Persona Design for Educational Chatbots

A thesis submitted for the degree of Doctor of Philosophy

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ABSTRACT

Designing chatbots for use in an educational setting is challenging, as users' behaviours and expectations differ greatly. Little research has been conducted on designing and building context and persona-based chatbots for university students. New approaches to the design of educational chatbots are required. This study applied a design science research (DSR) methodology and was executed in three iterations, starting with persona elicitation using machine learning techniques. A data-driven persona development (Persona3D) method and modelling approach was undertaken that drew on the earlier machine learning and structured equation modelling concerning technology acceptance. Finally, instantiations of the Persona3D approach were realised through designing (with journey mapping and Persona3D models) and building a range of chatbot prototypes. The results from the machine learning analysis show that there are eight distinct student groups. The results of the second iteration show that performance expectancy, effort expectancy and habits are the three main predictors of behavioural intention towards the use of chatbots. The third iteration evaluated the approach by designing and building eight chatbots, including knowledge acquisition, knowledge assessment, assignment guider and lab support chatbots. This study makes several contributions, primarily the Persona3D method and model. Moreover, the design, build, and evaluation cycle extended the Extended Unified Theory of Acceptance and Use of Technology model (UTAUT2 model) into the domain of university students' acceptance and use of chatbots, as well as identified the chatbot features that support these constructs. Furthermore, this study is the first to examine the effects of persona moderators on students' acceptance and use of chatbot technology. Future work could evaluate the effectiveness of the resulting chatbots on students, utilising an adapted version of the System Usability Scale (SUS) or other approaches.

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DEDICATION

رَبِّ أَوْزِعْنِي أَنْ أَشْكُرَ نِعْمَتَكَ الَّتِي أَنْعَمْتَ عَلَيَّ وَعَلَىٰ وَالِدَيَّ وَأَنْ أَعْمَلَ صَالِحًا تَرْضَاهُ
وَأَدْخِلْنِي بِرَحْمَتِكَ فِي عِبَادِكَ الصَّالِحِينَ

My Lord, enable me to be grateful for Your favour, which You have bestowed upon me and upon my parents, and to do righteousness of which You approve. And admit me by Your mercy among Your righteous servants.

ABBREVIATIONS

AI	Artificial Intelligence
ACE	Artificial Conversational Entity
AIML	Artificial Intelligence Markup Language
AMOS	Analysis for a Moment Structure
AVE	Average Variance Extracted
AWS	Amazon Web Services
BI	Behavioral Intention
CJM	Customer Journey Mapping
CR	Composite Reliability
CS	Computer Science
CTA	Calls-to-action
DoI	Diffusion of Innovation Theory
DSR	Design Science Research
ECA	Embodied Conversational Agent
EE	Effort Expectancy
FAQs	Frequently Asked Questions
FC	Facilitating Conditions
GEM	Geneva Emotion Wheel
HC	Hierarchical Clustering
HCI	Human-Computer Interaction
HEIs	Higher Education Institutions
HM	Hedonic Motivation
HT	Habit
I/O text	Input and output text
IT	Information Technology
IS	Information System
JS	JavaScript
JSON	JavaScript Object Notation
KMC	K-Means Clustering
KMO	Kaiser-Meyer-Olkin
LMS	Learning Management System
LSA	Latent Semantic Analysis
LVC	latent variable correlations
MGA	Multiple Group Analysis

MOOC	Massive Open Online Courses
ML	Machine Learning
NLP	Natural Language Processing
NMF	Non-negative Matrix Factorisation
P2P	Peer-to-Peer
PCA	Principal Component Analysis
PE	Performance Expectancy
PEOU	Perceived ease of use
Persona3D method	Data-driven Persona Development Method
Persona3D model	Data-driven Persona Development Model
PLS-SEM	Partial Least Squares Structural Equation Modelling
PU	Perceived usefulness
PV	Price Value
R	R programming language
SCT	Social Cognitive Theory
SD	Standard Deviation
SEM	Structural Equation Modelling
SES	Simple Email Services
SI	Social Influence
SJM	Student Journey Mapping
SLT	Social learning theory
SPSS	Statistical Package for the Social Sciences
SSE	Sum of squared errors
STT	Speech to text
TAM	Technology Acceptance Model
TAM2	Extension of Technology Acceptance Model
TPB	Theory of Planned Behavior
TPO	Teaching Program Office
TRA	Theory of Reason Action
TRA	Theory of Reasoned Action
TTS	Text to Speech
UCD	User-Centred Design
UTAUT	Unified Theory of Acceptance and Use of Technology

UTAUT2	The Extended Unified Theory of Acceptance and Use of Technology
VLE	Virtual Learning Environment
WWW	World Wide Web

PUBLICATIONS

The following papers have been published, accepted for publication and submitted for peer review as a result of the research conducted for this thesis:

- Almahri, F., Bell, D. and Arzoky, M., 2019. Augmented education within a physical Space. UK Academy for Information Systems., pp.1-12. (Conference Paper)
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Awards

- I won the Three-Minutes Thesis Competition (3MT)– College Heats, College of Engineering Design and Physical Science, Brunel University, 2020, UK.
- I am a SAS certified Based Programmer for SAS 9, 2018.

Posters

- Almahri, F, Bell, D. and Kent, Si. (2019). 'Enhancing undergraduate students engagement using a novel chatbot, CSBPS2020, Brunel University London, UK.
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- Almahri, F, Bell, D. and Kent, Si. (2020).'Augmented Educational Interactions within a Physical Space for University Students Using Conversational Systems', CSBPS2019, Brunel University London, UK.

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CHAPTER 1 – INTRODUCTION

1.1 Introduction

There is a challenge in designing and building chatbots for students in educational settings (Winkler and Söllner, 2018; Yang and Evans, 2019). Hence, there is a need to design and build a persona framework (Persona3D modelling approach) and validate it using chatbots. In order to achieve this, it is essential to understand the student groups firstly to provide each group with effective chatbots. This chapter provides an overview of the whole thesis, which details an effective design methodology for personalised educational chatbots. It starts by showing a review of mobile educational technologies. The chapter also explores the use of chatbots as a mobile technology tool and as a tool in an educational setting. Chatbots will be presented, then the aim and objectives of this study will be outlined. The research methodology adopted for this study is discussed, followed by a summary of the thesis chapters. A diagrammatic illustration of the thesis outline is presented that serves as a guide for the reader.

Section 1.2 presents the background of the research problem domain. Moreover, it covers the research motivation and research gap. Section 1.3 presents the research aim and objectives. Section 1.4 explains the research approach used to conduct this research, and Section 1.5 describes the thesis structure and presents a diagrammatic sketch of the key points of each chapter of the thesis.

1.2 Theoretical Background and Research Problem

1.2.1 Mobile Technology

Mobile technology refers to technology that provides cellular communication (Patil *et al.* 2012) and other services for financial (Shirali-Shahreza and Shirali-Shahreza, 2007), education (Gomez *et al*. 2014), and healthcare (Kenny *et al.*, 2012) sectors, to name a few. Mobile technologies are continuously developing, and the diversity of mobile devices is tremendous (Ortiz *et al.*, 2015) – this has resulted in a corresponding increase in the number of people using mobile devices to play games, read books, listen to music, accessing websites and social media (Rideout, Foehr and Roberts, 2010).

Mobile technologies have many features that allow integrating these devices in educational institutions (Chen *et al.*, 2008; Keskin and Metcalf, 2011; Ortiz *et al.*, 2015). First, they are small in size so they can fit into a pocket (Ortiz *et al.*, 2015). Secondly, they allow easy access to a large amount of information (Ortiz *et al.*, 2015). Thirdly, mobile technologies allow a user to build a usable and attractive user interface with their HD screens (Ortiz *et al.*, 2015). Fourthly, they allow information management – mobile devices have a wide variety of software that makes them a suitable platform with which to create, modify and organise information, and to employ it for learning and teaching (Chen *et al.*, 2008; Keskin and Metcalf, 2011; Ortiz *et al.*, 2015). Finally, they have various built-in sensors and auxiliary devices, such as GPS, accelerometers, cameras, and communication ports (Ortiz *et al.*, 2015).

Therefore, unsurprisingly, the educational communities are attracted by the possibilities using this technology in education could bring (Kukulska-hulme and Traxler, 2013; Godfrey, 2016). Mobile devices improve students' skills – they can work on their communication skills using the camera and voice recorder and can use the calendar and reminders' features to enhance their management skills. The online dictionary or the Internet can be used to enhance learning (Godfrey, 2016). Consequently, the mobile learning (m-learning) concept has risen, and the technologies for teaching and learning purposes has become popular (Ortiz *et al.*, 2015; Naismith, Lonsdale, Vavoula, *et al.*, 2004).

Other aspects of mobile technologies serve as motivation for educational institutions to use them (Mechlih and Mechlih, 2015). One of these is the fact that educational institutions aim to increase student performance. Mechlih and Mechlih (2015) stated that higher academic performance achieved in a traditional classroom by either reducing the capacity of the classroom, i.e. reducing the number of students, or increasing the number of instructors in the class. However, introducing mobile technologies into education provides a better solution as it enables the creation of a virtual classroom where the number of instructors outnumbers the number of students (Mechlih and Mechlih, 2015).

Furthermore, another critical reason to include new technologies in learning is the students' willingness to use them for learning purposes (Liu *et al.*, 2003; Markett *et al.*, 2006; González *et al.*, 2014; Yang and Liao, 2014). Yang and Liao (2014) believe that this motivates language and culture teachers to apply new technologies to the learning experience (Yang and Liao, 2014). The research finding by Yang and Liao (2014) showed that the use of new technologies positively impacted language learning and student-teacher communication. Moreover, Markett et al. (2006) state that students' desire to use mobile technologies in their learning tool to motivate them to activate their participation (Markett *et al.*, 2006; González *et al.*, 2014). Mobile technology also helps students increase their engagement and interest in learning (Liu *et al.,* 2003; González *et al.*, 2014).

When applied in the educational context, mobile technology brings many benefits, and consequently, students', instructors', and administrators' perceptions of mobile technology have been positively affected (Zaldivar *et al.*, 2015). Zaldivar *et al.* (2015) studied the impact of mobile technologies on student learning in the Faculty of Computer Science at the University of Autónoma de Sinaloa, México. They conducted interviews with 152 participants, including instructors, students, and administrators. The participants believed that these technologies enhanced student's academic performance and qualifications because of the valuable features of mobile technologies explained above. Seventy-nine per cent of the participants were interested in deploying mobile technologies officially in their university (Zaldivar *et al.*, 2015). Technology also plays a role in education by enhancing student engagement and increasing their learning outcome. For example, using Twitter for educational purpose enhances students engagement and improves their performance (Junco, Heiberger and Loken, 2011).

1.2.2 Chatbots as a Mobile Technology Tool

A chatbot is referred to as a 'chatterbot' (Al-Zubaide and Issa, 2011), an artificial conversational entity (Al-Zubaide and Issa, 2011) or an interactive conversation agent (Hung *et al.*, 2009). A chatbot is a computer program that can carry out a conversation with a user in a natural language (Abdul-Kader and Woods, 2015) using textual or auditory methods or both. Chatbots can reply to users' queries, suggest topics to discuss and provide comments, to name a few of their abilities. Chatbots are used for different purposes, such as customer services, entertainment, education, to name a few (Al-Zubaide and Issa, 2011). Some well-known chatbots are ALICE (ALICE, 2011), Cleverbot and SimSimi (Angga *et al.*, 2016).

Chatbots are widely used in many sectors, and they can solve problems in different areas. Chatbots are used as personal assistants on mobile phones, as health intervention tools and as technical support over the telephone (Iulian V. Serban, Chinnadhurai Sankar, Mathieu Germain, Saizheng Zhang *et al.*, 2017; Winkler and Söllner, 2018). The chatbots market in the US is worth $113 million and is expected to be worth $994.5 million in 2024 (McKinsey and Company, 2016; Winkler and Söllner, 2018). The use of messaging applications on mobile devices has increased exponentially over the last few years. In 2016, the percentage of mobile users who use messaging applications reached 75% (McKinsey and Company, 2016; Winkler and Söllner, 2018). In 2030, it is expected that around 30% of web browsing sessions will be done verbally without screens, 50% of searches will be done using voice commands, and around 85% of customers' interactions with enterprises will take place without interacting with a human being (McKinsey and Company, 2016; Winkler and Söllner, 2018).

The rapid increase in the development and adoption of chatbots has brought several advantages. For instance, the implementation of chatbots in the business domain, particularly in customer services, can save costs by replacing all human assistants with chatbots. According to Juniper Research (2017), using chatbots in customer services will save companies around $8 billion per year in customer supporting costs by 2022. Also, chatbots save around $0.70 per interaction in comparison with traditional support conversations. Moreover, chatbots improve user satisfaction by increasing the response time and being available 24/7. For example, the Marriott International hotel chain started using chatbots to provide hotel booking services in 2017. Around 44% of all registered customers in the specified hotel received services using chatbots available on Facebook (Juniper Research, 2017).

1.2.3 Chatbots in Educational Settings

Recently, the average number of students in each lecture at universities has increased, with lecturers often having to teach more than 100 students per lecture (Nicol and MacFarlane-Dick, 2006; Winkler and Söllner, 2018). Massive open online courses (MOOCs) are widely used and have become the default learning scenario in some instances. Therefore, it has become impossible to provide individualised support to each student, and students cannot be engaged in effective learning (Brinton *et al.*, 2015; Winkler and Söllner, 2018). Research has shown that a lack of individualised learning produces weak learning outcomes, dissatisfaction and high dropout rates (Oeste, S.0 Lehmann, K.0 Janson, A.0 Söllner, M. and Leimeister, 2015; Winkler and Söllner, 2018).

The number of implementations of chatbots in education has been limited. Instead, researchers have often tried to implement traditional intelligent tutoring systems and pedagogical agents in learning scenarios (Goos *et al.*, 1998; Baker, 2016; Winkler and Söllner, 2018). An intelligent tutoring system is a computer system that provides instant feedback and customised instructions to the learner (Goos *et al.*, 1998; Kim, Baylor and Shen, 2007; Winkler and Söllner, 2018). A pedagogical agent is a "human-like interface between the learner and the content in an educational environment" (Winkler and Söllner, 2018, p. 3). In contrast, chatbots provide asynchronous interaction with students and react to individual intents. This allows students to control their learning process, which is the main factor for effective learning, based on the predominant constructivist learning theory (Glasersfeld, 1987; Winkler and Söllner, 2018).

A few studies have successfully implemented chatbots in learning scenarios (Kerly, Hall and Bull, 2007; Winkler and Söllner, 2018). For instance, the University of Georgia created a chatbot called 'Jill Watson', based on IBM's Watson platform, to handle computer science students' forum posts (Ashok *et al.*, 2015; Winkler and Söllner, 2018). Using chatbots can improve student engagement, and students may wish they had chatbots for other courses (Winkler and Söllner, 2018). In MOOCs or large-scale learning scenarios at universities, chatbots have the power to cover the insufficient individual learning support provided by lecturers. For instance, in

MOOCs, the retention rate is 10% (Hone and El Said, 2016). Using chatbots can help to improve individual learning support with limited investment from the organisation.

Chatbots are an exciting technology that can bring several benefits to education: they are enjoyable, support continuous learning, enhance student motivation, enhance students' skills, offer an exciting form of encouragement and assist teachers in their jobs (Knill *et al.*, 2004; Shawar and Atwell, 2007). Also, chatbots can positively impact students' satisfaction and learning success (Winkler and Söllner, 2018).

1.2.4 Research Motivation and Research Gap

The motivation of this research is to improve student engagement in higher education institutions (HEIs). Student engagement has received significant attention from researchers since the 1990s (Trowler, 2010). It is considered a predictor of student performance (Astin, 1984; Martin and Torres, 2016). Poor engagement is one of the main factors behind students' boredom, alienation, low performance and high dropout rates (Martin and Torres, 2016). HEIs are challenged by low-level student engagement. Several teaching methods, tools and strategies have been developed to solve this problem. For instance, with the significant increase in the number of internet users and mobile phone owners, there has been interest in employing these devices in class and outside of class to improve student participation (Parsons and Taylor, 2011; Lim, 2017).

There are several indicators of student engagement, such as attendance, task completion, self-reported interest and enthusiasm. Benotti, Martínez and Schapachnik (2014) studied the effects of using chatbots on high school students' engagement. They compared the use of chatbots and ALICE as educational tools to teach students basic Computer Science programming concepts, such as variables and conditions. The two tools were applied in: 1) 15 lessons in class in two schools and 2) online competitions. The research findings show that the students were more interested in using chatbots than ALICE (Benotti, Martínez and Schapachnik, 2014).

Research covering chatbots and artificial intelligence (AI) has indicated that chatbots typically follow a one-size-fits-all approach, where all users receive the same services in the same language and using the same data, regardless of their preferences, needs and digital literacy (Følstad and Brandtzæg, 2017; Kadariya *et al.,* 2019), as well as regardless of their location *(Bradesko et al.*, 2017; Følstad, Nordheim and Bjørkli, 2018), particularly in educational settings (Yang and Evans, 2019). From a theoretical perspective, a research gap exists regarding the design of chatbots (with personas) in an educational setting. Therefore, this study overcame this limitation by designing an approach that combines machine learning and personas, providing chatbots services to university students based on their persona types.

1.3 Research Aim and Objectives

This research aimed to create an effective design methodology for personalised educational chatbots. Furthermore, this research aimed to answer the following research question: what steps should be followed to design effective chatbots for different students in different educational settings? The research objectives of this study were:

Objective 1: review the literature on mobile educational technology and the state of the art of chatbots.

Objective 2: identify the different student groups at Brunel University London by using machine learning to build student persona models (Persona3D).

Objective 3: extend the Persona3D modelling approach with constructs of the extended UTAUT2 model.

Objective 4: assess the practical effectiveness of the Persona3D approach by building a range of chatbot prototypes.

1.4 Research Methodology

Design science research (DSR) is the research approach adopted for conducting this study. Design science is a field within Information Systems (IS) research that builds and evaluates IT artefacts to provide a solution to an organisational issue (Hevner *et al.*, 2004). The building is based on creating an artefact to do specific tasks and answering the query "does it work?". Whereas evaluating an artefact specifies whether or not it performs any progress, answering the query "how well does it work? (March and Smith, 1995).

March and Smith (1995) proposed a research framework that consists of two dimensions: research activities and research outputs. Research activities consist of four elements; build, evaluate, theorise and justify. While research outputs contain four product categories as follows:

• Constructs or concepts used to explain the problems in a specific domain and the proposed solutions.

• Models are a set of statements that articulate the relationship between constructs.

• Methods are the procedure used to do a task based on models and constructs.

• Instantiations are the realisation of the artefacts in their problem domain. It articulates how practical and feasible these artefacts are, based on the model and methods they used.

The DSR phases proceeded as follows:

Design: "design is essentially a research process to discover an effective solution to a problem" (Hevner *et al.,* 2004, p. 88). This research designed a solution to support the aforementioned objectives. The design process took place in three iterations. The first iteration started with designing a means to identify student groups. This was achieved by using machine learning to create a data-driven persona development method. In the second iteration, the research designed a solution to identify the chatbots features. This was achieved by studying students' acceptance and use of technology. In the third iteration, a range of chatbots was designed for different student groups.

Build: this involves building theories or artefacts (Hevner *et al.*, 2004, p. 80). In the present study, this entailed building the artefacts proposed in the earlier design. It started with creating a data-driven persona development method (Persona3Dd method) that would lead to the development of the student personas. In the second iteration, the required chatbots features were identified by building on / extending the UTAUT2 model. The third iteration covered building a range of chatbots based on the results of the first iteration (personas) and the second iteration (chatbots features).

Evaluate: "The evaluation of the artefact then provides feedback information and a better understanding of the problem to improve both the quality of the product and the design" (Hevner *et al.*, 2004, p. 78). This step of the research focused on evaluation. In the first iteration, the persona model was evaluated in terms of completeness. In the second iteration, the extended UTAUT2 model was evaluated based on internal consistency and composite reliability. In the third iteration, the effectiveness of the extended Persona3D model and method was evaluated by developing a range of chatbots for different personas. Further information about artefacts evaluation is covered in Chapter 3.

1.5 Thesis Structure

Figure 1-1 presents a diagrammatic sketch outlining the entire thesis. It highlights the critical points in each chapter. In order to achieve the objectives of this study, the research is organised as follows.

Chapter 2 draws extensively from the literature. This chapter shows relevant studies and research, discusses the state-of-art of chatbots, data-driven persona development method and model, the existing theory of acceptance and use of technology, journey mapping, and chatbots design and development. At the end of this chapter, the research gap is presented, followed by a chapter summary.

Chapter 3 discusses this research's epistemology and ontology, the reasons why positivism was chosen for this research and the sampling approach. Furthermore, it introduces DSR as the research approach to conduct IS research effectively. Moreover, it presents background on design research, including the design science process to solve a design problem and the differences between design science and behavioural science. It then shows the process to apply and evaluate DSR to address the proposed question. This chapter covers the design science for chatbots design, building, and evaluation, as well as specifies the research activities and artefacts. Also, it discusses the different types of triangulation and the method in this research.

Chapter 4 presents the first DSR iteration in this study. It covers the design, building, and evaluation of the data-driven persona development method (Persona3D method). It uses a machine learning framework as the central part in building the method. Implementing a prototype of the method using R programming language and applying it on real datasets will generate the persona model – this goes through design, development and evaluation. The iteration produces several artefacts, including persona templates, methods and models.

Chapter 5 presents the second DSR iteration in this study. This iteration extends the result generated from the first iteration with chatbot features. It studies one of the technology acceptance theories or models and extends it with elements generated from the first iteration. This research covers the design, development and evaluation of the survey, hypothesis and model. The evaluation of the proposed model will be done using Structure Equation Modelling (SEM).

Chapter 6 presents the last DSR iteration of this study and assesses the effectiveness of the generated model from the first and second iteration. This iteration considers the output of the first and second iterations as an input. Two User-centred designs will be used for the design and development of the chatbots, including persona model and journey mapping for university students, designed based on the persona model.

Chapter 7 summarises the whole thesis and presents the main contributions and limitations of implementing DSR to solve the proposed issue. The proposed DSR iterations will be evaluated based on the aim and objectives of the study. The summary of this chapter includes the limitations of this study, and recommendations for future work will be covered in the last section.

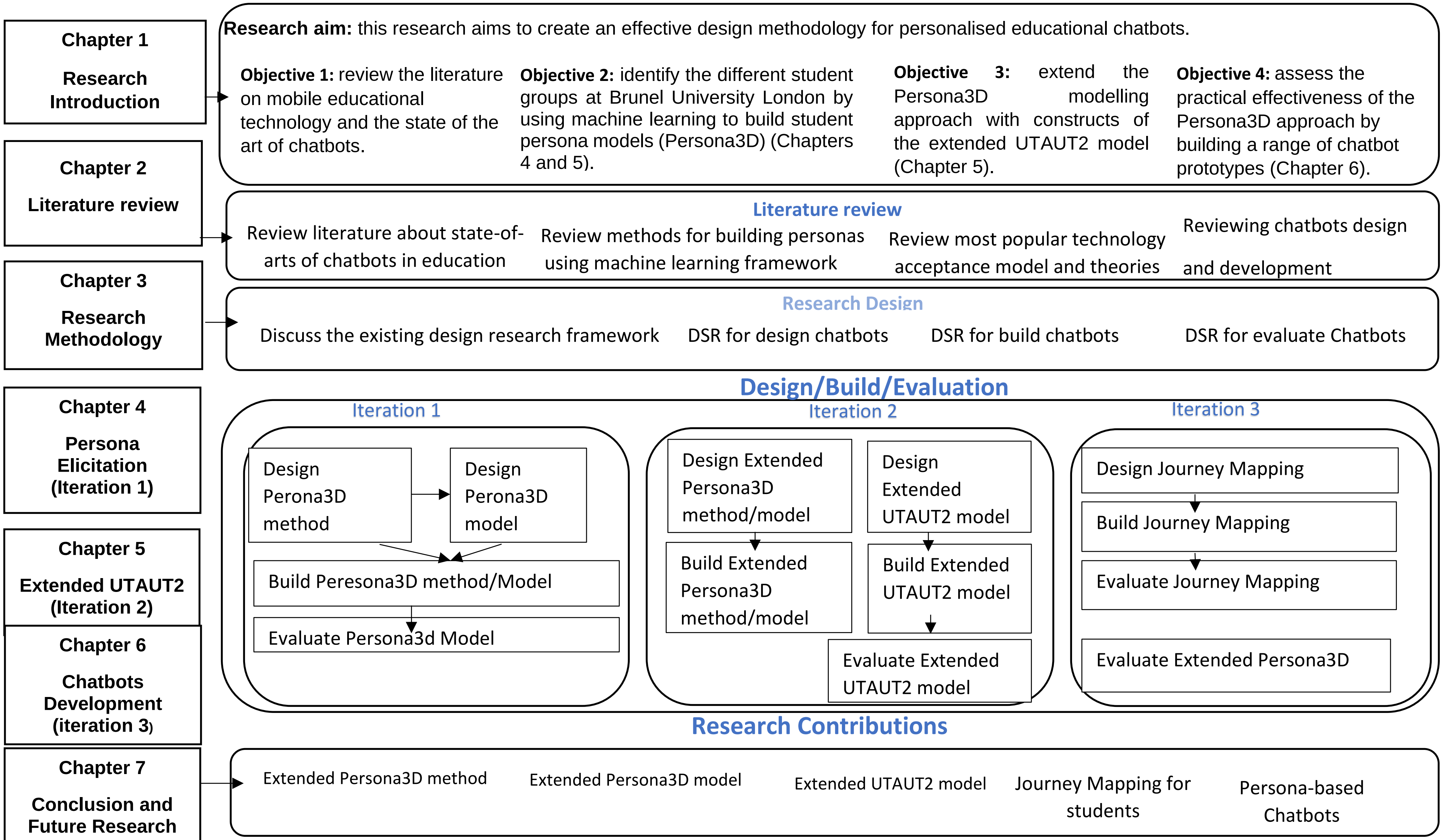


Figure 1- 1: Overview of the Thesis

CHAPTER 2 – LITERATURE REVIEW

2.1 Introduction

This chapter investigates and reviews chatbot design for university students at Higher education institutions (HEIs) to solve low-level student engagement and performance problems. The chatbot is persona-based and context-based. The acceptable chatbots target improving student engagement and performance during the day. This chapter is structured as follows; Section 2.2 provides an overview of research relating to chatbots. Section 2.3 discusses personas, their uses, benefits and development. It introduces different data-driven persona development methods to build personas, including a machine learning framework. Section 2.4 discusses the most popular technology acceptance models and theories, along with their features and limitations. Section 2.5 provides an overview of Journey Mapping as a design tool. Section 2.6 discusses the existing chatbots design and development, including design techniques. Section 2.7 discusses the current state of chatbots design. Section 2.8 provides a summary of the chapter.

2.2 Chatbots

The modern era is known as the era of machine intelligence (MI), also referred to as artificial intelligence (AI), in which machines are made to imitate human features. A good example of AI is the interactive artificial intelligence referred to as chatbots (Kerly, Hall and Bull, 2007). The term 'chatbot' was coined by Mauldin (Mauldin, 1994; Pereira and Coheur, 2013). It is defined as a computer application that can carry out conversations with people in a natural way (Khanna *et al.*, 2015) using their natural language (Kerly, Hall and Bull, 2007). The conversation can be made through voice, text (Khanna *et al.*, 2015) or a combination of text and voice.

Chatbots are known under a variety of different names; chatterbots, chatter-bots (Thorne, 2017), conversational agents (Kerly, Hall and Bull, 2007), machine conversation systems, virtual agents, dialogue systems (Abu Shawar and Atwell,

2007) or an Artificial Conversational Entity (ACE) (Al-Zubaide and Issa, 2011). They are a limited type of task-directed dialogue systems where the interaction is text-based rather than voice-based. Chatbots have been in existence since the 1970s, and they utilise natural language processing. Winograd's SHRDL is an early example of a chatbot (Winograd, 1972).

Interests in chatbots have been growing rapidly since the 1990s. The growth of interest in chatbots is due to the emanation and explosion of the World Wide Web (WWW) and its chatting facilities (Thorne, 2017). Chatbots perform productive and straightforward tasks such as setting up alarms, reminders or calculation tasks (Khanna *et al.*, 2015), checking the news, booking flights, ordering food and organising meetings (Pereira, 2016).

Chatbots have been used in several domains such as education (Jia, 2004), business (Sankar, 2018), e-commerce(Gupta *et al.*, 2015), automatic telephone answering systems, help desk tools, and entertainment (Abu Shawar and Atwell, 2007). Moreover, chatbots are used for technical assistance and troubleshooting activities (Acomb *et al.*, 2007). Enterprises use chat forums to help their staff or clients resolve operational problems that concern equipment or services (Thorne, 2017).

Chatbots are considered one of the most potent examples of Human-Computer Interaction (HCI). A considerable number of chatbots are available in the world; many are smart, and some have won the Loebner Prize. However, these chatbots are not creative; none of them is capable of learning or keeping memories of events for a long time. Creativity is one of the essential features of AI. Currently, AI systems can apply a set of specific instructions, but they neither present any intelligence nor do they understand what is happening around them. Rule method (Whitby, 2009; Khanna *et al.*, 2015) is the most commonly used methodology. Its main idea is to search and find suitable matches from a database, which does not show any intelligence. According to the Theory of Machine Intelligence (Khanna *et al.*, 2015), chatbots, like other systems, score only 0.5 in performance factors. Therefore, a great deal of improvement is required in this scope in the future (Khanna *et al.*, 2015).

2.2.1 Chatbots and Intelligent Behaviour

A chatbot is “ a computer program designed to simulate an intelligent conversation with one or more human users via auditory or textual methods" (Al-Zubaide and Issa, 2011, p. 7). Although chatbots seem to work intelligently by interpreting users' input before providing an answer. Some chatbots merely scan the keyword input and respond with the most suitable matching keyword reply from its database (Al-Zubaide and Issa, 2011).

A chatbot represents intelligent behaviour based on the nature of its reply to humans. If the communication between the human and the chatbot convinces the human that they are chatting to another human rather than a chatbot, it can be claimed to be an intelligent chatbot. The level of the chatbot's intelligence depends on its knowledge, which means the higher their level of the knowledge base, the smarter they are (Al-Zubaide and Issa, 2011). It requires several years to create a strong chatbot knowledge base. Therefore, most chatbots apply a simple strategy to make them appear lifelike (Al-Zubaide and Issa, 2011)

A considerable number of chatbots have been implemented in a limited area; for site guidance, information requests, and the provision of answers to frequently asked questions (FAQs). Most chatbots contain dialogue management to manage the chatting process and a knowledge base to answer user input. The ideal chatbot implementation of knowledge base consists of templates that match keyword input to produce replies. As a result, creating knowledge bases for chatbots is time-consuming and complicated to adopt in new areas (Al-Zubaide and Issa, 2011).

However, some chatbots are developed using standard programming languages instead of using Artificial Intelligence Markup Language (AIML). A good example is OntBot, developed by Al-Zubaide and Issa (2011) using VB.Net. They used a relational database to construct and store the chatbots' knowledge base. Furthermore, the knowledge-based source is the WWW ontologies, which are converted automatically to eligible instances. These instances are then saved in local databases to overcome the problem of manual writing of thousands of conversational gambits, as applied in ALICE (ALICE, 2011). Additionally, the development of an 'OnBot' requires neither knowledge-archiving skills nor AIML, which overcomes the limitations of traditional chatbots (Al-Zubaide and Issa, 2011).

2.2.2 Applications of Chatbots

Although chatbots are a fundamental and straightforward AI application, they are critical due to their various applications and their potential uses, which may be developed by future research. Chatbots can be applied in many areas, such as:

1) Health care: Chatbots can be used as a medical health intervention approach. The study by Elmasri and Maeder (2012) aimed to assess whether chatbots are suitable for use in mental health interventions. The study was conducted in Australia, with adult participants between the age of 18 to 25 years, particularly those with high alcohol consumption. The chatbot was created to carry out an essential assessment of the participants' alcohol drinking habits and to specify the health risk level. Furthermore, it educated alcohol users about alcohol use. Seventeen participants evaluated the usability and user satisfaction of the chatbots; the overall result shows that users have robust perceptions about the intervention. The limitation of the study was the use of a small sample size, and the inclusion of control would lead to better statistical analysis (Elmasri and Maeder, 2012).

2) Customer services: A frequently asked question is an essential page on many websites. It contains answers to common issues that concern users. However, when the FAQ page contains many addressed issues, it becomes impractical for users to read through the many distinct entries to find the one that the user is searching for. Moreover, the user might not feel confident about the terms used to address the issues on the page. Therefore, in website design, chatbots can be used to address these problems by creating conversational interfaces for the FAQ page (Shaw, 2012a). Further studies are needed to develop chatbots that can allow users to give their feedback and answer their queries on the FAQ page (Shaw, 2012a).

3) Entertainment: Chatbots can be a source of entertainment based on a users' profile to alleviate boredom (Khanna *et al.*, 2015). ELIZA (Weizenbaum, 1966) was considered to be one of the earliest created chatbots (Kerly, Hall and Bull, 2007); it was developed in the 1960s by Joseph Weizenbaum (Abu Shawar and Atwell, 2007). His idea was to simulate a psychotherapist in clinical treatment (Weizenbaum, 1966). The idea was straightforward, and it used the keyword matching approach (Abu Shawar and Atwell, 2007). ELIZA accepts input text, analyses it and produces responses by applying the reassembly rules that come with input decomposition (Kerly, Hall and Bull, 2007). The ELIZA response shows its concerns for users. However, it has no memory to retain the conversation, and it is unable to become involved in any targeted types of negotiation or collaboration. ELIZA syntactic language processing has been developed dramatically. Thus, a large number of chatbot language processes have been created.

4) Teaching and education: Chatbots can be used as a powerful tool in education. They can work as a language tutor, as in the example known as Sofia. Chatbots can also assist with the teaching of mathematics and help users to solve algebra problems, as with Pari and Mathematica chatbots. In the study of medicine, chatbots help medical students by simulating patients and providing responses during interviews with medical students; an example of this type of chatbot is the Virtual Patient bot (VPbot).

A large number of chatbots have been developed and are available on the web (Pereira and Coheur, 2013). However, not all of them are intelligent. Intelligent chatbots can get humans into believing that they are interacting with another human (Al-Zubaide and Issa, 2011). Consequently, an evaluation technique that assesses the intelligence level of chatbots has been developed and referred to as the Turing Test.

2.2.3 Chatbots and Education

Chatbots are used in different domains, one of which is the education domain (Jia, 2004). Chatbots in schools can be used for various purposes, such as encouraging blind students to enrol in a computer science major (Bigham *et al.*, 2008). They have also taught students about AI courses and concepts (Keegan, Boyle and Dee, 2012) and socially intelligent computing concepts in introductory computer science modules (Shaw, 2012b). Chatbots, used outside the school settings, are applied in educating people on healthy living and lifestyles (Gardiner *et al.*, 2017).

For high schools students, chatbots could encourage blind students to enrol in computer science major by selecting persona chatbots and further developing these chatbots (Bigham *et al.*, 2008). Bigham et al.'s study (2017) covers a four-day computer science workshop that attracted 200 blind and low-vision high school students in the National Federation of the Blind Youth Slam students. The workshop, attended by 15 blind high school students, provided students with an opportunity to fix the false knowledge about the difficulty and hopelessness of blind students to pursue a computer science major.

The participating students created personalised and impressive chatbots using a programming language such as C#. Students were given a set of suggestions for persona chatbots such as a fortune teller, a psychologist and Yoda from StarWars. However, they chose to implement different persona chatbots such as an insult-giving smart chatbot, a poetic mathematician, and an anti-Bush conservative (Bigham *et al.*, 2008). Chatbots can pull information from the web to reply to questions such as “where are the nearest Chinese restaurants?”, ”Who won the Orioles game last night?” (Bigham *et al.*, 2008, p. 450). They used a C# programming language and text editor, TextPad version 4.7.3, which works well with JAWS screen reader and instant massaging libraries suitable for a .NET platform and support Yahoo, AOL and Windows Live and Jabber protocols (Bigham *et al.*, 2008).

Chatbots can be utilised in education to teach some socially intelligent computing principles (Shaw, 2012b). Undergraduate students studying introductory computer science courses can learn about the concept of “socially intelligent computing” using Peer-to-Peer (P2P) libraries. Students are provided with a library to create a sophisticated chatbot, which processes input texts and produces replies. Chatbots created by students can communicate with their peer using a centralised P2P server and client-server framework. Students create a project using Java Programming Language that collaborates with individual chatbots created; whenever there is a question that cannot be handled by first chatbots, it searches for an answer in other chatbots (Shaw, 2012b).

Chatbots can be used to teach humans a new healthy lifestyle. Gardiner et al.'s study (2017) explores the feasibility of using Embodied Conversational Agent (ECA) on engaging and teaching urban women new healthy lifestyles. Women were divided into two groups: 1) uses ECA that teach them contents about stress management, healthy eating, physical activity and mindfulness. 2) uses a paper prototype of the content used in ECA and medication - one tablet daily for one month. The result shows that the ECA group made a significant improvement in a healthy lifestyle. There was an increase in daily fruit consumption and a decrease in alcohol consumption compared to the second group.

2.2.4 Benefits of Using Chatbots to Education

There are many benefits of using chatbots in education:

1) learning becomes enjoyable as students feel more relaxed and comfortable chatting with chatbots more than their teachers or partner within the traditional teaching setting. 2) support continuous learning- chatbots enable students to repeat and view the same learning materials many times without fatigue or boredom compared to the teacher. 3) enhanced student motivation .4) enhancing students skills- chatbots support speech and text, which can improve students listening and reading abilities (Abu Shawar and Atwell, 2007). 5) a way of encouragement – teachers can use chatbots as a way of awarding excellence in students who finish their class activities to chat with chatbots on certain topics. 6) supports self-evaluations – chatbots store all conversation transcripts which enable students to view their conversation and evaluate themselves (Abu Shawar and Atwell, 2007). 7) assists teachers – students can ask chatbots, and teachers can view what types of question each student asks; this helps in identifying areas of students concern. Teachers can also see log files to measure students' learning and weaknesses.

The Sofia chatbot was developed to assist teachers in teaching mathematics. The Sofia chatbot can work simultaneously by conducting a conversation with users and communicating with other mathematical chatbots such as Mathematica and Pari to solve Algebra issues (Knill *et al.*, 2004; Abu Shawar and Atwell, 2007).

2.2.5 Chatbots and Student Engagement

Student engagement is classified into three types of engagement: 1)Behavioral engagement represents behavioural norm such as attendance and involvement, 2)emotional engagement represents engaging emotionally, such as enjoyment, interest and/or sense of belonging, 3) and cognitive engagement by engaging cognitively with learning by studying what is required and beyond that and even taking challenges (Bloom, 1965). Higher educational institutions (HEI) face a critical problem with a low level of student engagement, which leads to poor learning performance. Several teaching methods, tools, and strategies are developed to solve this problem. With the high increase in the number of internet users and mobile owners, there is a great interest to employ these devices in-class and out-class to improve students' participation (Parsons and Taylor, 2011; Lim, 2017).

Chatbots have been utilised in distinct scenarios to make people interested in computer science for decades (Benotti, Martínez and Schapachnik, 2014). Worldwide, young students have a lack of engagement in computer sciences (CS). For instance, in Argentina, only 4000 computer science students graduate per year; of which only half end up in the industry, while there are 15000 students in economics and 10000 in the field of law (S. d. P. U. Departamento de Informaci´on Universitaria, 2016). Benotti, Martinez and Schapachnik (2017) created an innovative way to introduce high school students to computer science by programming chatbots. Chatbots teach students basic concepts such as conditions, variables, and finite state automata, to name a few. They provide automatic formative assessments to the student using finite state automata, pattern matching, and "state of the art lemmatisation techniques". Formative feedback generates immediately when an error occurs – females reported more interest than their male counterparts, and they are more willing to use chatbots to learn more (Benotti, Martinez and Schapachnik, 2017).

The researcher studied the effectiveness of using chatbots on student engagement using two observational studies: 1) compulsory in-classroom pilot course containing 15 lessons and conducted in 3 high schools, 2) a nationwide online contest with at least 10000 participants. Students' engagement indicators, such as attendance, enthusiasm, task completion, willingness, self-reported interest, among others, were measured. The result shows that in both studies, females engaged more with chatbots than males. As for online courses, the percentage of students who completed their tasks with chatbots was five times more than those who use Alice. In a classroom course, females had a higher self-reported interest than males, and they were more willing to use chatbots to learn more (Benotti, Martinez and Schapachnik, 2017).

Chatbots have been utilised in distinct scenarios to enhance human interest in computer sciences for decades. However, Benottis states that there is no study has focused on using chatbots to teach basic concepts and on measuring the effectiveness of using chatbots on student engagement. Benotti's study (2014) designs a chatbot to enhance students engagement while teaching them some basic computer science concepts such as variables, finite state automata and conditionals, among others for high school students (Benotti, Martínez and Schapachnik, 2014). Two experiments were conducted using chatbots, one of which is ALICE; a well-known educational tool. Both tools were used in a nationwide online competition and classroom environment (15-lessons in two high schools). The results, indicating student engagement, show that females' self-reported interest and retentions are higher while using chatbots than ALICE (Benotti, Martínez and Schapachnik, 2014).

2.3 Personas

As mentioned in Chapter 1, this study aimed to create an effective design methodology for personalised educational chatbots. Therefore, it is essential to know what persona is and how to build it. The Persona concept was coined in 1999 by Alan Cooper in chapter 9 of his book "The Inmates are Running the Asylum" (Cooper, 2004). Personas have become conventional design methods that are widely used. However, there is no standard definition for 'persona'. Research in literature presents persona as user-centred design (UCD) methods that represent a group of users who share common goals, attitudes and behaviour during interaction with a product (Putnam, Kolko and Wood, 2012; Cabrero, 2014). A persona is defined as "a precise description of a hypothetical user and what s/he wishes to accomplish” (McGinn and Kotamraju, 2008, p. 1). A persona is also referred to as a ‘target customer characterisation’, ‘profile’ or ‘user archetype’ (Adlin *et al.*, 2006).

Initially, with the popularity of UCD, the usability of systems, websites and products were improved (Vredenburg *et al.*, 2002; Miaskiewicz and Kozar, 2011). UCD is also referred to as ‘customer-centred design’ or ‘human-centred design’ and is a type of design that brings customers or users into the design process (Vredenburg *et al.*, 2002; Miaskiewicz and Kozar, 2011). UCD has spread widely; however, there has been some frustration related to the design of modern products. Many corporations have failed to focus on consumer needs as the most crucial aspect of the design process (Gulliksen *et al.*, 2003). Therefore, many design processes have failed to reach the target users or consumers (Dahl, Chattopadhyay and Gorn, 2006; Miaskiewicz and Kozar, 2011). The well-documented usability issues of products, systems and websites prove that current product design processes need improvement. For instance, many products are returned because they are difficult to use, or the users are unable to use their preferred features (Miaskiewicz and Kozar, 2011).

Personas provide a solution to some of these problems with the current UCD approach. ‘Persona’ concept was proposed by Cooper (Cooper, 2004) as a design process methodology (Friess, 2012a). Personas are not real people but imaginary archetypes of actual users (Friess, 2012a). Persona development is an alternative method for representing and communicating users’ needs (Miaskiewicz and Kozar, 2011). There is much research in the literature that discusses persona templates (Blooma, Methews and Nelson, 2013; Nielsen *et al.*, 2015), creating personas (Blomquist and Arvola, 2002; Sinha, 2003; Adlin *et al.*, 2006) and what they are suitable for (Pruitt and Grundin, 2003; Sinha, 2003; Cooper, 2004; Adlin *et al.*, 2006a) — in particular, using personas for interface and interaction design has attracted significant attention (Adlin *et al.*, 2006a). Persona development, as a design technique, is becoming increasingly popular, as it presents the primary users’ features to be used for product design and marketing (Sinha, 2003). Additionally, it is an efficient way to improve users’ experiences with products and services (Adlin *et al.*, 2006a). Moreover, personas provide product designers with powerful representations of target consumers (Miaskiewicz and Kozar, 2011).

Furthermore, using personas has other benefits: 1) providing a better understanding of users, 2) providing design requirements at an early stage, 3) requiring design thinking, 4) focusing on users' goals, requirements and characteristics, 5) facilitating stakeholder communication, and 6) including political and social factors in design decisions (Cabrero, 2015). However, according to (McGinn and Kotamraju, 2008), there are a number of problems with persona development, including creating personas that are not based on first-hand datasets (Pruitt and Grundin, 2003), which is not the case in this study. Personas can be unreliable if they do not have a clear relationship with the data, such as instances of being designed by committee(Pruitt and Grundin, 2003).

Several studies cover the best practice with persona by practitioners (Pruitt and Grundin, 2003; Nieters, Ivaturi and Ahmed, 2007). Creating a persona is a problem because they are not based on first-hand customer data (Lee, Kiesler and Forlizzi, 2010; McGinn and Kotamraju, 2008), and in some cases, the sample size is statistically insufficient (Lee, Kiesler and Forlizzi, 2010; McGinn and Kotamraju, 2008). The data-driven persona was proposed by (McGinn and Kotamraju, 2008; Vandenberghe, 2017) such as clickstreams (Zhang, Brown and Shankar, 2016; Vandenberghe, 2017) or statistical data (McGinn and Kotamraju, 2008; Vandenberghe, 2017). Machine learning methods such as K-Means Clustering analysis were used to build personas (Ketamo, Kiili and Alajääski, 2010).

2.3.1 Data-Driven Persona Development Methods

There are three methods of creating personas: 1)quantitative personas, 2) qualitative personas with quantitative validation, and 3)qualitative personas(Mulder and Yaar, 2006; Salminen *et al.*, 2020). On the one hand, most academic literature on persona creation uses qualitative techniques (around 81%), including ethnography, field studies, interviews, and usability tests(Brickey, Walczak and Burgess, 2012). However, these qualitative techniques have some limitations, including high cost, lack of objectivity and rigour, lack of scaling and non-representative data. On the other hand, creating personas using quantitative personas are verifiable, replicable and statistically representative (Salminen *et al.*, 2020). Therefore, this research target building personas using quantitative methods A study by Salminen et al.(2020) entitles “a literature review of quantitative persona creation” review the literature. The inclusion criteria include a full search article published in a conference or peer-reviewed journal, written in English and an empirical paper that builds personas using quantitative data. After applying the criteria, 49 articles remain out of 149. Analysing the literature shows that there are five methods that are used to build the personas. They are K-means clustering (KMC), Hierarchical Clustering (HC), Principal Component Analysis (PCA), Latent Semantic Analysis (LSA) and Non-negative Matrix Factorization (NMF). Salminen et al. (2020) state that k-mean clustering is the most popular used method to create a persona (Salminen *et al.*, 2020). K-means Clustering one of the popular Machine learning method.

Method	**Description**
Method K-means Clustering (KMC)	Machine learning algorithm that classifies a dataset using a a predetermined prime number (k) of clusters.
Hierarchical Clustering (HC)	Machine learning algorithm that computes distances between different elements to produce clusters in a hierarchical order based on similarity
Principal Component Analysis (PCA)	Linear dimension-reduction algorithm used to extract information by removing non-essential elements with relatively fewer variations.
Latent Semantic Analysis (LSA)	Machine learning algorithm that uses singular value decomposition to detect hidden semantic relationships between words.
Non-negative Matrix Factorization (NMF)	Matrix factorization method in which matrices are constrained as non-negative. A matrix is decomposed into two matrices to extract sparse and meaningful features

Table 2- 1: Most Popular Methods for Building Personas (Salminen *et al.*, 2020).

2.3.2 Machine Learning Methods and Techniques

Arthur Samuel coined the concept of Machine Learning (Samuel, 1959). Machine Learning (ML) is defined as “*a process of building computer systems that automatically improve with experience, and implement a learning process. Machine Learning can still be defined as learning the theory automatically from the data, through a process of inference, model fitting, or learning from examples*” (Ayodele, 2010, p. 2). There are two main classifications of machine learning: 1) Supervised learning, such as classification algorithm, which classifies groups based on pre-defined classes. 2) Unsupervised learning, such as the clustering algorithm. With Unsupervised learning, cluster groups find some relationships between objects without having a pre-defined class.

Clustering, data clustering, or clustering analysis aims to find the natural grouping of a set of objects, points or patterns (Jain, 2008). Objects in the same groups are similar to each other while being different from objects in other groups. Webster defines clustering analysis as a "*statistical classification technique for discovering whether individuals of a population fall into different groups by making a quantitative comparison of multiple characteristics*" (Merriam Webster online dictionary, 2008). The literature presents many clustering algorithms and various ways to evaluate the clusters. K-mean clustering method is a fast and straightforward clustering technique that is suitable to achieve the objective of the first iteration of this study, which is identifying different students' groups(personas).

Clustering methods are used in this study to identify the groups of students and extract the students' attributes to build the personas. Clustering refers to the task of grouping a set of objects so that objects in the same group are similar to each other but different from objects in other groups. Clustering is an unsupervised ML method that does not require any training data before using it (Kolomvatsos and Anagnostopoulos, 2017), unlike the classification method (Foody and Mathur, 2006). The literature identifies several clustering algorithms, such as *K*-means clustering (Zhao *et al.*, 1967; Wang *et al.*, 2017; Hartigan and Wong, 2018). Hartigan describes this in detail. (Hartigan, 1975).

2.3.3 K-Means Clustering Analysis

The *K*-means clustering method is the most popular and widely used clustering algorithm due to its simplicity (Kodinariya and Makwana, 2013). It is robust, fast and easy to understand. It also has good performance in clustering even with the presence of noisy data or outliers, though it is unsuitable for categorical data (Singh, Yadav and Rana, 2013). Therefore, it suits the two datasets in this study (see Chapter 4).

The core idea of *K*-means clustering is to define *K* centroids for *K* clusters. It is recommended to choose *K* centroids that are far away from each other to simplify the process of creating the cluster. Each data point is then assigned to the nearest centroid until no data points are left. These data points and their centroid form a cluster. For each *K* cluster, a new centroid recalculated, and then each data point reassigned to the nearest centroid to form a new *K* cluster. This step is repeated until no changes noticed – until the *K* centroids do not change (Kodinariya and Makwana, 2013). The *K*-means algorithm forms clusters in such a way that each data point has the minimum square error between the point in the cluster (itself) and its cluster mean, as shown in Equation (1). *K*-means method aims to obtain the minimum sum of the squared error in all *K* clusters, as shown in Equation (2).

$$J(C_k) = \sum_{x_i \in C_k} ||X_i - \mu_k||^2 \tag{1}$$

$$J(C_k) = \sum_{k=1}^{k} \sum_{x_i \in C_k} ||X_i - \mu_k||^2 \tag{2}$$

Let X be the set of data points X = {x_1, x_2, x_3,…….., x_n} and V be the set of centres V = {v_1, v_2,……., v_c}. The algorithmic steps for *K*-means clustering are as follows(Singh, Yadav and Rana, 2013):

1. Select ‘C’ centroids, cluster centres, randomly.
2. Compute the distances between each data point in set X and the cluster centroids. Assign each data point to a cluster that has the minimum distance from the point to the centroid.
3. Re-compute the new cluster centre using the formula, as shown in Equation (3):

   $$V_i = \left(\frac{1}{C_i}\right) \sum_{j=1}^{ci} x_i \quad (3),$$

   Where ‘c_i’ represents the total number of data points in the I^{th} cluster.
4. Recalculate the distance between each data point and the new centroids.
5. Repeat steps 2–4 until there is no change in assigning the data points to the centroids (Singh, Yadav and Rana, 2013).

Assuming X = {x_1, x_2, x_3,…., x_n} is the set of data points and V = {v_1,v_2, …v_c} is the set of centres, the similarity or regularity of the data items is measured using a distance metric. Some of the popular distance metrics to calculate the difference between two points p(x_1,y_1) and p(x_2, y_2) are Euclidean distance (Perlibakas, 2004;

Gower, 1985), Manhattan distance (Gower, 1985; Singh, Yadav and Rana, 2013) Chebyshev distance (Singh, Yadav and Rana, 2013) and Minkowski distance (Gower, 1985; Singh, Yadav and Rana, 2013), as shown in Equations (4), (5), (6) and (7), respectively. In this study, Euclidean distance is used to measure the centre of a new cluster because it is suitable for continuous data (Norušis, 2012); see Equation (8).

$$Dist_{xy} = \sqrt{\sum_{k=1}^{m} \left(X_{ik} - X_{jk}\right)^2}$$

$$= \left|X_{ik} - X_{jk}\right|$$

$$= \max_{k} \left| X_{ik} - X_{jk}\right|$$

$$Dist_{xy} = \left(\sum_{k=1}^{d} \left|X_{ik} - X_{jk}\right|^{1/p}\right)^{P}$$

$$V_i = \left(\frac{1}{C_i}\right) \sum_{1}^{c1} x_i$$

Clustering results vary based on the number of cluster parameters. Thus, the main challenge of using clustering is to identify the right number of clusters before performing the clustering (Kodinariya and Makwana, 2013). To address this issue for the *K*-means method, the developer can query the end-user to provide the number. However, this is not always feasible, as the end-user might not be familiar with the domain knowledge of each dataset. Therefore, researchers propose some statistical methods to estimate the number of clusters, such as the elbow method (Kodinariya and Makwana, 2013; Syakur *et al.*, 2018), the silhouette method (Kodinariya and Makwana, 2013), and the gap statistic method (Tibshirani, Walther and Hastie, 2001).

2.3.4 Methods to Identify the Number of Clusters

As mentioned earlier, there are three well-known methods of identifying the number of clusters: elbow method (Kodinariya and Makwana, 2013; Syakur *et al.*, 2018), the silhouette method (Kodinariya and Makwana, 2013) and the gap statistic method (Tibshirani, Walther and Hastie, 2001).

