were involved in this research were 300 students. In this study, there were 8 supported hypotheses out of the 13 hypotheses that introduced the relationships across dependent and independent variables, which

alternately had an effect on students' acceptance of the voice assistant technology. Based on the study's findings, the results indicate that there was a strong influence of enjoyment and trust on students' perceived usefulness of using voice assistant technology. In addition to that, trust and facilitating conditions have positively impacted the students' perceived ease of use of voice assistant systems. Moreover, perceived usefulness and perceived ease of use has contributed to grow the students' behavior intention to use voice assistant technology.

6.2 Implications for Practice

In order to understand how students accept the voice assistant technology, an extended TAM model was produced. The results of the study provide further insight into external variables and offer recommendations for educational management to successfully implement voice assistant systems. First, educational institution requires to develop an effective structure for voice assistant technology and determine students' readability for voice assistant system. Secondly, the directors of the education institution need to create a study plan in order to implement such facilities that include voice-based of system to enhance the students' acceptance in UAE. This recommendation helps lecturers and professors with their teaching performance, as well as students' efficiency grows moreover. Thirdly, to encourage students on engaging with the voice assistance system, building advanced computer labs and providing training sessions could potentially boost up their perceived ease of use and usefulness towards these systems. This could also improve their attitudes and their behavioral intention as an outcome of implementing the voice assistant technology.

6.3 Limitations and future research

The findings of the research were quite impressive and contributed in representing students' adoption of voice assistant technology, and the study concluded with some limitations. First of all, the analysis was exclusively for students, and if the responses of educators were taken into account,

distinctions could be made between the studies carried out by educators and students. Second of all, the sample of participants was very limited from few universities. Future studies should then consider significant numbers to even more enhance and interpret the findings for the other higher education institutions. Third, the effect of moderating variables (such as gender and age) on the association between the external variables and behavioral intention to implement voice assistant technology was not examined in this research. This would be a useful analysis approach for potential work in the future.

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Appendices: Survey

Acceptance of voice assistant technology among university students in UAE survey

Dear Participant,

My name is Jawaher Hamad Al Shamsi and I am a master candidate from The British University in Dubai, Faculty of Engineering and Information Technology. You are invited to participate in my final dissertation survey. The aim of this survey is to examine the factors influencing the acceptance of voice assistant technology in UAE universities.

Thank you for your cooperation and support.

*Required

1. Age group *

   Mark only one oval.

   - 18 - 21
   - 22 - 26
   - 27 - 30
   - 31 - 35
   - 36 - 40
   - 40+

2. Gender *

   Mark only one oval.

   - Female
   - Male

3. Which universitylcollege are you from? *

   Mark only one oval.

   - Zayed University
   - Higher Colleges of Technology
   - The British University
   - United Arab Emirates University

4. Level of Education: *

   Mark only one oval.

   - Diploma
   - Higher Diploma
   - Bachelor
   - Master
   - Doctorate

5. I use _____as my digital assistant *

   Mark only one oval.

   - Siri (Apple)
   - Google
   - Alexa (Amazon)
   - Cortana (Microsoft)
   - Others

Perceived Usefulness

6. I think voice assistant technology can improve my productivity *

Mark only one oval.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

7. I think voice assistant technology can increase my performance *

Mark only one oval.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

8. I think voice assistant technology can encourage me to finish my tasks quicker *

Mark only one oval.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

9. I would find using voice assistant technology can be useful *

Mark only one oval.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

Perceived Ease of Use

10. Learning how to use a voice assistant technology is easy to me *

Mark only one oval.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

11. My interaction with a voice assistant technology is clear and understandable *

Mark only one oval.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

12. I find voice assistant technology is easy to use *

Mark only one oval.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

Behavioral Intention to Use

13. I intend to use a voice assistant in the future *

Mark only one oval.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

14. I will recommend using voice assistant technology to my friends and family *

Mark only one oval.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

15. I will keep myself updated with the latest voice assistant technology *

Mark only one oval.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

Actual Use

16. I use the voice assistant technology frequently *

Mark only one oval.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

17. I prefer to use the voice assistant technology *

Mark only one oval.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

Social influence/Subjective norm

18. People who are close to me recommend using a voice assistant technology. *

Mark only one oval.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

19. People around me use voice assistant technology *

Mark only one oval.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

20. People who are close to me would guide me to use a voice assistant technology *

Mark only one oval.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

Enjoyment

21. I enjoy interacting with the voice assistant technology *

Mark only one oval.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

22. The conversation with the voice assistant is interesting *

Mark only one oval.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

23. My creativity can be stimulated when using a voice assistant *

Mark only one oval.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

Facilitating conditions

24. I have the knowledge to use voice assistant *

Mark only one oval.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

25. I have the required skills to use voice assistant technology *

Mark only one oval.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

26. I can get assistance from others when I get trouble using a voice assistant *

Mark only one oval.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

Trust

27. Voice assistants are trustworthy *

Mark only one oval.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

28. I think voice assistants are reliable *

Mark only one oval.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

29. I believe voice assistants are honest *

Mark only one oval.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

Security

30. I am concerned about voice assistant technology on leaking my personal information without my authorization *

Mark only one oval.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

31. Using voice assistant might threaten my personal privacy *

Mark only one oval.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

32. I am afraid of voice technology might collect my personal information without me acknowledging *

Mark only one oval.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly Agree