The elbow method is considered the oldest method for determining the appropriate number of clusters for a dataset. The elbow method is a visual method that starts with *K*=2, increments *K* by a factor of 1 in each iteration and computes the *K* clusters and the cost that comes with the training. With each value of *K*, the cost declines dramatically and eventually reach a plateau; this identifies the *K* value (Figure 2-1). However, a limitation of the elbow method is that there might be no clear elbow or more than one elbow, as shown in Figure 2-2 (Kodinariya and Makwana, 2013; Robert Tibshirani, Walther and Hastie, 2001). the elbow method is calculated using the sum of squared errors (SSE) (Syakur *et al.*, 2018), as shown in Equation (9).

$$SSE = \sum_{k=1}^{k} \sum_{x_i \in S_k} \|X_i - C_k\|_2^2 \qquad (9)$$

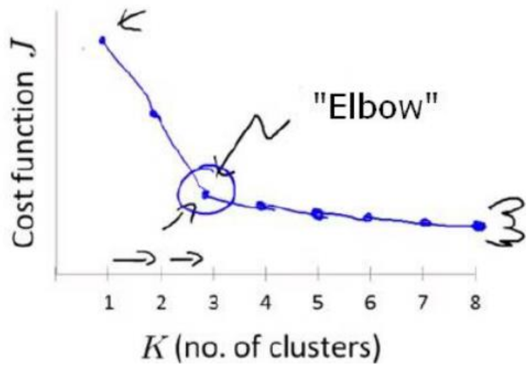


Figure 2- 1: Identification of Elbow Point (Kodinariya and Makwana, 2013).

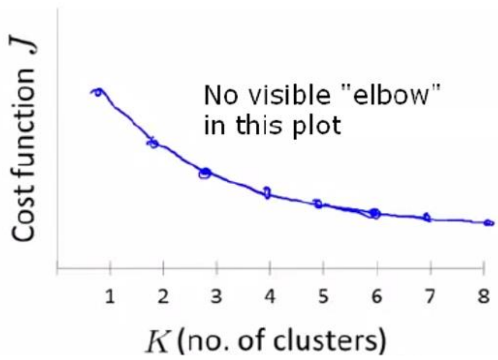


Figure 2- 2: Ambiguity in Identifying Elbow Point (Kodinariya and Makwana, 2013).

The gap statistic method, designed to work with any clustering method, is another method used in identifying the most suitable number of clusters (Tibshirani, Walther and Hastie, 2001). It compares $\log(W_k)$ with $E_n * \{log\ (W_k)\}$, as shown in Equation (10), which computes the estimation of the *K* value (Tibshirani, Walther and Hastie, 2001):

$$Gap_n(k) = E_n * \{log\ (W_k)\} - log\ (W_k) \qquad (10)$$

The silhouette method is a new graphical method developed for partitioning technique (Rousseeuw, 1987) such as K-Means to identify separated clusters clearly (Milligan and Cooper, 1985). Its core idea is based on clusters' tightness and separation (Milligan and Cooper, 1985). It compares within-cluster distances to between-cluster distances. The higher the number, the more it fits. The actual partition of the object in the silhouette method does not depend on the clustering algorithms used in obtaining it. Instead, it depends on the actual partitions of the objects themselves, as shown in Equation (11). This is one of the strengths of the silhouette method.

$$s(i) = \frac{b(i) - a(i)}{max\ (a(i), b(i))} \tag{11}$$

The average silhouette width is used to evaluate the cluster validity and find the optimal value of *K* (Rousseeuw, 1987). Silhouette Coefficient for *K* clusters is the average silhouette width of mentioned k-clusters (Ng and Han, 1994). The silhouette width introduced by Kaufman and Rousseuw (Kaufman and Rousseuw, 1990) is a well-balanced coefficient that has an excellent performance. The silhouette width *s(i)* presents the difference between the within-cluster tightness and disconnection from the rest. Equation (8) defines the silhouette width *s(i)* for the entity *i* € *I*. The silhouette width value ranges from -1 to 1, as shown in (12). Set *I* is well structured when the silhouette width value is close to 1, and it is misleading when the silhouette width value is close to -1. However, when the value is 0, it means that the entity belongs to another cluster (Kodinariya and Makwana, 2013).

$$1- \leq s(i) \leq 1$$

As mentioned in chapter 1, the second objective of this study is to identify different student groups at Brunel University London using machine learning to build student persona models (Persona3D). Therefore, after using the k-means clustering analysis to build personas for university students, it is essential to study student acceptance and use of chatbot technology and identify some chatbots features for all personas in order to design and build these chatbots. It is important to investigate the existing technology acceptance theory and models and choose one that suits the nature and aim of this study.

2.4 Technology Acceptance Theories and Models

This section presents a review of the well-known technology acceptance models and theories in information technology and information system research, including Diffusion of Innovation Theory, Social Cognitive Theory (SCT), Theory of Reasoned Action (TRA), Theory of Planned Behavior (TPB), Technology Acceptance Model (TAM), Extension of Technology Acceptance Model (TAM2), Unified Theory of Acceptance and Use of Technology (UTAUT) and The Extended Unified Theory of acceptance and use of technology (UTAUT2).

2.4.1Diffusion of Innovation Theory (DoI)

Rogers created the Diffusion of Innovation Theory (DoI) (Rogers, 1983). DoI is based on the S-shaped diffusion curve theory developed by (Trade, Parsons and Giddings, 1903). The idea of DoI is to explain how, over time, the product or idea spread via a particular population or social system. According to Rogers(1997), diffusion is "*the process by which (1) an innovation (2) is communicated through certain channels (3) over time (4) among the members of a social system"* (Rogers, 1997 p.11). Four main elements of diffusion of innovation theory stem out from this definition; innovation, communication channels, time, and social system (Figure 2-3).

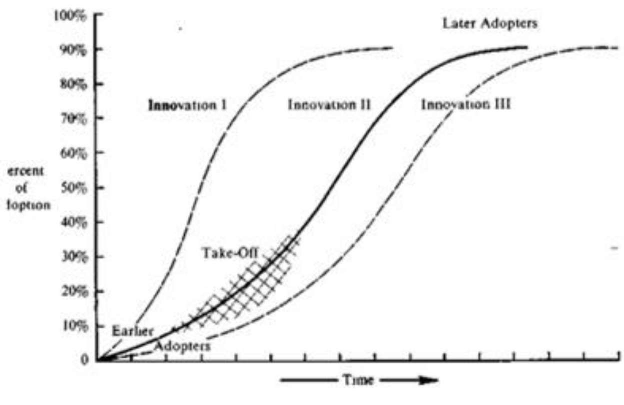


Figure 2- 3: Elements of Diffusion Theory (DOI) (Rogers, 1997)

In each diffusion study, five main attributes of innovation can be perceived, namely compatibility, rate of adoption, complexity, relative advantages, and observability (Hoffmann, Probst and Christinck, 2007). Compatibility refers to the extent of consistency of innovation with experience, existing values and the need for possible adopters. The rate of adoption refers to the extent of adoption of innovation by a social system member. Relative advantages are the extent to which the user recognises the usefulness of the new technology in comparison with the existing one. Complexity, as the name implies, refers to the level of difficulty in understanding, implementing or utilising an innovation. Observability is the extent to which an innovation is evident to others (Rogers, 2010**;** Hoffmann, Volker, Kirsten Probst, 2007).

The process of innovation-decision by which the technologies can be rejected or adopted consist of five stages (Figure 2-4): knowledge of the innovation, attitude toward the innovation, the decision to adopt or reject the innovation, implementation of the new idea and confirmation of the decision(Rogers, 2010**;** Hoffmann, Volker, Kirsten Probst, 2007). 1) knowledge **-** the potential users of the innovation should be aware of the existence of the innovation and understand how it performs. 2) persuasion – individuals show a positive or negative attitude toward the innovation. 3) decision – individuals involvement inactivity to decide either to adopt or reject the innovation. 4) implementation – individual uses the innovation, 5) confirmation-individuals confirm or reject the decision which has been made (Rogers, 2010**;** Hoffmann, Volker, Kirsten Probst, 2007).

Though DoI has several advantages, there are also several limitations affecting its large-scale applicability. There is no clear reason or justification behind including certain attitudes in the model and how these attitudes lead to the adoption or rejection decision. Furthermore, DoI fails in linking the innovation properties and expected attitude (Karahanna, Straub and Chervany, 1999; Chen, Gillenson and Sherrell, 2002). Therefore, one solution to overcome the limitation of DOI is achieved by proposing a new model, called Social Cognitive Theory (SCT), that considers the process of developing attitude.

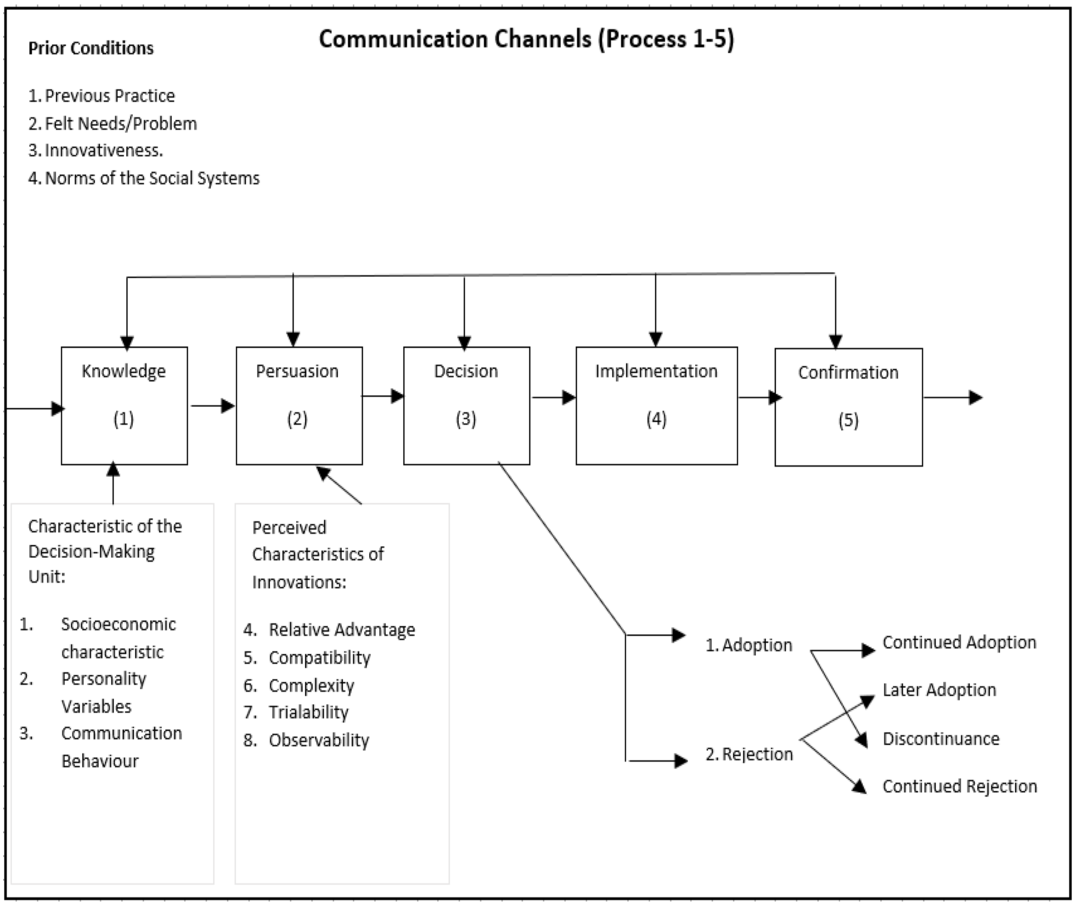


Figure 2- 4: Innovation Decision Process(Hoffmann, Probst and Christinck, 2007; Rogers, 2010)

2.4.2 Social Cognitive Theory (SCT)

Albert Bandura (Bandura, 1986) developed the Social Cognitive Theory (SCT) as an extension of social learning theory (SLT) studied by Miller and Dollard in 1941 (Miller and Dollard, 1941). It is used in education, communication and phycology. STC is a learning theory that states that individuals learn by observing others. SCT by Bandura 1986 contains three core variables: personal factors such as biological events and cognitive effects, environmental factors, and behavioral factor (Figure 2-5). SCT helps in understanding how people adopt technology and how they learn.

SCT is different from other acceptance theories and models, including DoI, TAM, and TPB. SCT presents the importance of self-efficacy. However, a study by Venkatesh et al. (2003) shows that computer self-efficiency become weaker and disappears with time.

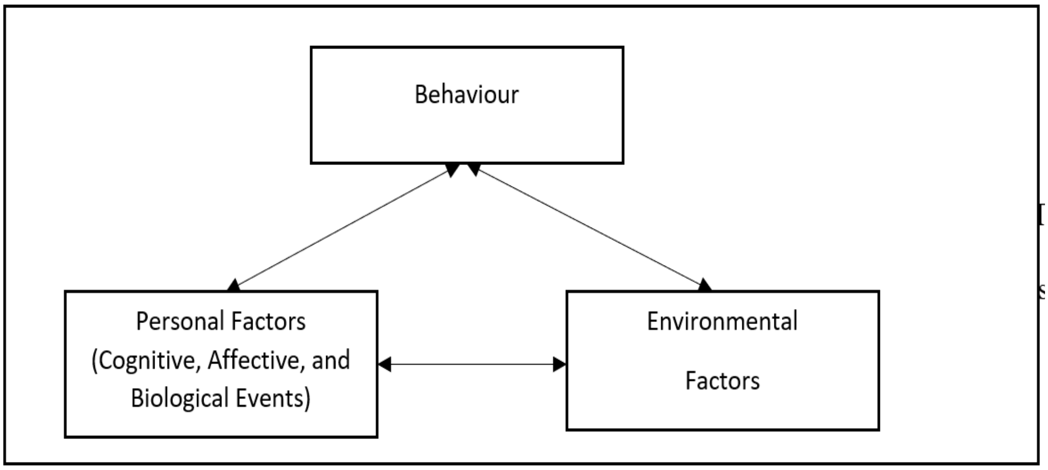


Figure 2- 5: Social Cognitive Theory (Bandura, 1986)

2.4.3 Theory of Reasoned Action (TRA)

The Theory of Reasoned Action (TRA) was introduced and created by Fishbein and Ajzen (1975) and Ajzen and Fishbein (1980) (Madden, Ellen and Ajzen, 1992). TRA aims to reveal and predict social behaviour (Godin, 1994). TRA assumes behavioural intention is the primary and direct determent to doing or not doing certain behaviours. Thus, TRA interprets a particular behaviour based on individual decision-making (Godin, 1994). TRA, developed as a model for predicting behavioural intention or behaviour, provides a simple way of identifying how and where to target individual behavioural change attempts (Sheppard, Hartwick and Warshaw, 1988). TRA consists of three main constructs, as shown in Figure 2-6. Attitude (A), Subjective Norm (SN) and Behavioral Intention (BI). BI is not the actual behaviour of performing an action, but the intention towards doing particular behaviour (Fishbein and Ajzen, 1975; Ajzen and Fishbein, 1980; Sheppard, Hartwick and Warshaw, 1988). TRA has been proven to be useful in revealing the decision-making process related to exercise behaviour.

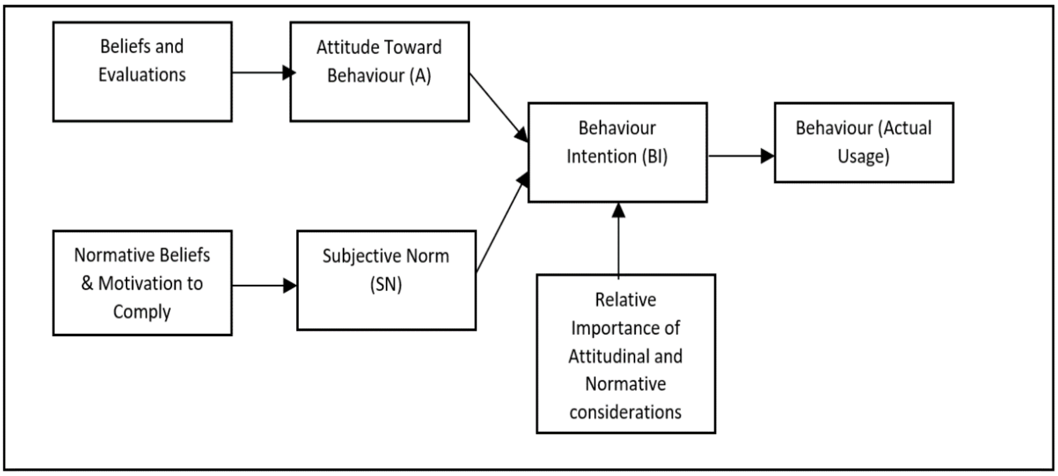


Figure 2- 6: Theory of Reasoned Action (TRA) (Ajzen and Fishbein, 1980)

TRA has considerable attention in IS research such as (Ajzen, 1985; Bagozzi, 1981). However, the TRA has some limitations; for example, TRA fails to predict individual behaviour if the intention is unknown in the first instance(Ajzen, 1985).

2.4.4 Theory of Planned Behavior (TPB)

The Theory of Planned Behavior (TPB), developed by Ajzen (1985; 1991) to overcome the limitation of TRA, is an extension of the TRA (Fishbein and Ajzen, 1975; Ajzen and Fishbein, 1980; Ajzen, 1991). TPB was developed by adding an extra variable, more specifically, Perceived Behavior Control (PBC). TPB is considered one of the most fundamental human behavioural theories (Morris *et al.*, 2012) and used in various studies (Taylor and Todd, 1995c; Taylor and Todd, 1995a; Limayem, Khalifa and Frini, 2000). Both TPB and TRA have BI as the main factor to perform specific behaviours (Ajzen, 1991). According to Aizen (2006), three factors affect behavioural intention: perceived behaviour control (PBC), subjective norm, and attitude toward behaviour (Figure 2-7).

According to Abraham and Sheeran (2003), TPB has two strong points; 1) the model is parsimonious – it contains only a few numbers of variables used to produce an accurate behaviour prediction. 2) it has clear guidance that allows the researcher to measure cognitions to ensure predictive accuracy. However, TPB has some criticism (Taylor and Todd, 1995b); both TPB and TRA have the assumption that an individual is interested in performing a particular behaviour which is mainly a problem when studying individual adoption behaviour. There is also the assumption that respondents have an identical belief structure. Furthermore, subjective norm, perceived behavioural control and attribute toward the behaviour are the only factors that determine individual intention. Empirical research result shows that using TPB and TRA can explain only 40% of the variance of behaviour (Ajzen, 1991; Sarosa, 2009). The difference between TPB and TRA is covered in (Godin, 1994).

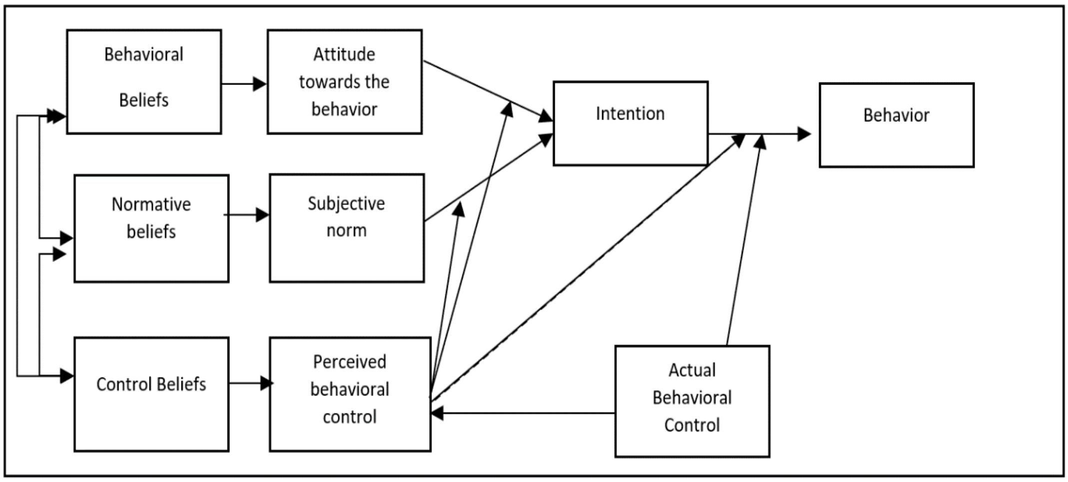


Figure 2- 7: Theory of Planned Behaviour (Aizen, 2006)

2.4.5 Technology Acceptance Model (TAM)

The Technology Acceptance Model (TAM), developed in the 1980s by Davis (Davis, 1989; Venkatesh and Davis, 2000), is shown in Figure 2-8. TAM is adopted from the theory of reasoned action (TRA) by Ajzen and Fishbein (Ajzen and Fishbein, 1980). TAM has gained significant attention in the Information System and Information Technology Research (Wadie and Lanouar, 2012). Two main components of TAM determine individual intention to use the system: perceived usefulness (PU) and perceived ease of use (PEOU). PU is the extent to which an individual believes that using the system will increase his or her performance. While PEOU is the extent to which using the system will be effortless (easy to use) (Venkatesh and Davis, 2000). External characteristics such as training, development process, system characteristics, mediated by PU and PEOU, impact BI (Venkatesh and Davis, 2000). Perceived ease of use influences perceived usefulness because the more the system is easy to use, the more useful it can be (Venkatesh and Davis, 2000). A decade after the introduction of TAM in two journal papers, TAM became a compelling, robust, and "a parsimonious model for predicting user acceptance" (Venkatesh and Davis, 2000).

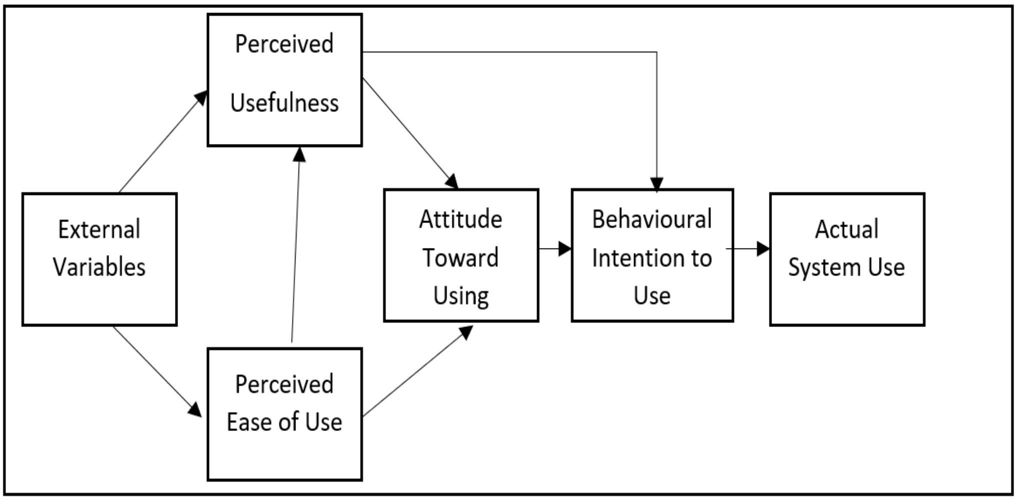


Figure 2- 8:Technology Acceptance Model(Davis, 1985)

2.4.6 Extension of Technology Acceptance Model (TAM2)

One strength of TAM is in its capability to provide a framework to understand user acceptance and usage of technology and to explore the effects of various external variables on system usage (Hong *et al.*, 2001; Wadie and Lanouar, 2012) Venkatesh and Davis (2000) extended TAM to develop TAM2, as shown in Figure 2-9. TAM2 was developed for an organisational setting (for staff). TAM2 includes two new theoretical constructs: 1) cognitive instrumental process (perceived ease of use, job relevance, result demonstrability and output quality). 2) social influence process (image, subjective norm, and voluntariness) (Venkatesh and Davis, 2000).

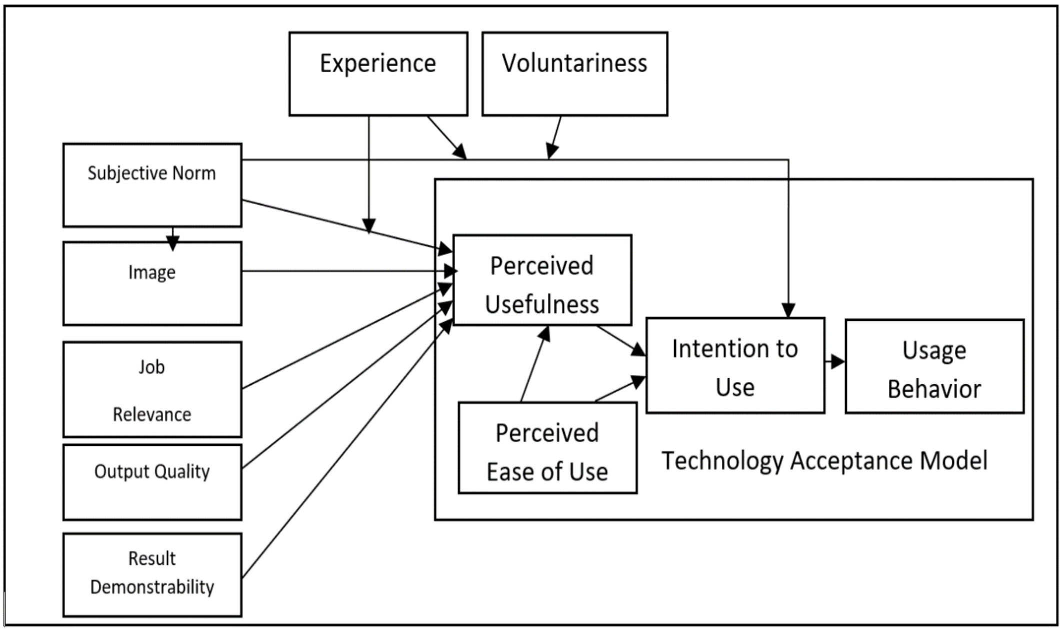


Figure 2- 9: TAM2 -Extension of the Technology Acceptance Model (Venkatesh and Davis, 2000)

2.4.7 Unified Theory of Acceptance and Use of Technology (UTAUT)

The literature shows several theatrical models developed from theories in sociology and phycology (Venkatesh, Thong and Xu, 2012). Venkatesh et al. (2003) developed the Unified Theory of Acceptance and Use of Technology (UTAUT) to fill the existing acceptance theories and models and study student acceptance and use of technology in an organisational context. UTAUT was developed as a result of reviewing eight main theories and models of technology acceptance: Theory of Reasoned Action (TRA), Technology Acceptance Model (TAM), Motivational Model (MM), Theory of Planned Behavior (TPB), Combined TAM and TPB, Model of PC Utilisation, Diffusion of Innovation Theory (DoI) and Social Cognitive Theory (SCT) (Venkatesh *et al.*, 2003)

UTAUT consist of four constructs, as shown in Figure 2-10, namely: performance expectancy, effort expectancy, social influence, and facilitating condition. UTAUT factors (constructs) affect the behaviour intention (BI) and usage of technology. The effects of these constructs have four moderators; age, gender, experience and voluntariness of uses (Venkatesh *et al.*, 2003). UTAUT constructs are similar to other constructs in other models. For example, performance expectancy (PE) and effort expectancy similar to two TAM constructs, perceived usefulness (PU) and perceived ease of use (PEOU), respectively. Moreover, social influence (SI) is similar to the social norm (SN) in TRA and facilitating conditions (FC) is similar to PBC in TPB.

Multiple sectors use UTAUT, such as E-government (Carter and Weerakkody, 2008), online-banking, e.g. (Abu-Shanab and Pearson, 2009; Yenyuen and Yeow, 2009), and health/hospital, IT, e.g. (Yenyuen and Yeow, 2009); though not much emphasis was given to it as compared to other existing models. However, there are criticisms related to explanatory power and parsimony (Williams *et al.*, 2011).

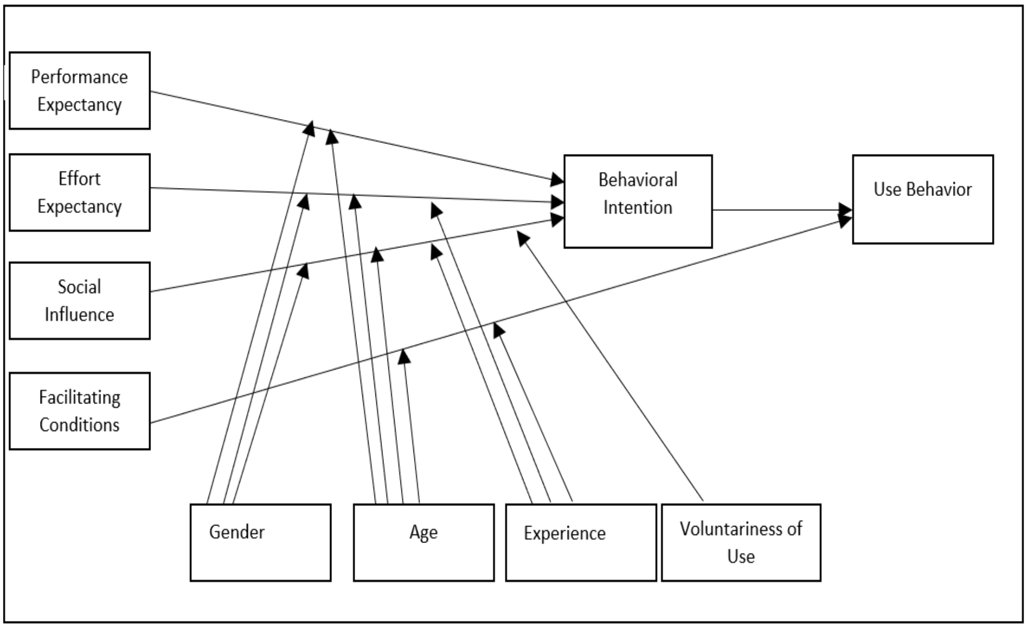


Figure 2- 10: The Unified Theory of Acceptance and Use of Technology (Venkatesh *et al.*, 2003)

2.4.8 The Extended Unified Theory of Acceptance and Use of Technology (UTAUT2)

The Unified Theory of Acceptance and Use of Technology (UTAUT) was extended by Venkatesh et al. (2012) and named The Extended Unified Theory of Acceptance and Use of Technology (UTAUT2). UTAUT and UTAUT2 were developed for different environments. The former was developed for organisational context while the latter for consumer context (Venkatesh, Thong and Xu, 2012). UTAUT has four constructs performance expectancy (PE), effort expectancy (EE), facilitating conditions (FC) and hedonic motivation (HM). These constructs are also in UTAUT2 along with three added constructs: hedonic motivation (HM), price value (PV), and habit (HT), as shown in Figure 2-11. UTAUT has four moderators: experience, gender, age and voluntariness of use. The first three moderators exist in UTAUT2, while voluntariness of use eliminated. Chapter 5 discusses further, in detail, the UTAUT2 constructs and moderators**.**

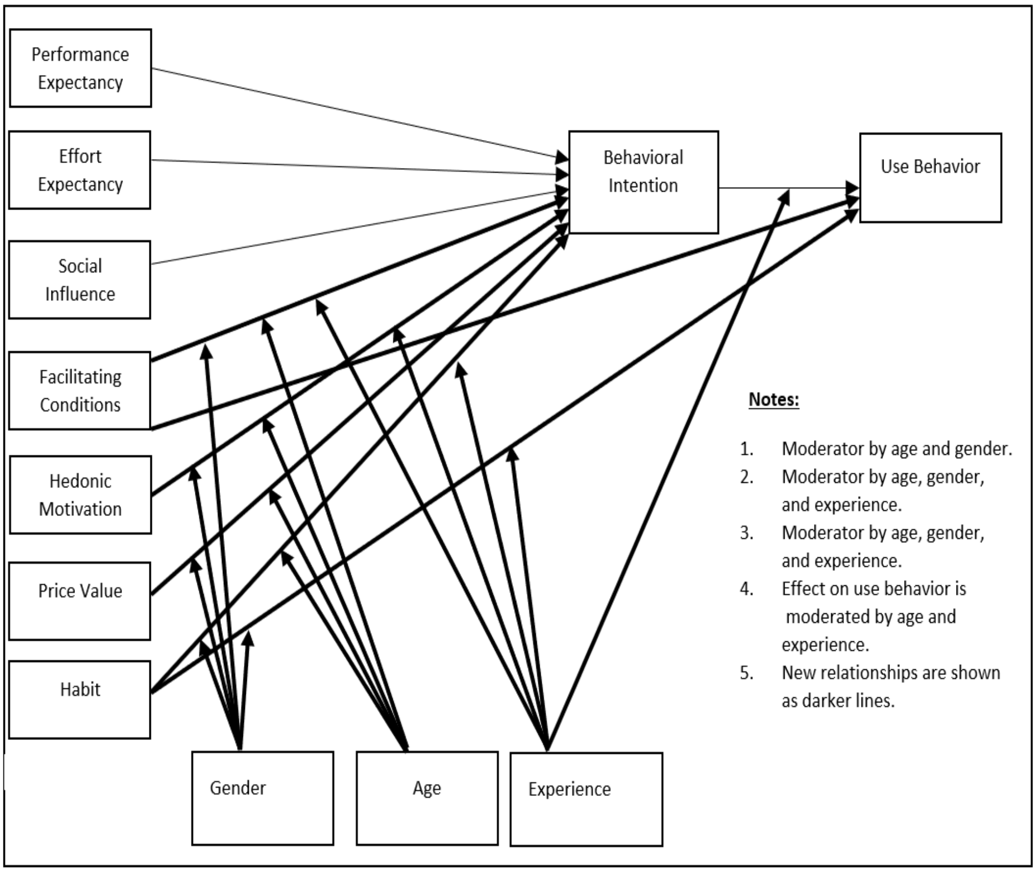


Figure 2- 11:The Extended Unified Theory of Acceptance and Use of Technology (UTAUT2) (Venkatesh, Thong and Xu, 2012)

As mentioned previously, three new constructs were added to UTAUT2: PV, HM and HT. PV is defined as the " consumers' cognitive trade-off between the perceived benefits of the applications and monetary cost for using them" (Fuksa, 2013; Venkatesh, Thong and Xu, 2012; Raman and Don, 2013). With PV, there is an essential difference between the organisational setting in UTAUT and the consumer setting in UTAUT2. The former is not involved with the cost of using the technology, while the latter is. Moreover, according to Venkatesh, Thong and Xu, (2012), since users bear the cost of obtaining the technology, there is control over their adoption decision (see Brown and Venkatesh, 2005; Chan *et al.*, 2008; Coulter and Coulter, 2007; Dodds, Monroe and Grewal, 1991; Venkatesh, Thong and Xu, 2012).

On the other hand, PV is often omitted from research based on students' perspectives (Lewis *et al.*, 2013; Raman and Don, 2013; Ain, Kaur and Waheed, 2016; Khan and Adams, 2016; Herrero, San Martín and Garcia-De los Salmones, 2017), because students cannot bear the cost of the provided technology (Lewis *et al.*, 2013; Raman and Don, 2013; Ain, Kaur and Waheed, 2016). Therefore, the PV construct will be omitted from the proposed theoretical framework.

Upon reviewing the existing technology acceptance model and theory to study student acceptance and use of technology (see Section 2.4.1 to 2.4.8), A comparison of the technology acceptance theories and model is shown in Table 2-2 (Ameen, 2017). Thus, UTAUT2 has been identified as the most suitable model to be adopted in this study. UTAUT2 is robust, and it is an extension of the UTAUT model, which comes as a result of reviewing and analysing eight models of technology acceptance and usage: Innovation Diffusion Theory (IDT); Theory of Planned Behaviour (TPB); Theory of Reasoned Action (TRA); the Motivational Model (MM); Social Cognitive Theory (SCT); the Model of Perceived Credibility (PC); the Technology Acceptance Model (TAM); and a hybrid model combining constructs from TPB and TAM (Venkatesh, Thong and Xu, 2012; Ali Tarhini *et al.*, 2016). Also, UTAUT2 was mainly to study the acceptance and use of technology for consumer context, which suit the nature of this study(Venkatesh, Thong and Xu, 2012). Chapter 5 will provide further justification regarding the rationale for adopting UTAUT2 in this study. UTAUT2 as a technology acceptance model can provide guidance for identifying the features of the chatbots to be developed later in this study. It is important to mention that none of these technology acceptance models uses moderators related to educational data such as grade, performance, virtual engagement, or physical engagement.

Model	Author	Independent							Dependent			Moderators			
		PE	EE	SI	FC	HT	HM	PV	BI	USE	ATU	AGE	GENDER	EXP	VOL
DoI	(Rogers, 2003)	√	√	√	√	*						*		*	
SCT	(Bandura, 1986)	√	*	√	*		√			√				√	
TRA	(Fishbein and Ajzen ,1975)			√					√	√	√				
TPB	(Ajzen, 1991)			√	√				√	√	√				
TAM	(Davis, 1989)	√	√						√	√	√				
TAM2	(Venkatesh and Davis, 2000)	√	√	√					√	√				√	√
UTAUT	(Venkatesh *et al.*, 2003)	√	√	√	√				√	√		√	√	√	√
UTAUT2	(Venkatesh, Thong and Xu, 2012)	√	√	√	√	√	√	√	√	√		√	√	√	

* - Partly Found

Table 2- 2: Comparison of Technology Acceptance Theories and Models adapted from (Ameen, 2017)

2.5 Journey Mapping (JM)

As mentioned earlier, a persona is a User-Centered Design (UCD) method that represents a group of users who share common goals, attitudes and behaviour during the interaction with the product (Putnam, Kolko and Wood, 2012**;** Cabrero, 2014). However, the persona is a two-dimensional static profile and according to Friess (2012), referring to personas during the decision-making time represents only 3% (Friess, 2012b). Therefore, there is a need to use another design tool that adds a 3rd dimension to the persona using the journey map.

Customer Journey Mapping (CJM), also referred to as customer experience mapping, user journey mapping, customer lifecycle mapping or user scenario mapping. CJM is a visualisation tool used to obtain an insight into how users/customers interact with a business (Ortbal, Frazzette and Mehta, 2016). CJM has been used widely in the last decade. CJM visualises the customer/user journey map from the beginning of the journey to the end to understand the steps, touchpoints and stages the user passes through to complete a task (Marquez, Downey and Clement, 2015).

In general, CJM contains three components: 1) touchpoints, 2) stages, and 3) actual journey, as shown in Figure 2-12 (Marquez, Downey and Clement, 2015). The touchpoints represent the interaction between the customer and the services. The stages represent the steps the users pass through from the original prompt to initiate the journey to the final prompt to finish the task (Marquez, Downey and Clement, 2015). Whereas, Ortbal et al. (2016) state that there are critical components in journey mapping, which include stage, goals, action, touchpoints, feeling, pain points, opportunity points and key insights (Ortbal, Frazzette and Mehta, 2016). Different journey maps contain different components. Table 2-3 shows an analysis of a CJM article summarising the main components adapted from (Alsubhi, 2018) with new journey map components that fit the nature of this study, before and after emotion, chatbots feature and personas usage. This study covers a new journey map template design in Chapter 6.

Figure 2- 12: Anatomy of a Customer Journey Map(Marquez, Downey and Clement, 2015)

Author	Represent customer perspective	Use research	Represent Customer segment	Include customer goals	Focus on emotion	Represent touchpoints	The highlight moment of truth	Measure brand promise	Include time	Ditch The PowerPoint	Channel (mobile/ PC)	Include stages
(Ortbal, Frazzette and Mehta, 2016)		√	√	√	√	√	√			√		√
(Alves and Nunes, 2013)		√	√	√	√	√	√	√			√	√
(Nenonen, Rasila and Junnonen, 2008)		√	√	√	√	√	√	√			√	√
(Crosier and Handford, 2012)		√	√	√	√	√				√		√
(Marquez, Downey and Clement, 2015)		√	√	√		√	√				√	√
(Sandler, 2015)		√	√	√	√	√	√	√			√	√
(Temkin, 2010)		√	√	√	√	√	√	√		√	√	√
(Andrews and Eade, 2013)		√	√	√	√	√	√			√	√	√

Table 2- 3: Analysis of Customer Journey Map Articles Summarizing the Main Components adapted from (Alsubhi, 2018)

2.6 Chatbots Design and Development

There is no standard approach identified in designing chatbots, as there is no consensus reached towards this process. Thus, this issue affects chatbots improvement solved by creating a complete knowledge base (Abdul-Kader and Woods, 2015). Abdul-Kader and Woods's (2015) study surveyed chatbots' design techniques, and they compared these techniques in 9 selected papers based on their adopted methods (Abdul-Kader and Woods, 2015). Table 2-4 represents this comparison. However, the table misses some essential techniques, such as email services.

Factors influencing chatbots design										
Study	**Voice**	**Text**	**Creating new chatbots**	**Using available chatbots**	**AIML usage**	**Email services**	**SQL usage (Relational Database)**	**Matching technique**	**Corpus (Knowledgebase)**	**Application**
(Pereira and Coheur, 2013)	√	√		√	√	-		Edger chatbot matching technique (a combination of TfIdf algorithm with natural language normalisation)	Edgar chatbot	Chatbot design
(Rosmalen *et al.*, 2012)		√		√	√	-	√	QA matching form	AIML	Medical education
(Lokman and Zain, 2009)		√	√		√	-	√	QA matching form	VP bot	Health assistance
(Lokman and Zain, 2010a)		√		√		-	√	Prerequisite Matching	ViDi chatbot	Health assistance
(Lokman and Zain, 2010b)		√		√		-	√	One-Match All-Match Category(OMAMC)	ViDi chatbot	Health assistance
(Mikic *et al.*, 2009)		√		√	√	-		AIML category pattern matching	AIML	Educational systems
(Bhargava and Nikhil, 2009)	√		√		√	-		AIML category	AIML	E-learning

								pattern matching		
(Vrajitoru, 2003)		√	√			-		Genetic Algorithm (GA)	Manual pattern and data were chosen	Any
(Vrajitoru and Ratkiewicz, 2004)		√	√			-		Genetic Algorithm (GA)	Manual pattern and data were chosen	Any

Table 2- 4: A summary of a Selected Factors Influencing Chatbots Design adapted from (Abdul-Kader and Woods, 2015)

2.6.1 Chatbots Design Techniques

It is essential to understand the main chatbots design techniques and approaches, as highlighted by Abdul-Kader and Woods (2015) :

1. Parsing: analyse the input text and use NLP functions to manipulate it, such as python NLTK.
2. Pattern matching: it is a conventional technique used by most chatbots, particularly in a question-answer system that relies on matching types such as simple statements, natural language enquiries and semantic meaning of enquires (Meffert, 2006; Abdul-Kader and Woods, 2015).
3. AIML: it is the primary technique utilised in most chatbot designs.
4. Chat Script: this method plays its role when there are no matches in the AIML technique. It focuses on providing the ultimate syntax for generating a reasonable default answer. It provides some functionalities such as facts, logical and-or, and variable concepts.
5. Relational databases (SQL): this technique, mainly used in chatbot design, allows chatbots to remember the previous conversations.
6. Markov Chain: this technique generates applicable and potential replies, and thus, it is more accurate. There is some stable probability of occurrence for every word or letter in a text (Jacob, 2016; Abdul-Kader and Woods, 2015).
7. Language tricks: these are phrases, sentences or paragraphs available in chatbots to produce various and convincing knowledge bases. There are several types of language tricks such as typing errors, canned responses, not sequitur, and model of personal history (Jacob, 2016; Abdul-Kader and Woods, 2015).

8. Ontologies: also referred to as semantic networks. It is defined as “a set of concepts that are interconnected relationally and hierarchically” (Abdul-Kader and Woods, 2015, p. 74). Ontologies are used in chatbots to calculate the relationship between these concepts, such as synonyms. The interconnection between these concepts can be represented in a graph enabling the computer to search by using particular rules for reasoning (Jacob, 2016; Abdul-Kader and Woods, 2015).

Designing and developing an intelligent system involves combinations of several technologies. Kerly, Ellis and Bulls’ (2008) study discussed the design and development of an intelligent tutoring system called CALMsystem, which integrates educational theories, database manipulation and natural language technologies. The system provides the learner with their learner model; they provide users with facilities to compare users’ self-assessment to system user-assessment (Kerly, Ellis and Bull, 2008).

Chatbots help users to raise the precision of self-assessment decrease the number of contradictions in the learner model between user and system beliefs. A trial involving 30 pupils in UK primary school in Year 4 shows positive results; it proves the system enhances students’ self-assessment about their capabilities. A study by (Kerly, Ellis and Bull, 2008) highlights the development lessons for other researchers and developers such as database management, natural language, Intelligent tutoring systems and web development. One of the lessons learned was using Wizard of Oz for the initial system development (Kerly, Ellis and Bull, 2008).

2.7 The Current State of Chatbots Design

For decades, practitioners and researchers in the human-computer interaction (HCI) field have put great effort into designing graphical user interfaces for applications, websites, etc. However, a recent revolution has changed the design of user interfaces towards natural language user interfaces, where the interaction between human and system does not take place through swiping, scrolling, or clicking a button but through natural language text. This is clear in recent chatbot developments (Dale, 2016; Følstad and Brandtzæg, 2017). For example, in the context of messaging applications, chatbots (e.g. Jarvis chatbots) can provide reminders. Poncho, the artificial weather cat, provides information about the weather in a specific city. Technology giants such as Facebook, Microsoft, and Google expect that digital interaction will move from graphical user interfaces in applications and websites to messaging platforms such as Allo and Messenger. Thus, there are tremendous opportunities and challenges in the field of HCI (Følstad and Brandtzæg, 2017). It has been argued that "*natural language user interfaces are nothing new to the field of HCI. In fact, HCI researchers have studied these before, for example, in the context of multimodal systems, interactive voice response systems, voice control in the context of accessibility, and conversational systems*"(Allen *et al.*, 2001; Følstad and Brandtzæg, 2017).

There are many implications of moving to chatbots and natural language user interfaces. For instance, chatbot design represents a movement from a visual layout and interaction mechanism to a conversational design. Regarding usability, the design of a visual layout focuses on navigation through links and menus and interaction with graphical elements. However, the usability in a conversational design involves making suggestions based on the user's expectations of the system's services and interpreting their responses. The content and the services provided are mostly hidden from the user, and the services largely depend on the user's input.

Chatbots typically follow a one-size-fits-all approach, where all users receive the same services in the same language and using the same data, regardless of their preferences, needs and digital literacy degree (Følstad and Brandtzæg, 2017; Kadariya *et al.*, 2019), as well as regardless of their location (Bradesko *et al.*, 2017; Følstad, Nordheim and Bjørkli, 2018), particularly in educational settings (Yang and Evans, 2019). From a theoretical point of view, there is a research gap, as few researchers have explored the design of chatbots in an educational setting based on persona types. Therefore, this study overcomes this limitation by designing persona-based chatbots that provide services to university students based on their persona types.

2.8 Conclusion

In conclusion, chatbots are conversational systems that interact with users using text or audio, such as Amazon Alexa by Amazon, Siri by Apple, Cortana by Microsoft and Google Assistant by Google. Chatbots are used in different domains, such as education, health interventions, e-commerce and entertainment, to name a few. For example, in education, chatbots introduce students to concepts, enable self-guided learning, and make students interested in specific domains. Using chatbots in education brings many benefits; it supports continuous learning, enhances student motivation, enhances students' learning and listening skills, and makes learning more enjoyable.

A chatbot is a conversational agent and a computer program that can conduct a conversation with the user using natural language speech (Abdul-Kader and Woods, 2015). ELIZA (Weizenbaum, 1966) is considered one of the earliest created chatbots (Kerly, Hall and Bull, 2007); it was developed in the 1960s by Joseph Weizenbaum to simulate a psychotherapist in clinical treatment (Atwell and Shawar, 2007). The idea was straightforward, and it used a keyword matching approach (Atwell and Shawar, 2007). ELIZA accepts input text, analyses it and produces responses by applying the reassembly rules that come with input decomposition (Kerly, Hall and Bull, 2007). ELIZA's responses show concern for users. However, it has no memory to retain the conversation, and it is unable to become involved in any targeted types of negotiation or collaboration. ELIZA's syntactic language processing has been developed dramatically. Thus, a large number of chatbot language processes have been created.

Chatbots are also referred to as 'artificial conversational entities' (ACEs) or 'conversational systems'. Currently, well-known examples of chatbots are Amazon Alexa, Siri on iPhone, Cortana and Google Assistant (Gustavo *et al.*, 2017). Although chatbots seem to work intelligently by interpreting users' input before providing answers, some chatbots merely scan the keywords inputted and respond with the most suitable matching keyword replies from their databases (Al-Zubaide and Issa, 2011). Although chatbots are a fundamental and straightforward application of artificial intelligence (AI), they are critical due to their various applications and potential uses.

Chatbots can be used as a powerful tool for teaching and educating students. They can work as a language tutor, as in the example known as Sofia. Also, they can assist with the teaching of mathematics and help users solve algebra problems, as with the Pari and Mathematica chatbots. Moreover, they help medical students by simulating patients and providing responses during interviews with medical students; an example of this type of chatbot is the Virtual Patient bot (VPbot) (Khanna *et al.*, 2015).

Using chatbots in education can have many benefits for students and teachers, as presented by (Fryer and Carpenter, 2006), including: 1) they make learning more enjoyable, as students feel more relaxed and comfortable and enjoy chatting with chatbots more than their teachers or peers in traditional teaching (Fryer and Carpenter, 2006; Abu Shawar and Atwell, 2007); 2) they support continuous learning, as chatbots enable students to repeat and view the same learning materials many times without feeling tired or bored, in contrast to teachers (Fryer and Carpenter, 2006; Abu Shawar and Atwell, 2007); 3) they enhance student motivation by offering a new way of learning that attracts students (Fryer and Carpenter, 2006; Abu Shawar and Atwell, 2007); and 4) they enhance students' listening and reading abilities (Fryer and Carpenter, 2006; Abu Shawar and Atwell, 2007). The literature shows that few researchers have explored the design of chatbots for different types of users in an educational setting. Therefore, this study filled this gap by designing chatbots that provide services based on user types (personas).

CHAPTER 3 – RESEARCH METHODOLOGY

3.1 Introduction

The research gap highlighted in Chapter 2 revealed that little research has been conducted on using persona-based chatbots to enhance student engagement in HEIs, as it has been considered a complex structure. A systematic approach is needed to conduct this type of research. According to Simon (1996), one way to solve the complex structure is by decomposing it into semi-independent components and then designing each component independently to work together to achieve the overall aim and objectives (Simon, 1996). It is essential to mention that designing a novel solution that does not exist means that empirical research cannot be used. In comparison, design science is used to design a novel solution. Design science attempts to build artefacts that serve a human purpose (Stewart, 1984; March and Smith, 1995). Therefore, Design Science Research (DSR) has been adopted as a suitable research methodology for conducting this study. DSR is operationalised in three iterations in this study, described methodologically using machine learning, structural equation modelling and journey mapping.

This chapter is structured as follows. Section 3.2 discusses the epistemology and ontology of this research, the reasons for choosing positivism and the sampling approach. Section 3.3 explains the background of DSR, including the reasons for choosing DSR as the principal research methodology for this study. Section 3.4 describes how DSR is used in Information System (IS) research, reviews the main IS DSR frameworks and discusses their strategies. Section 3.5 introduces the methods for evaluating DSR, including the artefact types and evaluation criteria. Section 3.6 presents the three DSR iterations in this study. Section 3.7 discusses the DSR method for designing chatbots, including the practical methods used to carry out the design. Section 3.8 focuses on the DSR methods for building the chatbots, including the practical method used to carry out the building process. Section 3.9 discusses the DSR methods for evaluating the chatbots, including the practical methods used to carry out the evaluation. Section 3.10 discusses the different types of triangulation and the method of triangulation used in this study, while Section 3.11 summarises the main points in this chapter.

3.2 Epistemology and Ontology of This Research

Research philosophy is “a belief about the way in which data about a phenomenon should be gathered, analysed and used” (Uusitalo, 2014, p. 1). There are two major ways of thinking about research philosophy and the research process: ontology and epistemology (Saunders, Lewis and Thornhill, 2009). Ontology examines the nature of reality and is interested in answering the question ‘what is reality?’, while epistemology considers how you can examine the reality or, in other words, what constitutes acceptable knowledge (Saunders, Lewis and Thornhill, 2009).

There are two main research philosophies/paradigms that can be identified in the Western tradition: positivism (also referred to as the ‘scientific method’) and interpretivism (also referred to as ‘antipositivism) (Uusitalo, 2014). The positivist philosophy/paradigm involves studying phenomena through observation without interfering (Uusitalo, 2014), which leads to the generation of credible data (Saunders, Lewis and Thornhill, 2009). Researchers are likely to use existing theories to develop hypotheses. These hypotheses are tested and confirmed, which leads to the development of new theories, which are in turn tested in further research (Saunders, Lewis and Thornhill, 2009). By contrast, interpretivism entails studying phenomena in their natural environments while understanding that scientists cannot avoid affecting the phenomena they study (Uusitalo, 2014).

3.2.1 Choosing the Positivist Paradigm for This Research

After studying the two main research paradigms and considering the nature of the study, the positivist paradigm was selected for the following reasons:

- The positivist approach is the dominant approach among the discussed approaches, with 75% of research applying this approach.
- This research proposed several hypothesised relationships in the context of technology adoption and acceptance that needed to be tested and quantitatively measured. Also, the choice of the positivist approach was

justified from a methodological viewpoint, as this approach has a strong link with quantitative methodologies that use a deductive process, as applied in this research, more specifically in the second iteration (Bryman, 2008).

- This research proposed a conceptual framework that is well defined. It shows the relationships among the constructs. The framework is based on a validated technology acceptance model, as explained in Chapter 5. Therefore, this study was justified from an epistemological perspective.
- This study used structural equation modelling (SEM) techniques to test the hypotheses and examine the moderator's effects (Chapter 5). The statistical package used adopts a positivist approach.

3.2.2 Sampling Approach

Researchers have neither the resources nor the time to analyse the whole population; therefore, they apply a sampling approach to reduce the number of examined cases. To achieve this, there are five stages: 1) clearly define the target population, 2) select the sampling frame, which must be representative of the population, 3) choose the sampling technique (Further information is provided in this section and Chapter 5), 4) determine the sample size, 5) collect data and 6) assess the response rate (Taherdoost, 2018).

There are two types of sampling techniques: probability (random) sampling and non-probability (non-random) sampling. In probability sampling, every item in the population has an equal chance of being included in the sample. Probability sampling techniques include simple random, stratified random, cluster, systematic and multi-stage sampling. Non-probability sampling techniques include quota, snowball, judgement and convenience sampling (Taherdoost, 2018). The strengths and weaknesses of the different sampling techniques are discussed by (Malhotra, Birks and Wills, 2006; Taherdoost, 2018). Convenience sampling was considered the most appropriate sampling technique for this study. It is the least expensive, least time-consuming, and most convenient. However, it has some limitations: it is not recommended for descriptive or causal research, the sample is not representative of the population, and there is selection bias. The type of collected data (quantitative or qualitative) will be covered in the discussion on the design of each iteration in Section 3.7.

3.3 Design Research Background

Information System design is described by Hevner et al. (2004) as “the purposeful organisation of resources to accomplish a goal” (Hevner *et al.*, 2004, p. 78). Using design as a research method becomes essential, mainly when the research aims to improve the current state of an organisation or social system into a better one by developing new artefacts (Hevner *et al.*, 2004). Researchers view and discuss design science from different perspectives. For example, Winter (2008) and Edelson (2002) recognise design research by its generalisation, the potential of applying the proposed research design in a different context. The researcher must produce a design that possibly utilises various situations (Edelson, 2002; Winter, 2008). Hevner et al. (2004) view design science as an innovative tool for solving a problem. Simon (1996) differentiates between design science and behaviour science by unfolding the science of artificial (Simon, 1996). Simon introduces the artefact concept that provides a satisfactory solution to a problem, not an optimal one. He viewed artefacts as a link between the outer and the inner environment. The design is a learning process that can be observed and learned differently through the development process of the underlying artefacts.

A design research study by March and Smith (1995) represented the start of a new research era that produces effective and relevant research. They presented a two-dimensional design science research framework that aggregates research output and research activities from design and behaviour science, as shown in Table 3-1. The first dimension consists of four design science research outputs or artefacts: constructs, models, methods and instantiations. The second dimension consists of four research activities: build, evaluate, justify and theorise — these activities are drawn from natural science and design science research. Design science research accomplishes an optimal solution to the design issue in an iterative and refining way.

Research Activities

Research Outputs	Build	Evaluate	Theorise	Justify
Constructs				
Model				
Method				
Instantiation				

Table 3- 1: A research Framework by (March and Smith, 1995)

It is essential to categorise research artefacts using March and Smith's (1995) research outputs classification because it helps in identifying the suitable research procedures such as build, evaluate, theorise, and justify the research. The four categories of research artefacts are listed and explained below:

- Constructs: shape the vocabulary of a specific domain. They are used to explain the problem and its solution (March and Smith, 1995). For example, in semantic data modelling, constructs can be entities, relationships, attributes, constraints and identifiers (Hull and King, 1987).
- Models: are a set of statements or propositions explaining relationships between constructs. Models are used to express a real-world situation as an issue along with its solution statement (March and Smith, 1995).
- Methods: are a set of steps used to carry out a task. They provide instructions on how to use constructs and models to solve problems. Methods are considered as methodological tools that are produced by design science and utilised by natural sciences (March and Smith, 1995).
- Instantiations: are the articulation of constructs, models or methods within a natural world. They clearly show the effectiveness and feasibility of the models and methods they hold (March and Smith, 1995). Instantiations perform a vital role in assisting the researcher to gain knowledge about artefacts in a real-world scenario. Newell and Simon (1976) assert the importance of instantiations to clearly understand the problem and offer appropriate solutions (Newell and Simon, 1976).

3.4 Design as an IS Research Methodology

The design methodology is a set of processes, methods, and tools used to perform research in a research domain (Nunamaker, Chen and Purdin, 1991). Design research framework endeavours to equip the IS community with a design research methodology (Nunamaker, Chen and Purdin, 1991; March and Smith, 1995; Hevner *et al.*, 2004). Hevner et al. (2004) proposed a framework and guidelines that help understand, execute and evaluate the research (Simon, 1996). The design is a problem-solving method; it is a research process to find an effective solution to a particular problem, such as IT problems.

IT has a significant impact on organisations' efficiency either positively or negatively. Therefore, it gains excellent attention from scientists. Scientists are also interested in IT phenomena and how scientific theories can interpret them, which lead to an improvement in IT practice (Drucker, 1988). Mostly, scientists are interested in two types of IT research: perspective and descriptive. The former aims at understanding the nature of IT, which is related to natural science (Hempel, 1966). While the latter aims at improving IT performance, which is related to design science (March and Smith, 1995). In both types, design science and natural science, IS research works as a connection point among organisations, people, and technology. Therefore, undoubtedly IS includes IT research.

IT research is encompassed under two distinct species: natural science and design science (Simon, 1996). Simon (1996) draws the differences between design science and natural science. Natural science focuses on explaining why and how things are, while design science focuses on devising artefacts to attain goals (Simon, 1996, p. 133). Natural science also encompasses traditional research in social, biological, physical, behavioural, and social domains, focusing on understanding reality, while design science focuses on creating artefacts that serve human purposes. In other words, natural science is a naturally occurring phenomenon, while design science is technology-oriented (Achinstein, 1968; March and Smith, 1995). With this clear distinction between design science and natural science, IS research community needs to understand and justify the necessity for design to be considered as a research area that integrates the two research.

Design research or design science research, as IS research methodology, consists of two research paradigms: behavioural science and design science. On the one hand, the behavioural science paradigm is concerned with creating and developing theories that interpret or predict human or organisational behaviour. On the other hand, the design science paradigm is concerned with expanding human and organisational capabilities by creating novel and innovative artefacts (Hevner *et al.*, 2004). Moreover, behavioural science attempts to answer the question "what is true", while design science attempts to answer the question "what is effective". In other words, the target of behaviour science is the truth, while the target of design science is a utility. IS theories provide truth, and artefacts provide utility (Hevner *et al.*, 2004).

The design is an iterative and incremental activity that starts with a clear conceptualisation and illustration of the problem that feeds the next iteration, and at the end, it produces an improved artefact that matches problem requirements and constraints (Hevner *et al.*, 2004). Nunamaker, Chen and Purdin (1990) proposed an earlier research framework that details the relationship between research methodology and research domain (Nunamaker, Chen and Purdin, 1991). The framework links aspects of design and design science. It also assigns system development as a reliable research methodology to play a vital role in the lifecycle of complex research. Using system development with other research methodologies in various disciplines leads to successful and productive projects. System development methodology, a vital research methodology, proves its ability in conducting IS research successfully (Nunamaker, Minder and Purdin, 1990).

The design research framework provides the Information System research community and practitioners with information on the presentation, execution and evaluation of design science research. A concise conceptual design research framework is proposed by Hevner et al. (2004), as shown in Figure 3-1, that encamps design science and behavioural science paradigms. The environment in the figure below represents the problem spaces and consists of people, organisations and technology. As stated earlier, IS research encompasses behavioural science and design science research. Behavioural science researches two complementary phases: development and justification of theories related to the specified business needs. In contrast, design science research studies the two commentary phases: building and evaluating the designed artefacts that address the business needs. In both sets of research, the evaluation phase represented by justification or evaluation assists in identifying weaknesses in the theory or artefact and presents the necessity to refine and appraise. The knowledge-based provides the raw materials to conduct IS research either as foundations or methodologies. Hevner et al. (2004) proposed evaluation criteria for different artefacts covered in section 3.5.

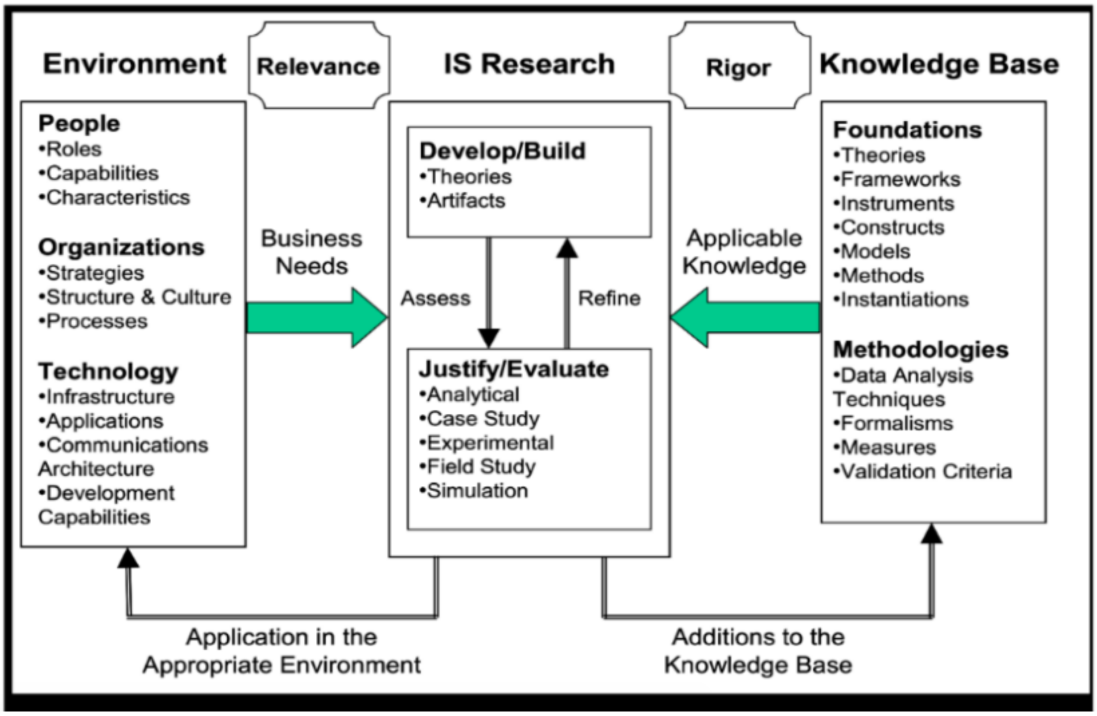


Figure 3- 1: IS Research Framework (Hevner *et al.*, 2004)

3.5 Design Research Evaluation

Design research evaluation is a crucial phase that aims to measure artefacts' performances and progress according to precise metrics (March and Smith, 1995). On the one hand, assessing the progress made by the created artefacts on performing specific tasks demonstrates its utility and thus validates the research. On the other hand, in iterative research such as design science, the evaluation is also considered as a critical role where the generated result from the evaluation phase can be maintained again to a subsequent iteration. Therefore, it is essential to develop proper evaluation metrics to evaluate artefact performance based on the evaluation criteria (March and Smith, 1995). Metrics present the target aim, and the absence of metrics and lack of artefacts of performance assessment make it challenging to judge research efforts adequately. March and Smith (1995) proposed the evaluation criteria for each type of artefact, summarised in Table 3-2.

In general, evaluating artefacts helps answer the primary question "How well does the artefact work?" (March and Smith, 1995). The answer can be obtained by applying the appropriate evaluation metric and its related artefact measurement from the knowledge base and proving the proper evaluation criteria.

Artefact Type	Brief description	Evaluation Criteria
Constructs	Alternatively, concepts represent the vocabulary and terms used in explaining a problem within a domain.	Completeness, simplicity, elegance, understanding and ease of use.
Models	A collection of statements or propositions discussing connections between constructs. It is a representation of how things are.	Fidelity with real work phenomena, completeness, level of detail, robustness and internal consistency.
Methods	A set of steps such as guidelines or algorithms used to perform a task, methods might be tied to specific models. They are used to translate from a model to another.	Operationality (the ability of others to efficiently use the method), efficiency, generality and ease of use.
Instantiations	Demonstrates the effectiveness and feasibility of the model, and the methods they contain. Instantiations use constructs, models and methods they use.	Efficiency, effectiveness and impact on an environment and its users.

Table 3- 2: Summarized Evaluation Criteria with Artefact Types (March and Smith, 1995)

Initially, the evaluation metrics and criteria are identified, and then the experiment is conducted in the real world (March and Smith, 1995), where an appropriate research method is selected. Hevner et al. (2004) assert that the evaluation methods should be chosen carefully to match both the chosen designed artefacts and evaluation metrics (Hevner *et al.*, 2004). Table 3-3 illustrates a summary of evaluation methodologies proposed by Hevner et al. (2004). It shows the primary evaluation method types with their description. IT artefacts can be evaluated using various quality attributes such as completeness, consistency, reliability, and functionality. (Hevner *et al.*, 2004).

Research Evaluation Method Types and their Description	
Observational	Case Study: Study artefact in-depth in the business environment.
	Field Study: Monitor use of artefact in multiple projects.
Analytical	Static Analysis: Examine the structure of artefact for static qualities (e.g., complexity).
	Architecture Analysis: Study fit of the artefact into technical IS architecture.
	Optimisation: Demonstrate inherent optimal properties of an artefact or provide optimality bounds on artefact behaviour.
	Dynamic Analysis: Study artefact in use for dynamic qualities (e.g., performance).
Experimental	Controlled Experiment: Study artefact in a controlled environment for qualities (e.g., usability).
	Simulation: Execute artefact with artificial data.
Testing	Functional (Black Box) Testing: Execute artefact interfaces to discover failures and identify defects.
	Structural (White Box) Testing: Perform coverage testing of some metric (e.g., execution paths) in the artefact implementation.
Descriptive	Informed Argument: Use information from the knowledge base (e.g., relevant research) to build a convincing argument for the artefact's utility.
	Scenarios: Construct detailed scenarios around the artefact to demonstrate its utility.

Table 3- 3: Design Evaluation Methods (Hevner *et al.*, 2004)

3.6 Research Design Iterations

Design research is executed via iterative design cycles, that can either be both improvement and incremental iteration or improvement iteration only (Hevner *et al.*, 2004). This research is conducted using iterative, incremental iteration, so each iteration is utilised to expand and refine the research problem. This research aimed to create an effective design methodology for personalised educational chatbots. This study was executed in three iterations: 1) persona elicitation, 2) extended UTAUT2, and 3) chatbot development, as shown in Figure 3-2.

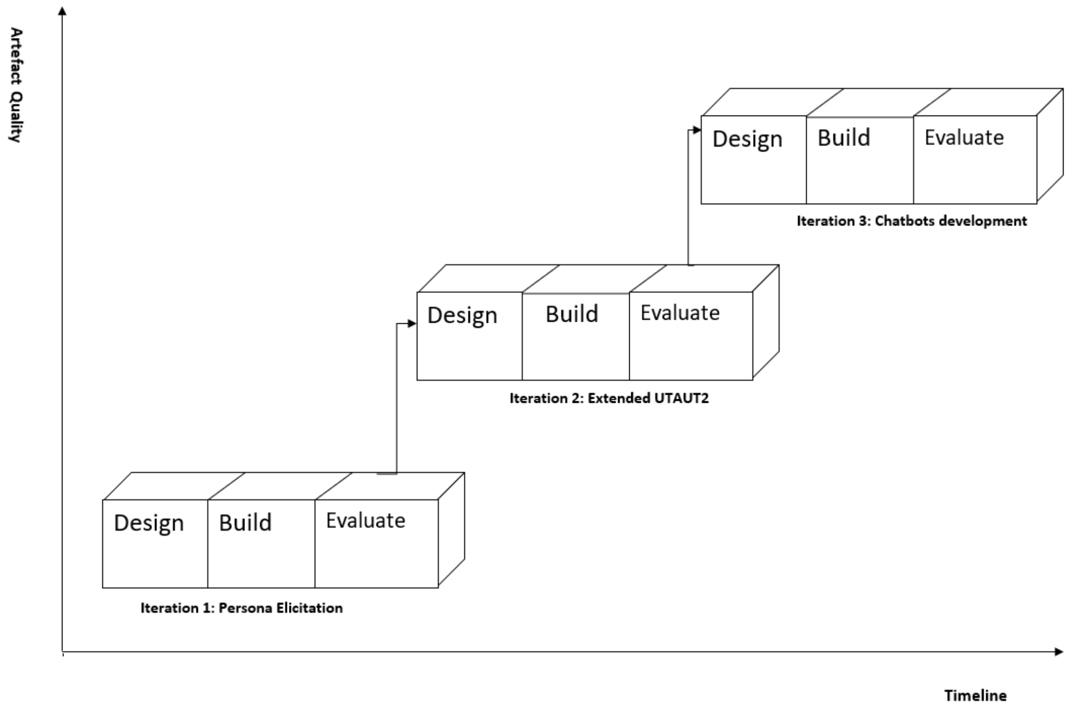


Figure 3-2: The Research Iterations

Iteration 1: identifying student groups at Brunel University London by utilising a machine learning framework to create a data-driven persona development method and model (Persona3D method and model). This iteration covered designing, building and evaluating the personas.

Iteration 2: extending the persona modelling (Persona3D model and method) generated from the previous iteration with new chatbot features suitable for all the personas. These chatbot features were identified by building on one of the most popular technology acceptance models (UTAUT2). This iteration contributed to the development of an extended version of the UTAUT2 model and an extended persona model. Several artefacts were evaluated using the evaluation criteria identified from this iteration. The primary artefacts were the extended Persona3D model and method and the extended UTAUT2 model.

Iteration 3: the effectiveness of this persona modelling approach was assessed by building a range of chatbots prototypes. A user-centred design technique was used to accommodate different user interactions with the chatbots and contribute to the chatbots' development. A range of DSR artefacts was evaluated using new evaluation criteria. The primary artefacts were journey mapping and a range of chatbots.

Persona worked as a moderator in the extended UTAUT2 model to moderate the effects of UTAUT2 constructs on students' acceptance and use of chatbots technology. As shown in Figure 3-2, the three iterations were linked together. The outcome of the first iteration was the personas, which were used as input in the second iteration. The outcome of the first iteration (personas) and the outcome of the second iteration (chatbot features) were used as input in the third iteration to design chatbots for different personas.

3.7 DSR Methods for Chatbot Design

This section covers the design science research method for chatbots design. Executing this research using Design Science Research incrementally and iteratively enables the result generated from the first iteration, then be fed into the second iteration. The new result goes back to the first iteration until an optimal result is achieved. Then it goes to its normal flow. The result of the first iteration is fed into iteration two and extended to the third iteration. The identified design research iterations for this study, along with their activities, output and artefact types, are shown in Table 3-4. The three proposed design research iterations will be discussed further in detail in chapter 4, 5 and 6.

Iteration No	**Steps**		**Input Artefact**	**Output Artefact**	**Output Artefacts type**
Iteration One	1. Design and development of Data-Driven Persona Development method	1.1 Search for a framework to build personas.	Literature review	Machine Learning Framework (K-Means clustering)	Method
		1.2 Search for existing Data-driven persona development method	Literature review	Selected Data-driven persona development method	Method

		1.3 Adapt the existing list of methods to suit the requirement	Selected persona development method	Data-driven persona development method	Method
	2. Design and build Persona Template		Literature review and the result of running Data-driven persona development	Data-driven persona development template	Model
	3. Design and build a data-driven persona development model		Data-driven persona development template and result of running the Data-driven persona development method	A data-driven persona development model	Model
Iteration Two	4. Identify technology acceptance models and theories suitable for personas		Popular technology acceptance models and theories	UTAUT2 model	Model
	5. Extend UTAUT2 model		UTAUT2 model	Extended UTAUT2 and result of iteration 1 (persona elements)	Model
	6. Design survey that supports Extended UTAUT2		Survey of UTAUT2 (Literature) and new questions which support the extended part of UTAUT2.	Extended-UTAUT2 Survey	Instantiation
	7. Build Extended UTAUT2 Survey		Extended UTAUT2 Survey	Collected survey responses	Instantiation
	8. Validate the proposed model Using Structure Equation Modelling		Extended UTAUT2survey	Validated Extended UTAUT2	Instantiation
	9. Extend the data-driven persona development model		Extended UTAUT2 and data-driven persona	The extended data-driven persona	Model

		development model	development model	
Iteration Three	1. Identifying possible features for interaction types	A good quality conference and journal papers	List of features for interaction types	Instantiation
	2. Filling the data-driven persona development model with interaction type	Data-driven persona development model and list of features for interaction types	An updated data-driven persona development model	Model
	3. Design Journey mapping template	Data-driven persona development model and identifying component of a journey mapping	Journey mapping template	Model
	4. Design and build student Journey mapping for different personas	Journey mapping template and data-driven persona development model	Range of journey maps design for different types of personas	Model
	5. Evaluate the effectiveness of data-driven persona development model in supporting the journey mapping	Journey mapping and data-driven persona development model	Result of Evaluating the data-driven persona development model approach	Constructs

Table 3- 4: Summary of Research Iterations

Three practical methods will be used to carry out the design in this study. In the first iteration, appropriate machine learning techniques carry out the design of the data-driven persona development method used to build persona models for university students that suit the nature of the dataset. Machine learning (ML) is “*a process of building computer systems that automatically improve with experience, and implement a learning process*” (Ayodele, 2010, p. 2). According to Dey (2016), there are four types of machine learning: supervised learning, unsupervised learning, semi-supervised learning and reinforced learning. However, the two fundamental types of machine learning are supervised learning and unsupervised learning (Shabajee, Hannabuss and Tilsed, 1998). Clustering is a type of unsupervised learning that aims to find the natural grouping of a set of objects, points or patterns (Jain, 2008). Therefore, objects in the same group are similar to each other and different from objects in other groups. The *K*-means clustering method is the most popular and widely used clustering algorithm due to its simplicity (Kodinariya and Makwana, 2013). It is robust, fast and easy to understand and has a good performance when there is no noisy data or outliers. However, K-means is unsuitable for categorical data (Singh, Yadav and Rana, 2013). In this study, the K-means clustering algorithm is suitable to cluster students into groups due to the nature of the two datasets.

In the first iteration, as mentioned earlier, the main research approach to design the primary artefacts is ML techniques. Three main artefacts will be designed; 1) Persona template, designed by analysing the literature regarding the elements of personas template, 2) Data-driven persona development method, designed based on the literature review, more specifically ML technique, and 3) Data-driven persona development model, designed based on the persona template and the result of running the data-driven persona development method as shown in Figure 3-3.

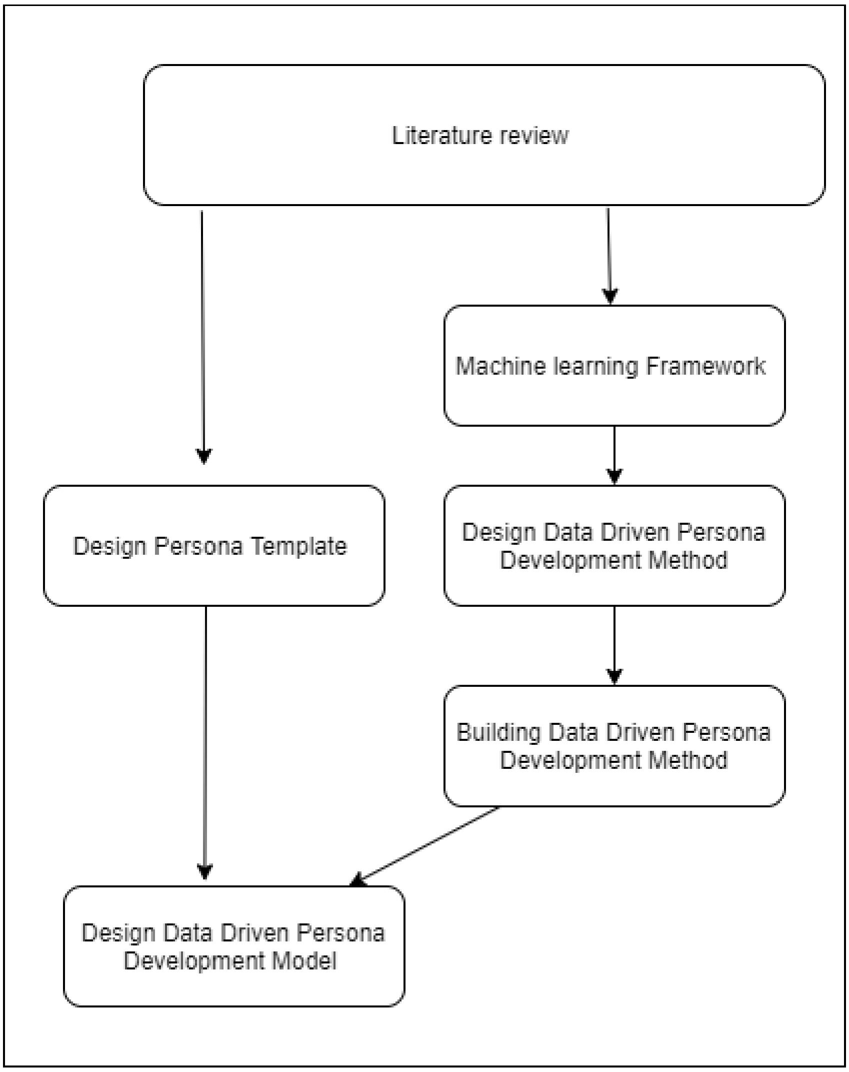


Figure 3- 3: DSR for Chatbot Design - Iteration One

In the second iteration, UTAUT2 is the primary research model used in designing the Extended UTAUT2 model. UTAUT2 is a proper model to study the acceptance and use of technology developed by (Venkatesh, Thong and Xu, 2012). The UTAUT2 model is robust, and it is an extension of UTAUT, which comes from reviewing and analysing eight models of technology acceptance theories and models. The Extended UTAUT2 model will be designed and extended with a persona moderator that will be extracted from the previous iteration (Chapter 4). UTAUT2 is a model that studies students acceptance and use of technology. The designed Extended UTAUT2 is used to design the survey, and the hypothesis of the Extended UTAUT2, as shown in Figure 3-4.

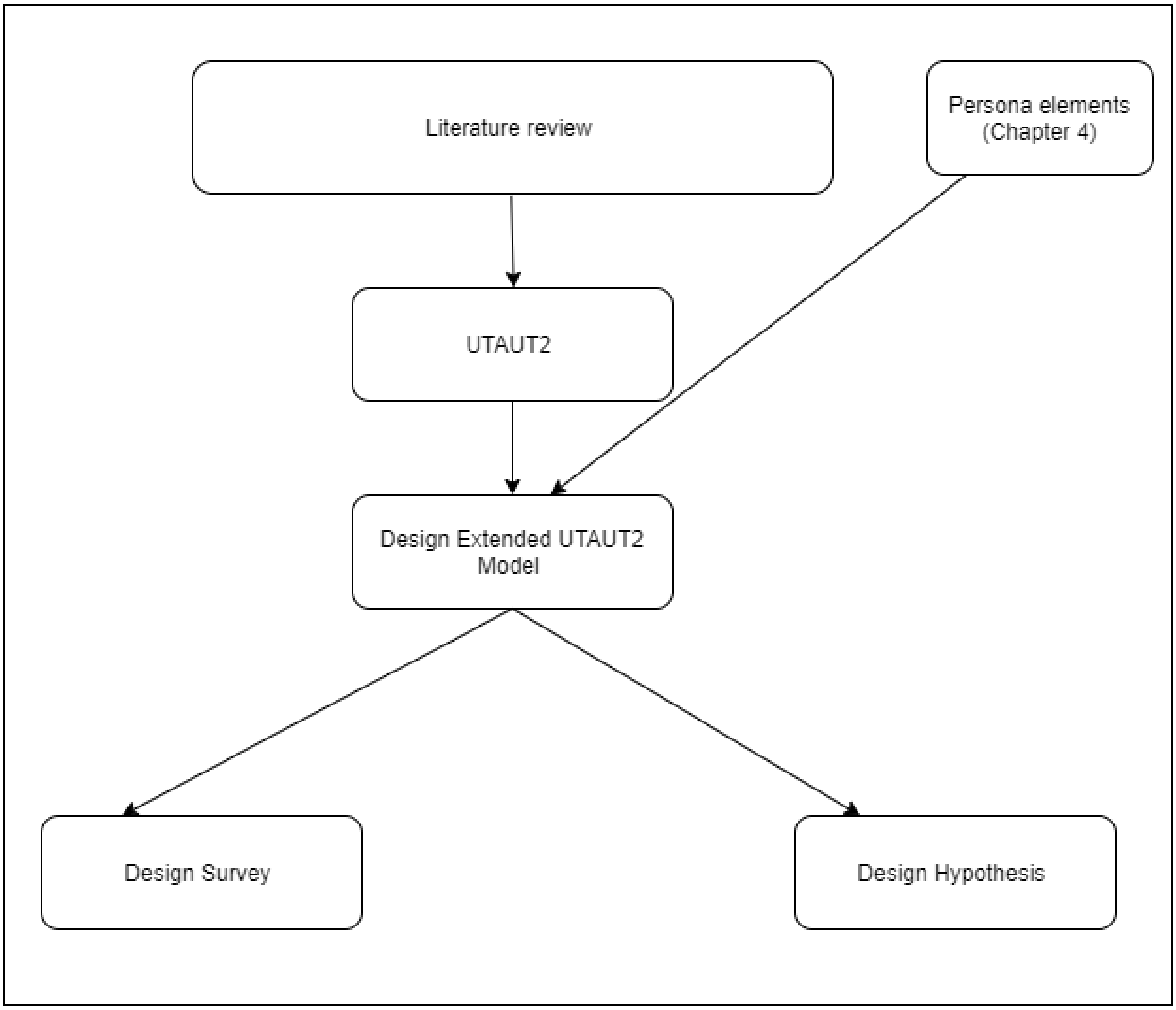


Figure 3- 4: DSR for Chatbot Design - Iteration Two

In the third iteration, Customer Journey Mapping (CJM) is the practical method used. CJM is a visualisation tool utilised to obtain an insight into how a user/customer interacts with a business (Ortbal, Frazzette and Mehta, 2016). CJM has been used widely in the last decade. CJM visualises the customer/user Journey from the beginning of the journey to the end to understand the steps, touchpoints and stages the user passes to complete a task (Marquez, Downey and Clement, 2015).

Journey Mapping is similar to persona; both are UCD methods. However, the persona represents a group of users who share common goals, attitudes and behaviour during the interaction with the product (Putnam, Kolko and Wood, 2012**;** Cabrero, 2014). Persona is a two-dimensional static profile. Journey Mapping will be used and built to overcome the shortage of personas, which adds the 3rd dimension to the persona. It shows a high-level overview of user interaction or experience with each touchpoint in the journey mapping.

Moreover, journey mapping makes communication clear in front of the design team, such as software engineers, product managers, and marketers. Thus, Journey Mapping is a valuable tool for collaboration and communication in the user experience (Friess, 2012b; Howard, 2014). In the final iteration, a set of chatbots features that support UTAUT2 constructs will be identified from the literature review. Journey Mapping and persona models are used as the design tool to design and build a range of chatbots prototypes. Designing chatbots requires using two sources of data: 1) Journey mapping template that will be designed based on the analysis of the literature (components of the journey mapping from several studies summarised in chapter two) and 2) persona model (Persona3D model) that will be designed, built, evaluated, and extended in the first two iterations (Chapter 4 and 5), as shown in Figure 3-5.

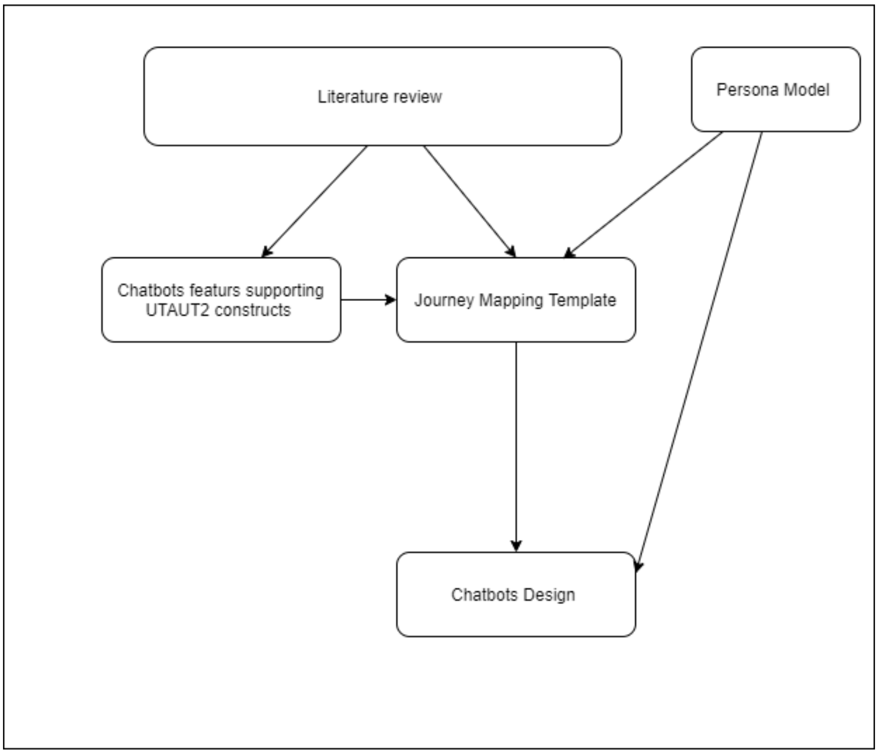


Figure 3- 5: DSR for Chatbot Design - IterationThree

3.8 DSR Methods for Building a Chatbot

There are several steps in building context-based and persona-based chatbots, covered in the first, second and third iterations. In each iteration, certain artefacts contribute to the development of chatbots. The first iteration, designing the persona template and data-driven persona development method, was covered in Section 3.6. In the building part, the data-driven persona development method, which mainly relies on the K-mean clustering algorithm, will be developed in the R-programming language. Different methods will be used to identify the k-value before running the K-means. These methods include; Elbow method, Gap Statistic and Silhouette method. The Average Silhouette Width will be used to find the optimal value of K. Running the method will produce several clusters. The attributes that will generate from running the data-driven persona development method, with the elements in the designed persona template, will contribute to the development of a range of personas models for university students (Figure 3-6).

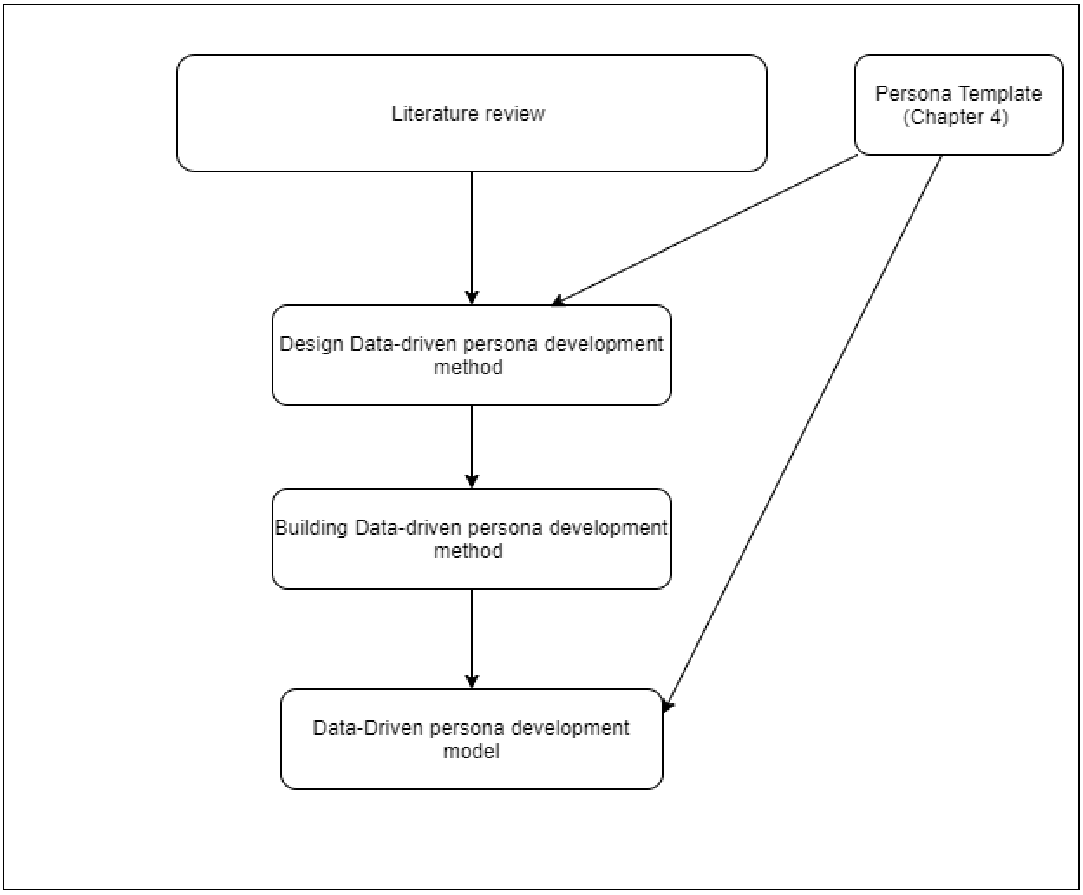


Figure 3- 6: DSR for Chatbot Building – Iteration One

In the second iteration, the design part covers designing the Extended UTAUT2 model that studies student acceptance and use of chatbots, covered in Section 3.6. This iteration also covers building the survey, hypothesis, and the Extended UTAUT2 model. The new features will be extended in the data-driven persona development model, and further extended to the data-driven persona development method. The Extended UTAUT2 will extend the data-driven persona development model and method to include effective methods of interaction with each group (including specific calls-to-action CTA), as shown in Figure 3-7.

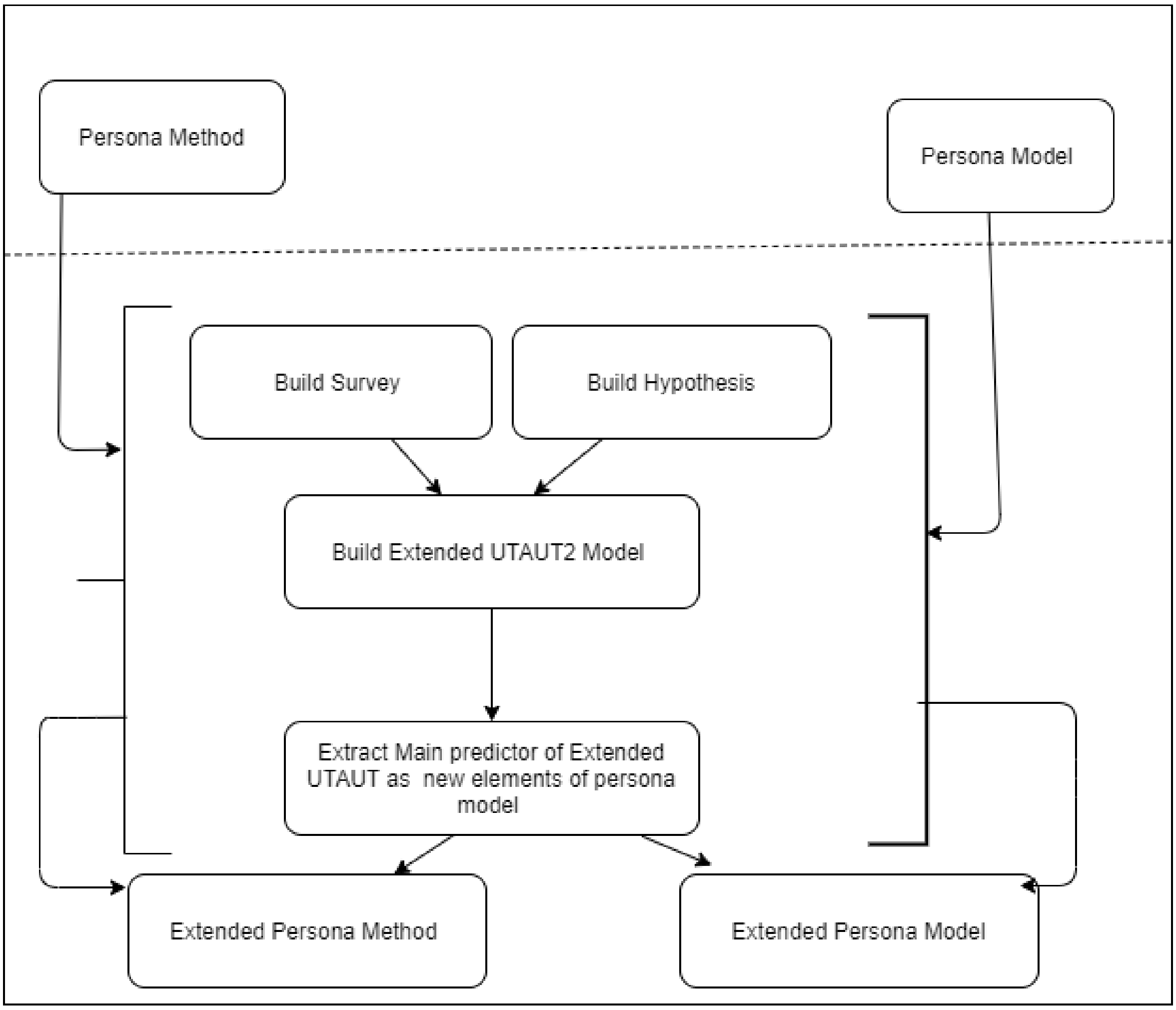


Figure 3- 7: DSR for Chatbot Building – Iteration Two

In the third iteration, the Journey Mapping will be built for different personas based on a range of data-driven persona development models resulting from the first and second iterations. The Journey Mapping and personas will work as the basis to design and built a range of chatbots (Figure 3-8). Currently, chatbots are either embedded in messaging applications or appear as a stand-alone service in well-known devices such as Amazon Alexa, Microsoft Cortana, and Apple Siri(Yan *et al.*, 2016). However, in this research, Amazon Alexa will be the target service.

Amazon Alexa provides interfaces for the client and the server-side. Also, it offers several services; Simple Mail Service (SES) that send email to the user, and DynamoDB to hold the information in the database. The client-side will be developed in Amazon Alexa Kit (https://developer.amazon.com/alexa/console/ask). It starts with creating a skill name, invocation name, interaction model that includes intents, slots and identifies the type of each intent and slot. The server side is in Amazon AWS developer https://aws.amazon.com/developer/. The code will be written in JavaScript and uploaded to the Lambda Function. Based on the requirement of chatbots, a range of services will be used, such as the earlier mentioned SES and DynamoDB. Jovo Framework (https://www.jovo.tech/) can be used to run and test the chatbots on how it responds to the interaction from the client-side to save time while testing the chatbots.

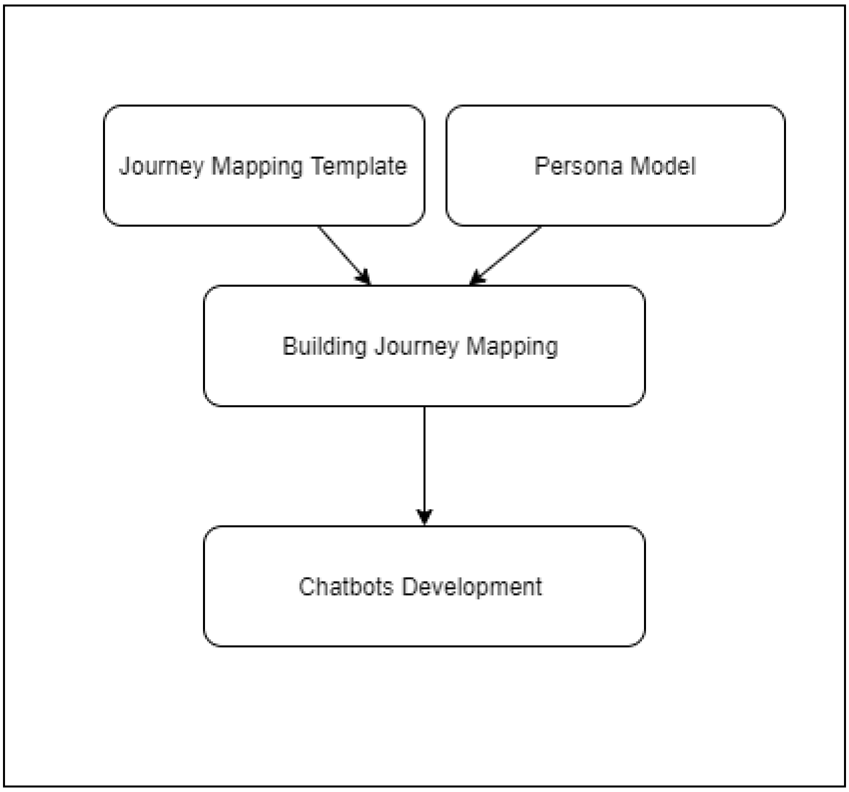


Figure 3- 8: DSR for Chatbot Building – Iteration Three

3.9 DSR Methods for Evaluating a Chatbot

This section covers artefacts evaluation, including constructs, models, methods, or instantiations (March and Smith, 1995), as shown in Table 3-5. According to March and Smith (1995), there are specific criteria to evaluate the artefact based on its type. For instance, the criteria to evaluate the model are fidelity with real work phenomena, completeness, level of detail, robustness and internal consistency.

	Build	Evaluate	Theorise	Justify
Constructs				
Model	Persona3D model	Completeness (Chapter 4)		
	Extended Persona3D model	Completeness (Chapter 6) Effectiveness (chapter 6) Effectiveness of Extended persona3D model and method in building the chatbots (Chapter 6)		
	Extended UTAUT2 model	Internal consistency reliability and composite reliability (Chapter 5)		
	Journey Mapping model	Effectiveness (Chapter 6) Completeness (Chapter 6)		
Method	Persona3D method	Efficiency (Chapter 4)		
Instantiation				

Table 3- 5: A research Product versus Research Process

In the first iteration, the data-driven persona development model (Persona3D model) will be evaluated in terms of completeness. This evaluation will be done by comparing the elements of the proposed persona3D model with persona elements from a list of high-quality papers and comparing whether the persona3D model contains these elements or other ones. According to March and Smith (1995), methods are evaluated with specific criteria such as Operationality (the ability of others to use the method efficiently), efficiency, generality, and ease of use. The data-driven persona development method (Persona3D method) will be evaluated in terms of efficiency by comparing the time required to build the persona model with the typical building of the persona using workshops (Table 3-5).

In the second iteration, the Extended UTAUT2 model will be evaluated using structural equation modelling (SEM) in terms of internal consistency reliability and composite reliability. SEM is a general and widely accepted technique among researchers in behavioural and social science and information system (IS) (Blunch, 2008; Gefen, Straub and Boudreau, 2000). SEM is the primary practical approach in the second iteration. Given a conceptual model, SEM is used to test and examine the hypothesised relationship between variables in the specified model. SEM is considered to be the second generation of multivariate analysis, which differs from first-generation techniques such as regression and factor analysis. SEM is a statistical technique to test and estimate a set of hypotheses relationships between dependent and independent variables in a model (Gefen, Straub and Boudreau, 2000). Hair et al. (2010) also define SEM as a multivariate technique that aggregates features from factor analysis and multiple regression to estimate several networking relationships in the proposed model simultaneously.

There are several reasons for choosing SEM as the primary analysis technique in this iteration. The main reason is that the SEM is a very appropriate technique as compared to others for this study, notably when exogenous (dependent) variables such as Behavioural Intention become endogenous (independent) variables (Tabachnick and Fidell, 2000). This has an impact on the use of chatbots. While it is complicated using a first-generation statistical tool, in this study, PLS-SEM using SmartPLS3 will be used to analyse and test the data within the proposed conceptual model. Hair *et al.* (2010) recommended evaluating the structural model using two steps; 1) the measurement model and 2) the structural model. Furthermore, Multiple Group Analysis (MGA) finds out how the moderators impact the conceptual model.

According to March and Smith (1995), a model is evaluated in terms of completeness, level of details, the fidelity with real work phenomena, robustness, and internal consistency. In the third iteration, the evaluation will cover the effectiveness and completeness of the journey mapping. Furthermore, the Extended persona3D model will be evaluated in terms of completeness and effectiveness.

Also, this iteration covers evaluating the effectiveness of the extended persona3D model and method in building the chatbots. Further details about how to evaluate the artefacts in iteration three will be covered in Chapter 6.

3.10 Triangulation

Triangulation refers to "using more than one particular approach when doing research in order to get richer, fuller data and/or to help confirm the results of the research" (Wilson, 2014, p. 74). According to Flick (2002), there are four types of triangulation: 1) data triangulation – using a distinct source of data, 2) investigation triangulation – using several people in the data gathering and data analysis processes, 3) theory triangulation – using different theories to approach the data and 4) methodological triangulation – using more than one method to gather data.

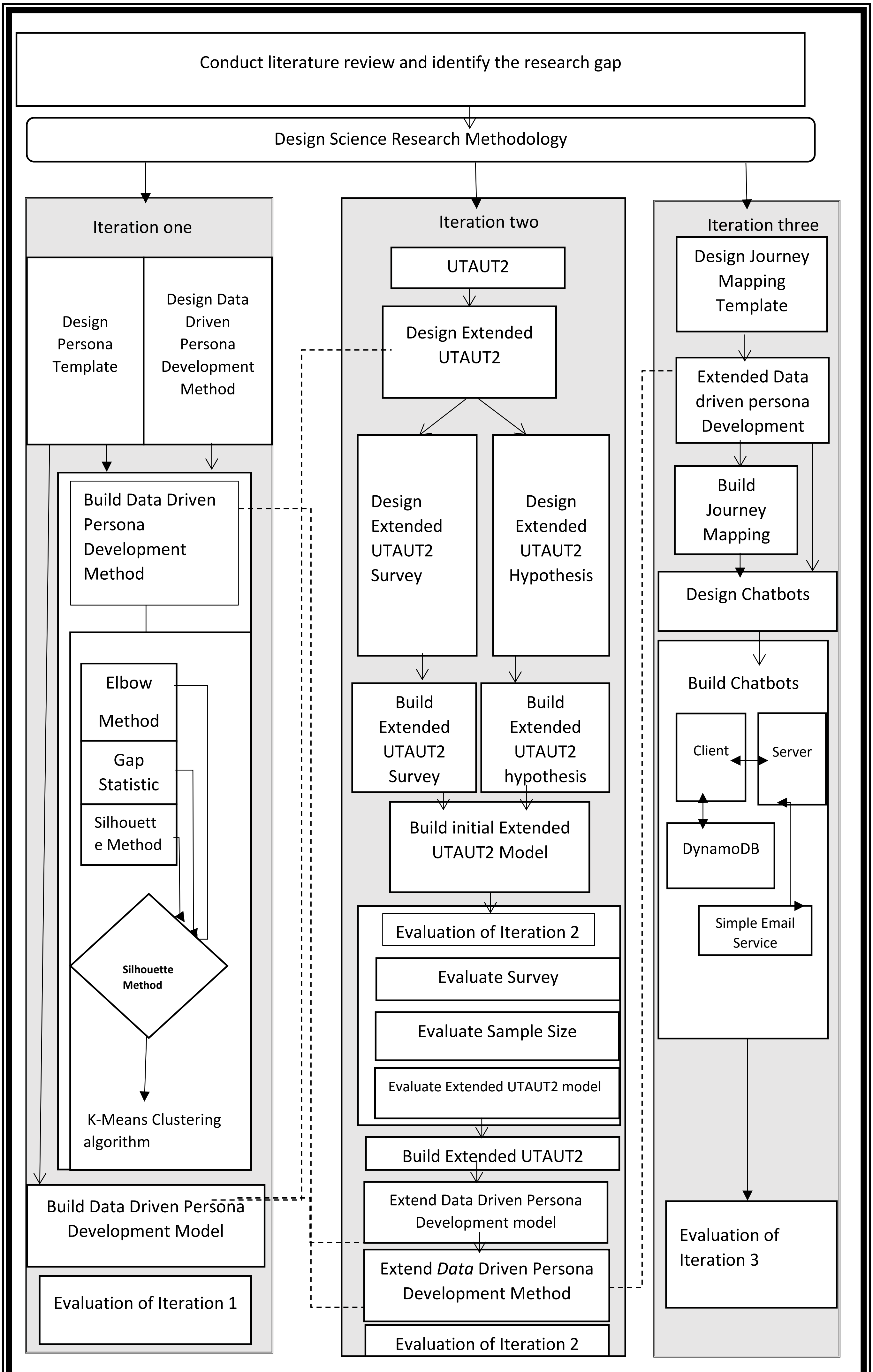
This study used two types of triangulation: data triangulation and methodological triangulation. Regarding data triangulation, this study used different sources of data in each iteration. In the first iteration, the data included students' physical engagement, virtual engagement and performance. These data were used in the data analysis to build the personas used in the second iteration. In the second iteration, data were collected via an online survey to study students' acceptance and use of chatbot technology. The data collected from the second iteration and the persona elements generated from the first iteration were used to identify the factors that influence university student acceptance and use of chatbots technology. In the third iteration, the chatbots features were identified from the literature review. Using data triangulation, the different sources of data in the third iteration provided a robust design for the persona-based chatbots.

Methodological triangulation is the most common type of triangulation (Wilson, 2014). Methodological triangulation can refer to 'mixed-methods research', which combines quantitative and qualitative research. This research is a mixed-methods study that covered three iterations. In each iteration, different methods were used. For example, in the first iteration, persona elicitation, a machine learning framework (specifically, K-means clustering) was used to analyse student data and build student personas. In the second iteration, extending the UTAUT2, an online survey was used to study university students' acceptance and use of chatbots. Also, it is used to identify the required chatbot features for these personas.

However, it was not possible to use methodological triangulation (both surveys and interviews) in each iteration due to time and resource constraints, despite the possible benefits. For example, using both a survey and interviews would have strengthened the persona elicitation in the first iteration. Also, it would have provided the researcher with a deeper understanding of the population. Furthermore, in the second iteration, using both interviews and a survey would have provided a deeper understanding of students' acceptance and use of chatbot technology and why students use or do not use chatbots to support their learning.

3.11 Conclusion

In conclusion, this chapter presents the research methodology used in this study, the design science research methodology. This chapter is divided into three parts: the first part covers the ontology and epistemology of this research, the reason for choosing the positivist paradigm and the selected sampling approach. The second part covers the design science research community used. It presents the popular design science research frameworks, including the one developed by Hevner in 2004 and March and Smith in 1995. The third part discusses how to use design science research and applies it in the three iterations using design, build, and evaluation of the framework. Also, it discusses the use of DSR methods to design, build and evaluate chatbots. Using DSR to design the chatbots covers the input and output artefacts from each iteration and the practical methods that are used to carry out the design, including ML techniques, structural equation modelling, and Journey Mapping. Using DSR to build the chatbots covers the artefacts used to build the chatbots and the practical methods used and discusses the steps to build the chatbots prototype using Amazon Alexa. Using DSR to evaluate the chatbots covers the artefacts, their type, and how they will be evaluated. Furthermore, the different types of triangulation and the triangulation method applied in this study were covered. A summary of using DSR for this research is illustrated in Figure 3-5.



Conduct literature review and identify the research gap
Design Science Research Methodology
Iteration one
Design Persona Template
Design Data Driven Persona Development Method
Build Data Driven Persona Development Method
Elbow Method
Gap Statistic
Silhouette Method
Silhouette Method
K-Means Clustering algorithm
Build Data Driven Persona Development Model
Evaluation of Iteration 1
Iteration two
UTAUT2
Design Extended UTAUT2
Design Extended UTAUT2 Survey
Design Extended UTAUT2 Hypothesis
Build Extended UTAUT2 Survey
Build Extended UTAUT2 hypothesis
Build initial Extended UTAUT2 Model
Evaluation of Iteration 2
Evaluate Survey
Evaluate Sample Size
Evaluate Extended UTAUT2 model
Build Extended UTAUT2
Extend Data Driven Persona Development model
Extend Data Driven Persona Development Method
Evaluation of Iteration 2
Iteration three
Design Journey Mapping Template
Extended Data driven persona Development
Build Journey Mapping
Design Chatbots
Build Chatbots
Client
Server
DynamoDB
Simple Email Service
Evaluation of Iteration 3

CHAPTER 4 -PERSONA ELICITATION

4.1 Introduction

As highlighted in Chapter 2, the design of chatbots generally follows a one-size-fits-all approach (Følstad and Brandtzæg, 2017). The approach provides the same contents to all students regardless of their type (Følstad and Brandtzæg, 2017; Kadariya *et al.*, 2019) and their location (Bradesko *et al.*, 2017; Følstad, Nordheim and Bjørkli, 2018), particularly in the educational setting (Yang and Evans, 2019). This study overcomes this limitation by designing persona-based chatbots. It is essential to understand student groups first to achieve this. This iteration proposes a data-driven persona development method (Persona3D method) that contributes to the development of data-driven persona development models (Persona3D model) for university students. The development of an application prototype of the Persona3D as an instantiation artefact is used to evaluate the Persona3D method. Also, the Persona3D models will be evaluated using different criteria.

This chapter is structured as follows: Section 4.2 discusses how design research is applied for persona elicitation iteration to produce the target artefacts and presents the novelty of this iteration. Also, it presents the design of a Persona3D method and the initial design Persona3D template. Section 4.3 discusses the building and development of the Persona3D method and Persona3D models for university students. Section 4.4 covers evaluating the persona3D model and method in terms of completeness and efficiency, respectively. Section 4.5 moves on to highlight the limitations of this iteration. Section 4.6 presents the learning outcome of this iteration, while section 4.7 presents a summary of the chapter.

4.2 Design Science Research and Output Artefacts

This iteration applies design research as an iterative process, where the artefact building and evaluation process creates an optimal artefact. Models are used to express a real-world situation as an issue along with its solution statement (March and Smith, 1995). In contrast, a method defines a collection of steps to be followed to achieve a specific task (March and Smith, 1995). Here, an instantiation of the proposed Persona3D method developed focuses on building the Persona3D model for university students using their existing data. This iteration produces three primary artefacts: Persona3D method, Persona3D template, and Persona3D models. Figure 4-1 illustrates the three research iterations of this study that represent the iterative cycle of artefact building, development, and evaluation based on design research by Vaishnavi and Kuechler(2004).

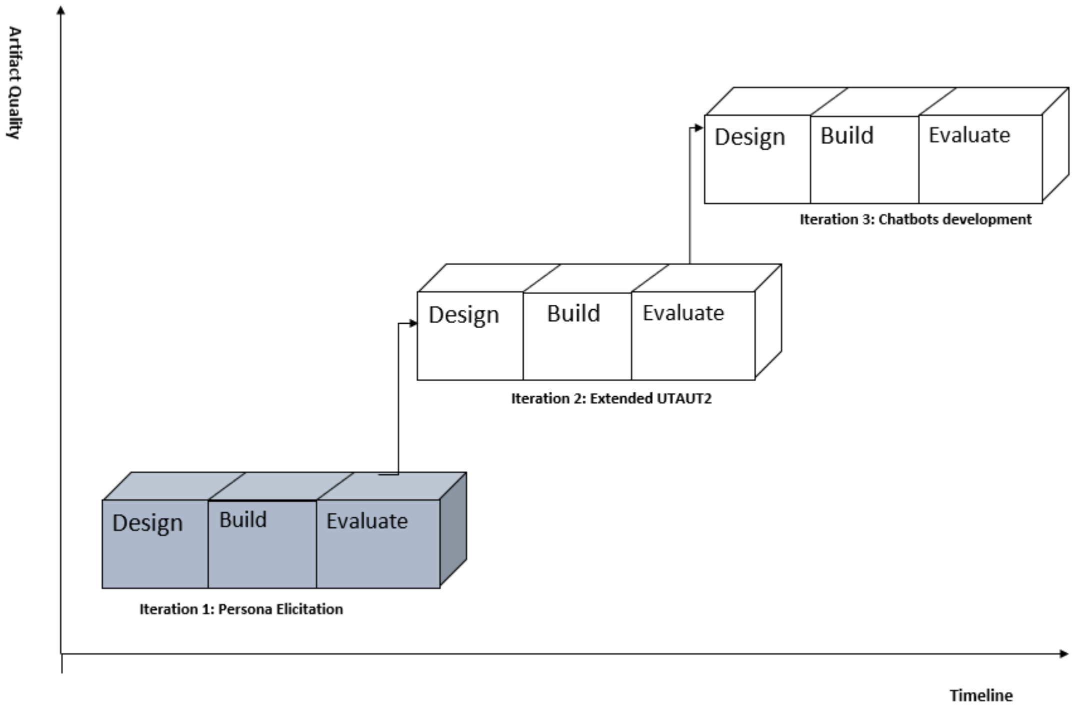


Figure 4- 1: Research Iterations

The novelty of this iteration is how to move from clustering to building the Persna3D model. The result of the clusters produces several features that distinguish each student group from one another. These features, combined with attributes in each Persona3D template, create the final product; the Persona3D model for university students. Further information related to the design and building of the Persona3D template is provided in section 4.2.3 and section 4.3.3, respectively.

4.2.1 Design Science Research Artefact

The persona elicitation iteration identifies student groups at HEI, which involves designing and building the Persona3D method, Persona3D template, and Persona3D models. Persona elicitation requires a few steps to build the Persona3D model for university students, as shown in Table 4-1. The process starts with designing and building the Persona3D method, which comprises of three points; A) searching for a proper framework to build the Persona3D model by conducting a literature review. It guides us to the machine learning framework used in the development of personas using a clustering method covered in Chapter 2. B) select a few data-driven persona development methods after conducting a literature review on the existing data-driven persona development method. C)choose a data-driven persona development method from the previously selected method that will suit the nature of the study (see, Chapter 2). The output of the previous step, the data-driven persona development method, will be adapted to suit the requirement of this study which produces the proposed Persona3D method.

The second step is designing and building a Persona3D template. The initial Persona3D template design will be built after analysing the literature review and result of running the persona3D method. Section 4.2.3 provides more details of this process. Finally, using the available data and running the proposed Persona3D method extracts characteristics from the generated clusters, which work as elements of the Persona3D template. This Persona3D template, when combined with student data, creates the students' Persona3D model, which is the primary outcome of the whole process.

Steps		Method	Input Artefact	Output Artefact
1. Design and development of Persona3D method	1.1Search for a proper framework to build personas.	Method Searching and Selection	Literature review	Machine Learning Framework (K-Means clustering)
	1.2Search for existing Data-driven persona development method	Method Searching and Selection	Literature review	Selected Data-driven persona development method

	1.3 Adapt the existing list of development method to suit the requirement	Method Adaption	Selected persona development method	Persona3D method
2. Design and build Persona Template		Building Persona template	Literature review and the result of running Persona3D method	Persona3D template
3. Design and build a persona model		Build a persona3D model	Persona3D template and result of running the Persona3D method	Persona3D model

Table 4- 1: Iteration 1- Input and output model

This iteration aimed at evaluating the output artefacts: 1)Persona3D model in terms of completeness and 2) Persona3D method with regards to efficiency.

4.2.2 Designing Data-driven Persona Development Method (Persona3D Method)

This section discusses the proposed Persona3D method, as shown in Figure 4-2. It is adapted from the literature on data-driven persona development (McGinn and Kotamraju, 2008; Wang *et al.*, 2017; Dobbins and Rawassizadeh, 2018; Hartigan and Wong, 2018) and the cross-industry standard process for data mining CRISP methodology (Wirth and Hipp, 2000)– a structured approach for data mining projects. The Persona3D method contains three main phases: 1) data pre-processing, 2) data analysis, and 3) persona3D method design and building. The data collection involves determining the type of dataset required for the analysis. The proposed Persona3D method is applicable, cheap, and straightforward compared to the methods used by Cisco and Microsoft (Hartigan, 1975; Ali *et al.*, 2019). The datasets in this study include two types of behavioural engagement: attendance and interaction with VLEs (Almahri, Bell and Arzoky, 2019b).

The pre-processing data phase is part of the Persona3D (shown in Figure 4-2). It covers data understanding, data preparation, and feature selection. It is essential to mention that student data is sensitive; obtaining such data required ethical approval (see Appendix A for ethical approval), which required a considerable amount of time before getting approval from the University's ethics committee. The data pre-processing started with the creation of Visual Basic for Applications (VBA) macros. In this study, VBA macros were developed to anonymise and combine student data from three worksheets into one Microsoft Excel workbook for the first dataset and similar for a second dataset. The macro anonymised and combined the data from a total of four datasets.

Data understanding is about understanding the attributes of the dataset, the data types, and the data values; this includes accessing the Blackboard Learn to understand the attributes within, with the help of staff in the university. It also includes preparing the data, dealing with missing data, and transforming some data types from categorical to continuous. This study utilises the R programming language, using the free software environment RStudio, for data preparation. Statisticians widely use the R programming language for data analysis(Gentleman and Ihaka, 2015). It contains many visualisation packages, such as ggplot2, dplyr, magrittr, tidyr, Factoextra, and NbClust (Kassambara, 2018), to name a few.

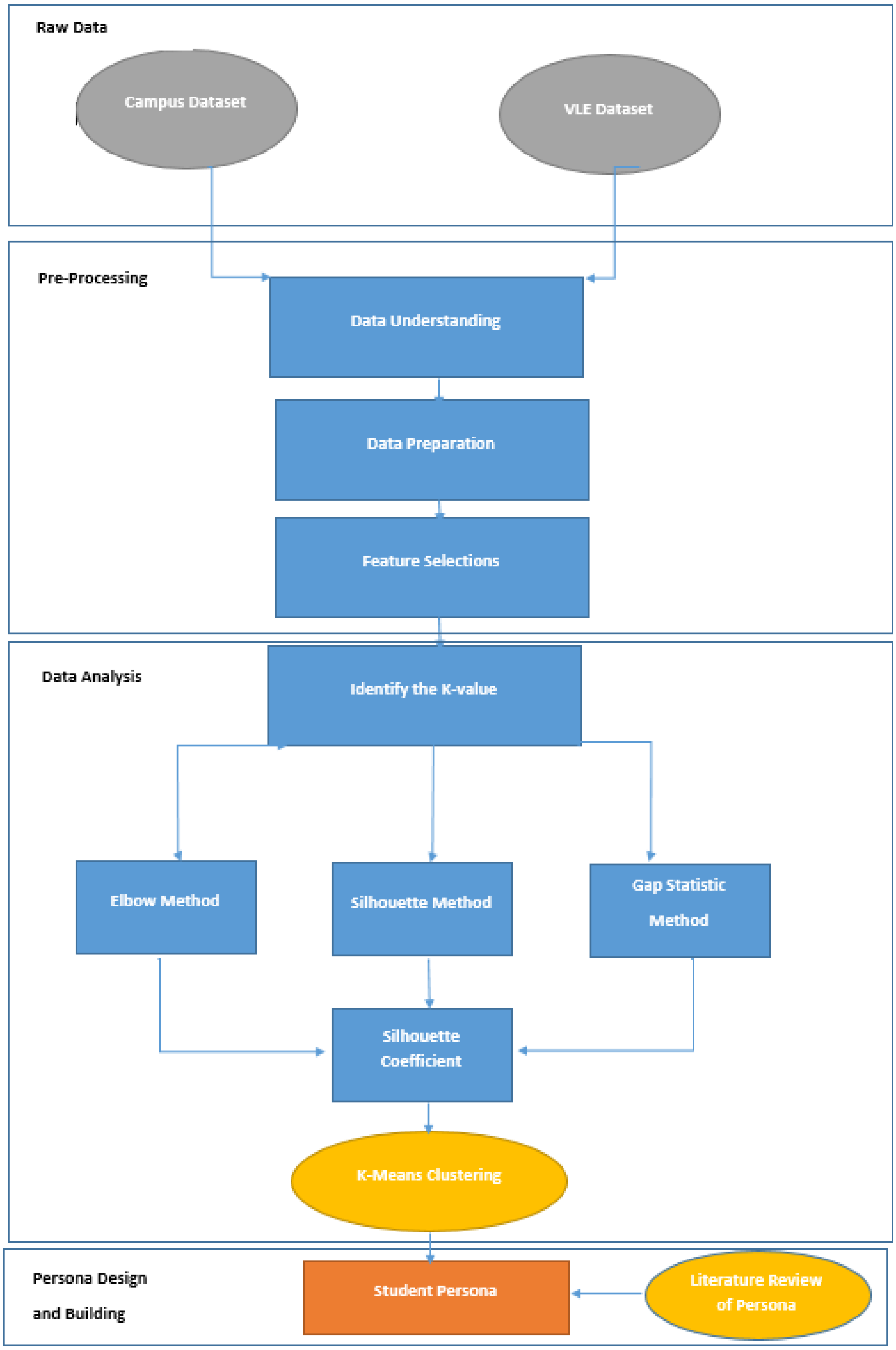


Figure 4-2: Proposed Persona3D Method (Almahri, Bell and Arzoky, 2019b), adapted from Dobbins and R. Rawassizadeh.

The feature selection involves identifying only the appropriate attributes to be included in the dataset. The first dataset was for second-year computer science students at Brunel University London in 2014, and it included student engagement (physical engagement) and performance data. Attendance represents student engagement (physical engagement), while student grades represent performance. The second dataset was for second-year computer science students at the same university in 2016 and represented students' interactions with a VLE (virtual engagement) and performance, represented by grades. Moving forward, Campus Dataset will be referred to as the "First Dataset", while VLE Dataset will be referred to as the "Second Dataset". Descriptions of the First Dataset and the Second Dataset are shown in Table 4-2 and Table 4-3, respectively(Almahri, Bell and Arzoky, 2019b).

Attribute	Description
Attendance	Represents the total lab attendance by each student out of 12 labs
Grade	Represents the final grade in that module, ranging from 1 to 17, where 1 represents F, and 17 represents A*

Table 4- 2: Attributes Description for the First Dataset(Almahri, Bell and Arzoky, 2019b)

Attribute	Description
Course activity	The total amount of course activity in hours the user completed
Content	The total amount of time in hours that the user spent accessing content for the course (files, links, and videos)
Collaboration	The total amount of time in hours that the user spent on collaborative activities
Communication	The total amount of time in hours that the user spent engaging in discussion boards/forums
Grade	The final student grade in the specific module

Table 4- 3: Attributes Description for the Second Dataset (Almahri, Bell and Arzoky, 2019b)

4.2.3 Designing Persona3D Template

The persona concept was proposed by (Cooper, 2004) as a design process methodology (Friess, 2012a). Personas are not real people but imaginary archetypes of actual users (Friess, 2012a). Persona templates or persona-based designs have been covered in many studies (Roussou *et al.*, 2013; Cahill, McLoughlin and Wetherall, 2018). There are different examples of personas, such as company personas (Ali *et al.*, 2019), and student personas (Nunes, Silva and Abrantes, 2010; Nishiuchi and Shiga, 2015). Persona template elements differ based on the reasons behind creating them. Persona templates usually include demographic data (Roussou *et al.*, 2013), such as name (Hill *et al.*, 2017), age (Milligan and Cooper, 1985; Wirth and Hipp, 2000; Tibshirani, Walther and Hastie, 2001), gender (Nieters, Ivaturi and Ahmed, 2007), occupation (Hill *et al.*, 2017), language (Roussou *et al.*, 2013), place of residence(Hill *et al.*, 2017), and picture (Hartigan, 1975; Tibshirani, Walther and Hastie, 2001; Singh, Yadav and Rana, 2013; Syakur *et al.*, 2018). Furthermore, they can include users' interests (Milligan and Cooper, 1985), activities(Guo and Razikin, 2015), preferences (Hill *et al.*, 2017), and attitudes (Guo and Razikin, 2015). Moreover, they can cover skills and experience, such as educational level (Roussou *et al.*, 2013) and IT experience. The initial student Persona3D template proposed in this study consists of the following categories: demographic data (Hartigan, 1975) motivations and interests(Singh, Yadav and Rana, 2013; Syakur *et al.*, 2018) and skills and experience (Roussou *et al.*, 2013). Further details are outlined below(Almahri, Bell and Arzoky, 2019b). Further improvement on the Persona3D template is shown in Section 4.3.3.

4.3 Artefacts Building and Development

This section represents the analysis phase in the Persona3D method, as shown in Figure 4-2. Two subsections discuss the results of data analysis performed on the two datasets (First Dataset and Second Dataset), while a third describes the building of the Persona3D model.

4.3.1 Results of the First Dataset Analysis

As discussed previously in the literature review chapter (Section 2.3.3), three well-known methods can be used to identify K-values: the elbow, silhouette, and gap statistic methods. These methods used in analysing the First Dataset produced three different values: K=4, 9 and 1 (Figures 4-3, 4-4 and 4-5, respectively). K=1, the result of the gap statistic method, was excluded because it would make no change to the existing data, and the initial value of the K-means clustering technique starts from K=2. Therefore, for identifying the optimal values for K, the silhouette coefficient method where K=4 and K=9 were used, and the results were 0.44 and 0.49, respectively (Figures 4-6 and 4-7). Given the slight difference between the two values, K=4 was chosen as the optimal value for K. Running the K-means clustering when K=4 produced four clusters, as shown in Figure 4-8. The two components in this dataset explain 100% of the point variability(Almahri, Bell and Arzoky, 2019b).

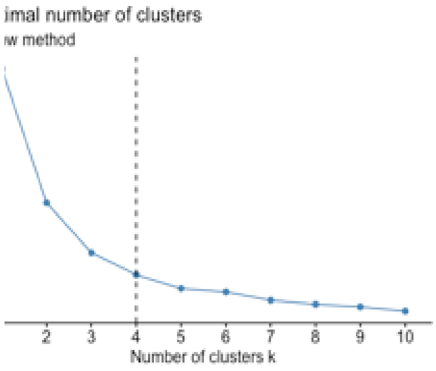


Figure 4- 3: Elbow Method (Almahri, Bell and Arzoky, 2019b)

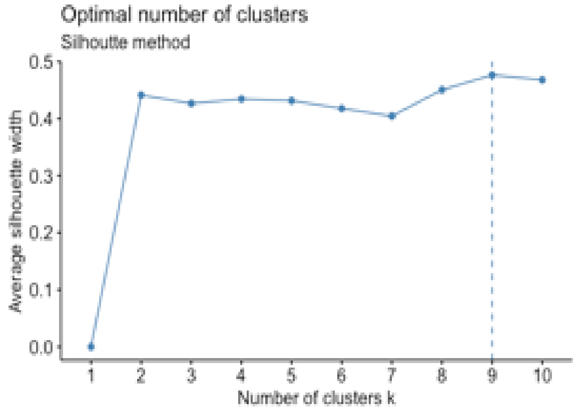


Figure 4- 4: Silhouette Method (Almahri, Bell and Arzoky, 2019b)

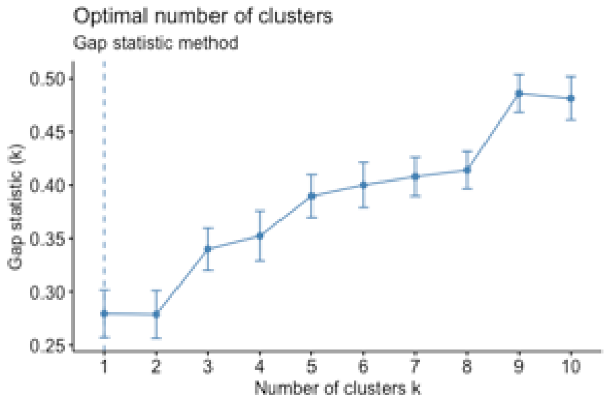
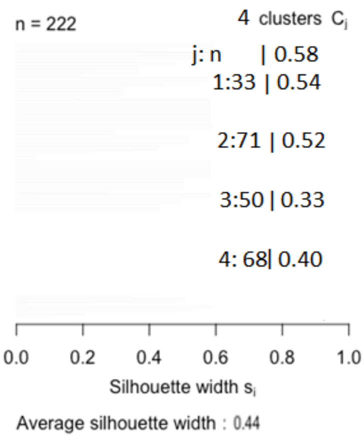


Figure 4- 5: Gap Satistic Method (Almahri, Bell and Arzoky, 2019b).



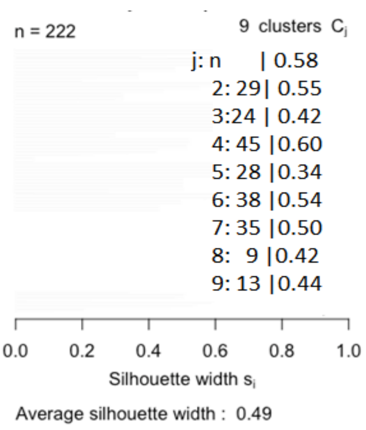


Figure 4- 6: Average Silhouette Width when *K*=4 (Almahri, Bell and Arzoky, 2019b)

Figure 4- 7: Average Silhouette Width when *K*=9 (Almahri, Bell and Arzoky, 2019b)

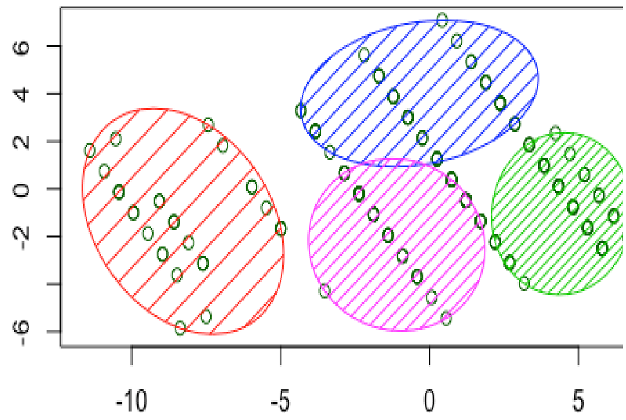


Figure 4- 8: Four Clusters of Students (first phase of data analysis) (Almahri, Bell and Arzoky, 2019b)

The first data analysis resulted in four student clusters. Figure 4-9 presents the distribution of the student data in each cluster. There were 15%, 32%, 22% and 31% of students in Cluster 1, Cluster 2, Cluster 3 and Cluster 4, respectively. Statistical summaries of the first phase of data analysis in Table 4-4 shows the results of applying K-means clustering to the First Dataset. The two main attributes are attendance, which is an indicator of behavioural engagement (physical engagement), and grade, which represents students' performance.

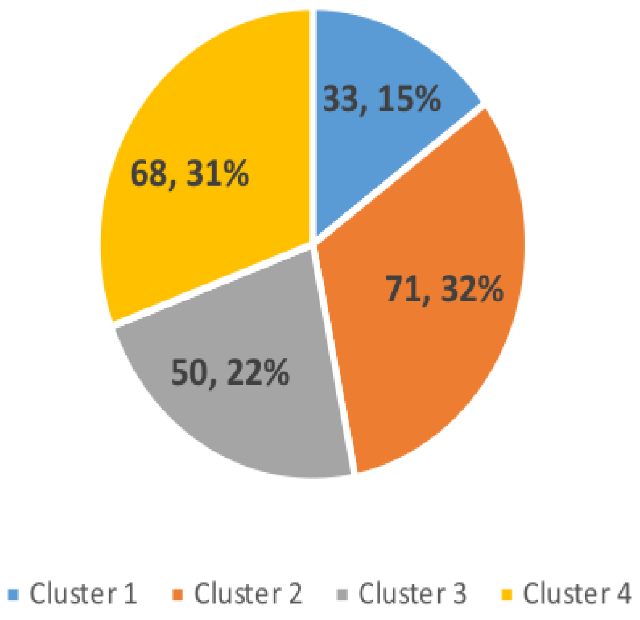


Figure 4- 9: The Four Clusters from the First Phase of Data Analysis (Almahri, Bell and Arzoky, 2019b)

Cluster Number	**Attributes**	**Mean**	**Median**	**Min**	**Max**
Cluster 1	Attendance	4.00	4.00	0.00	8.00
	Grade	3.36	3.00	1.00	6.00
Cluster 2	Attendance	9.97	10.00	7.00	12.00
	Grade	14.80	15.00	12.00	16.00
Cluster 3	Attendance	3.92	4.00	1.00	6.00
	Grade	12.48	12.00	9.00	15.00
Cluster 4	Attendance	7.56	7.00	5.00	12.00
	Grade	10.19	9.00	6.00	12.00

Table 4- 4:Statistical Summary of the First Phase of Data Analysis (Almahri, Bell and Arzoky, 2019b)

Cluster 1 includes students with low grades and low attendance rates. Table 4-4 shows that the median of student attendance was 4 out of 12 labs (30%); the median of the grade attained was 3 out of 17 (17%). The attendance of students in Cluster 1 ranged between 0% and 66%. Similarly, their grades were all less than 50% (F to D). Cluster 1 is referred to as "very low engagement and very low performance" (Table 4-5). Cluster 2 includes students with high attendance rates and high grades. Table 4-4 shows that the median of student attendance was 10 out of 12 labs (83%); the median of the grade attained was also high at 15 out of 17 (88%). Their attendance rates ranged between 56% and 100%, and their grades ranged from 12 to 16 (B to A+). Cluster 2 is referred to as "high engagement and high performance" (Table 4-5). Cluster 3 includes students with low attendance rates and very good grades. Table 4.-4 shows that the median of student attendance was only 4 out of 12 labs (30%), and the median of the grade attained was 12 out of 17 (70%). The rates of attendance were all less than 50%, while the grades ranged between 52% and 88% (C to A). Cluster 3 is referred to as "low engagement and high performance" (Table 4-5). Finally, Cluster 4 includes students with good attendance rates and low grades. Table 4-4 shows that the median of student attendance was 7 out of 12 labs (58%), and the median grade was 9 out of 17 (52%). The attendance ranged between 5 and 12 (40% to 100%), while the grades ranged between 35% and 70%. Cluster 4 is referred to as "better engagement and low performance" (Table 4-5). Descriptions of the four clusters that resulted from the analysis of the First Dataset, along with their rules, are provided in Table 4-5 (Almahri, Bell and Arzoky, 2019b).

Cluster Number	Cluster Title	Description	Rule
Cluster 1	Very low engagement and very low performance	A positive correlation between student engagement and performance	Attendance around 30%; grade around 17%
Cluster 2	High engagement and high performance		Attendance around 83%; grade around 88%
Cluster 3	Low engagement and high performance	A negative correlation between student engagement and performance	Attendance around 30%; grade around 70%
Cluster 4	Better engagement and low performance		Attendance around 58%; grade around 52%

Table 4- 5: The Four Clusters' Descriptions and Rules (Almahri, Bell and Arzoky, 2019b)

4.3.2 Results of the Second Dataset Analysis

The elbow, silhouette, and gap statistics are methods used to identify the K-values before running the K-means clustering, as discussed in Chapter 2. Three methods were run to analyse the Second Dataset, producing three different values: K=4, 2 and 1, as shown in Figures 4-10,

4-11 and 4-12, respectively. However, because the initial value of the K-means clustering algorithm started at K=2, K=1 was excluded, which results from running the gap statistic method. Therefore, to identify the optimal values for *K*, the elbow method and silhouette method were used, and it produced two results: 0.47 and 0.34 (Figures 4-13 and 4-14, respectively). *K*=2 was chosen as the optimal value for *K*. Running the K-means clustering when *K*=2 produced two clusters. Interpreting the results of the analysis presents two clusters of students (Almahri, Bell and Arzoky, 2019b).

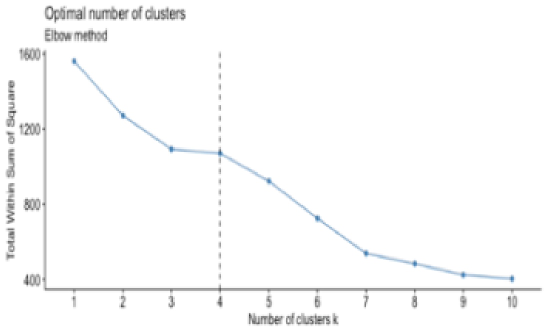


Figure 4- 10: Elbow Method
(Almahri, Bell and Arzoky, 2019b)

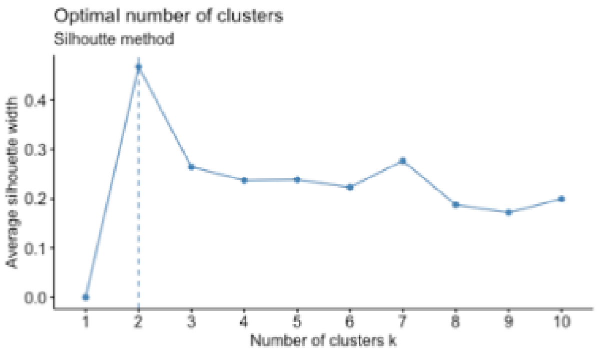


Figure 4- 11: Silhouette Method
(Almahri, Bell and Arzoky, 2019b)

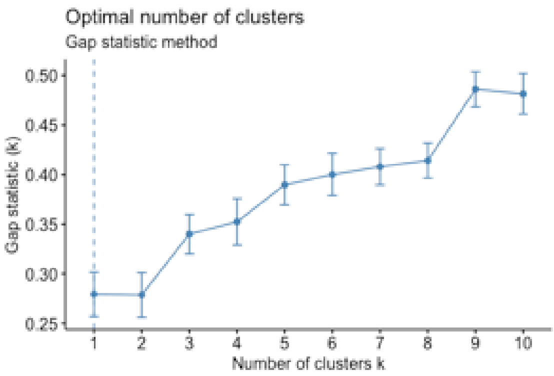


Figure 4- 12: Gap Statistic Method
(Almahri, Bell and Arzoky, 2019b)

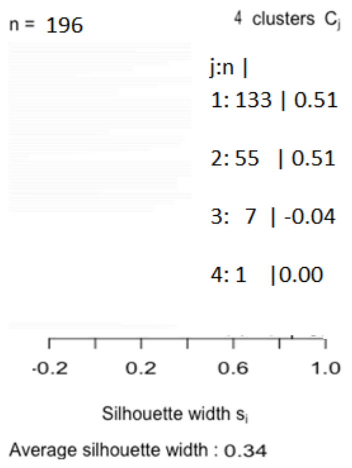


Figure 4- 13: Average Silhouette Width when *K*=4(Almahri, Bell and Arzoky, 2019b)

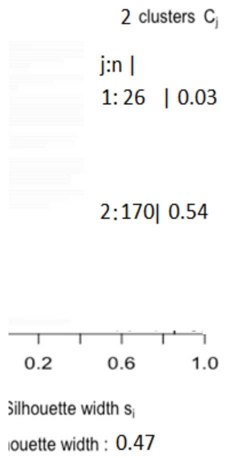


Figure 4- 14 Average Silhouette Width when *K*=2(Almahri, Bell and Arzoky, 2019b)

The clustering analysis for the Second Dataset, described in Table 4-5, produced two clusters. Most students were in Cluster 1 (87%), and a minority were in Cluster 2 (13%) (Figure 4-15). Cluster 1 refers to "less active" students, and Cluster 2 refers to "more active" students. Interestingly, most students were less active – they did not spend much time interacting with materials in the VLE. All variables in Cluster 1 had mean values less than Cluster 2, except for grade. Students in Cluster 2 spent more hours on course activity (course access), content (content access), collaboration (course user participation), and communication (user form participation). However, they had the same median value as students in Cluster 1. The mean grade values for Cluster 1 and Cluster 2 were also the same. Another interesting finding is that active participation in the VLE found to be an indicator of student engagement (Dale and Lane, 2007), did not influence student performance. The two clusters had the same grade results, as represented by the median grade in Table 4-6. Descriptions of the two clusters that resulted from the second analysis, along with their rules, are shown in Table 4-7.

Findings from the data analysis point that the gap statistic method resulted in *K*=1 in both datasets compared to other methods, which gave different values(Figures 4-5 and 4-12) (Almahri, Bell and Arzoky, 2019b).

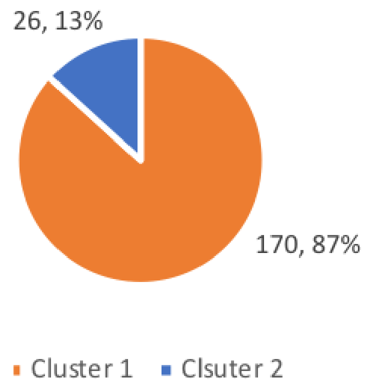


Figure 4- 15: The Two Clusters from the Second Phase of Data Analysis (Almahri, Bell and Arzoky, 2019b)

Cluster Number	Attributes	Mean	Median	Min	Max
Cluster 1	Course Activity	6.11	4.96	0.39	25.62
	Content	10.88	10.00	1.00	31.00
	Collaboration	16.04	13.00	1.00	55.00
	Communication	1.43	1.00	0.00	9.00
	Grade	10.97	12.00	1.00	16.00
Cluster 2	Course Activity	17.05	13.32	6.25	34.55
	Content	31.27	32.00	8.00	53.00
	Collaboration	71.73	42.50	13.00	682.00
	Communication	6.69	6.00	0.00	24.00
	Grade	10.96	11.50	3.00	16.00

Table 4- 6: Statistical summary of the second phase of data analysis (Almahri, Bell and Arzoky, 2019b)

Cluster Number	Cluster Title	Description	Rules
1	Less active or less engaged	The means of all the variables were two or three times lower than those for Cluster 2, except the grade variable	The means were 6.11, 10.88, 16.04, 1.43 and 10.97 for course activity, content, collaboration, communication, and grade, respectively
2	More active or more engaged	The means of all the variables were two or three times higher than those for Cluster 1, except the grade variable	The means were 17.05, 31.27, 71.73, 6.69 and 10.96 for course activity, collaboration, content, communication, and grade, respectively

Table 4- 7:The Two Clusters' Descriptions and Rules (Almahri, Bell and Arzoky, 2019b)

4.3.3 Building Persoan3D Models

Section 4.2.3 covers designing the Persona3D template for university students based on analysing the persona model elements in the literature review. The proposed university student persona consists of several main components and their elements. They are 1) demographic data; including name, age, gender and language, 2) educational data; including major, year of study, college name and university name, and 3) skills. Furthermore, the First Dataset analysis produced two main attributes that distinguished the groups: attendance, which is an indicator of behavioural engagement representing the physical engagement, and grade, which represents students' performance. These two attributes were added to the Persona3D template. The analysis of the Second Dataset produced another essential characteristic: the level of interaction with the VLE (either low or high), representing the virtual engagement. Skills data are obtained from the 2nd-year computer science module outline. This attribute also added to the Persona3D template. Table 4-8 shows the list of all categories in the university student Persona3D template. Persona3D template for university students and an example university student persona are shown in Figures 4-16 and 4-17, respectively (Almahri, Bell and Arzoky, 2019b).

Components of student Persona3D template	
Demographic data	Educational data
Interaction with the VLEs (Virtual engagement)	Engagement (physical engagement) and performance
Skills	

Table 4- 8: Components of the Student Persona3D Template adapted from (Almahri, Bell and Arzoky, 2019b)

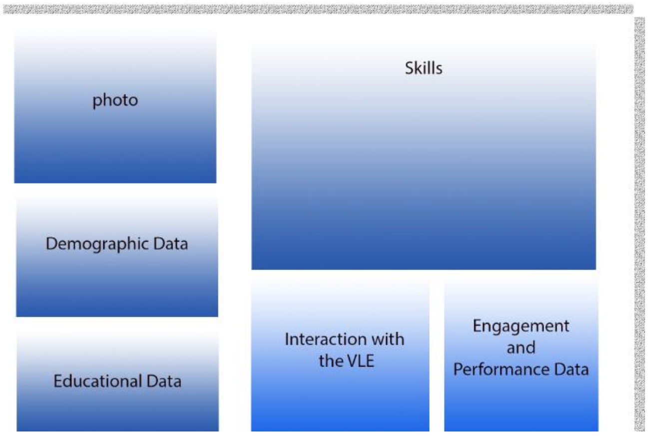


Figure 4- 16: Persona3D Template for University Students adapted from(Almahri, Bell and Arzoky, 2019b).

As presented in Section 4.3.2, the first data analysis produced four Persona3D models, based on physical engagement data (attendance) and performance (grade), as shown in Tables 4-4 and 4-5. The second data analysis produced two Persona3D models, based on virtual engagement (interactions with VLEs) and performance (grade), as shown in Tables 4-6 and 4-7. As the two datasets were for second-year computer science students at Brunel University and performance was a common attribute in the two datasets, combining the results of the two data analysis processes produced eight Persona3D models, as shown in Table 4-9 (Almahri, Bell and Arzoky, 2019b).

Result of the first data analysis	**Result of the Second data analysis**	**Result of combining the two data analysis result**	**Persona name**
Very low engagement (physical engagement) and very low performance	High engagement (virtual engagement)	Very low engagement (physical engagement) High engagement (virtual engagement) very low performance)	Unsuccessful self-learner
	Low engagement (virtual)	Very low engagement (physical engagement) Low engagement (virtual) very low performance	Disengaged student

High engagement (physical engagement) and high performance	High engagement (virtual engagement)	High engagement (physical engagement) High engagement (virtual engagement) high performance	The top student
	Low engagement (virtual engagement)	High engagement (physical engagement) Low engagement (virtual engagement) high performance	Successful student
Low engagement (physical engagement) and high performance	High engagement (virtual engagement)	Low engagement (physical engagement) High engagement (virtual engagement) high performance	Self-learner
	Low engagement (virtual engagement)	Low engagement (physical engagement) Low engagement (virtual engagement) high performance	Experienced student
Better engagement (physical engagement) and low performance	High engagement (virtual engagement)	Better engagement (physical engagement) High engagement (virtual engagement) low performance	The student with Learning Difficulty
	Low engagement (virtual engagement)	Better engagement (physical engagement) Low engagement (virtual engagement) low performance	Unsuccessful student

Table 4- 9: Combining the Results of the Two Data Analysis Process (Almahri, Bell and Arzoky, 2019b)

Based on the discussion above, specific and tangible attributes were selected to build the Persona3D template (Figure 4-17). After identifying the Persona3D template, the next step was identifying a typical user and building the Persona3D model for each group to create a Persona3D model that represented a real person. Therefore, for each cluster, the average score is calculated. This iteration identified the groups and the attributes that distinguished them. The average score for each distinct criterion is computed, and a record for the student who had the score nearest to the average score of the cluster is chosen. The user was a typical user, and their data used to present the persona (Tu *et al.*, 2010). The student Persona3D in Figure 4-17 represents a high virtual and physical engagement and performance student persona. Physical engagement is represented by attendance, while virtual engagement represented by interactions with VLEs(Almahri, Bell and Arzoky, 2019b).

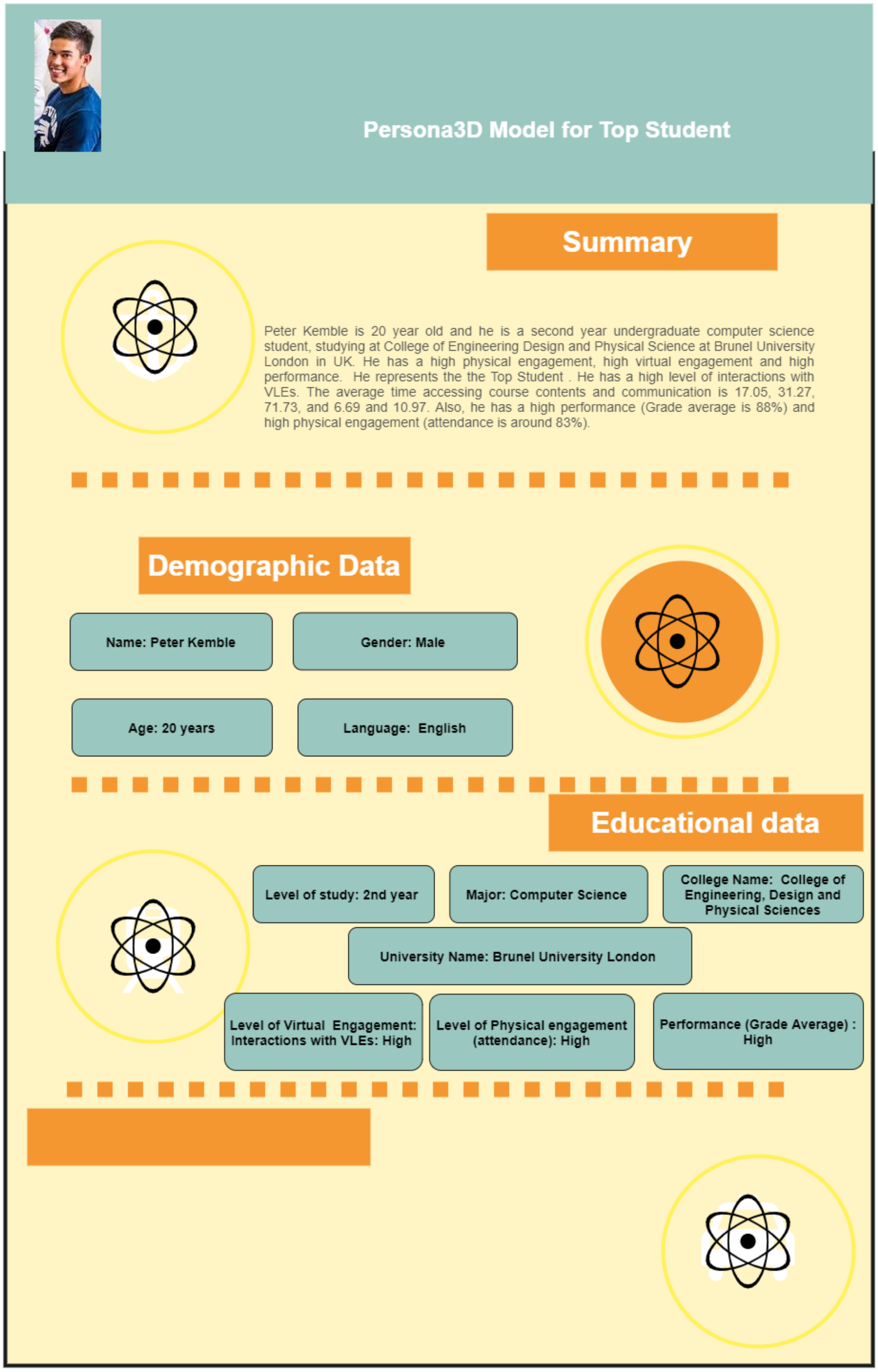


Figure 4- 17: An example of a University Student Persona3D Model

4.4 Artefacts Evaluation

As mentioned in Chapter 3, the DSR method covers iterations, and in each iteration, there is a design, build, and evaluation of the artefacts. Evaluation criteria vary based on the proposed artefacts, whether it is constructs, models, methods, or instantiations, as shown in Table 4-10, adapted from (Hevner *et al.*, 2004).

This section evaluates the completeness of the Persona3D model and the efficiency of the Persona3D method prototype. Firstly, the completeness of the model is evaluated by comparing the elements of the Persona3D template extracted from a list of high-quality papers and comparing if the proposed Persona3D template contains these elements and others, as shown in Table 4-10. The table shows that the Persona3D template contains all the elements suitable for educational purposes; there are other elements not applicable to student personas. This confirms the completeness of the Persona3D model. Secondly, the efficiency of the Persona3D method is evaluated by comparing the proposed method (computational approach) with literature that use workshops as a source to build personas. The proposed approach mainly focuses on looking at the data and building the personas based on that, which is easier and takes less time and effort when compared to the traditional way of conducting the workshop to build personas. In summary, this evaluation confirms the completeness of the Persona3D model and the efficiency of the Persoan3D method.

Authors	Name	Age	Gender	picture	Year of Study[i]	Major	College Name	University[ii]	Location[iii]	Persona Type	Interactions with VLEs	Physical engagement	Preference[iv]	Grade	Studying	Moving	Summary [v]	Technology used (or proposed)	Personality	General use of the computer and internet	Profession /job	Eating	Motivations for taking courses.	Residential status /relationship
(Shiga and Nishiuchi, 2013)	√	√	√	√	√									√										
(Quintana *et al.*, 2017)	√	√	√	√													√	√					√	
(Kimita, Nemoto and Shimomura, 2014)	√	√	√	√	√	√		√			√													√
(Ferreira *et al.*, 2018)	√	√	√	√	√															√			√	√

(Valentim, Silva and Conte, 2017)	√	√		√					√												√			
(Polst, S. and Stüpfert, 2019)	√	√		√							√						√		√		√			√
This research (Almahri, 2020)	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	NA	NA	NA	NA

Table 4- 10: Evaluating Completeness of Persona3D Model

[i] Or highest qualification
[ii] organisation
[iii] places of residence
[iv] Either: interactive learning or classroom lecture
[v] Or back story

4.5 Limitations of the Study

This section highlights the limitations of the study presented in this chapter. As mentioned previously in chapter 2, there are three types of engagements: behavioural engagement, emotional engagement, and cognitive engagement (Bloom, 1965). However, this study focuses only on one type, which is behavioural engagement. Additionally, this study covers two types of behavioural engagement: attendance (physical engagement) and interaction with VLEs (virtual engagement). There is a need to collect more data, which should include all factors of behavioural engagement and other types of engagement mentioned earlier. Also, the raw data belongs to computer science students; however, it would be much better if the data represents different departments in the university.

Another limitation is that this iteration uses a quantitative method to build the Persona3D model. The raw data was a representation of students in the years 2014 and 2016, which may be considered not up to date. The generated Persona3D model would be more apposite if interviews were used to collect further data. Also, the collected data used only one variable for measuring the outcome (grades) in the two data analysis processes.

4.6 Specify the Learning

The persona elicitation iteration reveals several primarily points of learning:

- Data preparation is a very critical step that requires understanding and cleaning the data before doing any analysis. However, this process can be time-consuming to perform.
- Performing the analysis with the R programming language is impressive. R provides a fascinating graphic to show the result of the data analysis and has many free packages to install. However, the development encountered several errors that needed resolution by searching the internet for possible solutions to solve the error.
- Remarkably, the results of the data analysis show that engagement does not always affect student performance. Besides, active participation does not influence

student engagement. Thus, there might be other factors that affect student engagement.

- Interestingly, the Gap Statistic method used to find the k-values produced *K* =1 in both datasets, which is an inconsequential value as the minimum value for *K* should be 2.

4.7 Conclusion

This chapter focuses on the first iteration, personas elicitation, which aims to identify student groups from the existing data. In order to achieve this, the Persona3D method was proposed, which contains three phases. Persona3D method utilises a machine learning framework, more specifically, k-means clustering. This iteration design and build have three primary artefacts: Persona3D template, Persona3D model, and Persona3D method. Persona3D models and method are evaluated in terms of completeness and efficiency, respectively, and the results confirm the completeness and efficiency of the proposed Persoan3D model and method.

The present iteration makes several noteworthy contributions to the current literature. Initially, it proposed a quantitative Persona3D that mainly uses *K*-means clustering analysis and three methods to identify the *K* values: elbow, silhouette, and gap statistic methods. It is an applicable, cheap, and straightforward method compared to other methods. Moreover, the data analysis produced the Persona3D template and eight distinct Persona3D models for university students.

The first design science iteration documented the Persona3D model for various user groups. However, these Persona3D models does not cover how these user groups will interact effectively with the chatbots technology. Therefore, the next chapter will overcome this limitation by extending the Persona3D model and methods by adding more elements to the Persona3D related to the chatbots supported interaction.

CHAPTER 5- EXTENDED UTAUT2

5.1 Introduction

In the first iteration, student groups were identified and described using personas. The next step would be to identify effective methods of interaction with each group (including specific calls-to-action; CTA). This necessitates extending the persona model (Persona3D) to provide appropriate categories/elements for chatbots supported interaction, which requires understanding how these personas are likely to accept and use the chatbots technology. This iteration extends the primary artefacts (Persona3D models and method) of the previous iteration to include additional elements that contribute to the final artefacts' development in the third iteration, that is, the chatbots.

This chapter is structured as follows; Section 5.2 introduces the research design and outputs artefacts and conceptual framework design (Extended UTAUT2. Also, it includes the pilot study result. Section 5.3 outlines the design and development of the survey, conceptual framework (Extended UTAUT2 Model), and hypothesis. Furthermore, it discusses the descriptive analysis of the respondents, the primary constructs, and the moderators of the proposed model. Section 5.4 presents the evaluation of the measurement model, the moderators, and the hypothesis. It also presents the evaluation of the sample size to determine its adequacy. Section 5.5 presents the extended persona3D models and method, which were initially built in Chapter 4. Section 5.6 highlights the limitations of this chapter, and Section 5.7 provides an overall summary of the chapter.

5.2 Design Research and Output Artefacts

The design science research methodology was applied as an iterative process in this iteration, where understanding the problem space is accomplished by developing and evaluating the artefacts. Models are used to simulate a real-world situation as an issue and its solution statement (March and Smith, 1995). Figure 5-1 shows the research iterations as an iterative process of artefact building and evaluation based on the design research methodology proposed by Vaishnavi and Kuechler (2004). The purpose of this design research iteration is to understand how different personas created in the previous iteration are likely to accept and use the chatbots technology and the way the system interacts effectively with the proposed user groups. The generated Persona3D model from chapter 4 contains only descriptive information about the student, such as demographic data, performance, and virtual and physical engagement. However, it does not include any details on how these personas can be motivated to interact with the system (including specific CTA). Therefore, this iteration overcomes this limitation by extending the Persona3D models and method with the required and missing information related to practical approaches.

As discussed in Chapter 2, various theories and models have been proposed to explain the relationship between users' attitudes, beliefs and behavioural intentions (BI) to use the technology (Tarhini *et al.*, 2016). A comparison of the technology acceptance theories and models is shown in Chapter 2 (see, Table 2-1). After analysing the literature, it was found that the Unified Theory of Acceptance and Use of Technology 2 (UTAUT2), developed by (Venkatesh, Thong and Xu, 2012), is a suitable model to study the acceptance and use of technology. UTAUT2 model is robust, and it is an updated version of UTAUT, which comes as a result of reviewing and analysing eight models/theories of technology acceptance and usage: Innovation Diffusion Theory (IDT), Theory of Planned Behaviour (TPB), Theory of Reasoned Action (TRA), the Motivational Model(MM), Social Cognitive Theory (SCT), the Model of Perceived Credibility (PC), the Technology Acceptance Model (TAM), and a hybrid model combining constructs from TPB and TAM (Venkatesh, Thong and Xu, 2012).

UTAUT2 has also been used to study student acceptance and use of technology in an educational context for different applications(Almahri, Bell and Merhi, 2020), such as the Learning Management Systems (LMS)(North-Samardzic and Jiang, 2015), mobile-based educational applications (Ameri *et al.*, 2019), lecture capture systems, MOOC platforms (Mafraq and Kotb, 2019), Google Classroom(Jakkaew and Hemrungrote, 2017), eLearning systems(El-Masri and Tarhini, 2017), mobile Etextbooks(Bhimasta, 2016) and mobile-learning(Yang, 2013). It is essential to mention that UTAUT3 is not suitable for this study because it is for the educational context. According to (Gunasinghe *et al.*, 2019), using UTAUT3 in an educational context has limited validity. Therefore, this study excluded using UTAUT3.

As discussed in Chapter 2, the UTAUT2 model contains three moderators: age, gender and experience. UTAUT2 model studies the effects of these moderators on the relationship between the primary constructs and BI and USE of technology constructs. These attributes are similar to attributes in the Persona3D models generated in Chapter 4. This iteration aims to find out how these different personas are likely to use and accept technology.

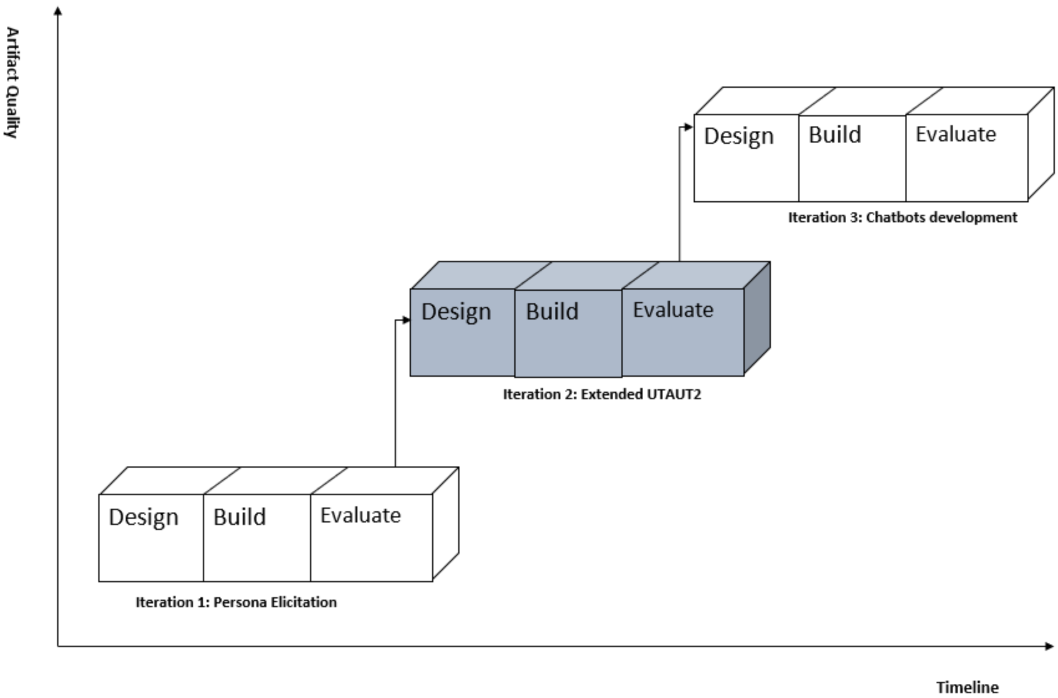


Figure 5- 1: Research Iterations

The novelty of this iteration is the extension of the Persona3D model generated from Chapter 4 to include further information. This information documents the persona elements/attributes of each group (such as demographic data, performance, and engagement) and shows how each user group effectively uses the system (chatbots). An Extended UTAUT2 is designed, built, and evaluated to contribute to the design of an effective method of interaction, which is then used in the subsequent design research iteration to build more effective persona-based chatbots.

5.2.1 Design Research Artefacts

As mentioned earlier, this chapter aims to extend the primary artefacts of the first design research iteration, which are the Persona3D model and method to include additional attributes/elements for chatbots supported interaction. This requires the designing, building, and developing the Extended UTAUT2 model that involves performing several steps shown in Table 5-1.

Step	Method	Input Artefacts	Output Artefacts
1.Identify technology acceptance models and theories	Model identification and analysis	Popular technology acceptance models and theories	UTAUT2 model
2.Extend the UTAUT2 model	Model adaption	UTAUT2 model and Persona Model	Extended UTAUT2 model
3.Design survey that supports Extended UTAUT2	Survey design	Survey of UTAUT2 (Literature) and new questions which support the extended part of UTAUT2.	Extended UTAUT2 Survey
4.Building and distribution of Extended UTAUT2 survey	Survey Distribution	Extended UTAUT2 Survey	Collected survey responses (Dataset)
5.Validate the Extended UTAUT2 model	Model Validation – Structured Equation Modelling	Extended UTAUT2 model	Validated Extended UTAUT2 model
1. Designing and building Extend Persona3D model	Model adaption	Attributes extracted from evaluating the Extended UTAUT2 model and Persona3D model	Extended Persona3D model

Designing and building Extend Persona3D method	Method adaption	Steps to extract features from the Extended UTAUT2 model and Persona3D method	Extended Persona3D Method

Table 5- 1: Iterations steps Input and Output Model

The iteration covers evaluating the Extended UTAUT2 survey regarding the adequacy of the sample size of the participants using two tests, the KMO and Bartlett's Test (see, Section 5.4.1). It also covers evaluating its validity and reliability to improve the survey questions' format, questions, and scales (see, Section 5.2.4.2). Furthermore, this iteration evaluates the Extended UTAUT2 model in terms of internal consistency reliability, indicator reliability, convergent validity, and discriminant validity (see, Section 5.4.2) (Pheeraphuttharangkoon, 2015).

5.2.2 Design Model for Understanding Student Acceptance of Chatbots for Different Personas- Extended UTAUT2

This section covers the design of the proposed Extended UTAUT2 model and aims to understand student acceptance of chatbots for different personas. The Extended UTAUT2 constitutes extending the Persona3D model with some attributes/features that contribute to the chatbot's design. It also explains the acceptance and use of chatbots technology within the undergraduate and postgraduate students (Masters level) at Brunel University London. UTAUT2 (Venkatesh, Thong and Xu, 2012) discusses how to use the technology, in this case, the chatbots. It explains the behavioural intention to use chatbots (BI) and seven constructs: performance expectancy, effort expectancy, social influence, facilitating conditions, hedonic motivation, price value, and habit. The moderators in UTAUT2 are age, gender, and experience. However, this study will exclude price value because the proposed chatbots will be free to use. An expanded list of moderators, including the UTAUT2 moderators, will also be included in the proposed model and test in the evaluation phase. The moderator is a persona, which contains seven main components: age, gender, experience, physical engagement (attendance), virtual engagement (level of engagement with VLEs), educational level, and grade (performance). Figure 5-2 shows the proposed conceptual framework (Extended UTAUT2), with a detailed explanation of each construct presented in Section 5.2.3.

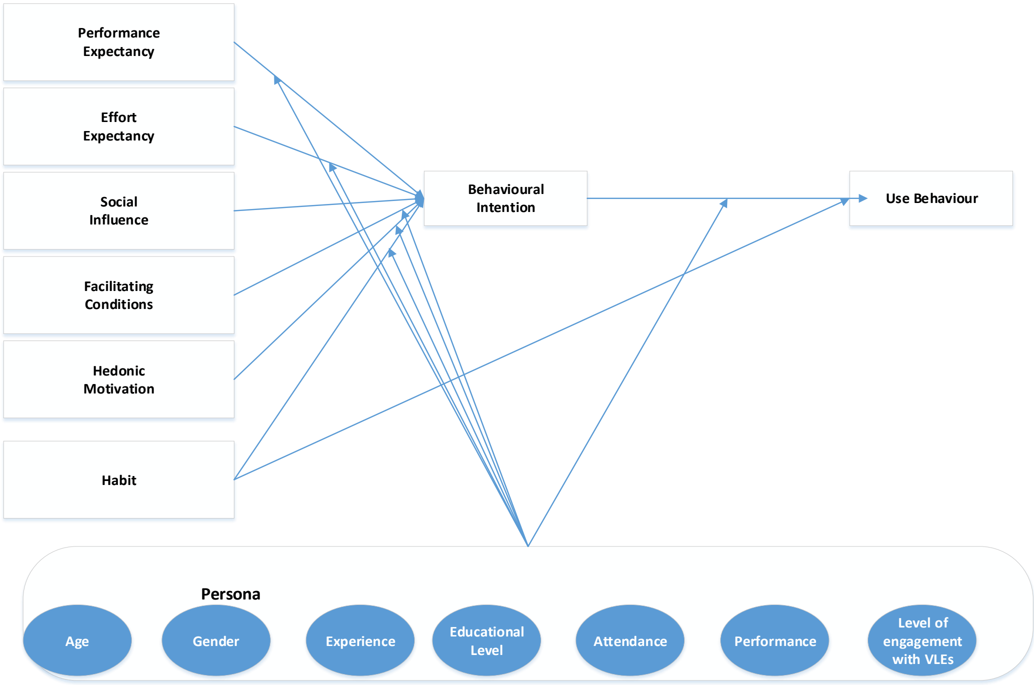


Figure 5- 2: Extended UTAUT2 Model -Conceptual Framework

5.2.3 Extended UTAUT2 and Hypothesis Design

This section explains the Extended UTAUT2 model introduced in the preceding section (Section 5.2.2) and the hypothesis design.

Performance expectancy (PE) is defined as "the degree to which an individual believes that using the system will help him or her to attain gains in job performance" (Venkatesh *et al.*, 2003, p. 447). Prior research has identified PE as a significant predictor of BI-(Venkatesh *et al.*, 2003; Raman and Don, 2013). **Hypothesis 1:** PE will have a positive effect on students' behavioural intention to use Chatbots.

Effort expectancy (EE) is defined as "the degree of ease associated with the use of the system" (Venkatesh *et al.*, 2003, p. 450). EE and its latent variable were significant in many research studies and proven to predict user intention to adopt new technology (Venkatesh, Thong and Xu, 2012; Zhou, Lu and Wang, 2010;

Raman and Don, 2013). **Hypothesis 2**: EE will have a positive effect on students' behavioural intention to use Chatbots.

Social influence (SI) is defined as "the degree to which an individual perceives that important others believe he or she should use the new system" (Venkatesh *et al.*, 2003, p. 451). SI was significant in specifying user intention to use the technology in many studies (Moore and Benbasa, 1991; Thompson, Higgins and Howell, 1991; Raman and Don, 2013). **Hypothesis 3:** SI will have a positive effect on students' behavioural intention to use Chatbots.

Facilitating condition (FC) is defined as "the degree to which an individual believes that an organisational and technical infrastructure exists to support the use of the system" (Venkatesh *et al.*, 2003, p. 453). **Hypothesis 4:** FC will have a positive effect on students' behavioural intention to use Chatbots.

Hedonic motivation (HM) is defined as "the fun or pleasure derived from using technology "(Venkatesh, Thong and Xu, 2012, p. 8). Studies have proven that HM plays a decisive role in determining technology acceptance and use of technology (Brown and Venkatesh, 2005; Venkatesh, Thong and Xu, 2012; Raman and Don, 2013). **Hypothesis 5:** HM will have a positive effect on students' behavioural intention to use chatbots.

Habit (HT) as a construct in UTAUT2 (Venkatesh, Thong and Xu, 2012) is defined in the Information Systems and Technology context as "the extent to which people tend to perform behaviours (use IS) automatically because of learning" (Limayem, Hirt and Cheung, 2007). HT is defined in two ways: prior behaviour (Limayem, Hirt and Cheung, 2007), or automatic behaviour (Kim and Malhotra, 2005). According to the UTAUT2 model, HT has a direct and indirect effect on the use of technology (Venkatesh, Thong and Xu, 2012; Raman and Don, 2013). **Hypothesis 6:** HT will have a positive effect on students' behavioural intention to use Chatbots.

Behavioural I**ntention (BI)** -prior research has defined behavioural intention as a "function of both attitudes and subjective norms about the target behaviour, predicting actual behaviour" (Pickett *et al.*, 2012). Their BI can assess the strength of individual commitment to engage with particular activities (Lewis *et al.*, 2013).

Hypothesis 7: BI will have a positive effect on students' behavioural use of Chatbots.

The study extends the moderator with more elements, which are now part of the personas moderator. An explanation of each moderator is provided as follows:

• **Age** – is a moderator in UTAUT and UTAUT2. It impacts all seven core constructs that affect users' intention and use of technology (Fuksa, 2013). This study tests whether age moderates the effect of determinants on BI and the use of technology. **Hypothesis 8 (H8a1, a2, a3, a4, a5, a6):** Age moderates the effects of PE, EE, SI, FC, HM and HT on student BI and use of chatbots technology.

• **Gender** – Like the age moderator, gender is a moderator in UTAUT and UTAUT2, and also impacts all seven core constructs that affect users' intention and use of technology (Fuksa, 2013). This study will test whether gender moderates the effect of determinants on BI and the use of technology. **Hypothesis 9(H9b1, b2, b3, b4, b5, b6):** Gender moderates the effects of PE, EE, SI, FC, HM, and HT on student BI and use of chatbots technology.

• **Experience** – is a moderator in the UTAUT and UTAUT2 model. It is defined as a mobile internet usage experience (Fuksa, 2013). In this study, experience presents the prior experience of using chatbots such as Siri or Amazon Alexa. This study will test whether experience moderates the effect of determinants on BI and the use of chatbots technology. **Hypothesis 10(H10c1, c2, c3, c4, c5, c6):** experience moderates the effects of PE, EE, SI, FC, HM and HT on student BI and use of chatbots technology.

• **Physical engagement (represented by attendance)** is a new moderator that stemmed from a proposed persona model in Chapter 4. It is a behavioural engagement indicator with the module. This study test whether attendance moderates the effect of determinants on BI and the use of technology. **Hypothesis 11(H11e1, e2, e3, e4, e5, e6):** attendance moderates the effects of PE, EE, SI, FC, HM and HT on student BI and use of chatbots technology.

• **Virtual engagement (represented by the level of engagement with VLEs**) is a new moderator that stemmed from a proposed persona model in Chapter 4. It is a behavioural engagement indicator with the course. This study tests whether virtual engagement with VLEs moderates the effect of determinants on BI and the use of technology. **Hypothesis 12(H12f1, f2, f3, f4, f5, f6):** virtual engagement with VLEs moderate the effects of PE, EE, SI, FC, HM and HT on student BI and use of chatbots technology.

• **Educational level (Year of Study)** is a new moderator representing the year of study for undergraduate students. This moderator tests whether year-of-study moderates the effect of determinants on BI and the use of technology. **Hypothesis 13(H13g1, g2, g3, g4, g5, g6):** educational level moderates the effects of PE, EE, SI, FC, HM and HT on student BI and use of chatbots technology.

• **Grade** is a new moderator that represents the performance of the student. It tests whether grade moderates the effect of BI and the use of technology. **Hypothesis14(H14d1, d2, d3, d4, d5, d6):** Grade moderates the effects of PE, EE, SI, FC, HM, and HT on student BI and use of chatbots technology.

5.2.4 Survey Design

The survey was designed to achieve this iteration's aim and answer the research question of this study (Saunders, M., Lewis, P. and Thornhill, 2009). The survey was developed after reviewing the literature, specifically the technology acceptance models and theories(see Chapter 2, Section 2.4). The adopted and extended UTAUT2 model is referred to as the Extended UTAUT2. The survey aims to study students' acceptance and use of chatbots at Higher Education Institutions (HEIs). The survey contains two sections. The first section includes questions related to the main determents/constructs of UTAUT2: PE, EE, SI, HM, FC, HT, BI and USE, as mentioned in section 5.2.3. The second section includes questions related to demographic data and moderators. Also, the survey consists of some questions related to the type of used chatbots, the experience of using chatbots, and how long participants have been using them.

5.2.4.1 Measurement

The scales of this study were adopted from previous studies that used UTAUT2, with all constructs measured using seven items (7-point Likert-scale), having items of each construct adopted from (Venkatesh, Thong and Xu, 2012). A seven-point Likert Scale was used to measure the items that represent each construct, ranging from 1 (strongly disagree) to 7 (strongly agree). Demographic questions were also included to describe the population under study. Further questions were added, each question with reference to the literature, to achieve the aim of this survey.

5.2.4.2 A Pilot Study

Before conducting the data collection, ethical approval from the ethical committee at Brunel University London was obtained (see, Appendix A, ethical approval). A pilot study is significant before conducting the actual data collection to test the validity and reliability of the survey and improve the questions, questions scale and scales (Creswell, 2014). A pilot study establishes the ability to answer the proposed research question and provide face validity (Presser *et al.*, 2004; Sekaran and Bougie, 2011; Zikmund *et al.*, 2009). The sample size for the pilot study should be relatively small, a maximum of 100 (Nargundkar, 2003). Therefore, a pilot study with 99 randomly selected students was carried out.

It is essential to mention that all the questions included in the survey were from the literature. They have been tested and proven valid and reliable to measure the constructs (see, Appendix B, for Survey). The survey questions were adopted from UTAUT2, which has been used in many studies to investigate user acceptance and use of different types of technology.

The pilot study highlighted several minor suggestions from the computer science and non–computer science participants. The computer science participants included PhD students, postdoctoral researchers, lecturers, and undergraduate students. Also, there are participants from outside the Department of Computer Science included a lecturer from the English Language Centre, an ASK team member from the library, staff in the Graduate School, and one undergraduate student from the Business School at Brunel University. As stated above, the pilot study resulted in minor corrections, including the survey layout and question-wording, and this confirmed the face validity.

The sampling approach used was convenience sampling. This non-probability sampling method involves taking a sample from a population that is close to hand. Convenience sampling is the most appropriate sampling technique for this study, as it is the least expensive, least time-consuming and most convenient.

The survey data were analysed to find any potential threats or drawbacks within the survey items to decide whether to keep, delete, or amend the item/question. It took participants a maximum of 8 minutes to complete the survey, which is relatively reasonable, and this confirms content validity. A table in Appendix D shows the result of the analysis on the data of the pilot study. The table shows Cronbach alpha, inter-item correlation, and item-to-item correlation. The result shows that all constructs have outstanding reliability ranging from 0.842 for HB to 0.956 for SI. This means that all measured variables used with each construct are positively correlated. Also, the table indicates two internal consistency reliability indicators: inter-item correlation ad inter-to-total correlation. According to Hair et al. (2010), the value of inter-item correlation should exceed 0.3, while item-to-total correlation 0.5. The result shows that all constructs exceed the cut-off value for inter-item correlation except for the USE construct. Therefore, after examining each USE item, it is found that USE-5 has a lower inter-item correlation (0.197); hence, USE-5 should be excluded from the survey.

5.3 Artefacts and Building Artefacts

This section covers the building and development of the Extended UTAUT2 model, which was designed in sections 5.2.2 and explained further in 5.2.3, as shown in Figure 5-2 above. Designing the survey and the hypothesis is covered in sections 5.2.3 and 5.2.4. The required steps to build the Extended UTAUT2 model are shown in Figure 5-3, with each step further described in the following subsections. This produces several artefacts, including the conceptual framework, survey, collected data, measurement model and structural model. It also involves part of the artefact evaluation covered further in the artefacts' evaluation in Section 5.4.

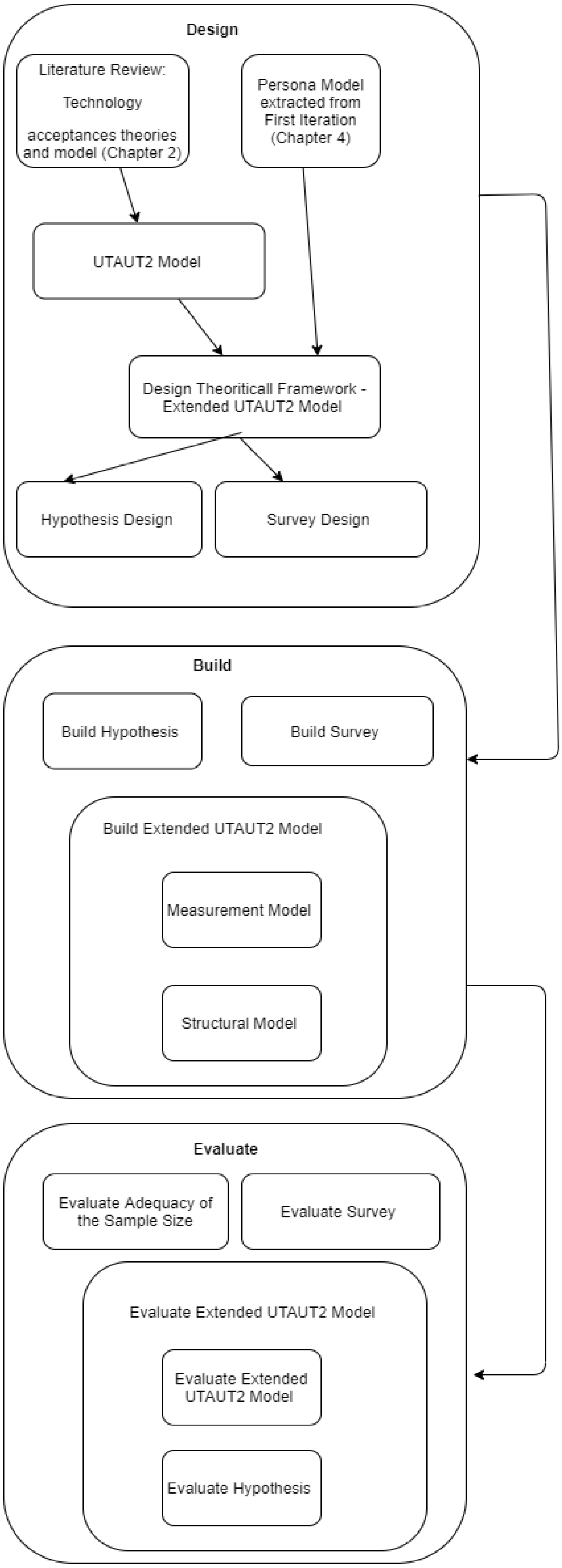


Figure 5- 3: Development of Extended UTAUT2

This chapter covers the process of designing, building and evaluating the extended UTAUT2 model, as shown in Figure 5-3. Initially, the design part involved conducting a literature review on technology acceptance models and theories, as covered in Chapter 2. It resulted in selecting the UTAUT2 model as the most suitable base model for this study. UTAUT2 and the persona model used as input in the design of the extended UTAUT2 model. The Extended UTAUT2 model was used to design the hypotheses and survey. In the building part, the designed artefacts were developed, including building the hypotheses and the survey using the Bristol Online Surveys tool and sending it to students. Then, the data were collected, and further analysis was conducted. Building the model included building the measurement model and the structural model (Figure 5-3). In the evaluation part, three evaluations were conducted: 1) evaluating the adequacy of the sample size, 2) evaluating the survey using the pilot study and 3) evaluating the extended UTAUT2 model, which included evaluating the model and hypotheses (Figure 5-3).

5.3.1 Survey Building, Distributions, and Hypothesis Building

The survey was developed using the Bristol Online Survey tool, which is a free web-based survey provided by the University. Participation in this study was completely voluntary. Participants were briefed about the aim of the study and informed about their right to withdraw at any time. In general, less than 8 minutes were required for the completion of the survey. The survey inquired about the participants' perception of chatbots. The opportunity to win one of ten £20 Amazon vouchers served as a participation reward and aimed to encourage survey responses. Weekly email reminders were sent by the Teaching Program Office (TPO) at the College of Engineering, Design and Physical Science at Brunel University London to undergraduate and postgraduate computer science students to fill in the survey. The survey was password-protected, so it could be accessed only by the targeted respondent. All of the important questions were set as mandatory in order to guarantee not missing out on data that might affect the data analysis, especially during the data analysis using SEM. Designing and building the final version of the survey spanned over five months. The survey was revised and reviewed by the expert and researcher during the pilot study (see, Section 5.2.4.2 and Appendix D). All hypotheses which were designed in section 5.2.3 were developed. The tool used to build the hypothesis is SmartPLS3, as shown in Figure 5-4.

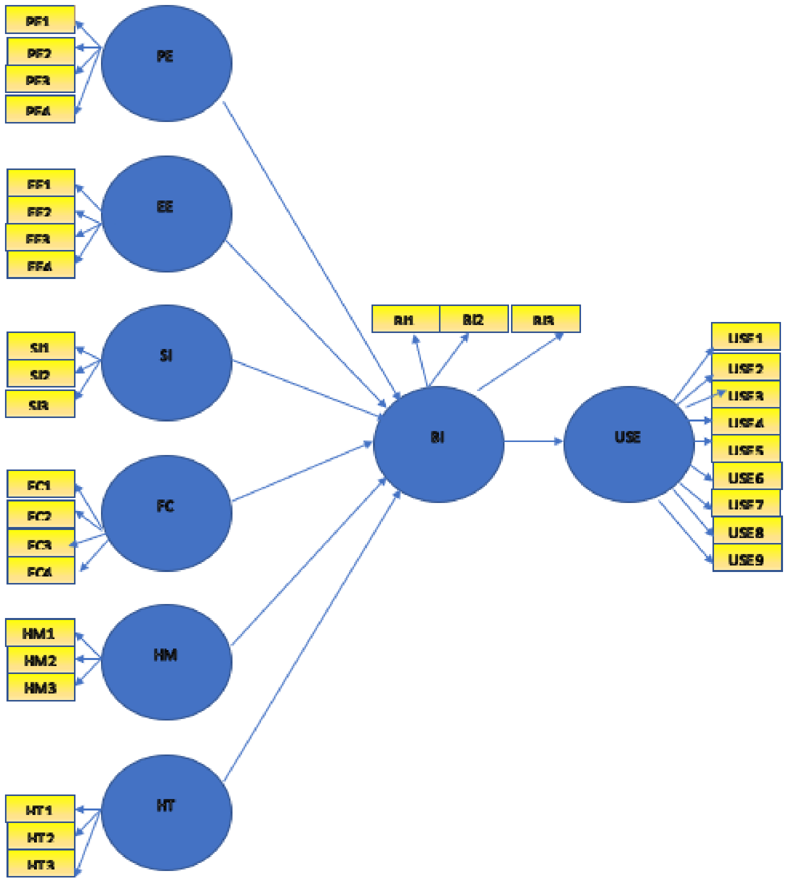


Figure 5- 4: Hypothesis Building in the Model

5.3.2 Model to Understand Students Acceptance and Use of Chatbots Technology – Extended UTAUT2

The proposed extended model (Extended UTAUT2), designed in Section 5.2.2, is developed in this section. Building the proposed model involved performing data analysis on the collected data. The collected data are in multiple formats, such as .csv and .spss. — the data analysis in this study was conducted in two main steps.

In the first step, descriptive analysis and a preliminary data analysis was performed using SPSS version 25 to understand further the collected data. It includes dealing with missing values, outliers, mean values and standard deviation (SD). In the second step, Structural Equation Modelling (SEM) was used to test the proposed Extended UTAUT2 and the relationship between variables. Further information about SEM is provided in Chapter 3.

5.3.2.1 Descriptive Analysis/ Profiles of Respondents

The descriptive analysis of the collected data using SPSS is shown in Appendix E. The result indicates that there were 233 (54.1%) male and 197 (45.7%) female participants. The participants' ages ranged five levels, with 82.1% participants in the age groups of 18-21 and 22- 25-years, while only 10% were in the 26-29 age group. The minority of age group were <18 and >= 30 age group, with 3% and 4.9% respectively.

The target participants were either at undergraduate or postgraduate level; the descriptive analysis of the participant's degree shows that most respondents were undergraduate students (94.2%), while only 5.8% were master students. Also, it shows that most students were full-time students, with 97.7%, while 2.3% were part-time students. Regarding the educational level, levels 1 and 2 presented 60% of undergraduate respondents, while 40% represented the percentage of placement and level 3. For the distributions of students grades, the result revealed that the majority of respondents (51%) and (27.4%) were in grade A's and B's respectively, while the minority (21.6%) were in grade C's, D's, F's and not applicable/prefer not to say.

The survey questioned respondents on the type of chatbots they have used (Siri by Apple, Alexa by Amazon, Cortana by Microsoft, Google Assistant by Google). Participants were allowed to select more than one answer. Siri and Google Assistant are the two most popular chatbots amongst students, while Cortana is the least popular chatbot. The result shows other chatbots that students use included Bixby by Samsung, S Voice and Tmall Genie.

In terms of chatbots usage and frequency of use, the chatbots usage category revealed that most students used chatbots (77.3 %), while 22.7% do not. The frequency use of chatbots showed more than 47.7% of students were using chatbots daily or several times a day, while the rest (52.3%) used them weekly or once a month. The category of chatbots experience shows that most participants had 1-3 years' experience and 3-5 years' experience, with 59 (35.1 %) and 35 (31.8%) respectively. Students who have less than one year of experience in using chatbots represents 20.7 %. The lowest group included more than five years, with 4%. Approximately 30% of respondents had some experience in using chatbots – they tried and used some basic functionality, while 5% of respondents had no experience.

5.3.2.2 Descriptive Analysis of the Main Study

This section covers the descriptive analysis of the primary constructs in Extended UTAUT2, including the following:

A. Performance Expectancy

Four items were used to measured PE construct and were adopted from work related to UTAUT2 (Venkatesh *et al.*, 2003; Venkatesh, Thong and Xu, 2012). These items were measured using a 7-point Likert scale. Table 5-2 shows the means for the items related to PE range between 4.58 (±1.882) and 5.21 (±1.734). The results indicated that the students found the chatbots helped in achieving their job performance.

Descriptive Statistics

	N	Mean	Std. Deviation
PE1	431	5.21	1.734
PE2	431	4.58	1.882
PE3	431	5.18	1.704
PE4	431	4.81	1.796
Valid N (listwise)	431		

Table 5- 2: Descriptive Statistics for Performance Expectancy Construct

B. Effort Expectancy

Four items were used to measured EE, and they were adopted from UTAUT2 (Venkatesh *et al.*, 2003; Venkatesh, Thong and Xu, 2012).   These items were measured using a 7-point Likert scale. Table 5-3 shows the mean for each item related to EE, construct ranges between 5.59 (±1.383) and 6.11 (±1.099), which reveal that most participants in this study agree that chatbot is easy to use.

Descriptive Statistics

	N	Mean	Std. Deviation
EE1. Learning how to use a chatbot is easy for me.	431	6.11	1.099
EE2. My interaction with a chatbot is clear and understandable.	431	5.59	1.383
EE3. I find chatbot/s easy to use.	431	6.00	1.210
EE4. It is easy for me to become skilful at using a chatbot.	431	5.84	1.291
Valid N (listwise)	431		

Table 5- 3: Descriptive Statistics for Effort Expectancy Construct

C. Social Influence

SI was measured using three adopted items from UTAUT2 (Venkatesh *et al.*, 2003; Venkatesh, Thong and Xu, 2012). Questions were measured using a 7point Likert scale. As can be seen in Table 5-4, the mean for each item related to EE construct ranges between 3.12 (±1.716) and 3.18 (±1.678), which indicate that most participants agree that significant others (friends and relatives) do not believe that they should use the chatbots.

Descriptive Statistics

	N	Mean	Std. Deviation
SI1. People who are important to me think that I should use a chatbot.	431	3.15	1.793
SI2. People who influence my behaviour think that I should use a chatbot.	431	3.18	1.678
SI3. People whose opinions that I value prefer that I use a chatbot.	431	3.12	1.716
Valid N (listwise)	431		

Table 5- 4: Descriptive statistic for Social Influence Construct

D. Facilitating Condition

FC was measured by four items adopted from the work of (Teo, 2009; Maldonado *et al.*, 2009; Venkatesh *et al.*, 2003) using a 7 point Likert scale. Table 5-5 shows that the mean of the four items ranges between 5.41 (±1.569) and 6.07 (±1.216), revealing an agreement on how necessary the technological resources are to the chatbots use.

Descriptive Statistics

	N	Mean	Std. Deviation
FC1. I have the resources necessary to use a chatbot.	431	6.03	1.347
FC2. I have the knowledge necessary to use a chatbot.	431	6.07	1.216
FC3. A chatbot is compatible with other technologies I use.	431	5.85	1.368
FC4. I can get help from others when I have difficulties using a chatbot.	431	5.41	1.569
Valid N (listwise)	431		

Table 5- 5: Descriptive Statistics for Facilitating Condition Construct

E. Hedonic Motivation

HE is measured by 3-items using a 7 point Likert scale, which were adopted from the work of (Venkatesh *et al.*, 2003;-Venkatesh, Thong and Xu, 2012). Table 5-.6 shows that the mean for the three items that measure the HM construct range between 5.43 (±1.478) and 5.50 (± 1.458), which shows that most respondents enjoy using chatbots.

Descriptive Statistics

	N	Mean	Std. Deviation
HM1. Using a chatbot is fun.	431	5.50	1.458
HM2. Using a chatbot is enjoyable.	431	5.43	1.478
HM3. Using a chatbot is very entertaining.	431	5.45	1.576
Valid N (listwise)	431		

Table 5- 6: Descriptive Statistics for Hedonic Motivation Construct

F. Habit

HT construct is measured by 3-items adopted from the work of (Venkatesh, Thong and Xu, 2012). Each was measured using a 7-point Likert scale. Table 5-7 presents descriptive statistics of the Habit construct. The mean of the three measured variables HT1, HT2 and HT3 ranged between 3.80 (±2.325) and 4.62 (±2.209), which indicates that using chatbots is not a habit for students.

Descriptive Statistics

	N	Mean	Std. Deviation
HT1. The use of chatbot/s has become a habit for me.	431	4.62	2.209
HT2. I am addicted to using a chatbot.	431	3.80	2.325
HT3. I must use a chatbot.	431	3.83	2.448
Valid N (listwise)	431		

Table 5- 7: Descriptive Statistics for Habit Construct

G. Behavioural Intention

BI construct is measured by a 3-items adopted from several studies such as (Davis, 1989; Moon and Kim, 2001; Chang and Tung, 2008; Park, 2009). They were measured using 7 points Likert scale. Table 5-8 provides a descriptive analysis of BI construct. The mean of measured variables of BI ranged between 4.57 (±2.024) and 5.13 (±1.822). The results present that students showed a good agreement on BI.

Descriptive Statistics

	N	Mean	Std. Deviation
BI1. I intend to continue using a chatbot in the future.	431	5.13	1.822
BI2. I will always try to use a chatbot in my daily life.	431	4.57	2.024
BI3. I plan to continue to use a chatbot frequently.	431	4.84	1.986
Valid N (listwise)	431		

Table 5- 8: Descriptive Statistics for Behavior Intention Construct

H. USE

USE is a dependent construct in the UTAUT2 model proposed by (Venkatesh, Thong and Xu, 2012). Nine items were adopted from these studies (Venkatesh, Thong and Xu, 2012; Mayisela, 2013; Özgür, 2016) and were measured using the 7 points Likert scale. The descriptive analysis of the USE construct is shown in Table 5-9. It shows that the means of the measured variable for USE1 to USE9 ranged between 4.19 (±1.869) and 6.31 (±1.399). The majority of mean values are greater than 4. The results show that students had a good agreement on this variable (Table 5-9).

Descriptive Statistics

	N	Mean	Std. Deviation
US1. Browse websites	431	6.31	1.399
US2. Search engine	431	6.17	1.252
US3. Mobile e-mail (i.e Brunel email)	431	5.85	1.409
US4. SMS (Short Messaging Service)	431	5.34	1.685
US5. MMS (Multimedia Messaging Service)	431	4.67	2.076
US6. Blackboard access	431	5.20	1.577
US7. An online check of study timetable	431	5.09	1.616
US8. Events reminders setting on mobile phone	431	4.87	1.727
US9. University event or workshop check	431	4.19	1.869
Valid N (listwise)	431		

Table 5- 9: Descriptive Statistics for USE construct

5.4 Artefacts Evaluation

This section covers evaluating the artefacts and evaluating the sample size's adequacy using Kaiser-Meyer-Olkin (KMO) and Bartlett's Test. It also covers the evaluation of the Extended UTAUT2 model using internal consistency reliability and composite reliability (Section 5.4.2).

5.4.1 Evaluating Sample Size

The first test was to measure the sampling adequacy and test the collected data is the KMO. KMO value ranges between 0 and 1. The higher the value than 0.6, the better the satisfaction (Brace, Kemp and Snelgar, 2003; Hinton *et al.*, 2004). The number of participants in the study is 431, and these are the data used for the path analysis. SPSS version 25 was used to conduct the analysis. Table 5-10 shows the result of two tests: 1) the KMO and Bartlett's Test with a result value of 0.924, which means the dataset is suitable for further analysis (conceptual model). 2) Bartlett's Test of Sphericity, which measures the relationship between variables. P-value is less than 0.05. This shows satisfaction (Hinton *et al.*, 2004), and in this study, it is less than 0.001, which means the data is suitable for further analysis (Pheeraphuttharangkoon, 2015).

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.	.924

Table 5- 10: KMO and Bartlett's Results

5.4.2 Evaluating the Model

Hair et al. (2010) recommend evaluating a conceptual model in two steps: 1) evaluate the measurement model and 2) evaluate the structural model. Furthermore, multiple group analysis (MGA) can determine how the moderators impact the conceptual model.

The reflective measurement model consists of several tests, including internal consistency reliability, indicator reliability, convergent validity, and discriminant validity (Pheeraphuttharangkoon, 2015). In the first test, Internal consistency reliability, a satisfactory value of composite reliability should be higher than 0.7 (Hair, Ringle and Sarstedt, 2011), as shown in Table 5-11.

Construct	Cronbach's Alpha	rho_A	Composite Reliability	Average Variance Extracted (AVE)
PE	0.934	0.934	0.934	0.780
EE	0.876	0.908	0.872	0.640
SI	0.951	0.975	0.952	0.872
FC	0.828	0.846	0.806	0.523
HM	0.934	0.934	0.934	0.826
HT	0.937	0.939	0.936	0.830
BI	0.937	0.939	0.938	0.834
USE	0.891	0.864	0.696	0.284

Table 5- 11: Adjusted Cronbach Alpha, Composite Reliability and Average Variance Extracted (AVE)

5.4.2.1 Internal Consistency Reliability and Composite Reliability

Usually, Cronbach alpha is used to test the internal consistency reliability of the measurement model. However, in the PLS-SEM model, evaluating the internal consistency reliability of the measurement model is done using composite reliability instead of Cronbach's alpha (Wong, 2016). Cronbach's alpha is not suitable for PLS-SEM because it is sensitive to the number of items in the scale. This measure also generates severe underestimation when applied to PLS path models (see, (Werts, Linn and Joreskog, 1974; Wong, 2016)). The composite reliability of, PE, EE, SI, FC, HM, HT, BI, and USE (Table 5-11), are; 0.934, 0.872, 0.952, 0.806, 0.934, 0.936, 0.938 and 0.696, respectively, indicating a high level of internal consistency reliability (Nunnally and Bernstein 3rd, 1995; Wong, 2016). In exploratory research, satisfactory composite reliability is achieved with a threshold level of 0.60 or higher (Bagozzi and Yi, 1988) that does not exceed 0.95 (Hair *et al.*, 2013).

5.4.2.2 Indicator Reliability

Indicator reliability is a condition for validity; therefore, indicator reliability is checked to ensure that the latent variables represent the constructs. The threshold level for outer loading is 0.4. Thus, any indicator with a value less than 0.4 will be excluded from the model (Hair *et al.*, 2013; Wong, 2016). These include USE2, USE3, USE6 and USE7. However, if the outer loading value ranges between 0.4 and 0.7, a loading relevance test is required to decide whether to retain or delete them from the model. In this study, five measured variables are in the range between 0.4 and 0.7. They are EE1, FC2, USE1, USE4, and USE5, with values 0.543, 0.461, 0.513, 0.535, and 0.681, respectively, as shown in Table 5-12 and Figure 5-5. The loading relevance test is Cronbach alpha, composite reliability (CR) and average variance extracted (AVE). In a loading relevance test in the PLS model, week indicators are possibly deleted just in case they lead to increases in construct's AVE and CR over the thresholds (0.5). The rest of the indicators are retained as their outer loading exceed the threshold (Wong, 2016), except for USE9. Though it has a higher value, deleting it improves the outer loading for other USE indicators.

	BI	**EE**	**FC**	**HM**	**HT**	**PE**	**SI**	**USE**
BI1	0.873							
BI2	0.941							
BI3	0.924							
EE1		0.543						
EE2		0.968						
EE3		0.719						
EE4		0.902						
FC1			0.643					
FC2			0.461					
FC3			0.833					
FC4			0.879					
HM1				0.904				
HM2				0.903				
HM3				0.918				
HT1					0.974			
HT2					0.879			
HT3					0.876			
PE2						0.888		
PE3						0.848		
PE4						0.899		
PE1						0.896		
SI1							0.74	

SI2							1.02	
SI3							1.013	
USE1								0.513
USE2								0.044
USE3								0.149
USE4								0.535
USE5								0.681
USE6								0.016
USE7								0.251
USE8								0.706
USE9								0.976

Table 5- 12: Initial Outer Loading

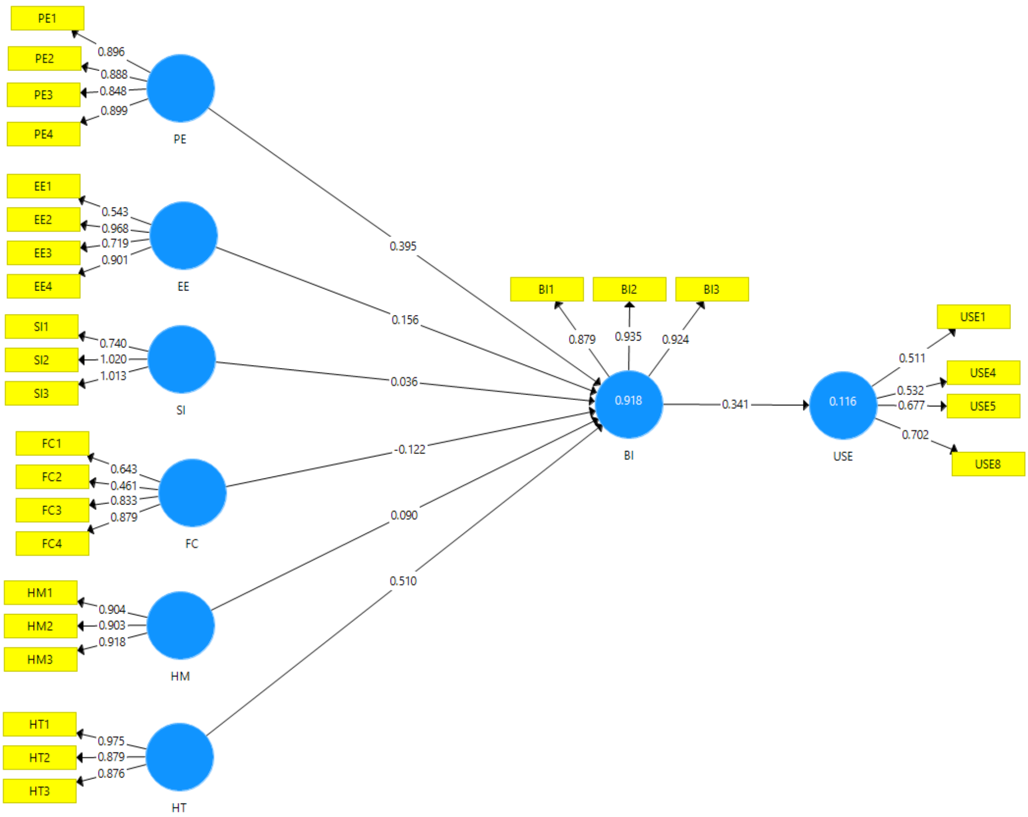


Figure 5- 5: Result of Consistent PLS Algorithm

The third test in the reflective measurement model is Convergent Validity. Convergent validity presents the model's ability to explain the variance of the indicator. According to Fornell and Larcker (1981), AVE confirms convergent validity, which should be greater than 0.5 for satisfaction (Hair et al., 2011). The AVE for the latent constructs BI, EE, FC, HM, HT**,** PE, SI, and USE are 0.834, 0.64,0.523,0.826,0.83,0.78, 0.872 and 0.374 respectively. All values are above the minimum threshold (Bagozzi and Yi, 1988; Wong, 2016) except for USE. The CR for latent constructs BI, EE, FC, HM, HT**,** PE, SI, and USE are 0.938, 0.872,0.806, 0.934, 0.936, 0.934, 0.952 and 0.701 respectively. According to Hair et al. (2010), the model confirms convergent validity when the AVE is greater than 0.5 and CR is higher than the AVE for all constructs (Hair *et al.*, 2010; Tarhini, 2016), and this applies to all constructs in this model; which confirms convergent validity as shown in Table 5-13a,b.

Constructs	**BI**	**EE**	**FC**	**HM**	**HT**	**PE**	**SI**	**USE**
BI	0.913							
EE	0.517	0.800						
FC	0.522	0.831	0.723					
HM	0.720	0.630	0.665	0.909				
HT	0.913	0.385	0.452	0.616	0.911			
PE	0.917	0.525	0.565	0.740	0.853	0.883		
SI	0.258	0.089	0.034	0.210	0.193	0.241	0.934	
USE	0.341	0.351	0.322	0.359	0.323	0.344	0.313	0.612

Constructs	**Cronbach's Alpha**	**rho_A**	**Composite Reliability**	**Average Variance Extracted (AVE)**	**R2**
BI	0.937	0.939	0.938	0.834	0.917
EE	0.876	0.907	0.872	0.640	
FC	0.828	0.846	0.806	0.523	
HM	0.934	0.934	0.934	0.826	
HT	0.937	0.939	0.936	0.830	
PE	0.934	0.934	0.934	0.780	
SI	0.951	0.975	0.952	0.872	

USE	0.715	0.715	0.701	0.374	0.114

Table 5- 13a, b: Item Loading, Cronbach Alpha, Composite Reliability and Average Variance Extracted (AVE)

Note: non-diagonal elements represent the latent variable correlations (LVC), while the diagonal element represents the square root of AVE values.

Discriminant validity is the last test in the measurement model. According to Hair et al. (2011), the indicator loading value should be more than all its cross-loading. Table 5-13a,b(above) shows that all indicator loading is higher than its cross-loading (Pheeraphuttharangkoon, 2015).

*5.4.*3 Formative Measurement

After completing the reflective measurement test, the next step is to perform a formative measure to assess the weight and loading of the indicator. According to Bogozzi (2011), the indicator in the measurement model has no error associated with them. Therefore, bootstrapping is used to estimate the significance of the indicators. In this study, Smartpls3 uses 5000 bootstrap sample before providing the report (Pheeraphuttharangkoon, 2015). See Figure 5-6 below.

5.4.4 A structural Model

R-square (R^2) shows the ability of the model to explain the phenomena, as shown in Table 5-13b and Figure 5-5. The R^2 value for BI and USE are 0.917 and 0.114, respectively. BI explains 91% of the variance in the model while USE explains only 11%, which is very strong for the former and weak for the latter. R^2 of 38% can be considered as significant (Hair, Ringle and Sarstedt, 2011).

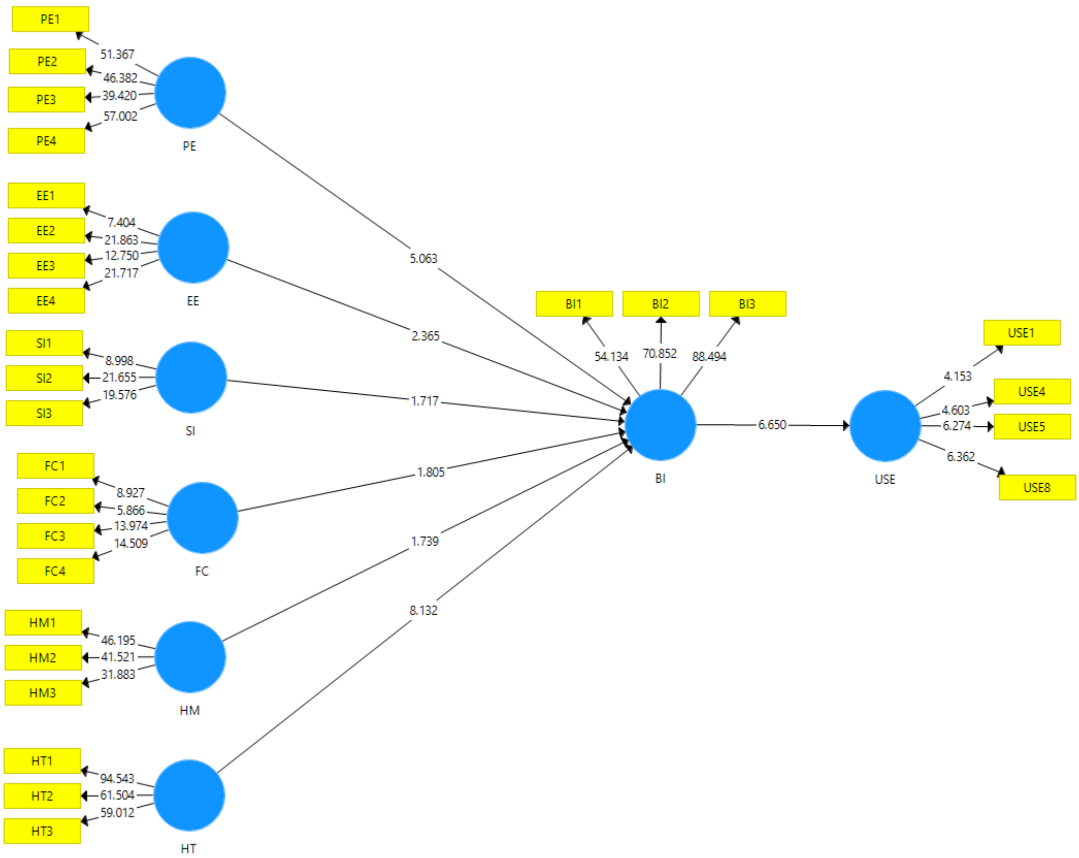


Figure 5- 6: Bootstrapping Result from SmartPLS3(Almahri, Bell and Merhi, 2020)

5.4.4.1 Hypothesis Testing

After performing bootstrapping using SmartPLS3, the result shows the Path Coefficient in Figure 5-6. As can be seen in Table 5-14, the result of bootstrapping shows that four hypotheses were supported, including HT and BI(P=0.00), BI and USE (P=0.00), PE and BI(P=0.00), and EE and BI(P=0.018). However, three hypotheses were rejected: FC and BI (P=0.071), HM and BI (P=0.082), and SI and BI(P=0.086). The three supported hypotheses will be used as the basis in iteration 3 to develop chatbots features.

Relationship	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values	Supported: Yes/NO
HT-> BI	0.510	0.508	0.065	7.881	0.000	Yes
BI -> USE	0.341	0.345	0.051	6.703	0.000	Yes

PE -> BI	0.395	0.397	0.080	4.915	0.000	Yes
EE -> BI	0.156	0.156	0.066	2.363	0.018	Yes
FC -> BI	-0.122	-0.121	0.068	1.807	0.071	No
HM -> BI	0.090	0.089	0.051	1.740	0.082	No
SI -> BI	0.036	0.036	0.021	1.719	0.086	No

Table 5- 14: Hypothesis, Path Coefficients (B), T-value, Significant (P-value) and Hypothesis Support Result.

5.4.5 Multiple Group Analysis (MGA)

MGA is used to find out how the moderator impacts the conceptual model. The following sections cover the moderator effects on moderating the relationship in the proposed model. These moderators are age, gender, experience, attendance, interaction with VLE, grade(performance) and educational level.

5.4.5.1 Multiple Group Analysis - Age Moderator

The survey design has five age groups levels: <18, 18-21, 22-25, 26-29 and >=30 years old, as shown in Figure 0-6 (Appendix E). Before conducting Multiple Group Analysis, the age moderator was divided into two levels: less than or equal to 21-year-old and greater than 21 years old. Out of the 431 participants, 244 were in the low-age group (LA), while 187 were in the high-age group (HA). This section investigates whether age moderates the effects of the relationships. In other words, this section tests the hypothesis of age moderator to determine whether age moderates the effects of EE, FC, HT, HM, PE, SI on BI. To support the relationship, P-value should be <0.05 or >0.95. Table 5-15 shows that age moderates the effect of some relationships: BI and USE (P=0.959, supporting H8a7) and PE and BI(P=0.959, supporting H8a1). However, age does not moderate the effects of other relationship EE and BI (P=0.497; rejecting H8a2), FC and BI (P=0.395; rejecting H8a4), HM and BI(P=0.105; rejecting H8a5), HT and BI(P=0.278, rejecting H8a6), and SI and BI(p=0.307; rejecting H8a3). It is essential to mention that the T-value measures the size of the difference relative to the variation in the sample data.

Relationship	t-Values (HA)	t-Values (LA)	p-Values (HA)	p-Values (LA)	Path Coefficients-diff (| LA - HA |)	p-Value(LA vs HA)	Supported Yes/No
BI >USE	5.988	5.317	0.000	0.000	0.151	0.959	Yes
EE -> BI	2.101	1.960	0.036	0.050	0.001	0.497	No
FC -> BI	0.856	0.708	0.392	0.479	0.019	0.395	No
HM ->BI	0.424	2.800	0.672	0.005	0.107	0.105	No
HT -> BI	5.788	9.461	0.000	0.000	0.053	0.278	No
PE -> BI	5.721	5.174	0.000	0.000	0.163	0.959	Yes
SI -> BI	1.115	1.827	0.265	0.068	0.022	0.307	No

***HA refers to High-Age, LA refers to Low-Age**

Table 5- 15: Result of Multiple Group Analysis –Age moderator

5.4.5.2 Multiple Group Analysis – Gender Moderator

Out of 431 respondents, there were 234 males and 197 females. As shown in Table 5-16, gender moderates the relationship between HT and BI (P=0.978; supporting H9b6) and the relationship between EE and BI (P= 0.022; supporting H9b2). However, age does not moderate the relationship between BI and USE (P=0.766, rejecting H9a7), the relationship between FC and BI (P=0.818, rejecting H9b4), the relationship between HM and BI was (P=0.508, rejecting H9b5), the relationship between PE and BI (P=0.225, rejecting H9b1) and SI and BI (P=0.125, rejecting H9b3).

Relationship	t-Values (F)	t-Values (M)	p-Values (F)	p-Values (M)	Path Coefficients-diff (| M - F |)	p-Value(M vs F)	Supported: Yes/No
BI ->USE	4.905	5.217	0.000	0.000	0.065	0.766	No
EE -> BI	0.007	2.730	0.994	0.006	0.154	0.022	Yes
FC -> BI	0.001	1.353	0.999	0.176	0.067	0.818	No
HM -> BI	2.789	1.918	0.005	0.055	0.001	0.508	No
HT -> BI	7.636	8.384	0.000	0.000	0.194	0.978	Yes
PE -> BI	3.581	5.972	0.000	0.000	0.077	0.224	No
SI -> BI	0.315	1.362	0.753	0.173	0.058	0.125	No

***F refers to Female and M to Male**

Table 5- 16: Result of Multiple Group Analysis –Gender moderator

5.4.5.3 Multiple Group Analysis – Experience Moderator

A descriptive analysis of the experience moderator in Table 0-15 and Table 0-16 (see, Appendix E) shows four experience levels. The data categorised in two groups: 1)no-low_expereince: participants with no experience and low level of experience using chatbots; they were 238 out of 431. 2) experienced: participants with some experience and a high level of experience in using the chatbots; they were 168 participants. Table 5-17 shows that experience moderates the effects of two relationships BI and USE (P=0.95; supporting H10c7), and SI and BI (P =0.95; supporting H10c3). However, experience does not moderate the relationship between EE and BI (p=0.40; rejecting H10c2), FC and BI (P=0.80; rejecting H10c4), HM and BI (P=0.30; rejecting H19c5), HT and BI (P=0.10, rejecting H10c6), PE and BI (P=0.80, rejecting H10c1).

Relationship	t-Values (E)	t-Values (LNE)	p-Values (E)	p-Values (LNE)	Path Coefficients-diff (| LNE-experienced |)	p-Value(LNE vs E)	Significance
BI >USE	4.300	3.200	0.000	0.001	0.100	0.950	Yes
EE -> BI	1.500	1.800	0.000	0.076	0.000	0.400	No
FC -> BI	0.100	1.300	1.000	0.204	0.100	0.800	No
HM ->BI	0.900	2.900	0.000	0.003	0.100	0.300	No
HT -> BI	6.200	8.500	0.000	0.000	0.100	0.100	No
PE -> BI	5.400	3.800	0.000	0.000	0.100	0.800	No
SI -> BI	2.000	1.300	0.000	0.202	0.100	0.950	Yes

***E refers to experience, LNE refers to low and no experience T**

Table 5- 17: Result of Multiple Group Analysis –Experience moderator

5.4.5.4 Multiple Group Analysis – Attendance Moderator

A descriptive analysis of the attendance is shown in Appendix E. Surprisingly, the attendance rate is very high. Two groups were created: low-attendance (LA) and high-attendance (HA). Attendance significantly moderates the relationship between BI and USE (P=0.048, supporting H11d7), as shown in Table 5-18. However, attendance does not moderate the relationship between EE and BI (P=0.688; rejecting H11d2), the relationship between FC and BI (P= 0.804, rejecting H11d4), HM and BI (P = 0.731; rejecting H11d5), HT and BI (P=0.433, rejecting H11d6), PE and BI (P=0.136, rejecting H11d1) and SI and BI (P=0.718, rejecting H11d3). In the following Table, HA refers to the high-attendance group, and LA refers to the Low-attendance group.

Relationship	t-Values (HA)	t-Values (LA)	p-Values (HA)	p-Values (LA)	Path Coefficients-diff (| LA - HA |)	p-Value(LA vs HA)	Significance
BI -> USE	4.195	5.168	0.000	0.000	0.100	0.048	Yes
EE -> BI	2.658	1.029	0.008	0.300	0.000	0.688	No
FC -> BI	0.670	1.427	0.503	0.150	0.100	0.804	No
HM -> BI	2.456	0.979	0.014	0.330	0.100	0.731	No
HT -> BI	9.057	7.293	0.000	0.000	0.000	0.433	No
PE -> BI	5.687	5.689	0.000	0.000	0.100	0.136	No
SI -> BI	2.431	0.568	0.015	0.570	0.000	0.718	No

Table 5- 18: Result of Multiple Groups Analysis - Attendance moderator

5.4.5.5 Multiple Group Analysis – Engagement with VLEs Moderator

A descriptive analysis of the engagement with VLEs is shown in Appendix E. In general, it shows a high level of engagement. The mean was 6.5 out of 7; therefore, engagement with VLE was divided into two groups: low- engagement (<6) with only 57 participants and high-engagement (6-7) with 374 participants. Running the Multiple Group Analysis produces the following Table 5-19. Interactions with VLE significantly moderates the relationship between FC and BI (P=0.964; supporting H11e4). However, interactions with VLEs does not moderate the relationship between BI and USE (P=0.405 rejecting H11e7), the relationship between EE and BI (P= 0.466; rejecting H11e2), HM and BI (P=0.103; rejecting H12e5), HT and BI (P=0.288; rejecting H11e6), PE and BI (P=0.749 rejecting H11e1), and the relationship between SI and BI (P=0.124; rejecting H11e3).

Relationship	t-Values (H_VLE)	t-Values (L_VLE)	p-Values (H_VLE)	p-Values (L_VLE)	Path Coefficients-diff (| L_VLE_ - H_VLE_ |)	p-Value(L_VLE_ vs H_VLE)	Significance
BI-> USE	6.530	0.794	0.000	0.427	0.075	0.405	No
EE -> BI	2.860	0.865	0.000	0.387	0.012	0.466	No
FC -> BI	0.820	1.271	0.410	0.204	0.159	0.964	Yes
HM -> BI	2.020	2.029	0.040	0.042	0.162	0.103	No
HT -> BI	9.720	6.582	0.000	0.000	0.048	0.288	No
PE -> BI	7.190	3.043	0.000	0.002	0.079	0.749	No
SI -> BI	1.780	1.664	0.080	0.096	0.087	0.124	No

***H_VLE refers to HigVLE and L_VLE refers to Low_VLE**

Table 5- 19:Result of Multiple Group Analysis - Engagement with VLEs moderator

5.4.5.6 Multiple Group Analysis -Educational level Moderator

A descriptive analysis of the educational level is shown in Appendix E. Two groups were created: 1) low-educational level – includes level 1 and level 2 with 238 students. 2) high-educational-level includes placement and level 3 students, with 158 students; the remaining were master students. Performing multiple group analysis results in the following table (Table 5-20). The results show that educational level has no moderating effects on any relationship including the relationship between BI and USE (P=0.87; rejecting H13F7), EE and BI (P=0.71; rejecting H13F2); FC and BI(P=0.81, rejecting H13F4), HM and BI (P=0.11; rejecting H13F5); HT and BI (P=0.81; rejecting H13F6), PE and BI (P=0.36; rejecting H13F1), and SI and BI (P =055, rejecting H13F3).

Relationship	t-Values (L3&4)	t-Values (L1&2	p-Values (L3&4)	p-Values (L1&2)	Path Coefficients-diff (| L1&2 – L3&4 |)	p-Value(L1&2 vs L3&4)	Significance
BI->USE	4.080	5.370	0.000	0.000	0.130	0.870	No
EE -> BI	1.660	1.850	0.100	0.070	0.050	0.710	No
FC -> BI	0.450	0.990	0.650	0.320	0.090	0.810	No

HM-> BI	0.090	1.990	0.930	0.050	0.110	0.110	No
HT -> BI	7.250	8.110	0.000	0.000	0.080	0.810	No
PE -> BI	3.890	5.750	0.000	0.000	0.040	0.360	No
SI -> BI	1.700	1.550	0.090	0.120	0.010	0.550	No

***L3&4 refers to level 3 and 4 (Bachelor degree), and L1&2 refers to level 1 and 2**

Table 5- 20: Result of Multiple Group Analysis- Educational Level moderator

5.4.5.7 Multiple Group Analysis - Performance (Grade) Moderator

A descriptive analysis of the performance is shown in Appendix E. Grades shown in levels greater than 17 are not ideal. Therefore, mathematical equations were used to transfer the 18 levels to 7 levels. Performing the Multiple Group Analysis shows that grade has no moderating effects on any relationship, as shown in Table 5-21. This includes the relationship between BI and USE (P= 0.216, rejecting 0H14f7), EE and BI (P =0.158, rejecting H14f2), FC and BI (P= 0.328; rejecting H14f4), HM and BI (P= 0.521, rejecting H14f5), HT and BI (P=0.816, rejecting H14f 6), PE and BI (P= 0.336, rejecting H14f1), and SI and BI (P=0.111, rejecting H14f3).

Relationship	t-Values (HG)	t-Values (LG)	p-Values (HG)	p-Values (LG)	Path Coefficients-diff (|LG - HG|)	p-Value (LG vs HG)	Significance
BI -> USE	3.557	1.140	0.000	0.254	0.110	0.216	No
EE -> BI	1.260	2.734	0.208	0.006	0.090	0.158	No
FC -> BI	1.045	0.363	0.296	0.717	0.040	0.328	No
HM -> BI	2.443	1.910	0.015	0.056	0.000	0.521	No
HT -> BI	9.840	3.466	0.000	0.001	0.110	0.816	No
PE -> BI	4.785	2.895	0.000	0.004	0.060	0.336	No
SI -> BI	0.637	1.539	0.524	0.124	0.070	0.111	No

*** HG refers to High Grade, and LG refers to Low Grade**

Table 5- 21: Result of Multiple Group Analysis –Grade moderator

5.5 Designing and Building Extended Persona3D Model and Method

As mentioned earlier, the Persona3D model generated in Chapter 4 presented and documented users' groups. However, it does not cover the specific calls-to-action (CTA). In other words, it does not cover how these personas can be motivated or how they effectively interact with the system. Therefore, there is a need to extend the Personas3D model with these specific CTA to provide an effective method of interaction that suits each persona. To achieve this, Extended UTAUT2 is designed, built and evaluated. In this iteration, Extended UTAUT2 study students acceptance of chatbots technology, and the result shows that certain constructs are essential to all personas. They are PE, EE and HT. These are the three main predictors for BI and the use of chatbots. These three constructs are used as new elements in the Persona3D model and produce the extended persona3D model (see, Appendix F, extended persona3D template). The persona3D model for top students which was produced in Chapter 4 is extended with the three elements, as shown in Figure 5-7. The steps to extend Persona3D models are added in the Extended Persona3D method (Figure 5-8), which include using extended UTAUT2 to extract the elements/attributes to be added into the Extended Persona3D model.

Multiple group analysis for the Extended UTAU2 tests the moderators' influence on the relationship between the primary constructs and BI and USE constructs. The result shows that not all moderators moderate the relationships in the model. This means all personas can use constructs identified as important, which are PE, EE and HT.

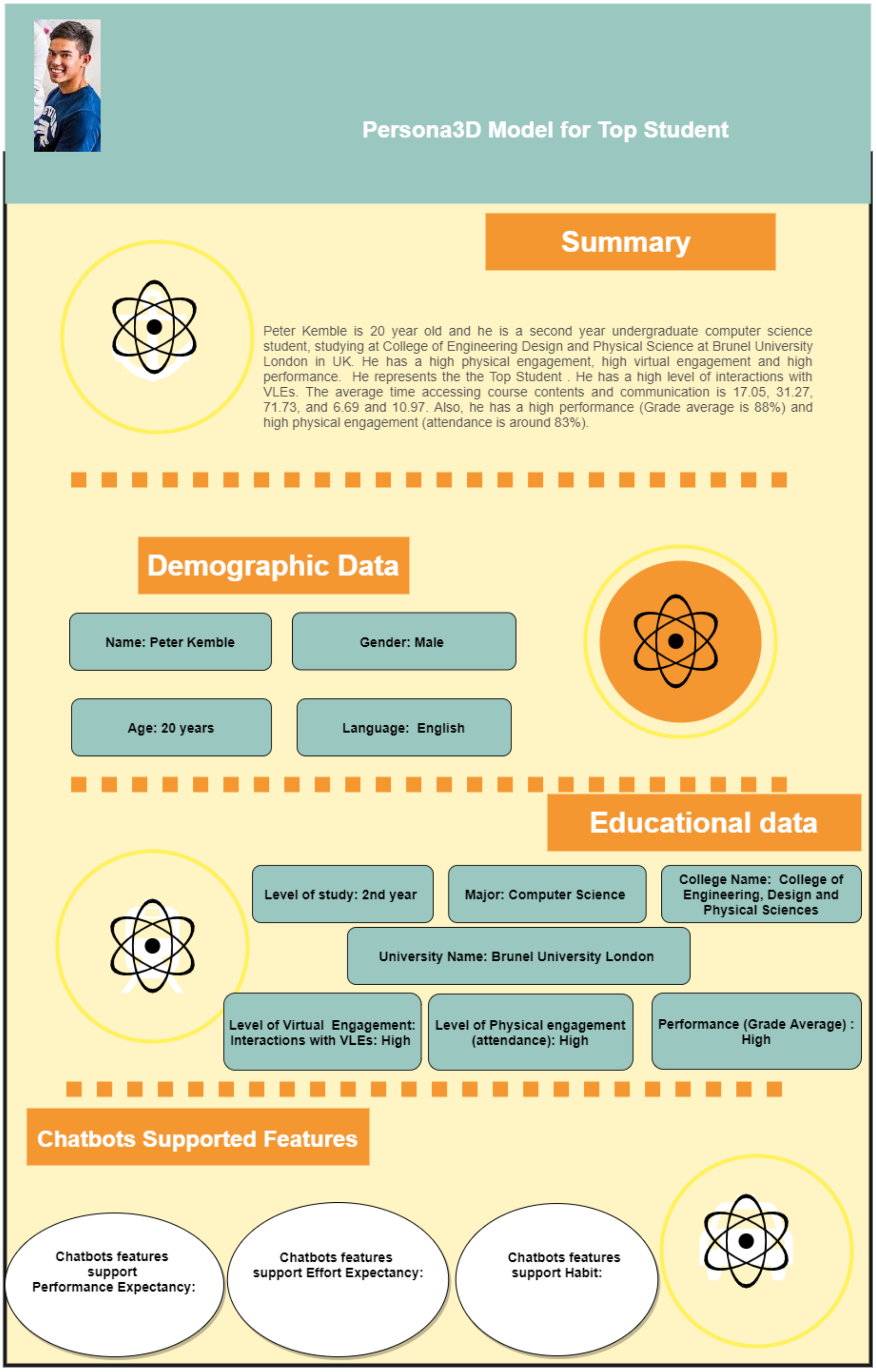


Figure 5- 7: Extended Persona3D Template

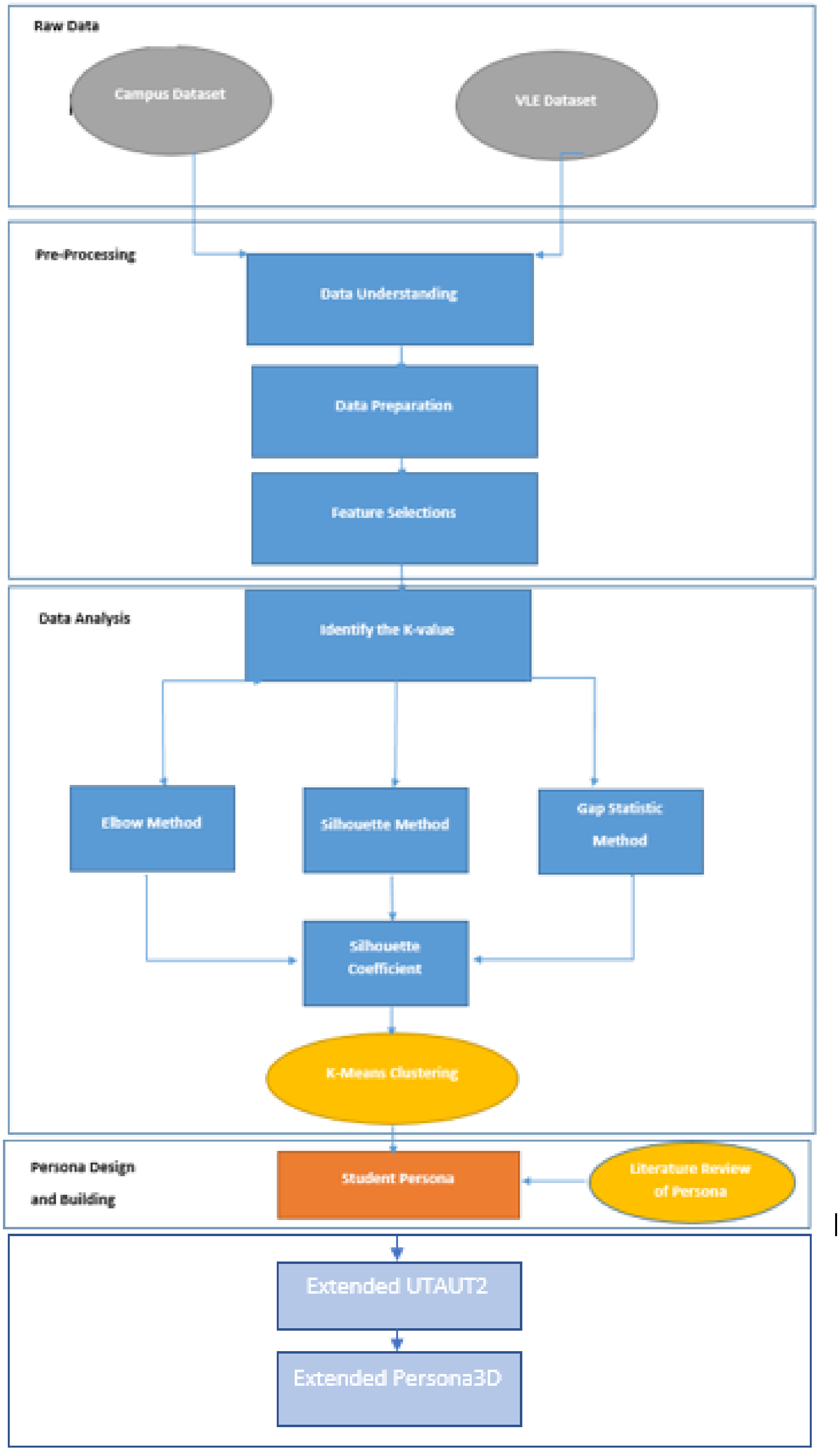


Figure 5- 8:Extended Persona3D Method

5.6 Limitations of this Study

This study highlights one limitation of this chapter. It is the possibility of having a bias in participants view. As mentioned in section 5.3.1, participants were informed about their chance of winning one of ten £20 Amazon vouchers if they completed the survey.

5.7 Conclusion

This second iteration extended the Persona3D model beyond student groupings. Personas from the previous iteration did not include effective methods of interaction with each of the groups (including specific CTA). Therefore, this iteration extends the Persona3D model to include appropriate elements/attributes using an adapted UTAUT2 model. The data analysis results show that the designer needs to consider PE, EE, HT when designing chatbots and use these elements in the extended Persona3D model. Identified elements were common across all persona and therefore warranted inclusion in the Persona3D template. Consequently, there is now a need to uncover practical approaches or chatbots features required in the next Iteration (Chapter 6) – testing the effectiveness of the Persona3D model.

Chapter 6 – Chatbots Development

6.1 Introduction

The first and Second Iterations resulted in a persona-based modelling approach (Persona3D) that identifies key student groups and interaction types. The practical effectiveness of this approach is assessed in this chapter. Consequently, several chatbots are designed and built; each tests the effectiveness of the Persona3D approach. Eight chatbots were designed and built using the Persona3D model as a basis for journey mapping and coding. The effectiveness of the Persona3D model was demonstrated in supporting Journey mapping and coding of chatbots. In this iteration, the Persona3D approach is evaluated by using it to construct eight Journey Mappings, each for a specific persona, and build eight chatbot prototypes (instantiations). The two primary artefacts of this iteration are journey mapping models and chatbots prototypes.

This chapter is structured as follows: Section 6.2 describes how design science is used in executing this iteration by identifying possible chatbots features for interaction types from the literature that supports Extended UTAUT2 constructs. The section will also describe, in detail, the Journey Mappings of two Persona3D models, the top students and the disengaged students, and summarise the other six persona3D models and Journey Mappings. Section 6.3 details the implementation of chatbots of the two Persona3D models mentioned in 6.2 and summarises the implementation of the others. Section 6.4 covers evaluating the effectiveness of the Persona3D model in supporting the Journey Mapping and the effectiveness of the Persona3D model in supporting the chatbots coding. Furthermore, it covers building the chatbots from developer logbooks, and it covers evaluating the completeness of the Persona3D model and the completeness of Journey Mapping Models. Section 6.5 highlights the novelity and contributions of this iteration . Section 6.6 present the limitations of this iteration, while Section 6.7 and 6.8 highlights the learning from this iteration and summarises the findings of this design research iteration, respectively.

6.2 Design Science Research and Output Artefacts

The Extended Persona3D model, an improved version of the Persona3D model in chapter 4, which includes new elements/attributes, guides researchers to the development of effective feature interactions (chatbots) for different personas. The literature review presents different applications that support different constructs in the Extended/UTAUT2 model. Furthermore, the findings of chapter 5 show that Performance Expectancy, Effort Expectancy, and Habit are the three elements that extend the Persona3D model and act as predictors of behavioural intention and use of chatbots. Therefore, this iteration focuses on the application that supports PE, EE and HT. Figure 6-1 presents the research iterations of this study with a focus on the last iteration.

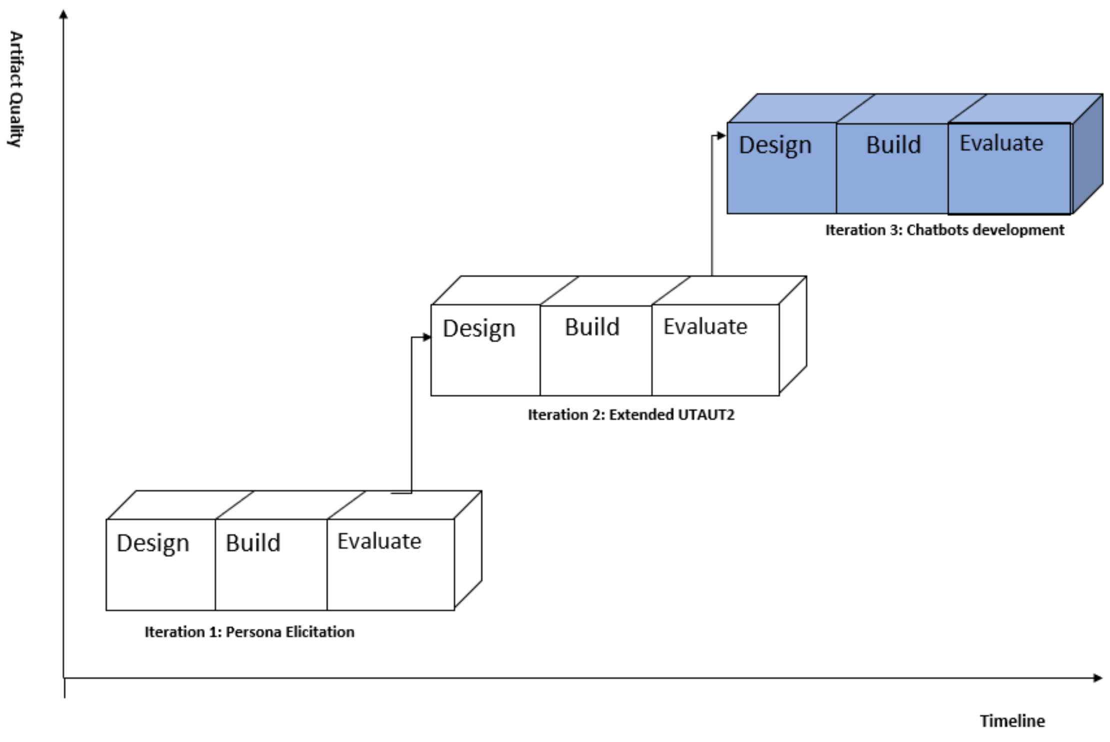


Figure 6- 1: Research Iterations

The novelty of this iteration is how we use the persona-based modelling approach (Persona3D), generated from the first and second iterations, to construct Journey Mapping and coding of chatbots for different personas. Then this study evaluates the effectiveness of this approach in supporting the Journey Mapping and coding of chatbots. Also, it evaluates the completeness of Persona3D models.

6.2.1 Design Science Research Artefacts

This iteration aims to evaluate the effectiveness of the Persona3D modelling approach by designing and building chatbots (instantiations). To achieve that, several steps should be applied with different method and input artefact to produce the output artefact, as shown in Table 6-1. The output artefact in this table mainly used as input in the next step.

Steps	Method	Input Artefact	Output Artefact
1. Identifying possible features for interaction types	Searching the literature review	A corpus of high-quality literature.	List of features for particular interaction types
2. Filling the Extended Persona3D model with interaction type	Extended Persoan3D update	Extended Persona3D model and list of features for interaction types	An updated version of the Extended Persona3D model
3. Design Journey Mapping template	Searching literature review	An updated version of persona3D model and identified component of a Journey Mapping	Journey mapping template
4. Design and build student Journey Mapping for different personas	Journey Mapping template update	Journey Mapping template and extended Persona3D model	Eight Journey Mapping design for different types of personas
5. Evaluate the effectiveness of extended Persona3D in supporting the Journey Mapping	Model evaluation	Journey Mapping and extended Persona3D	Result of Evaluating the extended persona3D approach
6. Evaluate the effectiveness of extended Persona3D in supporting the coding of the chatbots	Model evaluation	Chatbots code and extended Persona3D	Result of Evaluating the extended persona3D approach

Table 6- 1: Iteration Steps- Input and Output Model

6.2.2 Identifying Possible Features for Interaction Types

The literature review will be conducted to identify a list of chatbots features and select only a few for chatbots development. Then the effectiveness of the practical approach (Extended Persona3D model) will be determined. As discussed in chapter 2, the UTAUT2 model contains seven constructs PE, EE, HT, HM, FC, PV and SI. It is essential to mention that the primary construct of UTAUT2 and Extended UTAUT2 are the same except for PV, which is excluded from the Extended UTAUT2 as the chatbots will be free to use. Therefore, UTAUT2 is the term used to search the literature. To identify possible features for interaction types that support UTAUT2 constructs using three search engines IEEE, ACM and Google Scholar. Firstly, search the IEEE database using the keywords “UTAUT AND Application “, “UTAUT2 AND Application”, “UTAUT2 AND application AND education”, which resulted in 53, 14, and 16 papers/publications, respectively. A total of 83 articles were produced from the above search. After removing the four duplicated papers results in 79 that were reviewed to find the implementation of chatbots features for each UTAUT2 construct using the ACM database and the keywords “UTAUT2 AND application”. The review resulted in 3 final papers. Searching for the ACM database using the keywords “UTAUT2 AND Application” resulted in 3 papers, while searching Google Scholar using the keywords “UTAUT2 AND LMS” resulted in 115 papers.

After analysing the identified papers from the search results, the literature shows a list of possible features for interaction types that support each construct of UTAUT2, as shown in Table 6-2. However, the result found in chapter five indicates that there are only three indicators that predict the behavioural intention and use of chatbots technology by university students. Therefore, a list of possible features for interaction type that support these three indicators is shown below in Table 6-3.

Construct	**Chatbot Features**
Performance Expectancy	1) Knowledge acquisition (El-Masri and Tarhini, 2017), i.e. Additional sources of chapter
	2) Daily educational and research activities (Ameri *et al.*, 2019)
	3) Interactive quiz session (with peers) (Mehta and Bhandari, 2016)

	4) Presenting success stories as well as problems in the field (Indrawati and Pratomo, 2017)
	5) Getting material using the request form (Wasitarini and Tritawirasta, 2016)
	6) Goal-setting, performance monitoring, real-time feedback and competition (Oinas-Kukkonen and Harjumaa, 2008; Mohadis and Ali, 2018)
	7) Provide timely information (See, Yusof and Kianpisheh, 2010), accessing news and information, sharing more data and increasing the chances of communication with another person (Narkwilai, Funilkul and Supasitthimethee, 2015)
	8) Goal-oriented task: Beneficial usage of mobile apps because it helps them to achieve their goal-oriented tasks (Venkatesh *et al.*, 2003; Yeap, Yapp and Balakrishna, 2017)
	9) Short learning material: Limited time for knowledge transfer (Kuciapski, 2019)
Effort Expectancy	1) Grade checking (features) (Ain, Kaur and Waheed, 2016)
	2) Downloading and uploading files (Mazman and Usluel, 2010) (features)
	3) Instant messaging (feature) (Bere, 2018)
	4) Easy registration of membership in education; study group or project group (Wasitarini and Tritawirasta, 2016)
	5) Add friends/contacts (QR codes), free voice calls (Narkwilai, Funilkul and Supasitthimethee, 2015)
Habit	Habitual behaviour: 1) Meeting or collaborative activities using online collaborative activities (Indrawati and Pratomo, 2017)
	2) File downloading before the test (Kiss, 2013)
	3) Attending class (Dawood *et al.*, 2017)/ timetabling / Checking timetable (for today, for tomorrow, for a whole week, Exam week).
	4) Submit assignment (Dawood *et al.*, 2017)
	5) Note Taking (Palmatier, 1974)

Table 6- 2: Chatbots Feature Supporting the Construct of UTAUT2

1) **Performance Expectancy (PE)** is “the degree to which an individual believes that using the system will help him or her to attain gains in job performance” (Venkatesh et al., 2003, p. 447). The literature shows many chatbots features that support PE. For example, according to El-Masri and Tarhini (2017), the more knowledge the user obtains from using the application (i.e. learning system), the more willing they will be to use them. Therefore, chatbots features for the PE construct is 1) knowledge acquisition; students should be given more knowledge that will enhance their PE. Usually, there is a list of resources that enrich students' knowledge; therefore, the proposed chatbots features show the extra information

available at the end of each lecture (I. References). 2) Daily educational and research activities, according to Ameri *et al.* (2019), the usefulness of LabSafety application, which supports performance expectancy, can be achieved via daily educational and research activities. Therefore, a daily or weekly quiz to enhance students' performance expectancy. 3) Interactive quiz sessions with peers support the performance expectancy (Mehta and Bhandari, 2016). 4) Presenting success stories, as suggested by (Indrawati and Pratomo, 2017). Two design elements were proposed in (El-Masri and Tarhini, 2017), more knowledge and high content quality. 5) Getting material using search and request form; as shown in (Wasitarini and Tritawirasta, 2016)- the students can specify what they want in a request form and get it. 6) Real-time feedback and competition (Oinas-Kukkonen and Harjumaa, 2008; Mohadis and Ali, 2018). 7) Provides timely information: accessing news and information, sharing more data and increasing the chances to communicate with another person (Narkwilai, Funilkul and Supasitthimethee, 2015). 8) Goal-oriented task (Venkatesh *et al*., 2003; Yeap, Yapp and Balakrishna, 2017) and 9) Short learning materials- Limited time for knowledge transfer (Kuciapski, 2019).

2) Effort Expectancy (EE) is "the degree of ease associated with the use of the system" (Venkatesh *et al.*, 2003, p. 450). According to Ain, Kaur and Waheed, (2016), LMS has several features: 1) Grade checking can be used as a chatbot feature since it provides an easier way of knowing about student grades. 2) Photos and files uploading and downloading (Mazman and Usluel, 2010) is an application of EE. Grade checking is a design element that should be considered in the chatbot design phase, as well as photos and files uploading and downloading features, in addition to a simple and easy to use interface. 3) Instant messaging is an example of the support EE (Bere, 2018). The design elements are uploading and downloading files (Mazman and Usluel, 2010), easy navigation and easy downloading (Mazman and Usluel, 2010), and simple interface (Mazman and Usluel, 2010). 4) Easy membership registration (Wasitarini and Tritawirasta, 2016), such as a study group or project group. 5) Adding friends/contacts using QR code, free voice call (Narkwilai, Funilkul and Supasitthimethee, 2015).

3) Habit (HT), defined from the IS and technology context, is "the extent to which people tend to perform behaviours (use IS) automatically because of learning"

(Limayem, Hirt and Cheung, 2007). Many application features support HT: 1) meeting or collaborative activities using online collaborative activities (Indrawati and Pratomo, 2017).2) downloading the lecture materials before the test (Kiss, 2013) .3)Attending class (Dawood *et al.*, 2017)/ timetabling) and checking timetable, 4)Submit assignment (Dawood *et al.*, 2017), and 5) Note Taking (Palmatier, 1974).

Table 6-2 shows the different proposed chatbots features for each construct. However, this study will not cover all the features found in the literature. Therefore, only two chatbots features that support each of the three constructs: PE, EE and HT will be proposed for the design and implementation of each chatbot, as shown in Table 6-3. Interactive Quiz sessions (Mehta and Bhandari, 2016) and Knowledge Acquisition (El-Masri and Tarhini, 2017) are two chatbots features that will be nominated to support the PE for students. Downloading and uploading files-Mazman and Usluel (2010) are the chatbots feature that support EE. However, it is not practical to download and upload files on an Amazon Alexa device. Therefore, the required files or links will be sent to the student email. The proposed features that support EE are Assignment Guider and Lab Support chatbots. Timetabling (attending class) is a chatbot feature that supports HT. Two chatbots support attending classes: The Learning of the Day and The Skill of the Day chatbots.

Chatbots Features	Chatbots Name	Description	UTAUT2 Construct	Requirement
1) Interactive quiz session (Mehta and Bhandari, 2016) Knowledgeacquisition(El-Masri and Tarhini, 2017)	1.1 Knowledge assessment 1.2 Knowledge Acquisition	• True/false questions related to java programming module. • Questions and answers to acquire the knowledge	Performance Expectancy	A Challenging True/False quiz for the Top Student Persona and a Simple True/False quiz for the disengaged student. The chatbots provide answers to any question related to the lecture. The questions, answers and further explanation are stored in DynamoDB database. Further information is sent to users email using the Send Email Services (SES).
2) Downloading and uploading files (Mazman and Usluel, 2010) (features)/learning resources: assignment, lab and lecture	2.1 Assignment Guider 2.2 Lab Support	• Questions and answers to help students solve the assignment. • Questions and answers to help students solve the lab	Effort Expectancy	The chatbots provide an answer to any question, whether it is related to the assignment (Assignment Guider chatbots), or the lab (Lab Support chatbots) All the questions, answers are store in the DynamoDB. Further information is sent to the user email address using the Send Email Service (SES).
3) Attending class /timetabling (Dawood et al., 2017)/ timetabling	3.1 The Learning of the Day chatbot. 3.2 The Skill of the Day chatbot.	These two chatbots provide information to encourage students indirectly to attend the lectures and labs	Habit	These two chatbots provide information to the user about the knowledge they will gain by attending the lecture and the skill they will gain by attending the lab.

Table 6- 3: Chatbots Features for Three UTAUT2 Constructs.

6.2.3 Journey Mapping (JM)

After identifying the features of the nominated chatbots that support PE, EE and HT in section 6.2.2 and update the Persona3D model in section 5.5, there is a need to show different interaction with chatbots during the day. This section will cover the solution to this problem.

Persona3D is a representation of a group of students who share similar characteristics. The analysis in chapter 4 produces eight Persona3D for university students, further extended in chapter 5. According to Howard (2014), there is increasing evidences that using personas alone during the design process is not effective at putting the priority on users (the students) (Howard, 2014). Friess (2012) states that persona is a two-dimensional static profile and that time the companies invoked the developed personas represent only 3% of the decision-making time. Thus, Journey mapping (JM) was created, which adds the 3rd dimension to the persona. It provides a high-level overview of user interaction or experience with each touchpoint in the Journey Mapping. Also, JM makes the user interaction clear to the design team, such as software engineers, product managers, marketers, and others. Thus, Journey Mapping is a valuable tool for collaboration and communication in the user experience (Friess, 2012b; Howard, 2014). Detailed information about Journey Mapping was presented in chapter 2.

6.2.3.1 Designing Journey Mapping Template

This section covers the daily Journey Mapping for students, more specifically, different personas, which resulted in Iteration 1 (Chapter 4). A total of eight Journey Mappings were proposed to cover the previously identified eight personas, mainly based on persona type, time, location, interactions, and emotions (before and after). This section starts with designing and building a Journey Mapping template based on the Persona3D model, followed by making the Journey Mapping for the eight personas. Specific steps to create a Journey Mapping template for a day in the life of the student is as follow:

1. Design a Journey Mapping by adapting an existing Journey Mapping template (see Appendix G).

2. The tile of the Journey Mapping is placed at the top of the Journey Mapping template.

3. The title of the persona is placed at the bottom of the template. It is extracted from the Persona3D model for each persona type.

4. Place the Geneva Emotion Wheel keys (GEW) on the right side of the template. GEW represents students' emotions before and after the interaction with the touchpoint. The GEW (Sacharin, Schlegel and Scherer, 2012) is a theoretically driven and empirically tested instrument to measure emotional reactions to objects, events and situations.

5. Modify the y-axis to represent the location of the interaction with the touchpoints – including Home, Class, WLFB corridor, Lab, and COSTA. Also, add the x-axis to represent the time of the day from 8 am to 11 pm.

6. The proposed touchpoints (chatbots), extracted from the Persona3D model, are placed as a key on the left side of the template.

7. The Journey Mapping template is shown in Figure 6-2.

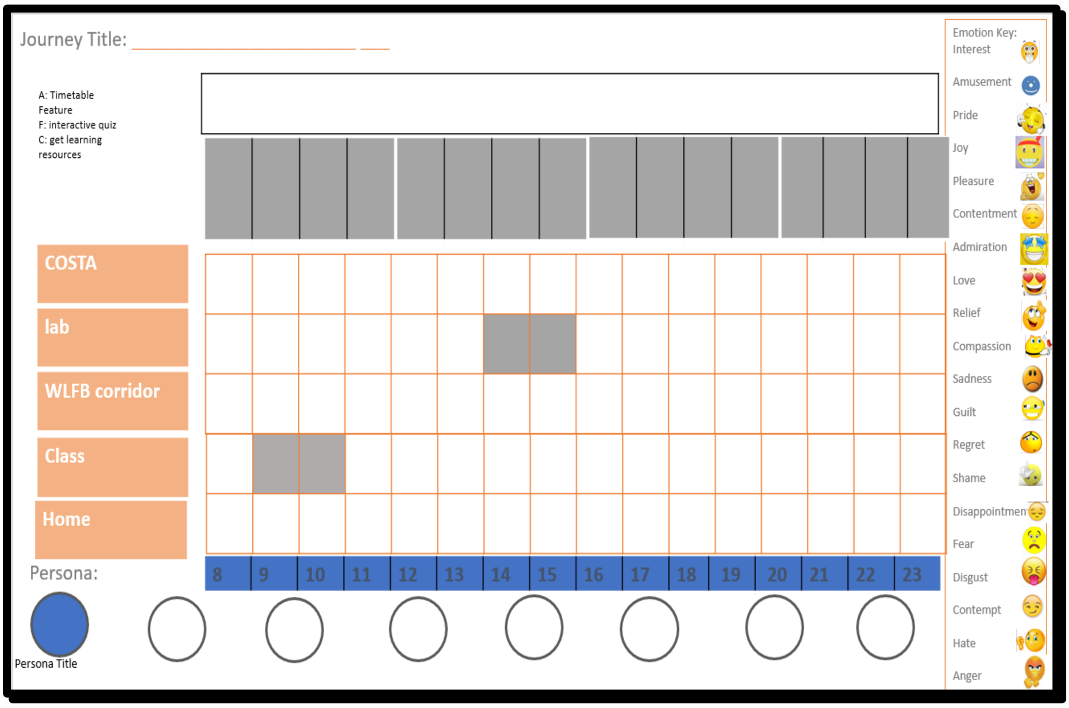


Figure 6- 2: Journey Mapping Template

6.2.4 A “Top Student “Journey

This section covers the Top Student Journey. It starts by showing the Persona3D model for top students who work as the basis to build Journey Mapping. Further, it shows designing and building chatbots that assess the effectiveness of the practical approach.

6.2.4.1 Persona3D Model for Top Students

Persona3D model for the Top Student was presented in Chapter 4, and as mentioned earlier, Chapter 5 extended the Persona3D with three elements/attributes that result from designing, building and evaluating the Extended UTAUT2. These elements are PE, EE and HT. Based on this, each element is supported by applications from the literature (Section 6.2.2) and a few elements were selected that support PE, EE and HT. Figure 6- 3 is an updated version of the persona3D for the top students, which shows the three elements PE, EE and HT, and each with its supported features chatbots.

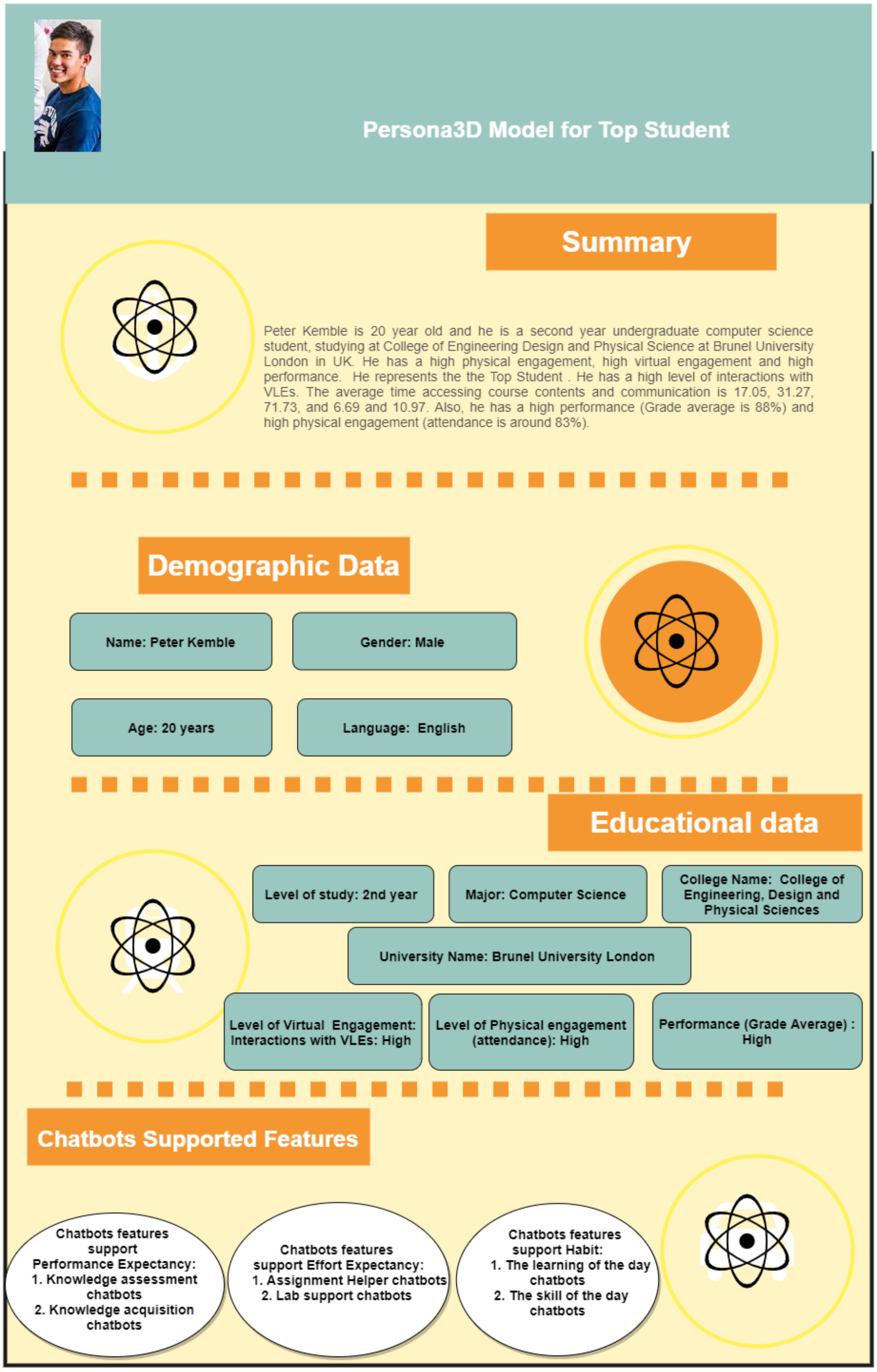


Figure 6- 3 Persona3D Model for Top Student

6.2.4.2: Journey Mapping for Top Students

This section covers the Journey Mapping for persona 3 (Figure 6-4), called “high virtual and physical engagement and performance”. It is also called the top students’ persona. The characteristic of this student persona is that they have a high attendance of the lab and lecture, a high performance (grade), and high engagement with VLE - time spent interacting with VLEs.

At the beginning of the day, student emotion is a relief at 8 am. The touchpoint A (the Learning of the Day) will interact with the student. The skill shows the importance of the day's lecture and lab by showing what students will gain by attending interestingly. In brief, it shows what the student is going to learn. Thus, the student attends the lecture. After the lecture, which was between 9-11 am, the skill (Knowledge Acquisition) will interact with students. The skill should answer the student's question about the lecture, such as concept meaning, further examples, and references, which change students feeling from contentment to amuse.

At 11 am in the WLFB corridor, when the student feels relief, the touchpoint (Knowledge Assessment) interacts with students. The skill assesses students' knowledge of the day's lecture and provides further feedback, turning students' emotion from relief to pleasure. It is a challenging quiz that covers the materials that students access that give more explanation of the topic. The student attends the lab, solving it without any difficulty. After school, at 7 pm, the touchpoint (get assignment guider) interacts with the student. This skill provides help to a student so he/she can successfully solve an assignment by breaking the assignment into sub-tasks and providing hints and guidance in each sub-task, which turn their feeling from contentment to amusement.

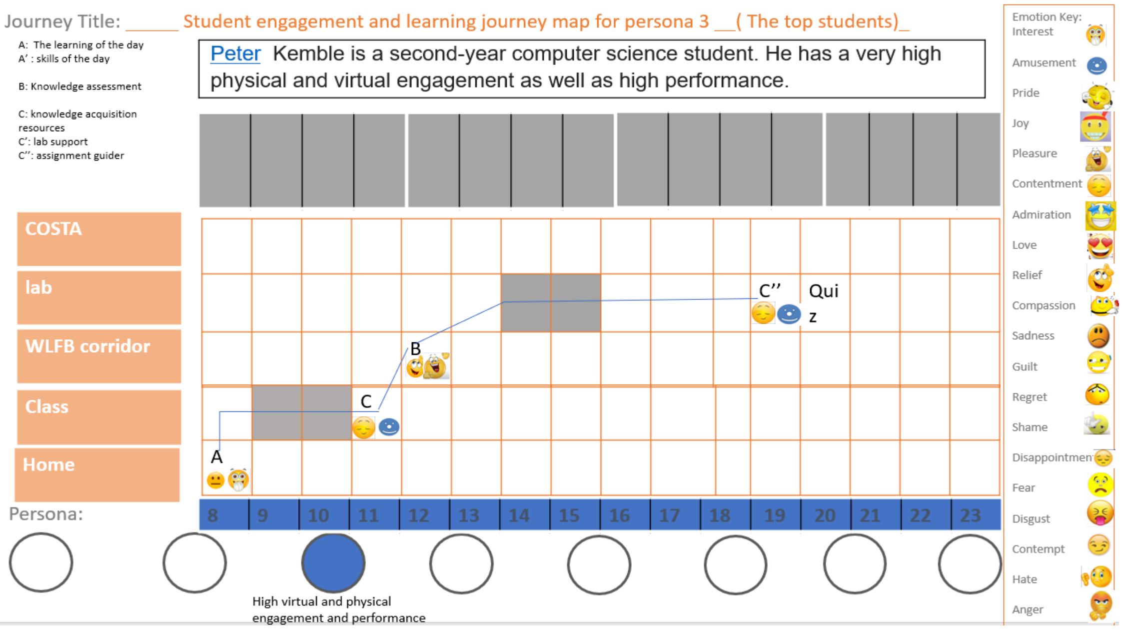


Figure 6- 4: Journey Mapping for Top Student

6.2.5 A "DISENGAGED STUDENT" Journey

This section covers the journey of the disengaged student. It starts by showing the Persona3D model, which works as the basis to build the Journey Mapping and eventually design and build the chatbots.

6.2.5.1 Extended Persona3D Model for Disengaged Students

Persona3D model for the disengaged student is similar to the Persona3D model for top students, both presented in chapter 4, then extended with three elements/attributes in chapter 5 after analysing the Extended UTAUT2. Based on the above discussion, each element is supported by applications from the literature and adapted to suit each persona type. Figure 6- 5 is an updated version of the persona3D for the disengaged student.

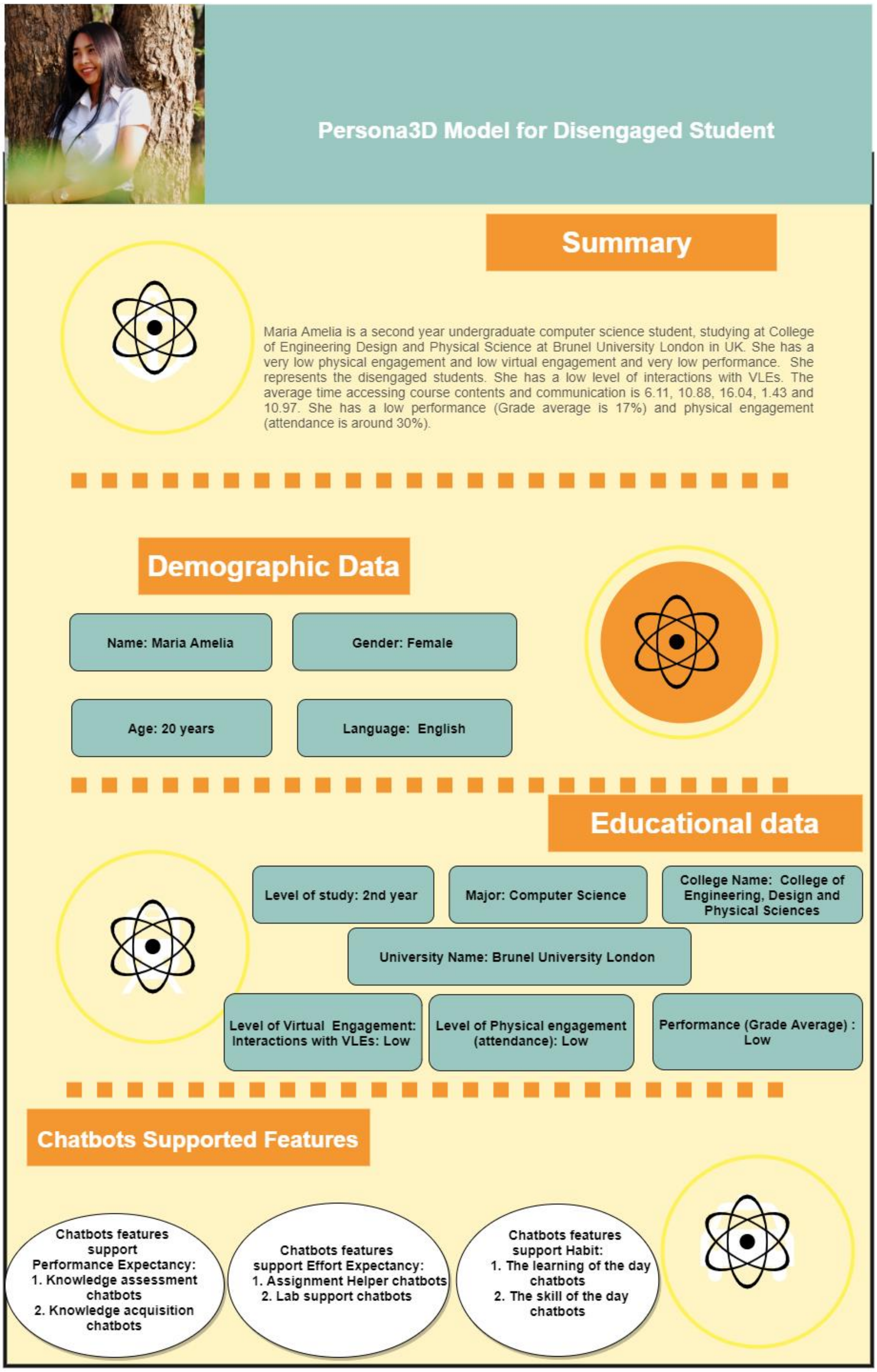


Figure 6- 5: Extended Persona3D Model for Disengaged Student

6.2.5.2 Journey Mapping for Disengaged Student

This section covers the Journey Mapping for persona 2, the “Very low physical engagement and performance and low virtual engagement” (Figure 6-6). It is also referred to as “disengaged student”. The characteristic of this student persona is that they have a very low attendance of the lab and lecture, a very low performance (grade), and a low level of interaction with VLE – they spend little time using VLE. Further information about students grouping (clusters) and the persona3D models are provided in Chapter 4, section 4.3.3.

The Journey Mapping in Figure 6-6 shows that student emotion is neutral at 8 am, at the beginning of the day. The touchpoint A (The learning of the Day) interacts with student and shows the importance of the day’s lecture and lab by showing what students will gain by attending in an interesting way, which turns them from neural to interested. It briefly states what the student is going to learn. Thus, the student attends the lecture. After the lecture, at 11 am, student emotion is likely to be in the ‘hate’ status; the touchpoint (Knowledge Acquisition) will interact with the user. The skill should answer student’s questions about the lecture, such as concept meaning, further examples, or references, which change students feeling from hate to relief. During the launch time in COSTA at 1 pm, the student hates to attend the upcoming lab; the touchpoint (Skills of the Day) interact with the student. The skill presents the usefulness of attending the lab, particularly the skills they will gain, which turn their emotion from hating to attend the lab to joy.

During the lab, from 2-4 pm, students face the challenge of solving the lab, the touchpoint (Lab Support) interacts with the student. The skill should assist a student so he/she can solve the lab successfully, which turn their emotion from disappointed to be amused. In other words, it helps students in dividing the task into sub-task and explain further the process of answering the lab’s questions.

After school, at 6 pm, the touchpoint (Knowledge Assessment) interacts with the student. The skills assess student knowledge about the day’s lecture and provide further feedback, turning student emotion from fear to relief. At 7 pm, the touchpoints (Assignment Guider) interacts with the student to provide help to the student so he/she can successfully solve the assignment by breaking the assignment into sub-tasks and providing hints and guidance in each sub-task, which turn their feeling from guilt to relief.

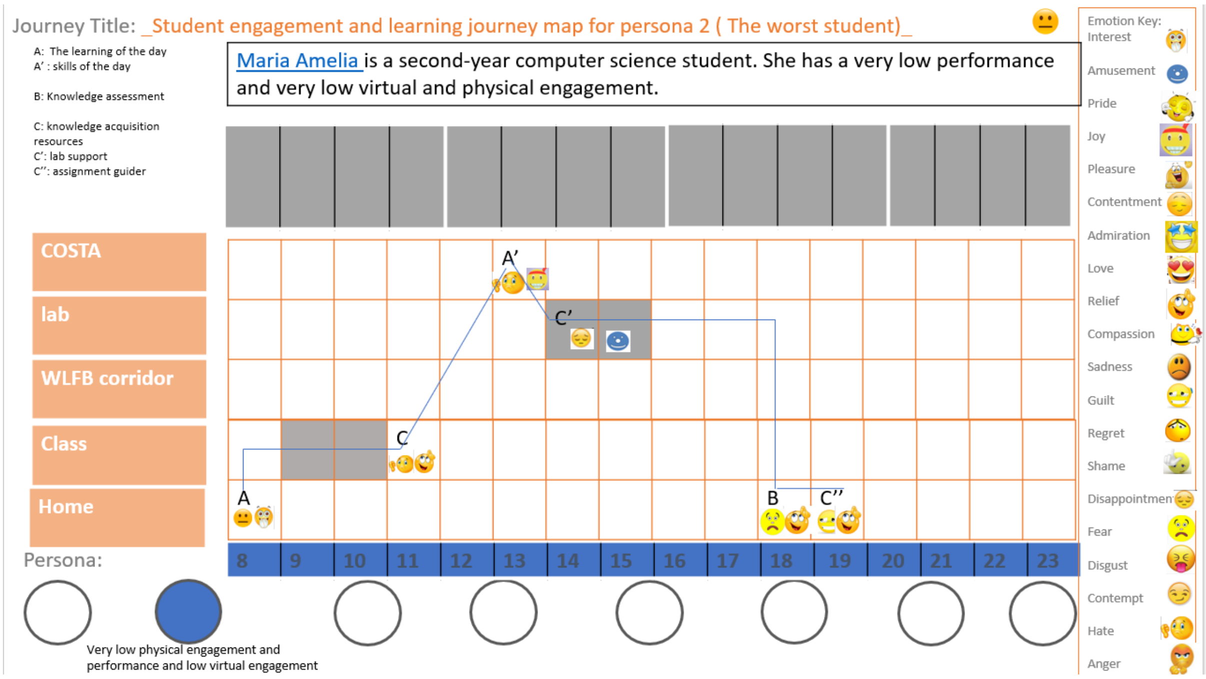


Figure 6- 6: Journey Mapping for Disengaged Student

6.2.6 Summary of Other 6 Personas

In addition to the above mentioned two personas, the top students and the disengaged students, there are six more personas. The design and development of each one of these six chatbots involve accessing the Persona3d model for that particular persona and the associated Journey Mapping. A summary of each persona is provided: 1) Unsuccessful self-learner (Persona1) represents a student with poor physical engagement and performance. However, the student has a high virtual engagement represented by interaction with VLE - more specifically, forum, viewing learning materials, etc. 2) Successful student (Persona 4) represents a student with high physical engagement and performance. However, the student has a low virtual engagement with VLE. 3) Self-learner student represents a student who has a high virtual engagement and high performance but low physical engagement (Persona 5). 4) The Experienced student (Persona 6) represents a student who has a high virtual engagement and performance but low physical engagement. 5) Learning difficulty student (Persona 7) represents a student who has good physical engagement, high virtual engagement but the low performance and 6) the unsuccessful student (Persona 8), represents a student who is engaging physically only, with low virtual engagement and low performance. The Persona3D for each of the above personas (see, Appendix H, Eight Persona3D Models) with its related Journey Mapping is attached (see, Appendix I, Journey Mapping model)

It is essential to mention that the Persona3D approach developed in the first and second design research iterations has identified elements and attributes that support the application of chatbots, which generated from evaluating the Extended UTAUT2 model (Chapter 5). They are PE, EE and HT, which are common for all personas. This iteration identified practical approaches or chatbots features based on the literature review, which shows different applications that support the three mentioned elements. A complete list of proposed applications that support PE, EE and HT are shown in Table 6-2, and features of the selected chatbot are shown in Table 6-3. Interactive quiz and knowledge acquisition support PE, and learning resources support EE – divided into two chatbots: assignment guider and lab support. Attending class (timetable) to support HT and it represented by learning of the day chatbots and the skill of the day chatbots, which encourage students indirectly to attend the lecture and the lab by providing information about the knowledge and skills the students will gain by attending. Further information about the location and time of the class and lab is also provided in the chatbots.

6.3 Artefacts Building and Development

There is a need to design and build a range of chatbots (instantiations) to test the effectiveness of the Persona3D approach that was built in iteration 1 and 2. This section covers the implementation of two chatbots for two personas: the top student persona and the disengaged student persona. Details about each persona are provided in its Persona3D model. These Persona3D models are the basis for building the Journey Mapping, which shows the interactivity between the chatbots and students in different locations, time, or emotions. The practical effectiveness of the Persona3D model approach is assessed by building a range of chatbots. A range of chatbots will be developed in the Amazon Alexa platform, including the client (Alexa Skill Kit) and the severs side (Amazon AWS developer). Further details about the interaction model (in client), the code of the server, database and email services are provided in the following sections. The snapshot of the chatbots execution for two chatbots are shown in Section 6.3.1 and 6.3.2, and the rest in Appendix J.

6.3.1 Knowledge Acquisition Chatbot (Implementation)

Before starting the chatbots implementation, it is essential to access its Persona3D model and Journey Mapping. Persona3D model will help in understanding this persona and provide suitable content and information to him/her. The implementation of these chatbots requires the client (Amazon Alexa kit), server (Amazon AWS developer), database (DynamoDB) and send email services (Send Email Services). The Knowledge Acquisition chatbot is the implementation of touchpoint C in Journey Mapping for Top Students persona, as shown in Figure 6-4 above. The interaction occurs at 11 am after attending the lecture (9-11 am).

The Knowledge Acquisition chatbot aims to provide answers to user questions about the java programming module. Also, it provides further information and links to their email address. The Knowledge Acquisition chatbot uses DynamoDB to hold the database, which contains the questions and answers. Also, this chatbot uses Simple Email Services (SES) to send email to the user with further links that have additional information the covers the answer. The Knowledge Acquisition chatbots architectures are shown in Figure 6-7.

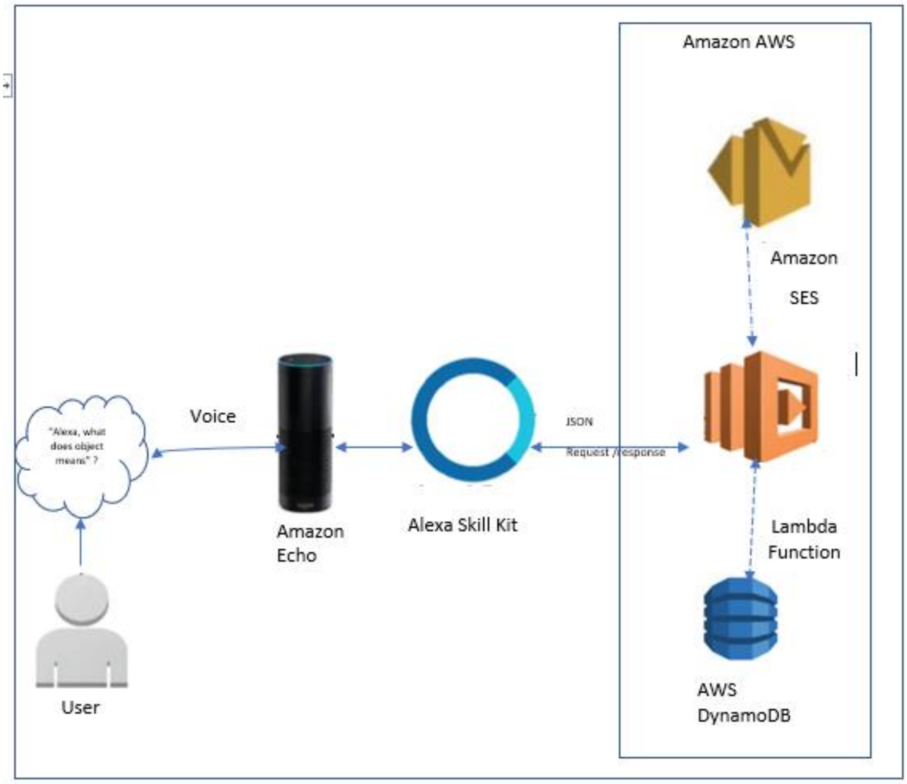


Figure 6- 7: Knowledge Acquisition Chatbot Architecture– Amazon Alexa platform

The interaction model of the Knowledge Acquisition chatbot (Client-side) is shown in Figure 6-8, which shows the intents, slots, and utterances. Figure 6-9 shows the implementation of the server-side of the chatbot. The code to set up the connection to the database “Java_Question2” is shown in Figure 6-10, while Figure 6-11 shows the code to set up the SES, including the receipt email address and the structure of the email. The execution of the Knowledge Acquisition chatbot is shown in Figures 6-12, 6-13, and 6-14; it starts with invoking the chatbot. Then, the chatbot sends further information to the user using their email address, as shown in Figure 6-15.

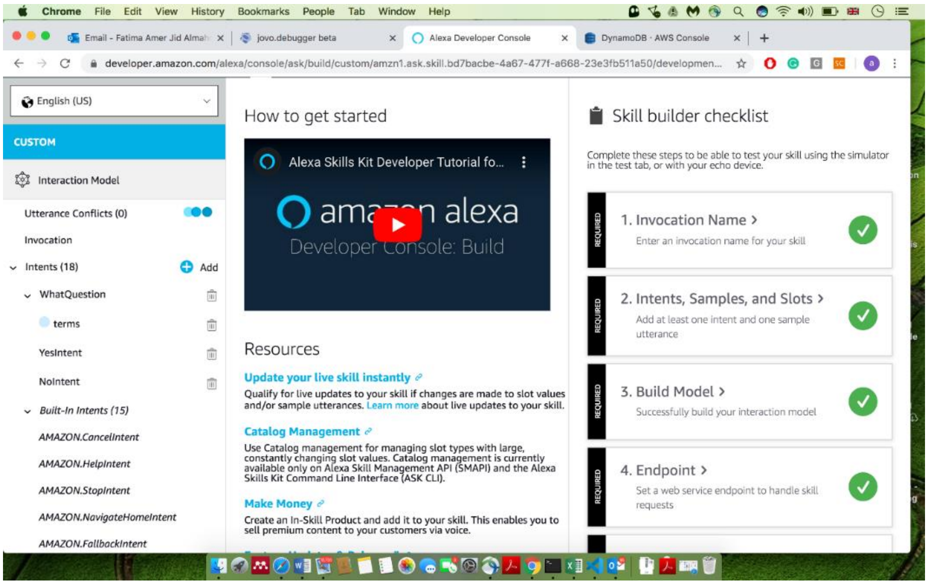


Figure 6- 8: Knowledge Acquisition Chatbot –Interaction Model

```
'use strict';

// ------------------------------------------------------------------
// APP INITIALIZATION
// ------------------------------------------------------------------

const { App } = require('jovo-framework');
const { Alexa } = require('jovo-platform-alexa');
const { GoogleAssistant } = require('jovo-platform-googleassistant');
const { JovoDebugger } = require('jovo-plugin-debugger');
const { FileDb } = require('jovo-db-filedb');
const dDB = require('./dynamoDB');
const dynamoDB = new dDB();
const ses = require('./ses');
const Ses = new ses();

const app = new App();

app.use(
new Alexa(),
new GoogleAssistant(),
new JovoDebugger(),
new FileDb()
);

// ------------------------------------------------------------------
// APP LOGIC
// ------------------------------------------------------------------

app.setHandler({
LAUNCH() {
return this.toIntent('Welcome to the advanced knowledge acquisition');
},

Welcome() {
this.setState('QuestionState')
this.ask("You can ask me questions about any lecture by typing the lecture title.")
},

QuestionState: {
async WhatQuestion() {
const id = this.$inputs.terms.id
if (id) {
const javaQA = await dynamoDB.get(parseInt(id))
this.setState('MoreInformationState')
this.setSessionAttribute('javaQA', javaQA)
this.ask(`${javaQA.answer} Do you want more information?`)
} else {
```

```
this.ask(`I did not get your question about ${this.$inputs.terms.value}. Please ask a question
about Java Programming.`)
}
},
Unhandled() {
this.ask(`I did not get your question. Please ask a question about Java Programming.`)
}


MoreInformationState: {
YesIntent() {
const javaQA = this.getSessionAttribute('javaQA')
Ses.email(javaQA)
this.setState('QuestionState')
this.ask('I have sent more information to your email. You can ask me more questions')
},
NoIntent() {
this.tell('Goodbye')
},
module.exports.app = app;
```

Figure 6- 9: Knowledge Acquisition Chatbot Code (app.js)

[redacted]

```
'use strict';
const AWS = require('aws-sdk');

AWS.config.update({

accessKeyId: "AKIA2NATPJN4BOYH67L6", // new

secretAccessKey: "xBGD4OGUva832CI4vb7l3GIgLccYpUGXfL2Fv5Mr", //new

region: "us-east-1", // new

class dDB {

constructor() {

this.client = new AWS.DynamoDB.DocumentClient();

this.userTable = 'Java_Questions2'; // new

}get(questionNumber) {

console.log({ questionNumber })

return this.client.get({

TableName: this.userTable,
Key: { questionNumber },
}).promise()
.then(item => item.Item);

put(data) {
return this.client.put({
TableName: this.userTable,
Item: data,
}).promise();
}
module.exports = dDB;
```

Figure 6- 10 :Knowledge Acquisition Chatbot Code (database.js)

```
`use strict';
var aws = require('aws-sdk');

// Provide the full path to your config.json file.
aws.config.update({
accessKeyId: "AKIA2NATPJN4BOYH67L6", // new
secretAccessKey: "xBGD4OGUva832CI4vb7l3GIgLccYpUGXfL2Fv5Mr", //new
region: "us-east-1", // new
```

```
}class ses {
constructor() {
this.client = new aws.SES();
this.sender = “Fatima Almahri <fatima.amerjidalmahri@brunel.ac.uk>”;
// new
}email(item) {
var params = {
Source: “Knowledge Acquisition for top student<fatima.amerjidalmahri@brunel.ac.uk>”,
// new
Destination: {
ToAddresses: [
“fatima.amerjidalmahri@brunel.ac.uk”, // new
“fatima.amerjidalmahri@outlook.com”, // new
“fatmam.sal@cas.edu.om”, // new
],
},Message: {
Subject: {
Data: “Amazon SES Test (AWS SDK for JavaScript in Node.js)”,
Charset: “UTF-8”
},Body: {
Text: {
Data: “Amazon SES Test (SDK for JavaScript in Node.js)\r\n”
+ “This email was sent with Amazon SES using the “

+ “AWS SDK for JavaScript in Node.js.”,
Charset: “UTF-8”
},Html: {
Data: `<html>
<head></head>
<body>
<h1>Question: ${item.question}</h1>
<h2>Answer ${item.answer} More information
in this link.<a href=’${item.link}’>${item.link}</a>
</h2>
</body>
</html>`,
Charset: “UTF-8”
}this.client.sendEmail(params, function (err,
data) {
// If something goes wrong, print an error message.
if (err) {
console.log(err.message);
} else {
console.log(“Email sent! Message ID: “, data.MessageId);

module.exports = ses;
```

Figure 6- 11: Knowledge Acquisition Chatbot Code (SES.js)

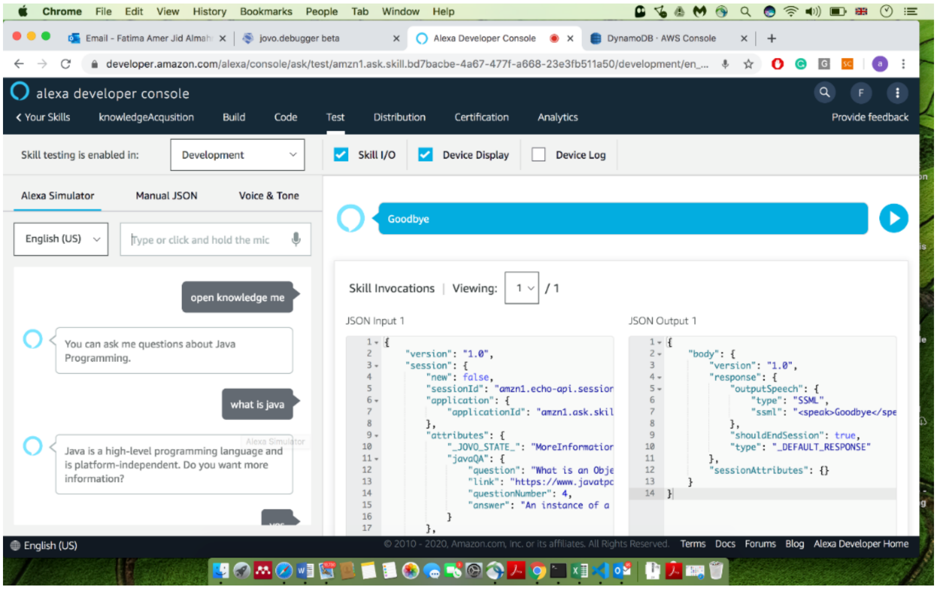


Figure 6- 12: Knowledge Acquisition Chatbot – Execution

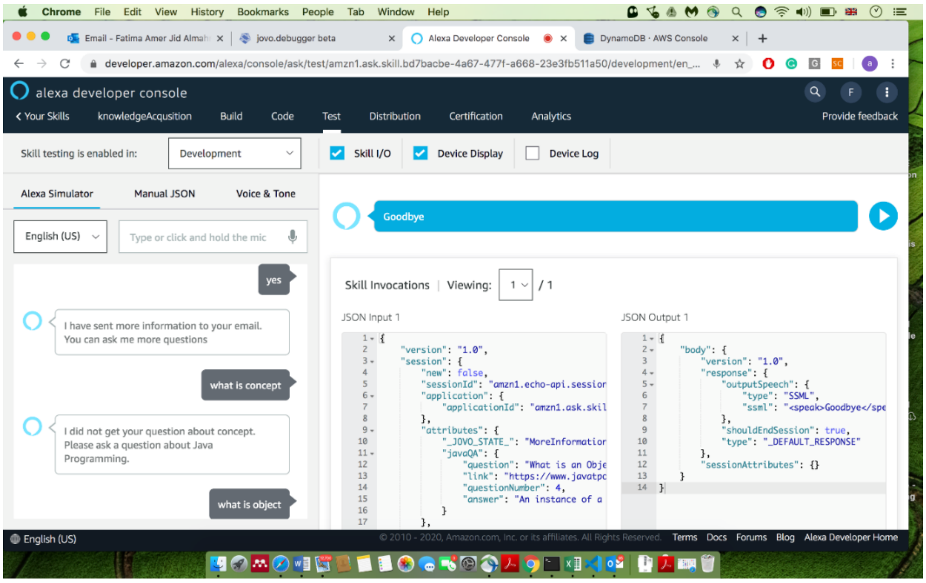


Figure 6- 13: Knowledge Acquisition Chatbot – Execution

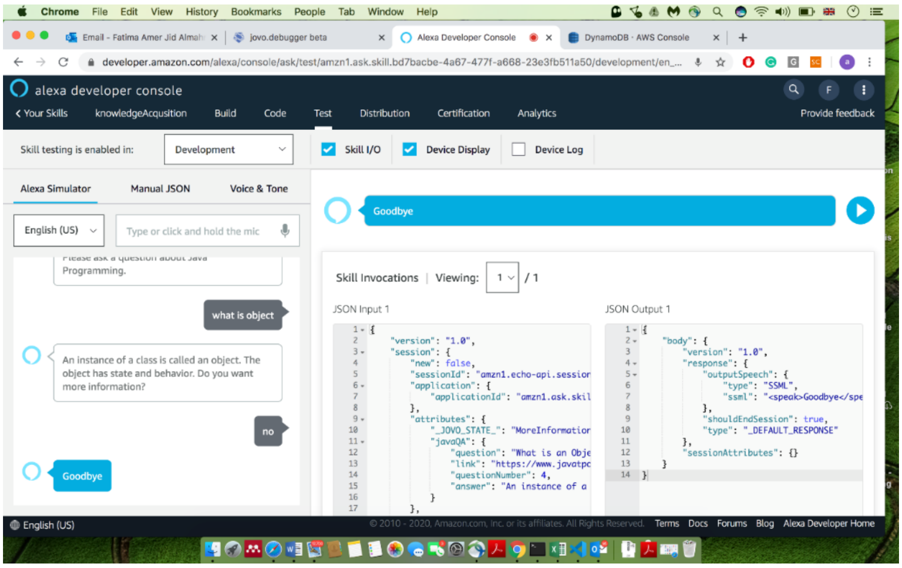


Figure 6- 14: Knowledge Acquisition Chatbot– Execution

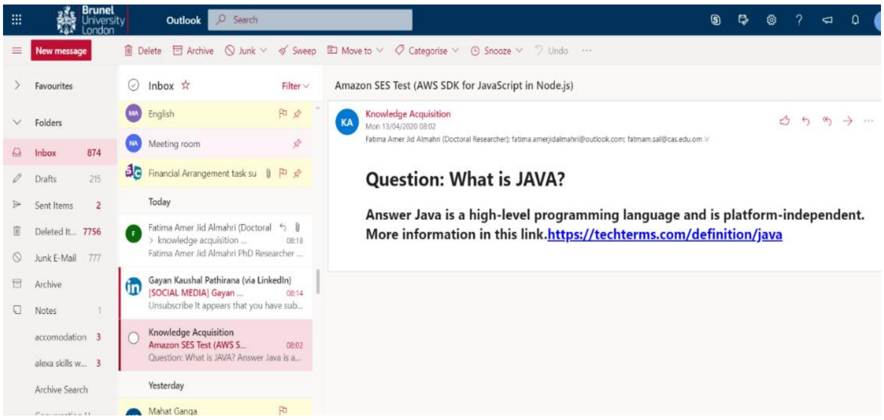


Figure 6- 15: Knowledge Acquisition Chatbot – Sending Email

6.3.2 Assignment Guider (IMPLEMENTATION)

As mentioned earlier, a range of chatbots is created to assess the effectiveness of the practical approach of Persona3D. Before developing each chatbot for each persona, it is essential to understand the persona by accessing the Persona3D model. It is also essential to access Journey Mapping and use it to understand further information regarding the interaction between the user and the chatbot. This section covers the implementation of touchpoint C from the Journey Mapping of disengaged student, as shown in Figure 6-6 above. Touchpoint C was at 8 pm at home. Persona3D and Journey Mapping are accessed several times to identify the requirements of the chatbot design. The Assignment Guider chatbot architecture is shown in Figure 6-16.

The implementation of this chatbot requires the client (Amazon Alexa kit), server (Amazon AWS developer), database (DynamoDB) and setting up the email services (Send Email Services). The client-side is implemented in Amazon Alexa Developer. The server-side implemented in Amazon AWS developer, with the code written in JavaScript and uploaded to Lambda function in Amazon AWS developer. The implementation also requires a database (DynamoDB), a service provided by Amazon AWS, that holds questions, answers and useful links. These chatbots utilise Simple Email Services, which allows the chatbot to send email to the user with further information. The idea of this chatbot is to help the disengaged student solve assignments by providing further information and sending links to his/her email address. Figure 6-17 shows the design of the chatbot (the interaction model). The server side is written in Javascript and uploaded to the Lambda function in Amazon ASW developer. The codes for the server-side include app.js, database.js and SES.js; shown in Figures 6-18, 6-19 and 6-20. The execution of the codes is shown in Figure 6-21, 6-22, 6-23 and 6-24.

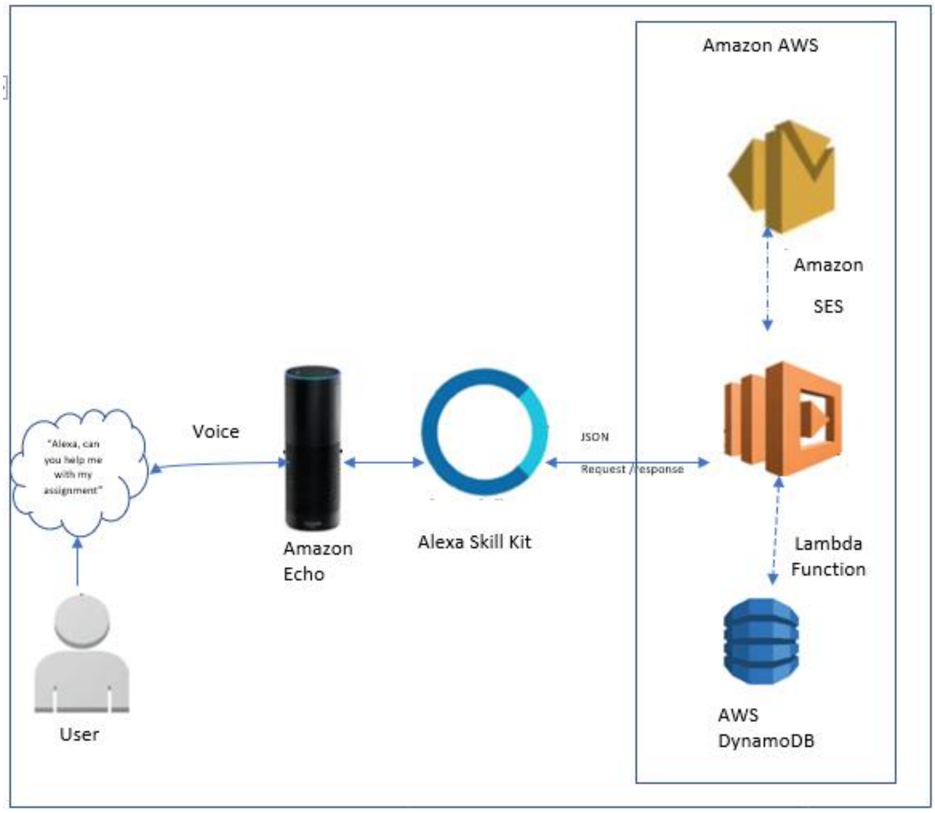


Figure 6- 16: Assignment Guider Chatbot Architecture – Amazon Alexa Platform

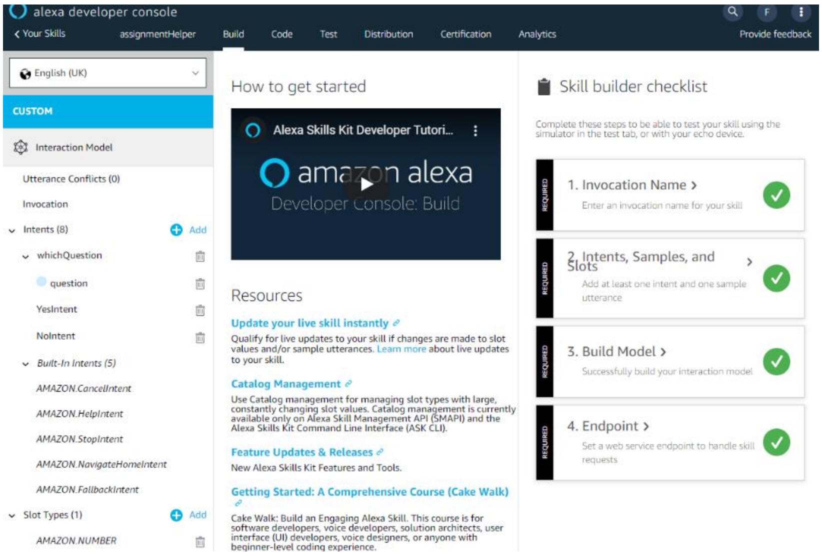


Figure 6- 17: Assignment Guider Chatbot – Interaction Model

```
'use strict';

// ---------------------------------------------------------------
// APP INITIALIZATION
// ---------------------------------------------------------------

const { App } = require('jovo-framework');
const { Alexa } = require('jovo-platform-alexa');
const { GoogleAssistant } = require('jovo-platform-googleassistant');
const { JovoDebugger } = require('jovo-plugin-debugger');
const { FileDb } = require('jovo-db-filedb');

const app = new App();

const dDB = require('./dynamoDB');
const dynamoDB = new dDB()
const ses = require('./ses');
const Ses = new ses();

app.use(
new Alexa(),
new GoogleAssistant(),
new JovoDebugger(),
new FileDb()
);

// ---------------------------------------------------------------
// APP LOGIC
// ---------------------------------------------------------------

app.setHandler({
LAUNCH() {
return this.toIntent('SelectNumber');
},

SelectNumber() {
this.setState('SelectNumberState')
this.ask('Welcome to the assignment helper! Which assignment question number you need help with?');
},

SelectNumberState: {

async whichQuestion() {
console.log(this.$inputs.question.value)
const number = parseInt(this.$inputs.question.value)
const item = await dynamoDB.get(number)
```

```
this.setSessionAttribute('item', item)
this.setState('MoreInformation')
this.ask(`You selected assignment ${item.question} ${item.answer}. Do you want more information? Yes or No?`)
}
},

MoreInformation: {
YesIntent() {
const item = this.getSessionAttribute('item')
Ses.email(item)
this.setState('SelectNumberState')
this.ask('I have sent more information to your email. What assignment question number do you need help with?')
},
NoIntent() {
this.tell('Goodbye')
}
}
}
);

module.exports.app = app;
```

Figure 6- 18. Assignment Guider Chatbot Code (app.js)

```
'use strict';

var aws = require('aws-sdk');

// Provide the full path to your config.json file.

Aws.config.update({

    accessKeyId: "AKIA2NATPJN4BOYH67L6",

    secretAccessKey: "xBGD4OGUva832CI4vb7l3GIgLccYpUGXfL2Fv5Mr",

    region: "us-east-1"

});class ses {

    constructor() {

        this.client = new aws.SES();

    }    email(item) {

        var params = {

            Source: "Assignment Helper<164atima.amerjidalmahri@brunel.ac.uk>",

            Destination: {

                ToAddresses: [

                    "164atima.amerjidalmahri@brunel.ac.uk",

                    "164atima.amerjidalmahri@outlook.com",

                    "fatmam.sal@cas.edu.om"


            Message: {

                Subject: {

                    Data: "Amazon SES Test (AWS SDK for JavaScript in Node.js)",

                    Charset: "UTF-8"

                }

                Body: {

                    Text: {
```

```
                        Data: "Amazon SES Test (SDK for JavaScript in Node.js)\r\n"
                            + "This email was sent with Amazon SES using the "
                            + "AWS SDK for JavaScript in Node.js.",
                        Charset: "UTF-8"
                   ,Html: {
                        Data: `<html>
                        <head></head>
                        <body>
                          <h1>Question: ${item.question}</h1>
                          <h2>Answer  ${item.answer}  More  information  in  this  link.<a
href='${item.link}'>${item.link}</a> </h2>
                        </body>
                        </html>`,
                        Charset: "UTF-8"
        this.client.sendEmail(params, function (err, data) {
            // If something goes wrong, print an error message.
            If (err) {
                console.log(err.message);
            } else {
                console.log("Email sent! Message ID: ", data.MessageId);
            }module.exports = ses;
```

Figure 6- 19: Assignment Guider Chatbot Code (SES.js)

```
const AWS = require('aws-sdk')
AWS.config.update({
    accessKeyId: "AKIA2NATPJN4BOYH67L6",
    secretAccessKey: "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",
    region: "us-east-1"
});class dDB {
    constructor() {
        this.client = new AWS.DynamoDB.DocumentClient();
    }    get(number) {
        return this.client.get({
            TableName: "AssignmentHelper",
            Key: { number }
        }).promise().then(item => item.Item)
  }}module.exports = dDB;
```

Figure 6- 20: Assignment Guider Chatbot Code (Database.js)

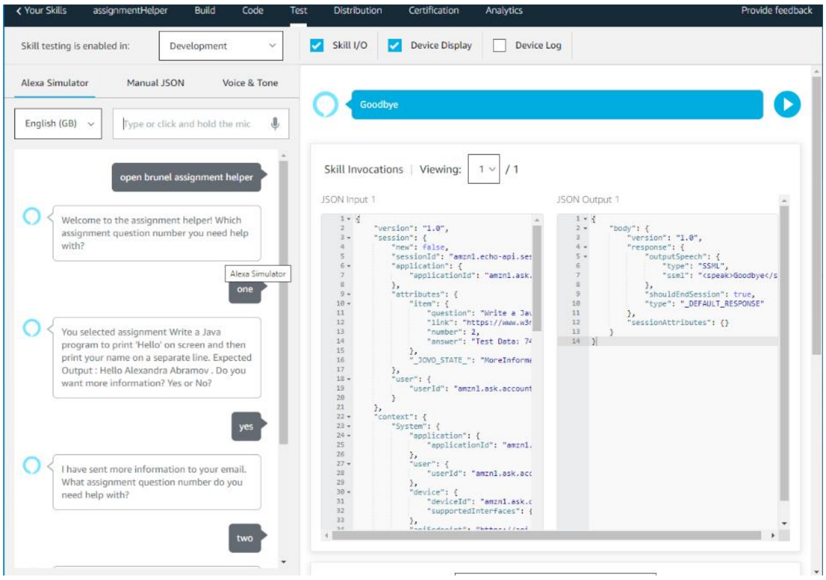


Figure 6- 21: Assignment Guider Chatbot -Execution

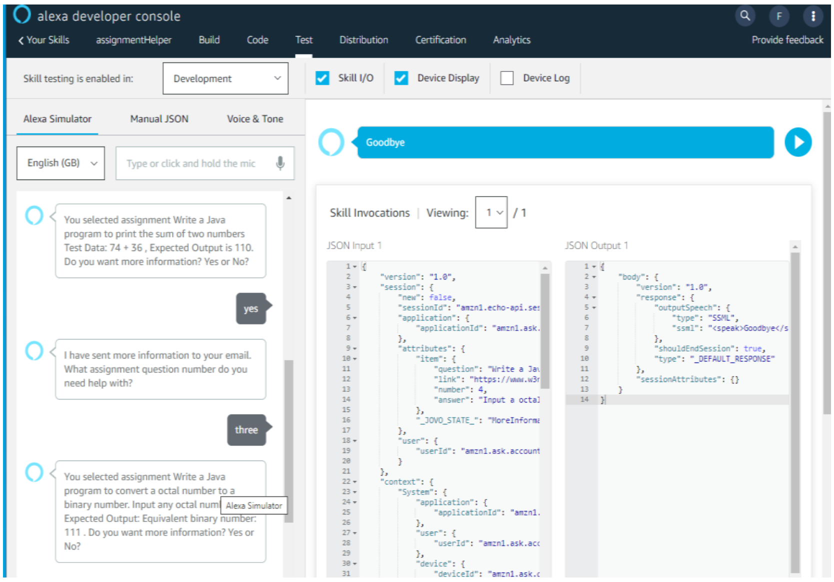


Figure 6- 22: Assignment Guider Chatbot -Execution

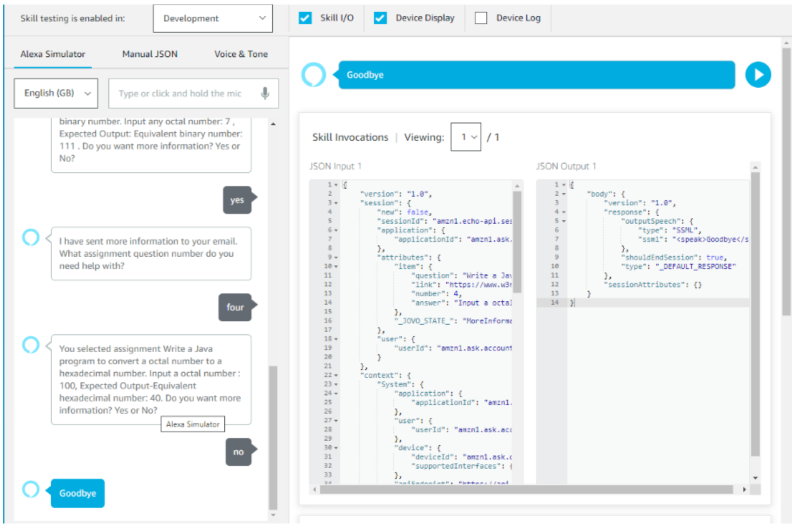


Figure 6- 23: Assignment Guider Chatbot -Execution

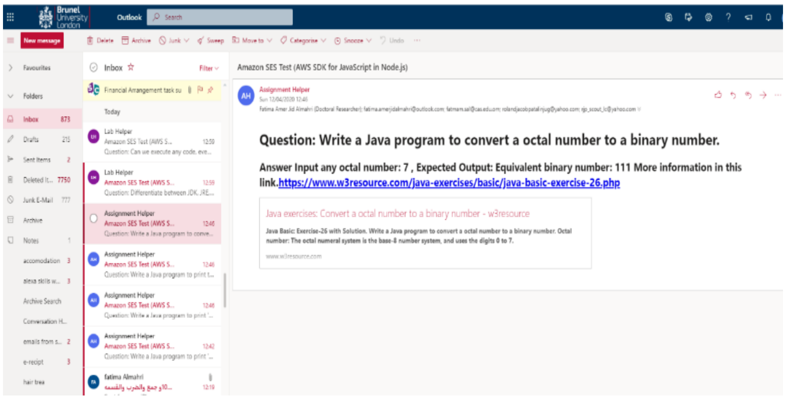


Figure 6- 24: Assignment Guider Chatbot -Execution

6.3.3 Summary of other Six Chatbots

As mentioned in section 6.1, eight chatbots were developed. Two of them covered in sections 6.3.1 and 6.3.2. The codes and execution of the remaining other six chatbots are shown in Appendix J. These six chatbots are summarised in this section as follow:

1) The Learning of the Day chatbot: this chatbot provides an overview of what the students will learn on any given day. It will provide information on the time and location of the lecture and the expected outcome to encourage students to attend the lab. For all personas, the touchpoints are A, and it starts at 8 am. A snapshot of the code execution is shown in Appendix J. 2) The Knowledge Acquisition chatbot: this chatbot, in Journey Mapping, run after the lecture, usually from 9-11 am. The

chatbot allows the user to ask questions about the lectures, and providing answers to those questions. 3) The Skill of the Day chatbot: is a chatbot that aims to encourage students to attend the lab by providing the type of skills they will gain by attending the lab. It also provides information about the location and time of the lab. 4) The Lab Support chatbot: assist students in understanding and performing the lab successfully; it allows users to specify which questions they need help with, provide answers to them, with further information sent to the user's email. This chatbot uses DynamoDB to hold the lab's questions and answers and uses Simple Email Service to send further information to the user email address. 5) The Knowledge Assessment chatbot for disengaged student assess student knowledge on the learning outcome on that day and others; done via a true/false quiz. This chatbot asks the user, checks the user answer with the stored data, and it marks the answer by either "your answer is correct" or "your answer is wrong". 6) Knowledge Assessment for top students: assess students' knowledge similar to the previous chatbot. However, these chatbots provide more challenging questions for the top students. The Journey Mapping is shown in Appendix I for each of the Persona3D models are shown in Appendix H,

6.4 Artefacts Evaluation

According to March and Smith (1995), artefact evaluation is a critical phase that measures artefacts' progress and performance based on a precise metric (March and Smith, 1995). The evaluation criteria of constructs, models, methods and instantiations by March and Smith (1995) is provided in Chapter 3 (Table 3-2). As shown above, different artefacts were produced in this iteration. This section evaluates several artefacts: 1) evaluating the effectiveness of the extended Persona3D model in supporting the Journey Mapping model. 2) evaluating the effectiveness of the extended Persona3D model in supporting the chatbot coding. 3) evaluating the effectiveness of extended Persona3D in supporting the building of chatbots, 4) evaluating the completeness of the extended Persona3D model, and 5) evaluating the completeness of the Journey Mapping model.

First, evaluating the effectiveness of extended Persona3D in supporting the Journey Mapping model. Extended Persona3D models identify key student groups (see, Chapter 4, Section 4.3.3) and interaction types with potential values (see, Chapter 5, Section 5.5 and Section 6.2.2). Eight persona3D models were produced from the first iteration, and three chatbots features resulted, in the second iteration, from designing, building and evaluating the extended UTAUT2 using the Structural Equation Modelling (SEM) approach. However, the information provided in the Persona3D model does not show the students interaction with the chatbots. Therefore, a Journey Mapping was developed based on the extended Persona3 model. It shows further information and interaction not relected in the extended Persona3D model. Both Journey Mapping and extended Persona3D (Persona Model) are essential tools in services design. In this iteration, extended Persona3D was used as the basis to build the Journey Mapping as covered in designing the Journey Mapping template (see, Section 6.2.3), including the persona title, chatbots features which are the two main components in the Journey Mapping. There are also new elements proposed in the Journey mapping that contributes to understanding student journey and interactions with chatbots, including time, location, user emotion before and after using the system, services touchpoints, and user requirements through interactions with the system (i.e. chatbots). Thus, this proves that the extended Persona3D model is effective in supporting Journey Mapping.

Second, evaluating the effectiveness of using extended Persona3D in supporting the chatbot coding. As mentioned above, the extended Persona3D model resulting from the first and second iteration contains demographic, educational data, virtual engagement, physical engagement and performance (see, Chapter 4, Section 4.3.3), in addition to the features of the chatbots that support PE, EE and HT which were added in iteration two and identified in this iteration. The chatbots features that support PE, EE and HT, apply to all users. However, it was developed differently based on each persona. For example, the knowledge assessment (Interactive Quiz) is more challenging for the top students than the knowledge assessment for the low-performance students (see Appendix J). The chatbot also sends further details related to the user query to the user based on the persona type. During the development of chatbots, extended Persona3D model and Journey Mapping were checked frequently. This confirms that extended Persona3D is effective in supporting the development of chatbots.

Third, evaluating the effectiveness of extended persona3D in building the chatbots. This iteration covers creating a logbook during the development of all chatbots. These files were analysed using Nvivo 12 pro software shows that an essential element in the thinking process is checking the Journey Mapping and the extended Persona3D model. The result of running the word frequency query in NVIVO for the lab support chatbots logbook while creating chatbots is shown in Appendix L. It reveals that checking persona3D and Journey mapping is an essential step in building the chatbots. Many steps in the development of chatbots involve checking the journey mapping and persona3D model. These steps are mainly related to understanding the personas and chatbots features which are covered in extended Persona3D and Journey Mapping. These steps, along with a supporting quotations from the logbook of the lab support chatbot developed, is provided as follow:

1)naming the skill on the client slide and naming the functions on the server side.

"one of the best practices in chatbot development is to provide meaningful name to the skill in the client-side and the function name in the server-side. To achieve that, I will check the persona model and journey mapping. "

2) specifying the requirements of the chatbots.

"I have to check the journey map and persona because I need to specify the requirements and design of the skill. The idea is that the skill will ask the user which part of the lab is difficult, and the user specifies the question number; then the skill provide answers and link for further information, this is basically the interaction model."

3) building the interaction model

"to build the interaction model on the client-side. I need to specify the intents name and the slots name with their type. I have to look at the journey map to imagine the interactions between the user and the chatbot. Also, I have to look at the persona model to know the type of persona that this chatbot is designed and developed for."

4)decided which text to provide in the conversations.

“ *Now, based on the requirements (check journey map: time, location) and persona model (types of the user), it will be much easier to identify the conversation/text between the client (user) and the server. “*

Doing the steps mentioned above and more requires accessing the Persona3D and journey Mapping model, which confirms the effectiveness of using extended persona3D in supporting building the chatbots.

Fourth, evaluating the completeness of the extended persona3D model. According to Bajaj and Ram (1999), evaluating the completeness of the conceptual models can be divided into two methods: non-empirical and empirical. There are two advantages of evaluating the model using the non-empirical method: 1) the evaluation leads to absolute answers about completeness that are independent of a particular empirical situation, 2) evaluation using non-empirical methods requires less effort and time to perform the validation (Batini, Ceri and Navathe, 1992). A new novel way of evaluating the completeness of the model will be proposed in this section that is based on evaluations presented in a high-quality paper adapted from Bailey and Pearson (1983)- which is cited by 4013 articles, also Batini, Ceri and Navathe, (1992) which is cited by 1828 articles and Soutou (1998).

Further details are provided in Appendix K. The proposed evaluation method contains the following steps: 1) list persona elements by reviewing the literature, 2) check that each element of the model represent user requirements and each user requirements represent an element in the user model, 3) evaluate the completeness of the model which should be done by close participants of the business user, in this case, the researcher, and 4) keep only the elements that match the user requirements and remove the rest.

To explain further, evaluating the completeness of the extended Persona3d model is done using the above-proposed evaluation method. The first step has been achieved in chapter 4, and the classification of these elements is shown in Table 4-8 plus others. These persona elements included name (Shiga and Nishiuchi, 2013; Kimita, Nemoto and Shimomura, 2014; Hill *et al.*, 2017; Quintana *et al.*, 2017; Valentim, Silva and Conte, 2017; Ferreira *et al.*, 2018; Polst, S. and Stüpfert, 2019)

, age (Milligan and Cooper, 1985; Wirth and Hipp, 2000; Tibshirani, Walther and Hastie, 2001; Shiga and Nishiuchi, 2013; Kimita, Nemoto and Shimomura, 2014; Quintana *et al.*, 2017; Valentim, Silva and Conte, 2017; Ferreira *et al.*, 2018; Polst, S. and Stüpfert, 2019), gender(Nieters, Ivaturi and Ahmed, 2007; Shiga and Nishiuchi, 2013; Kimita, Nemoto and Shimomura, 2014; Quintana *et al.*, 2017; Valentim, Silva and Conte, 2017; Ferreira *et al.*, 2018) , picture (Hartigan, 1975; Tibshirani, Walther and Hastie, 2001; Shiga and Nishiuchi, 2013; Singh, Yadav and Rana, 2013; Kimita, Nemoto and Shimomura, 2014; Quintana *et al.*, 2017; Valentim, Silva and Conte, 2017; Ferreira *et al.*, 2018; Syakur *et al.*, 2018; Polst, S. and Stüpfert, 2019), year of study/highest qualification/education level (Roussou *et al.*, 2013; Shiga and Nishiuchi, 2013; Kimita, Nemoto and Shimomura, 2014; Ferreira *et al.*, 2018) Major (Kimita, Nemoto and Shimomura, 2014), university name (Kimita, Nemoto and Shimomura, 2014), location / place of residence (Valentim, Silva and Conte, 2017), level of interactions with VLEs (Kimita, Nemoto and Shimomura, 2014; Polst, S. and Stüpfert, 2019), grade (Shiga and Nishiuchi, 2013) ,summary back story (Quintana *et al.*, 2017; Polst, S. and Stüpfert, 2019).

Furthermore, it includes other elements including studying, moving, the used technology (Quintana *et al.*, 2017), personality, the general use of the computer and interest (Ferreira *et al.*, 2018), profession(Valentim, Silva and Conte, 2017; Polst, S. and Stüpfert, 2019), eating, motivations of taking the course (Quintana *et al.*, 2017; Ferreira *et al.*, 2018), and residential status (Kimita, Nemoto and Shimomura, 2014; Ferreira *et al.*, 2018; Polst, S. and Stüpfert, 2019).

The second step related to user requirements; there are two user requirements: 1)The first user requirement is to build chatbots for different persona types. Therefore, it is vital to build persona models that allow people to understand different groups of students, including their demographic data, educational data, performance and engagement data. 2)The second user requirement is to identify these chatbots features that suit each persona. This is achieved in second and third iterations such as chatbots features supporting performance expectancy, chatbots feature supporting effort expectancy, and chatbots feature supporting habit. The third step is to evaluate the elements of personas. The final step is to keep only the elements of the persona3D model that match the above two user requirements and remove the rest. The remaining list contains the following attributes that support the first requirements: name, age, gender, picture, major, university name, Year of study /highest qualification/educational level, summary/back story, grade, level of interactions with VLEs. Also, it includes the attributes that support the second user requirements, including chatbots features, support performance expectancy, chatbots features support effort expectancy, and chatbots feature supporting habit. These are the exact elements provided in the Extended Persona3D model. Applying the above steps confirms the completeness of the extended Persona3D model.

Fifth evaluation is evaluating the completeness of the Journey Mapping model, which will be achieved using the exact evaluation method mentioned above: 1) list journey mapping elements by reviewing the literature (Nenonen, Rasila and Junnonen, 2008; Temkin, 2010; Crosier and Handford, 2012; Alves and Nunes, 2013; Andrews and Eade, 2013; Marquez, Downey and Clement, 2015; Sandler, 2015; Ortbal, Frazzette and Mehta, 2016; Maddox *et al.*, 2019), represent customer segment /student types (Nenonen, Rasila and Junnonen, 2008; Temkin, 2010; Crosier and Handford, 2012; Alves and Nunes, 2013; Andrews and Eade, 2013; Marquez, Downey and Clement, 2015; Sandler, 2015; Ortbal, Frazzette and Mehta, 2016; Maddox *et al.*, 2019)include customer goal (Nenonen, Rasila and Junnonen, 2008; Temkin, 2010; Crosier and Handford, 2012; Alves and Nunes, 2013; Marquez, Downey and Clement, 2015; Sandler, 2015; Ortbal, Frazzette and Mehta, 2016)., focus on emotion (Nenonen, Rasila and Junnonen, 2008; Crosier and Handford, 2012; Alves and Nunes, 2013; Andrews and Eade, 2013; Sandler, 2015; Ortbal, Frazzette and Mehta, 2016; Maddox *et al.*, 2019), represent touchpoint (Nenonen, Rasila and Junnonen, 2008; Temkin, 2010; Crosier and Handford, 2012; Alves and Nunes, 2013; Andrews and Eade, 2013; Marquez, Downey and Clement, 2015; Sandler, 2015; Ortbal, Frazzette and Mehta, 2016; Maddox *et al.*, 2019), include time (Nenonen, Rasila and Junnonen, 2008; Temkin, 2010; Crosier and Handford, 2012; Alves and Nunes, 2013; Andrews and Eade, 2013; Marquez, Downey and Clement, 2015; Sandler, 2015; Ortbal, Frazzette and Mehta, 2016)

Moreover, include channel(Mobile /PC) (Nenonen, Rasila and Junnonen, 2008; Temkin, 2010; Alves and Nunes, 2013; Andrews and Eade, 2013; Marquez, Downey and Clement, 2015; Sandler, 2015), use persona (Temkin, 2010; Andrews and

Eade, 2013; Ortbal, Frazzette and Mehta, 2016; Maddox *et al.*, 2019), include journey mapping title (Temkin, 2010; Crosier and Handford, 2012; Sandler, 2015) (Maddox *et al.*, 2019), , include different location(Temkin, 2010; Crosier and Handford, 2012; Alves and Nunes, 2013; Andrews and Eade, 2013; Marquez, Downey and Clement, 2015; Sandler, 2015; Maddox *et al.*, 2019) , represent customer (Nenonen, Rasila and Junnonen, 2008; Temkin, 2010; Crosier and Handford, 2012; Alves and Nunes, 2013; Andrews and Eade, 2013; Marquez, Downey and Clement, 2015; Sandler, 2015; Ortbal, Frazzette and Mehta, 2016; Maddox *et al.*, 2019), include the moment of truth (Nenonen, Rasila and Junnonen, 2008; Temkin, 2010; Alves and Nunes, 2013; Andrews and Eade, 2013; Marquez, Downey and Clement, 2015; Sandler, 2015; Ortbal, Frazzette and Mehta, 2016), including stages (Nenonen, Rasila and Junnonen, 2008; Temkin, 2010; Crosier and Handford, 2012; Alves and Nunes, 2013; Andrews and Eade, 2013; Marquez, Downey and Clement, 2015; Sandler, 2015; Ortbal, Frazzette and Mehta, 2016; Maddox *et al.*, 2019), measure your brand promise (Nenonen, Rasila and Junnonen, 2008; Alves and Nunes, 2013) and ditch the PowerPoints requirements (Temkin, 2010; Crosier and Handford, 2012; Andrews and Eade, 2013; Ortbal, Frazzette and Mehta, 2016)

2) check that each element of the model represents user requirements, and each user requirements represent an element in the user model. The result of these two steps shows the elements of the Journey Mapping including use research to build Journey Mapping, represent student type/persona, focus on emotion, represent touchpoints, time channel, location, persona title, and journey title, before and after emotion.   3) evaluate the completeness should be done by close participants of the business user, in this case, the researcher. 4) keep only the elements that match the user requirements and remove the rest. This means removing these elements: the customer perspective, the moment of truth, including stages, measure your brand promise and ditch the PowerPoints requirements. The remaining elements include customer segment/student type, user research, focus on emotion, represent touchpoints, including time, channel, use persona, include chatbots feature, include a summary, include persona title, include journey mapping title, and before and after emotion. Evaluating the completeness of the proposed Journey Mapping model confirms this.

6.5 Novelty and Contributions

This section covers two parts: the novelty and contributions in this chapter. The first part starts with discussing the generated artefacts and the novelty of that artefact and how it makes an advancement over the state of the arts and shows evidence of novelty with references to finding from this research. The second part discusses the contributions that this research makes over the existing knowledge.

Artefact or part of an artefact	**Novelty**	**An advancement over state of the art (with reference to papers- i.e. those should be in chapter c2)**	**Evidence of novelty (a reference to findings from your research)**
Extended Persona3D Model	The design and building of the extended persona3D model is achieved based on four steps; 1) the literature review. 2) result of applying machine learning techniques on student data. 3) the result of evaluating the Extended UTAUT2 model and 4) identifying these features from the literature.	All personas building methods are based on four main steps: 1) data collection, 2) segmentation and grouping, 3) analysis of the quantitative and/or qualitative data, and 4) creating/writing persona profiles to present the user groups and their attributes as user archetypes (Wöckl *et al.*, 2012; Zhu, Wang and Carroll, 2019; Salminen *et al.*, 2020) However, in this study, designing and building personas contains further steps including conducting empirical research to identify the chatbots interaction features that suit all personas represented by designing, building and evaluating the extended UTAUT2 using SEM and identifying the value of these features again from the literature.	1) Persona3D template was designed based on the literature review (see Chapter 4, Section 4.2.3). 2)Then, Persona3D model was initially developed in chapter 4 using machine learning technique – K-means Clustering methods (Chapter 4, Section 4.3). 3)The model is extended after evaluating the Extended UTAUT2 model and extracting the features of the chatbots that support extended UTAUT2 constructs: PE, EE, HT (Chapter 5, Section 5.5). 4) The value of chatbots features is extracted from the literature review (Chapter 6, Section 6.2.2)

Journey Mapping	Design and develop an evaluated Journey Mapping based on evaluated persona3D for different personas and persona template from the literature. CJM represents a day in a student's life that shows student interaction with chatbots at different time and location. The Journey Mapping model was evaluated, and it confirms completeness.	Various Journey Mappings were developed in the different domains (Ortbal, Frazzette and Mehta, 2016; Alves and Nunes, 2013; Nenonen, Rasila and Junnonen, 2008; Crosier and Handford, 2012). To the best of our knowledge, there is no Journey Mapping that targets different personas (students) to show their interaction with chatbots during the day that mainly targets student engagement and performance.	Journey Mapping design is covered in Chapter 6, Section 6.2.3. Evaluation of the completeness of the Journey Mapping is covered in Section 6.4. Journey Mapping model for top students is shown in Section 6.2.4, and Journey Mapping for disengaged students is shown in Section 6.2.5.
Chatbots design	This study shows new factors that influence the design of chatbots in an educational setting. They are personas, Journey Mapping and simple email services.	A summary of a selected factor influencing chatbots design is voice, text, creating new or using available chatbots, AIML usage, SQL Usage technique, matching technique, and the corpus is shown in (Abdul-Kader and Woods, 2015). However, as a developer, I have found that there are other factors that affect and contributes to the design of chatbots, including personas, Journey Mapping and email services.	Persona3D, Journey Mapping and Simple Email services are three factors that influence chatbots design from the developer perspective. Factors influencing chatbot design are shown in Chatbot design Table 6-5.
Range of chatbots Prototypes (instantiations)	Design and develop chatbots for different types of personas to assess the effectiveness of extended Persona3D model, which is generated based on analysing the data using machine learning framework and empirical study.	The design of chatbots generally follows a one-size-fits-all approach (Følstad and Brandtzæg, 2017). The approach provides the same contents to all students regardless of their type (Følstad and Brandtzæg, 2017; Kadariya *et al.*, 2019) and their location (Bradesko *et al.*, 2017; Følstad, Nordheim and Bjørkli, 2018) particularly in the educational setting (Yang and Evans, 2019). This study overcomes this limitation by designing and developing persona-based and location-based chatbots. Usually, a chatbot is developed for one purpose such as teaching students about AI concepts and courses, (Keegan, Boyle and Dee, 2012), teach new healthy lifestyles(Gardiner *et al.*, 2017), etc. However, this research covers a total of	Extended Persona3D model for top students and disengaged students are shown in Figure 6-3 and 6-5. The respective journey mapping for top student and disengaged students are shown in Figure 6-4 and 6-6, respectively. The implementation of app.js, database.js and SES.js for the Knowledge

		8 chatbots that target different personas. (students). These chatbots were basically design based on the extended persona3D and Journey Mapping models.	Acquisition for the top personas are shown in Figures 6-9, Figure 6-10 and Figure 6-11, and the chatbots implementation of Assignment Guider' chatbots representing by app.js, database.js and SES.js are shown in Figure 6-18, Figure 6-19 and Figure 6-20.

Table 6- 4: Novelty of Each Design Research Artefacts

This research has several contributions to knowledge:

1) Building a Persona3D model for university students that initially shows a static profile of the user that includes demographic data, educational data, performance, level of virtual engagement with VLEs and level of physical engagement with the university (Chapter 4). In addition, other attributes such as effective methods of interaction with chatbots (Chapter 5 and 6) presents the Extended Persona3D model. The Extended Persona3D model show different personas interact with chatbots features. Persona3D model was evaluated in terms of completeness in chapter 4, and it confirms that. These Persona3D models were extended in chapter 5 to contain new elements. In this chapter, the values of these elements were identified after conducting a literature review. These new elements of Persona3D models are chatbots features supporting PE, chatbots features supporting EE, and chatbots features supporting HT. These elements were included in the Persona3D model with values in the current iteration. The extended Persona3D model is evaluated again using DSR evaluation criteria, and it confirms completeness (Chapter 6).

2) Building a journey map for different personas (students) shows personas interaction with the chatbots at various locations, times, before and after emotion, chatbots features, touchpoints, summary, persona title, and journey mapping. The journey mapping is evaluated using the DSR evaluation criteria, completeness, and it confirms that (Chapter 6).

3) This study identifies a list of chatbots features that support all the UTAUT2 constructs stemming from analysing the literature review of the articles related to

the applications that support UTAUT2 constructs (see Appendix E1). Academics and researchers are likely to adopt this list for future research. A shortlist is provided in Chapter 6 (see Table 6-2).

4) From a developer perspective, several design factors affect the chatbots' design during the design process after analysing the literature review (see, Chapter 2, Table 2-4). This research reveals new factors influencing chatbot design, including Simple Email Service (Email), Persona and Journey Mapping (see, Table 6-5).

	Factors influencing chatbots design											
study	**Voice**	**Text**	**Creating new chatbots**	**Using available chatbots**	**AIML usage**	**Email services**	**Persona**	**Journey Mapping**	**SQL usage**	**Matching technique**	**Corpus (Knowledgebase)**	**Application**
(Pereira and Coheur, 2013)	√	√		√	√	-	-	-		Edger chatbot matching technique (a combination of Tfldf algorithm with natural language normalisation)	Edgar chatbot	Chatbot design
(Rosmalen *et al.*, 2012)		√		√	√	-	-	-	√	QA matching form	AIML	Medical education
(Lokman and Zain, 2009)		√	√		√	-	-	-	√	QA matching form	VP bot	Health assistance
(Lokman and Zain, 2010a)		√		√		-	-	-	Y	Prerequisite Matching	ViDi chatbot	Health assistance
(Lokman and Zain, 2010b)		√		√		-	-	-	√	One-Match All-Match Category(OMAMC)	ViDi chatbot	Health assistance
(Mikic *et al.*, 2009)		√		√	√	-	-	-		AIML category pattern matching	AIML	Educational systems
(Bhargava and Nikhil, 2009)	√		√		√	-	--	-		AIML category pattern matching	AIML	E-learning
(Vrajitoru, 2003)		√	√			-	--	-		Genetic Algorithm (GA)	Manual pattern and data chosen	Any
(Vrajitoru and Ratkiewicz, 2004)		√	√			-	-	-		Genetic Algorithm (GA)	Manual pattern and data chosen	Any

This research (Almahri, 2020)	√	√	√			√	√	√	√	QA matching form	Manual pattern and data chosen	Education

Table 6- 5: Factors Influencing Chatbots Design adapted from (Abdul-Kader and Woods, 2015).

6.6 Limitations of this Research

This study has some limitations which should be acknowledged, including the following:

1. This study identifies the features of the chatbots for all constructs that support UTAUT2 (Venkatesh, Thong and Xu, 2012), constructs including PE, EE, FC, HM, SI, and HT were identified from the literature review. A complete list of chatbots features that support all constructs is shown in Appendix E1. However, the result of the second iteration (Chapter 5) shows that only three constructs are considered as a predictor of behavioural intentions and use of chatbots technology: PE, EE, and HT. Therefore, the design and development of chatbots focus on these three constructs. At least two chatbots features that support each construct were developed, as shown in Table 6-3. However, it would be better for future research to include chatbots features that support all constructs as this will provide a better experience for the students, and it will increase the chances of adopting this model by researchers and developers.
2. The target users for this skill were undergraduate computer science students as they were the majority of the participants in the previous iteration: undergraduate students (94.2%), while only 5.8% were postgraduate (masters) students. Future research is proposed to create a range of chatbots to include more postgraduate students and secondary school students.
3. A range of chatbots was designed and developed but not evaluated with students. Future research will cover experimenting with 40 students to evaluate the developed chatbots. The evaluation will include the usability of the chatbots and will be done using the System Usability Scale (SUS) questionnaires (Brooke, 1996) that cover ten items and will be adapted to suit the current study.

4. These chatbots are designed for students only and not the lecturers nor the administrator (Mehta and Bhandari, 2016). Therefore, other sets of chatbots will be proposed to help instructors provide the necessary materials and guidance on using the chatbots.

6.7 Specify the Learning

By evaluating the output of this iteration, this study identified the following learning:

- Using a combination of persona and Journey Mapping as a design tool is an effective way to build persona-based and context-based chatbots for university students. The same approach can be used in other domains.
- Jovo (https://www.jovo.tech/) is a multiplatform framework which can work with Amazon Alexa (https://developer.amazon.com/alexa) and DialogFlow (Fontecha, González and Salas-Seguín, 2019). Jovo is a platform that allows the developer to efficiently test and run the chatbots, rather than re-uploading the code after every change in the code in the Lambda Function (https://aws.amazon.com/developer/).
- The development of the first chatbot based on the requirements is time-consuming. However, the development of the rest takes less time unless there is a new requirement, such as Simple Email Services (SES) or Database (DynamoDB), by comparing the time to develop the first chatbot and the last one.

6.8 Conclusion

To conclude, this iteration is the third and final design research iteration that studied the effectiveness of the persona-based modelling approach (persona3D), by designing and building various chatbots for different personas. It is important to mention that the Persona3D model was initially developed in chapter 4 and extended with new elements in chapter 5 – referred to as the extended Persona3D model. In this iteration, a set of chatbots features were proposed that support the Extended UTAUT2. Few chatbots features were selected to be included in each Persona3D model that supports PE, EE and HT- constructs in Extended UTAUT2. This iteration, with the Appendix I, covers the Journey Mapping for eight personas, including their extended Persona3D model, coding and execution of eight chatbots. The evaluation of the chatbots confirms the effectiveness of the Extended Persona3D model in supporting the Journey Mapping and supporting the code of chatbots.

CHAPTER 7 – CONCLUSION

7.1 Introduction

It is challenging to design and build chatbots for students in an educational setting (Winkler and Söllner, 2018; Yang and Evans, 2019). Therefore, this research designed and built the Persona3D model (personas modelling approach) and evaluated the effectiveness of this Persona3D modelling approach by building a range of chatbots. To achieve this, this study worked on understanding student groups (see, Chapter 4) and identified chatbots features (see, Chapter 5 and Chapter 6) that are suitable for these personas. Overall, this research provides several contributions in the form of constructs, models, methods, and instantiations, which will be discussed further in this chapter. Section 7.2 presents a summary of the thesis by providing the aim and objectives of this study, while also providing an overview of each chapter in the overall thesis. Section 7.3 presents the research contributions, and section 7.4 presents the limitations of this study, along with future works.

7.2 Research Summary

To create an effective chatbots design methodology in an educational setting, the chatbots design should consider different types of students (personas) based on their engagement, performance, and interaction with VLEs. Moreover, there is a need to identify acceptable chatbots features that are suitable for different user groups (personas) and identify student interaction with the chatbots at different times and locations using the students' Journey Mapping. Therefore, the objectives of this study which were stated previously in chapter 1, are summarised below:

Objective 1: review the literature on mobile educational technology and the state of the art of chatbots.

Objective 2: identify the different student groups at Brunel University London by using machine learning to build student persona models (Persona3D).

Objective 3: extend the Persona3D modelling approach with constructs of the extended UTAUT2 model.

Objective 4: assess the practical effectiveness of the Persona3D approach by building a range of chatbots prototypes.

The motivation for conducting this research was to improve student engagement at HEIs. Regarding the aim and objectives of this study, Chapter 2 presented the state of the art of chatbots and chatbots design. It also covered building the persona templates and model using persona development methods which cover the machine learning framework. This study analysed the existing technology acceptance theories and models including Diffusion of Innovation Theory, Social Cognitive Theory (SCT), Theory of Reasoned Action (TRA), Theory of Planned Behavior (TPB), Technology Acceptance Model (TAM), Extension of Technology Acceptance Model (TAM2), Unified Theory of Acceptance and Use of Technology (UTAUT) and The Extended Unified Theory of Acceptance and Use of Technology (UTAUT2).

These technology acceptance models and theories were studied to identify the one to be adopted in this research. UTAUT2 is found as the most suitable model to study student acceptance and use of chatbots for university students. The justification is found in Chapter 2 and Chapter 5. UTAUT2 is extended and referred to as the Extended UTAUT2 model. Moreover, the result of evaluating the Extended UTAUT2 model using Structural Equational Modelling (SEM), using Smartpls3, was used to identify chatbots features for later development. It introduced Journey Mapping as a design technique in User-Centred Design. Furthermore, it presented the chatbots design techniques available in the literature and checked the availability of these techniques in different studies.

Chapter 3 specified the means to achieve the objectives of this study through design research. It covered the ontology and epistemology of this research and the reasons for choosing the positivist paradigm. Also, it discussed the sampling approach used in this study and the reason for selecting it. Furthermore, it discussed the different types of triangulation and the triangulation method used in this study. The primary research methodology is the design science research methodology (DSR), which assists in understanding the research problem, improve the proposed solution and contribute to the knowledge by providing new research artefacts. This study resulted in few artefacts, including Persona3D models and methods, extended Persona3D models and method, journey mapping for university students, and a range of chatbots prototypes. Overall, this research used design research, more specifically, incremental and iterative design research, that covers three iterations~~.~~

The iterations were designed in a way such that the first iteration designed and built the Persona3D models and method. Persona3D method used the machine learning framework. Iteration 2 extended the Persona3D models and method to include effective methods of interaction with each group (including specific calls-to-action CTA). Iteration 3 evaluated the effectiveness of the practical approach by building a range of chatbots prototypes for different personas. Applying design science research produced a range of artefacts represented by constructs, models, methods and instantiations (March and Smith, 1995) including Persona3D models and method, Extended Persona3D models and method, Extended UTAUT models, Journey Mapping, a range of chatbots prototypes. Each iteration represented a design problem that performs through the building and evaluation of the research activities (Vaishnavi and Kuechler, 2004).

The design research artefacts were evaluated using evaluation criteria from March and Smith's (1995) framework, which is covered in chapter 3. Table 7-1 shows design research products for the three iterations, along with their evaluation criteria. More details were covered in chapter 3.

Research Activities

Research Outputs

	Build	**Evaluate**	**Theorise**	**Justify**
Constructs				
Model	Persona3D model	Completeness (Chapter 4)		
	Extended Persona3D model	Completeness (Chapter 6) Effectiveness (Chapter 6) Effectiveness of Extended persona3D model and method in building the chatbots (Chapter 6)		

	Extended UTAUT2	Internal consistency reliability and composite reliability (Chapter 5)		
	Journey Mapping	Effectiveness (Chapter 6) Completeness (Chapter 6)		
Method	Persona3D method	Efficiency (Chapter 4)		
Instantiation				

Table 7- 1: Design Research Products Versus Activities

Chapter 4 covered the first iteration, which is persona elicitation. Chapter 4 focuses on identifying students groups at Brunel University London using a machine learning framework. To achieve this, chapter 4 designed and built Persona3D models and methods. Persona3D method was used to identify student groups and build students persona (Persona3D models) using a machine learning framework, particularly the K-Means Clustering method. Furthermore, elbow, gap statistic and silhouette methods were used to identify the optimal k-value before starting the k-mean clustering analysis. To find the optimal value of K, the Silhouette width method is used. Chapter 4 presented a two data analysis of student data. Several constructs, models and methods were built to meet objective 2 of this research study. This iteration evaluated the completeness of Persona3D models and efficiency of the Persona3D method (see, Chapter 4, Section 4.4), as shown in Table 7-1 (Above).

Chapter 5 covered the second iteration, Extended UTAUT2. Chapter 5 extended the Persona3D method and models which were created in the previous iteration to include chatbots supported interactions. To achieve this, this study extended the Unified Theory of Acceptance and Use of Technology 2 (UTAUT2) with a persona moderator. The elements of the persona moderator resulted from the first iteration. The survey was designed based on a UTAUT2 survey from (Venkatesh, Thong and Xu, 2012) along with other resources, as shown in Appendix B. The survey was developed using a free web-based survey, Bristol Online Survey tool, provided by Bristol University. Also, this study investigated students' acceptance and use of chatbots technology using the Extended UTAUT2 model, which was evaluated using Structural Equation Modelling (SEM) using SmartPLS3 software. Chapter 5 produced several products represented by constructs, models, methods and instantiations to meet objective 3 of this research study. The produced artefacts including extended UTAUT2, Extended Persona3D model and method.

Chapter 6 covered the third iteration, which was chatbots development. Chapter 6 evaluated the effectiveness of the Persona3d model and approach by developing a range of chatbots prototypes for different personas. To achieve this, this study first searched the literature to identify the chatbots supported features that support result generated from iteration two—then designed and developed student Journey Mapping template and models that supported the Persona3D models for different personas. Similar to chapters 4 and 5, chapter 6 produced several constructs, models, methods, and instantiations to achieve the fourth objective of this research study. The artefacts, including Journey Mapping models and a range of chatbots prototypes for different personas.

It is essential to mention that applying data triangulation (using different data sources) in the three iterations helped build a robust design for the persona-based chatbots. The Persona3D model was created (as reported in Chapter 4), extended (Chapter 5) and used to design and build chatbots prototypes for different personas (Chapter 6). Improving the persona model through the three iterations led to the construction of robust artefacts. Furthermore, various machine learning methods are suggested in the literature. However, the methods are effective for different types of data. For example, K-means clustering analysis works effectively when the data is numeric. Therefore, K-mean clustering analysis was chosen and applied in Iteration 1(Chapter 4).

7.3 Research Contributions

Overall, the main contribution of this research is designing, building and evaluating the Persona3D model and method. This section presents the contributions made through this research, which are categorised based on design research product classification (March and Smith, 1995). The research contributions are detailed as follows:

Extended/Persona3D (method) is the first contribution of this study (Chapter 4 and 5). This method is a novel and efficient to build students persona. Like other studies (Masiero et al., 2011; Wöckl et al., 2012; Ford et al., 2017), this method builds personas using K-means clustering method. However, a study by (Almahri, Bell and Arzoky, 2019a) developed a two-methodological step to construct persona: 1) identify the k values using three methods including elbow, gap statistic and silhouette methods to identify student groups. 2) find the optimal value of k using silhouette width is used (see Chapter 4, Section 4.3). Furthermore, this study has proposed two more steps. Persona3D method is extended in chapter 5 by the step of using Extended UTAUT2 to identify chatbots supported features. The values of these chatbots supported features were identified (see Chapter 6, section 6.2.2). To the best of our knowledge, the Persona3D method is a novel persona modelling approach that covers the further steps to create a Persona3D model.

Extended/Persona3D (model) for university students is the second contribution in the first iteration (Chapter 4). As mentioned above, the Persona3D method is a novel method to build the persona3D model. Like other studies, persona3D model is created based on data analysis using K-Means clustering (Masiero *et al.*, 2011; Wöckl *et al.*, 2012; Ford *et al.*, 2017) (see, Chapter 4). However, the novelty of this Persona3D model is that it contains other elements represented by chatbots interactions features (see, Chapter 5), which are important elements in the model that provides more clarity to the persona3D model and allow people to understand the chatbots features that suit these personas. These elements are generated after conducting an empirical study to identify the proper chatbots features for these personas by designing, building and evaluating Extended UTAUT2 (see, Chapter 5). The values of these chatbots features are identified from the literature (see, Chapter 6). Furthermore, these extended Persona3D models are used as the basis to build journey mapping and both to design and develop a range of chatbots prototypes. Using Persona3D models can help policymakers and instructors understand their target users more and design applications that suit different university student personas.

Extended UTAUT2 (Model) is an extended model of the UTAUT2 model (Venkatesh, Thong and Xu, 2012), which is a robust and well-known model for studying student acceptance and use of technology. This contribution describes student acceptance and use of chatbots at the UK University, in this case, Brunel University. It also helps to design acceptable skills for each type of persona that feeds into the third iteration. Furthermore, to the best of our knowledge that this is the only study that investigates the effects of persona moderator on university student acceptance and use of chatbots technology at HEIs using the UTAUT2 model. Furthermore, the Extended UTAUT2 model is the first to investigate the effect of persona moderators on student acceptance and use of chatbots technology for university students.

Student Journey Mapping (Model) is a novel model that shows students interactions with chatbots technology during the day. Student Journey Mapping was designed and developed based on the Persona3D model (see, Chapter 6, Section 6.2.3). However, this model shows students interaction with different chatbots features at different times, locations, and emotions that are represented using the Geneva Emotion Wheel (GEW). This Journey Mapping is evaluated in terms of completeness, and it confirmed that (see Chapter 6, Section 6.4).

Chatbots prototypes (instantiation), this artefact is created to evaluate the effectiveness of the Persona3D modelling approach. A range of chatbots prototypes that supports the Persona3D model and Journey Mapping for university students. Chatbots were developed using the Amazon Alexa platform. The architecture of chatbots contains four main elements: client, server, database and Simple Email Service (SES) (see Chapter 6, Section 6.3). The client is written in JSON, and the server is written in JavaScript. DynamoDB, a database provided by AWS developer, is also available to hold the database connected to the server-side. Another service provided by Amazon AWS developer is the SES which allows sending email to a list of specified users.

7.4 Research Limitations and Future Work

Through the development of this research, many beneficial contributions to educational data mining, mobile educational technology, information system, human-computer interaction (HCI), and User-Centred Design (UCD), and application of machine learning areas have been made. However, there were some limitations and challenges in each iteration, which are detailed as follow:

Chapter 4 has two main limitations. Firstly, this study covers only two types of behavioural engagement, attendance (physical engagement) and interaction with VLEs (virtual engagement). Further data collection is required that includes all factors of behavioural engagement, cognitive engagement and emotional engagement. Secondly, this study used two datasets of 2nd-year computer sciences at Brunel University London in 2014 and 2016. So the generated models represent 2nd-year computer sciences students at Brunel University and can not be generalised.

Chapter 5 has two limitations. Firstly, the potential of having a bias in participants view because there was a draw of ten amazon vouchers, each worth £20, to encourage participants to answer the survey. Secondly, the result of the data analysis in chapter 5 cannot be generalised as it applies only to computer science students at Brunel University London.

Chapter 6 highlights two limitations. Firstly, a range of chatbots was developed based on the results of evaluating the Extended UTAUT2, which support only performance expectancy, effort expectancy and habits; the three main predictors of behavioural intention and use of chatbots. At the same time, there were no chatbots developed that support the other three constructs in the Extended UTAUT2 model, which include hedonic motivation, social influence, and facilitating conditions. Secondly, this chapter covers designing and buildings chatbots prototypes to evaluate the effectiveness of Persona3D models. However, these chatbots prototypes were not evaluated with students.

The limitations and weaknesses found in this study have indicated some areas as recommendations for further work. 1) building a more robust student persona using large datasets that contain all attributes of student behavioural engagement, cognitive engagement and emotional engagement. 2) applying the same study in a different context (Sultanate of Oman) and comparing the two studies' results and drawing a conclusion. 3) designing and developing a new range of chatbots features that support hedonic motivation, social influence and facilitating conditions not covered in this study. 4) evaluating the effectiveness of chatbots on students and measuring it using a System Usability Scale (SUS) (Brooke, 1996), and adapting this to suit the nature of this study. According to Binh et al. (2018), chatbots evaluation can be classified into four classes: pre/posttest, quantitative analysis, qualitative analysis or chatbot competitions(Binh *et al.*, 2018).

References

Abdul-Kader, S. A. and Woods, J. (2015) ‘Survey on Chatbot Design Techniques in Speech Conversation Systems’, *International Journal of Advanced Computer Science and Applications*, 6(7), pp. 72–80. doi: 10.14569/IJACSA.2015.060712.

Abraham, C. and Sheeran, P. (2003) ‘Implications of goal theories for the theories of reasoned action and planned behaviour’, *Current Psychology*, 22(3), pp. 264–280. doi: 10.4324/9781315126449-7.

Abu-Shanab, E. and Pearson, M. (2009) ‘Internet banking in Jordan: An Arabic instrument validation process’, *International Arab Journal of Information Technology*, 6(3), pp. 235–244.

Abu Shawar, B. and Atwell, E. (2007) ‘Chatbots: are they really useful?’, *LDV-Forum*, 22(1), pp. 29–49. doi: 10.1.1.106.1099.

Achinstein, P. (1968) *Concepts of science: A philosophical analysis.*

Acomb, K. *et al.* (2007) ‘Technical Support Dialog Systems: Issues, Problems, and Solutions’, *Proceedings of the Workshop on Bridging the Gap: Academic and Industrial Research in Dialog Technologies*, Rochester, pp. 25–31. Available at: http://dl.acm.org/citation.cfm?id=1556328.1556332.

Adlin, T. *et al.* (2006) ‘Panel : Putting Personas to Work’, *Chi 2006*, pp. 13–16. doi: 10.1145/1125451.1125456.

Ain, N. U., Kaur, K. and Waheed, M. (2016) ‘The influence of learning value on learning management system use: An extension of UTAUT2’, *Information Development*, 32(5), pp. 1306–1321. doi: 10.1177/0266666915597546.

Aizen, I. (2006) *Theory of Planned Behavior*. Available at: https://people.umass.edu/aizen/tpb.diag.html.

Ajzen, I. (1985) *From intentions to actions: A theory of planned behavior*. Springer.

Ajzen, I. (1991) ‘The theory of planned behavior’, *Organizational behavior and human decision processe*, 50(2), pp. 179–211. doi: 10.15288/jsad.2011.72.322.

Ajzen, I. and Fishbein, M. (1980) ‘Understanding attitudes and predicting social behaviour’. Available at: http://www.citeulike.org/group/38/article/235626.

Al-Zubaide, H. and Issa, A. A. (2011) ‘OntBot: Ontology based ChatBot’, in *2011 4th International Symposium on Innovation in Information and Communication Technology, ISIICT’2011*. IEEE, pp. 7–12. doi: 10.1109/ISIICT.2011.6149594.

Ali, F. *et al.* (2019) ‘Exploring “company personas” for informing Design for Sustainability implementation in companies’, *Sustainability*, 11(2). doi: 10.3390/su11020463.

ALICE (2011) *A.L.I.C.E Artifical intelligence Foundation promoting the development and adoption of ALICE and AIML free software*. Available at: http://alice.pandorabots.com (Accessed: 18 December 2017).

Allen, J. F. *et al.* (2001) ‘Toward conversational human-computer interaction’, *AI Magazine*, 22(4), pp. 27–37.

Almahri, F., Bell, D. and Arzoky, M. (2019a) ‘Augmented Education Within a Physical Space’, in *UK Academy for Information Systems*. Available at: https://www.ukais.org/resources/Documents/ukais procs 2019 ver1.pdf.

Almahri, F., Bell, D. and Arzoky, M. (2019b) ‘Personas Design for Conversational Systems in Education’, *Informatics*, 6(4), p. 46. doi: 10.3390/informatics6040046.

Almahri, F., Bell, D. and Merhi, M. (2020) ‘Understanding Student Acceptance and Use of Chatbots in the United Kingdom Universities : A Structural Equation Modelling Approach’, in *2020 the 6th IEEE International Conference on Information Management Understanding*. IEEE, pp. 284–288.

Alsubhi, N. (2018) *Heritage User Experience Design : A Journey Driven Simulation Approach*.

Alves, R. and Nunes, N. J. (2013) ‘Towards a Taxonomy of Service Design’, *Lnbip*, 143, pp. 215–229. Available at: http://nunonunes.info/publications/IESS2013.pdf%0Ahttp://www.nunonunes.info/publications/IESS2013.pdf.

Ameen, N. (2017) ‘ARAB USERS ’ ACCEPTANCE AND USE OF MOBILE

PHONES : A CASE OF YOUNG USERS IN IRAQ', *PhD thesis*.

Ameri, Arefeh *et al.* (2019) 'Acceptance of a mobile-based educational application (LabSafety) by pharmacy students: An application of the UTAUT2 model', *Education and Information Technologies*. Education and Information Technologies. doi: 10.1007/s10639-019-09965-5.

Andrews, J. and Eade, E. (2013) 'Listening to Students: Customer Journey Mapping at Birmingham City University Library and Learning Resources', *New Review of Academic Librarianship*, 19(2), pp. 161–177. doi: 10.1080/13614533.2013.800761.

Angga, P. A. *et al.* (2016) 'Design of chatbot with 3D avatar, voice interface, and facial expression', *Proceedings - 2015 International Conference on Science in Information Technology: Big Data Spectrum for Future Information Economy, ICSITech 2015*, pp. 326–330. doi: 10.1109/ICSITech.2015.7407826.

Ashok, G., Brian, C., Mithun, K., Shanu, S., Abhinaya, S., & Bryan, W. (2015) 'Using Watson for Enhancing Human-Computer Co-Creativity.', in *AAAI Symposium: 22–29.*

Astin, A. W. (1984) 'Student Involvement : A Development Theory for Higher Education', *Journal of College Student Development*, 25(4), pp. 297–308. doi: 10.1016/0263-.

Atwell, B. and Shawar, E. A. (2007) 'Chatbots: are they really useful?', *LDV-Forum*, 22(1), pp. 29–49. doi: 10.1.1.106.1099.

Ayodele, T. (2010) 'Machine Learning Overview', *New Advances in Machine Learning*, (February 2010), pp. 8–18. doi: 10.5772/9374.

Bagozzi, R. P. (1981) 'An examination of the validity of two measures of attitude', *Multivariate Behavioral Research*, 16(September), pp. 323–359. doi: 10.1207/s15327906mbr1603.

Bagozzi, R. and Yi, Y. (1988) 'On the Evaluation of Structure Equation Models.pdf', *Journal of the Academy of Marketing Science*, 16(1), pp. 74–94.

Bailey, J. E. and Pearson, S. W. (1983) 'Development of a Tool for Measuring and

Analyzing Computer User Satisfaction Author (s): James E . Bailey and Sammy W . Pearson Published by : INFORMS Stable URL : http://www.jstor.org/stable/2631354 REFERENCES Linked references are available on JSTOR f', *Institute for Operations Research and the Management Sciences*, 29(5), pp. 530–545.

Bajaj, A. and Ram, S. (1999) 'Evaluating Completeness of Conceptual Business Process Models (CBPMs): A Metric Based on Case Studies', *Journal of Information Technology Case and Application Research*, 1(4), pp. 5–30. doi: 10.1080/15228053.1999.10855945.

Baker, R. S. (2016) 'Stupid Tutoring Systems, Intelligent Humans', *International Journal of Artificial Intelligence in Education*, 26(2), pp. 600–614. doi: 10.1007/s40593-016-0105-0.

Bandura, A. (1986) *Social Foundations of Thought and Action : A Social Cognitive Theory*. Prentic-Hall.

Batini, C., Ceri, S. and Navathe, S. . (1992) *Conceptual database design: an Entity-relationship approach.*

Benotti, L., Martinez, M. C. and Schapachnik, F. (2017) 'A Tool for Introducing Computer Science with Automatic Formative Assessment', *IEEE Transactions on Learning Technologies*, XX(X), pp. 1–1. doi: 10.1109/TLT.2017.2682084.

Benotti, L., Martínez, M. C. and Schapachnik, F. (2014) 'Engaging high school students using chatbots', *Proceedings of the 2014 conference on Innovation & technology in computer science education - ITiCSE '14*, pp. 63–68. doi: 10.1145/2591708.2591728.

Bere, A. (2018) 'Applying an extended task-technology fit for establishing determinants of mobile learning: An instant messaging initiative', *Journal of Information Systems Education*, 29(4), pp. 239–252.

Bhargava, V. and Nikhil, M. (2009) 'An intelligent speech recognition system for education system'.

Bhimasta, R. A. (2016) 'An Empirical Investigation of Student Adoption Model toward Mobile E-Textbook : UTAUT2 and TTF Model'.

Bigham, J. P. *et al.* (2008) 'Inspiring blind high school students to pursue computer science with instant messaging chatbots', *ACM SIGCSE Bulletin*, 40(1), p. 449. doi: 10.1145/1352322.1352287.

Binh, T. *et al.* (2018) 'A Review of Technologies for Conversational Systems', in *Advances in Intelligent Systems and Computing*. doi: 10.1007/978-3-319-61911-8.

Blomquist, Å. and Arvola, M. (2002) 'Personas in action: ethnography in an interaction design team', *NordiCHI '02: Proceedings of the second Nordic conference on Human-computer interaction*, p. 197. Available at: http://portal.acm.org/citation.cfm?doid=572020.572044%5Cnpapers3://publication/doi/10.1145/572020.572044.

Bloom, B. . (1965) *Taxonomy of Educational Objectives: the Classification of Educational Goals*. New York: D McKay & Co, Inc .

Blooma, J., Methews, N. and Nelson, L. (2013) *Proceedings of the 4th International Conference on Information Systems Management and Evaluation*. Reading , UK: Academic Conferences and Publishing International Limited. doi: 10.13140/2.1.4924.3843.

Blunch, N. (2008) *Introduction to Structural Equation Modelling Using SPSS and AMOS*, *Introduction to Structural Equation Modelling Using SPSS and AMOS*. doi: 10.4135/9781446249345.

Brace, N., Kemp, R. and Snelgar, R. (2003) *SPSS for psychologists: a guide to data analysis using SPSS for windows*. New York: Palgrave Macmillan.

Bradesko, L. *et al.* (2017) 'Curious Cat – Mobile , Context-Aware Conversational Crowdsourcing r r r', 35(4).

Brickey, J., Walczak, S. and Burgess, T. (2012) 'Comparing semi-automated clustering methods for persona development', *IEEE Transactions on Software Engineering*. IEEE, 38(3), pp. 537–546. doi: 10.1109/TSE.2011.60.

Brinton, C. G. *et al.* (2015) 'Individualization for education at Scale: MIIC design and preliminary evaluation', *IEEE Transactions on Learning Technologies*. IEEE, 8(1), pp. 136–148. doi: 10.1109/TLT.2014.2370635.

Brooke, J. (1996) ‘SUS - A quick and dirty usability scale’, *12 Beaconsfield Way*. doi: 10.4236/9781618961020_0002.

Brown, S. and Venkatesh, V. (2005) ‘Model of Adoption of Technology in Households: A Baseline Model Test and Extension Incorporating Household Life Cycle’, 29(3), pp. 399–426.

Bryman, A. (2008) *Social Research Methods*. 4th edn. Oxford University Press. Available at: http://library1.nida.ac.th/termpaper6/sd/2554/19755.pdf.

Cabrero, D. G. (2014) ‘Participatory design of persona artefacts for user eXperience in non-WEIRD cultures’, *Proceedings of the 13th Participatory Design Conference on Short Papers, Industry Cases, Workshop Descriptions, Doctoral Consortium papers, and Keynote abstracts - PDC ’14 - volume 2*, pp. 247–250. doi: 10.1145/2662155.2662246.

Cabrero, D. G. (2015) ‘User-created persona: Namibian rural Otjiherero speakers’, *Proceedings of the 33rd Annual International Conference on the Design of Communication*, (1), p. 28. doi: 10.1145/2775441.2775484.

Cahill, J., McLoughlin, S. and Wetherall, S. (2018) ‘The Design of New Technology Supporting Wellbeing, Independence and Social Participation, for Older Adults Domiciled in Residential Homes and/or Assisted Living Communities’, *Technologies*, 6(1), p. 18. doi: 10.3390/technologies6010018.

Carter, L. and Weerakkody, V. (2008) ‘E-government adoption: A cultural comparison’, *Information Systems Frontiers*, 10(4), pp. 473–482. doi: 10.1007/s10796-008-9103-6.

Chan, K. Y. *et al.* (2008) ‘Examining user acceptance of SMS: An empirical study in China and Hong Kong’, *PACIS 2008 - 12th Pacific Asia Conference on Information Systems: Leveraging ICT for Resilient Organizations and Sustainable Growth in the Asia Pacific Region*.

Chang, S. C. and Tung, F. C. (2008) ‘An empirical investigation of students’ behavioural intentions to use the online learning course websites’, *British Journal* *of Educational Technology*, 39(1), pp. 71–83. doi: 10.1111/j.1467-8535.2007.00742.x.

Chen, L., Gillenson, M. L. and Sherrell, D. L. (2002) ‘Enticing online consumers: An extended technology acceptance perspective’, *Information and Management*, 39(8), pp. 705–719. doi: 10.1016/S0378-7206(01)00127-6.

Chen, W. *et al.* (2008) ‘Handheld Computers As Cognitive Tools: Technology-Enhanced Environmental Learning’, *Research and Practice in Technology Enhanced Learning*, 03(03), pp. 231–252. doi: 10.1142/S1793206808000513.

Cooper, A. (2004) *The Inmates are Running the Asylum*. Sams Publishing. doi: 10.1007/978-3-322-99786-9_1.

Coulter, K. and Coulter, R. (2007) ‘Distortion of price discount perceptions through the left-digit effect’, *Journal of Consumer Research*, 34(2), pp. 162–173. doi: 10.1007/s11002-015-9387-5.

Creswell, J. W. (2014) ‘Research Design_ Qualitative, Quantitative, and Mixed Method Approaches’. SAGE Publications, p. 273.

Croncbach, L. J. (1951) ‘Coefficient alpha and the internal structure of tests.’, *Psychometrika*, 16(3), pp. 297–334.

Crosier, A. and Handford, A. (2012) ‘Customer journey mapping as an advocacy tool for disabled people: A case study’, *Social Marketing Quarterly*, 18(1), pp. 67–76. doi: 10.1177/1524500411435483.

Dahl, D. W., Chattopadhyay, A. and Gorn, G. J. (2006) ‘The Use of Visual Mental Imagery in New Product Design’, *Journal of Marketing Research*, 36(1), p. 18. doi: 10.2307/3151912.

Dale, C. and Lane, A. (2007) ‘A Wolf in Sheep ’ s Clothing ? An Analysis of Student Engagement with Virtual Learning Environments’, *Journal of Hospitality, Leisure, Sport and Tourism Education*, 6(2). doi: 10.3794/johlste.62.156.

Dale, R. (2016) ‘The return of the chatbots’, *Natural Language Engineering*, 22(5), pp. 811–817. doi: 10.1017/S1351324916000243.

Davis, F. D. (1985) *A technology acceptance model for empirically testing new* *end-user information systems: Theory and results*. Massachusetts Institute of Technology. Available at: http://www.ncbi.nlm.nih.gov/pubmed/14224511.

Davis, F. D. (1989) ‘Perceived usefulness, perceived ease of use, and user acceptance of information technology’, *MIS Quarterly: Management Information Systems*, 13(3), pp. 319–339. doi: 10.2307/249008.

Dawood, H. *et al.* (2017) ‘Preliminary results on students ’ study habits and their grades in STEM courses’, pp. 25–26.

Devellis, R. F. (2003) *Scale Development Theory and Application*. Newbury Park: CA: Sage.

Dey, A. (2016) ‘Machine Learning Algorithms: A Review’, *International Journal of Computer Science and Information Technologies*, 7(3), pp. 1174–1179. Available at: www.ijcsit.com.

Dobbins, C. and Rawassizadeh, R. (2018) ‘Towards Clustering of Mobile and Smartwatch Accelerometer Data for Physical Activity Recognition’, *Informatics*, 5(2), p. 29. doi: 10.3390/informatics5020029.

Dodds, W. B., Monroe, K. B. and Grewal, D. (1991) ‘Effects of Price, Brand, and Store Information on Buyers’ Product Evaluations’, *Journal of Marketing Research*, 28(3), pp. 307–319. doi: 10.2307/3172866.

Drucker, P. F. (1988) ‘The Coming of the New Organization’, *Proceedings of 43rd North American Manufacturing Research Conference*, (July).

Edelson, D. C. (2002) ‘Design Research: What We Learn When We Engage in Design’, *Journal of the Learning Sciences*, 11(1), pp. 105–121. doi: 10.1207/S15327809JLS1101_4.

El-Masri, M. and Tarhini, A. (2017) ‘Factors affecting the adoption of e-learning systems in Qatar and USA: Extending the Unified Theory of Acceptance and Use of Technology 2 (UTAUT2)’, *Educational Technology Research and Development*. Springer US, 65(3), pp. 1–21. doi: 10.1007/s11423-016-9508-8.

Elmasri, D. and Maeder, A. (2012) ‘A Conversational Agent for an Online Mental Health Intervention’, 7670, pp. 243–251. doi: 10.1007/978-3-642-35139-6.

Ferreira, B. *et al.* (2018) ‘Technique for representing requirements using personas: A controlled experiment’, *IET Software*, 12(3), pp. 280–290. doi: 10.1049/iet-sen.2017.0313.

Fishbein, M. and Ajzen, I. (1975) *Belief, Attitude, Intention and Behavior: An Introduction to Theory and Research.*, *Reading, MA: Addison-Wesley.* doi: 10.2307/2065853.

Følstad, A. and Brandtzæg, P. B. (2017) ‘Chatbots and the new world of HCI’, *Interactions*, 24(4), pp. 38–42. doi: 10.1145/3085558.

Følstad, A., Nordheim, C. B. and Bjørkli, C. A. (2018) ‘What makes users trust a chatbot for customer service? An exploratory interview study’, *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, 11193 LNCS, pp. 194–208. doi: 10.1007/978-3-030-01437-7_16.

Fontecha, J., González, I. and Salas-Seguín, A. (2019) ‘Using Conversational Assistants and Connected Devices to Promote a Responsible Energy Consumption at Home’, *Proceedings*, 31(1), p. 32. doi: 10.3390/proceedings2019031032.

Foody, G. M. and Mathur, A. (2006) ‘The use of small training sets containing mixed pixels for accurate hard image classification: Training on mixed spectral responses for classification by a SVM’, *Remote Sensing of Environment*, 103(2), pp. 179–189. doi: 10.1016/j.rse.2006.04.001.

Ford, D. *et al.* (2017) ‘Characterizing Software Engineering Work with Personas Based on Knowledge Worker Actions’, *International Symposium on Empirical Software Engineering and Measurement*, 2017-Novem, pp. 394–403. doi: 10.1109/ESEM.2017.54.

Fornell, C. and Larcker, D. F. (1981) ‘Evaluating Structural Equation Models with Unobservable Variables and Measurement Error’, *Journal of Marketing Research*, 18(1), p. 39. doi: 10.2307/3151312.

Friess, E. (2012a) ‘Personas and Decision Making in the Design Process : An Ethnographic Case Study’, in *Proceedings of the 2012 ACM annual conference on*

Human Factors in Computing Systems - CHI '12, pp. 1209–1218. doi: 10.1145/2207676.2208572.

Friess, E. (2012b) 'Personas and Decision Making in the Design Process : An Ethnographic Case Study', in *Proceedings of the 2012 ACM annual conference on Human Factors in Computing Systems - CHI '12*, pp. 1209–1218.

Fryer, L. and Carpenter, R. (2006) 'emerging technologies Bots as language learning tools', *Language Learning and Technology*, 10(3), pp. 8–14. Available at: https://hub.hku.hk/handle/10722/225908.

Fuksa, M. (2013) 'Mobile technologies and services development impact on mobile internet usage in Latvia', *Procedia Computer Science*. Elsevier Masson SAS, 26(December 2013), pp. 41–50. doi: 10.1016/j.procs.2013.12.006.

Gardiner, P. M. *et al.* (2017) 'Engaging women with an embodied conversational agent to deliver mindfulness and lifestyle recommendations: A feasibility randomized control trial', *Patient Education and Counseling*. Elsevier Ireland Ltd, 100(9), pp. 1720–1729. doi: 10.1016/j.pec.2017.04.015.

Gefen, D., Straub, D. and Boudreau, M.-C. (2000) 'Structural Equation Modeling and Regression: Guidelines for Research Practice', *Communications of the Association for Information Systems*, 4(October). doi: 10.17705/1cais.00407.

Gentleman, R. and Ihaka, R. (2015) 'R : A Language for Data Analysis and Graphics', *Computational and Graphical Statistics*, 5(3), pp. 299–314. Available at: http://www.jstor.org/stable/pdf/1390807.pdf?acceptTC=true.

Gharaibeh, M. K. and Mohd Arshad, M. R. (2018) 'Determinants of intention to use mobile banking in the North of Jordan: Extending UTAUT2 with mass media and trust', *Journal of Engineering and Applied Sciences*, pp. 2023–2033. doi: 10.3923/jeasci.2018.2023.2033.

Glasersfeld, E. v. (1987) *Constructivism. The concise Corsini encyclopedia of psychology and behavioral science,*.

Godfrey, R. V. (2016) 'Mobile Phone Practices and Policies in Family and Consumer Sciences Programs in Texas', *Family and Consumer Sciences*

Research Journal, 44(3), pp. 295–308. doi: 10.1111/fcsr.12146.

Godin, G. (1994) 'The theories of reasoned action and planned behavior: usefulness for exercise promotion', *JMed Sci Sports Exerc*, 26(11), pp. 1391–1394. doi: 10.1080/10413209308411311.

González, M. Á. *et al.* (2014) 'Mobile Phones for Teaching Physics : Using Applications and Sensors', *Second International Conference on Technological Ecosystems for Enhancing Multiculturality - TEEM'14*, pp. 349–355. doi: 10.1145/2669711.2669923.

Goos, G., Hartmanis, J., van Leeuwen, J., Goettl, B. P., Halff, H. M., Redfield, C. L., & Shute, V. J. (1998) *Intelligent Tutoring Systems.* Berlin: Heidelberg: Springer Berlin Heidelberg.

Gower, J. C. (1985) 'properties of educlidean and non-euclidean distance matrices', 97, pp. 81–97.

Gramzow, R. H. and Willard, G. (2006) 'Exaggerating current and past performance: Motivated self-enhancement versus reconstructive memory', *Personality and Social Psychology Bulletin*, 32(8), pp. 1114–1125. doi: 10.1177/0146167206288600.

Groves, M. and Zemel, P. (2000) 'Instructional technology adoption in higher education: An action research case study,"', *Int. J. Instr. Media*, 27(1).

Gulliksen, J. *et al.* (2003) 'Key principles for user-centred systems design', *Behaviour and Information Technology*, 22(6), pp. 397–409. doi: 10.1080/01449290310001624329.

Gunasinghe, A. *et al.* (2019) 'The adequacy of UTAUT-3 in interpreting academician's adoption to e-Learning in higher education environments', *Interactive Technology and Smart Education*, 17(1), pp. 86–106. doi: 10.1108/ITSE-05-2019-0020.

Guo, H. and Razikin, K. B. (2015) 'Anthropological User Research : A Data-Driven Approach to Personas Development', pp. 417–421.

Gupta, S. *et al.* (2015) 'An E-Commerce Website based Chatbot', *International*

Journal of Computer Science and Information Technologies, 6(2), pp. 1483–1485. Available at: http://en.wikipedia.org/wiki/PARRY.

Gustavo, L. *et al.* (2017) 'Alexa vs. Siri vs. Cortana vs. Google Assistant: A Comparison of Speech-Based Natural User Interfaces Gustavo', in *International Conference on Applied Human Factors and Ergonomics*. Cham: Springer, p. Advances in Human Factors and Systems Interaction. doi: 10.1007/978-3-319-60366-7.

Hair, J. . *et al.* (2013) *A Primer on Partial Least Sequares Structural Equation Modeling(PLS-SEM)*. Sage Publication.

Hair, J. F. J. *et al.* (2010) *Multivariate data analysis.* New Jersey: Prentice-Hall.

Hair, J. F., Ringle, C. M. and Sarstedt, M. (2011) 'PLS-SEM: Indeed a silver bullet', *Journal of Marketing Theory and Practice*, 19(2), pp. 139–151. doi: 10.2753/MTP1069-6679190202.

Hartigan, J. (1975) 'Clustering Algorithms. Wiley, New York'. Available at: http://people.inf.elte.hu/fekete/algoritmusok_msc/klaszterezes/John A. Hartigan-Clustering Algorithms-John Wiley & Sons (1975).pdf.

Hartigan, J. . and Wong, M. A. (2018) 'A K-Means Clustering Algorithm', *Journal of the Royal Statistical Society*, 135(3), pp. 370–384.

Hempel, C. (1966) 'Philosophy of the Natural Sciences.pdf'.

Herrero, Á., San Martín, H. and Garcia-De los Salmones, M. del M. (2017) 'Explaining the adoption of social networks sites for sharing user-generated content: A revision of the UTAUT2', *Computers in Human Behavior*, 71, pp. 209–217. doi: 10.1016/j.chb.2017.02.007.

Hevner, A. R. *et al.* (2004) 'Design Science in the Information System Research', *MIS Quarterly Vol.*, 28(1), pp. 725–730. doi: 10.2307/25148869.

Hill, C. *et al.* (2017) 'Gender-Inclusiveness Personas vs . Stereotyping : Can We Have it Both Ways ?', *In Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*, pp. 6658–6671.

Hinton, P. R. *et al.* (2004) *SPSS Explained Perry*.

Hoffmann, V., Probst, K. and Christinck, A. (2007) ‘Farmers and researchers: How can collaborative advantages be created in participatory research and technology development?’, in *Agriculture and human values*, pp. 355–368. doi: 10.1007/s10460-007-9072-2.

Hone, K. S. and El Said, G. R. (2016) ‘Exploring the factors affecting MOOC retention: A survey study’, *Computers and Education*. Elsevier Ltd, 98, pp. 157–168. doi: 10.1016/j.compedu.2016.03.016.

Hong, W. *et al.* (2001) ‘Determinants of user acceptance of digital libraries: An empirical examination of individual differences and system characteristics’, *Journal of Management Information Systems*, 18(3), pp. 97–124. doi: 10.1080/07421222.2002.11045692.

Howard, T. (2014) ‘Journey mapping’, *Communication Design Quarterly*, 2(3), pp. 10–13. doi: 10.1145/2644448.2644451.

Hull, R. and King, R. (1987) ‘Semantic database modeling: survey, applications, and research issues’, *ACM Computing Surveys*, 19(3), pp. 201–260. doi: 10.1145/45072.45073.

Hung, V. *et al.* (2009) ‘Towards a method for evaluating naturalness in conversational dialog systems’, *Conference Proceedings - IEEE International Conference on Systems, Man and Cybernetics*, (October), pp. 1236–1241. doi: 10.1109/ICSMC.2009.5345904.

Indrawati and Amalia, F. (2019) ‘The used of modified UTAUT 2 model to analyze the continuance intention of travel mobile application’, *2019 7th International Conference on Information and Communication Technology, ICoICT 2019*. IEEE. doi: 10.1109/ICoICT.2019.8835196.

Indrawati and Pratomo, D. (2017) ‘Online collaboration adoption: A case study in Indonesia’ ABC Telco company in Indonesia’, *2017 5th International Conference on Information and Communication Technology, ICoIC7 2017*, 0(c), pp. 1–6. doi: 10.1109/ICoICT.2017.8074708.

Iulian V. Serban, Chinnadhurai Sankar, Mathieu Germain, Saizheng Zhang, Z. L. *et al.* (2017) ‘A Deep Reinforcement Learning Chatbot’, *arXiv preprint* *arXiv:1709.02349.*, pp. 1–40.

Jacob, C. (2016) ‘a Survey on Web Based Conversational’, 3(10), pp. 96–99.

Jakkaew, P. and Hemrungrote, S. (2017) ‘The use of UTAUT2 model for understanding student perceptions using Google Classroom: A case study of Introduction to Information Technology course’, *2nd Joint International Conference on Digital Arts, Media and Technology 2017: Digital Economy for Sustainable Growth, ICDAMT 2017*. IEEE, pp. 205–209. doi: 10.1109/ICDAMT.2017.7904962.

Jia, J. (2004) ‘CSIEC (Computer Simulator in Educational Communication): An Intelligent Web-Based Teaching System for Foreign Language Learning’, *Conference on Educational Multimedia, Hypermedia & Telecommunications*, pp. 1–8. Available at: http://arxiv.org/abs/cs/0312030.

Junco, R., Heiberger, G. and Loken, E. (2011) ‘The effect of Twitter on college student engagement and grades’, *Journal of Computer Assisted Learning*, 27(2), pp. 119–132. doi: 10.1111/j.1365-2729.2010.00387.x.

Kadariya, D. *et al.* (2019) ‘KBot: Knowledge-enabled personalized chatbot for asthma self-management’, *Proceedings - 2019 IEEE International Conference on Smart Computing, SMARTCOMP 2019*, pp. 138–143. doi: 10.1109/SMARTCOMP.2019.00043.

Karahanna, E., Straub, D. W. and Chervany, N. L. (1999) ‘Information technology adoption across time: A cross-sectional comparison of pre-adoption and post-adoption beliefs’, *MIS Quarterly: Management Information Systems*, 23(2), pp. 183–213. doi: 10.2307/249751.

Kassambara, A. (2018) *Determining The Optimal Number Of Clusters: 3 Must Know Methods*, *DataNovia*. Available at: https://www.datanovia.com/en/lessons/determining-the-optimal-number-of-clusters-3-must-know-methods/ (Accessed: 14 October 2019).

Kaufman, L. and Rousseeuw, P. J. (1990) *Finding Groups in Data: An Introduction to Cluster Analysis.*, *Biometrics*. New York: John Wiley & sons. doi: 10.2307/2532178.

Keegan, M., Boyle, R. D. and Dee, H. M. (2012) ‘Turi : Chatbot software for schools in the Turing Centenary Categories and Subject Descriptors’, *Proceedings of the 7th Workshop in Primary and Secondary Computing Education*, pp. 153–154. doi: 10.1145/2481449.2481489.

Kenny, R. F. *et al.* (2012) ‘Using Self-Efficacy to Assess the Readiess of Nursing Educator and Students for Mobile Learning’, *The International Review of Research In Open And Distance Learning*, 13.

Kerly, A., Ellis, R. and Bull, S. (2008) ‘CALMsystem: A Conversational Agent for Learner Modelling’, *Knowledge-Based Systems*, 21(3), pp. 238–246. doi: 10.1016/j.knosys.2007.11.015.

Kerly, A., Hall, P. and Bull, S. (2007) ‘Bringing chatbots into education: Towards natural language negotiation of open learner models’, *Knowledge-Based Systems*, 20(2), pp. 177–185. doi: 10.1016/j.knosys.2006.11.014.

Keskin, N. O. and Metcalf, D. (2011) ‘The current perspectives, theories and practices of mobile learning’, *Turkish Online Journal of Educational Technology*, 10(2), pp. 202–208.

Ketamo, H., Kiili, K. and Alajääski, J. (2010) ‘Reverse market segmentation with personas’, *WEBIST 2010 - Proceedings of the 6th International Conference on Web Information Systems and Technology*, 2(Webist), pp. 63–68. doi: 10.5220/0002781300630068.

Khan, R. A. and Adams, C. (2016) ‘Adoption of Learning Management Systems in Saudi Higher Education Context : Study at King Fahd University of Petroleum and Minerals & Dammam Community College’, *Society for Information Technology & Teacher Education International Conference. Vol. 2016. No. 1.*, (Barbera 2004), pp. 2909–2916.

Khanna, A., Pandey, B., *et al.* (2015) ‘A Study of Today’s A.I. through Chatbots and Rediscovery of Machine Intelligence’, *International Journal of u- and e-Service, Science and Technology*, 8(7), pp. 277–284. doi: 10.14257/ijunesst.2015.8.7.28.

Khanna, A., Jain, M., *et al.* (2015) ‘Anatomy and Utilities of an Artificial Intelligence

Conversational Entity', *Proceedings - 2015 International Conference on Computational Intelligence and Communication Networks, CICN 2015*, pp. 594–597. doi: 10.1109/CICN.2015.122.

Kim, S. S. and Malhotra, N. K. (2005) 'A Longitudinal Model of Continued IS Use: An Integrative View of Four Mechanisms Underlying Postadoption Phenomena', *Management Science*, 51(5), pp. 741–755. doi: 10.1287/mnsc.1040.0326.

Kim, Y., Baylor, A. L. and Shen, E. (2007) 'Pedagogical agents as learning companions: The impact of agent emotion and gender', *Journal of Computer Assisted Learning*, 23(3), pp. 220–234. doi: 10.1111/j.1365-2729.2006.00210.x.

Kimita, K., Nemoto, Y. and Shimomura, Y. (2014) 'Application of a Requirement Analysis Template to Lectures in a Higher Education Institution.', in *In International Conference on Human Interface and the Management of Information*. 594-601. Springer, Cham, 2014, pp. 594–601. doi: 10.1007/978-3-319-07731-4_39.

Kiss, G. (2013) 'The comparison of the computer science learning habits of the students on the Obuda University in the last five years', *2013 12th International Conference on Information Technology Based Higher Education and Training, ITHET 2013*. IEEE, pp. 1–3. doi: 10.1109/ITHET.2013.6671005.

Knill, O. *et al.* (2004) 'An artificial intelligence experiment in college math education', *Preprint available at http://www. math. harvard. edu/~ knill/preprints/sofia. pdf (2004).*, p. 9. Available at: http://www.math.harvard.edu/~knill/preprints/sofia.pdf.

Kodinariya, T. and Makwana, P. (2013) 'Review on determining number of Cluster in K-Means Clustering', *International Journal of Advance Research in Computer Science and Management Studies*, 1(6), pp. 90–95.

Kolomvatsos, K. and Anagnostopoulos, C. (2017) 'Reinforcement Learning for Predictive Analytics in Smart Cities', *Informatics*, 4(4), p. 16. doi: 10.3390/informatics4030016.

Kuciapski, M. (2019) 'How the Type of Job Position Influences Technology Acceptance : A Study of Employees ' Intention to Use Mobile Technologies for Knowledge Transfer', pp. 177397–177413. doi: 10.1109/ACCESS.2019.2957205.

Kukulska-hulme, A. and Traxler, J. (2013) ‘Draft of chapter for second edition of Rethinking Pedagogy for a Digital Age’, in *in Rethinking pedagogy for the Digital Age*.

Last, J. and Abramson, J. (2001) *International epidemiological association. A dictionary of epidemiology.* New York: Oxford University Press.

Lee, M. K., Kiesler, S. and Forlizzi, J. (2010) ‘Receptionist or information kiosk: How do people talk with a robot ?’, *Proceedings of the 2010 ACM conference on Computer supported cooperative work - CSCW ’10*, (January), p. 31. doi: 10.1145/1718918.1718927.

Lewis, C. C. *et al.* (2013) ‘Faculty Use of Established and Emerging Technologies in Higher Education: A Unified Theory of Acceptance and Use of Technology Perspective’, *International Journal of Higher Education*, 2(2), pp. 22–34. doi: 10.5430/ijhe.v2n2p22.

Lim, W. N. (2017) ‘Improving Student Engagement in Higher Education through Mobile-Based Interactive Teaching Model Using Socrative’, *2017 IEEE Global Engineering Education Conference (EDUCON). IEEE*, (April), pp. 404–412.

Limayem, M., Hirt, S. G. and Cheung, C. M. K. (2007) ‘How Habit Limits the Predictive Power of Intention: The Case of Information Systems Continuance’, *MIS Quarterly Vol.*, 31(4), pp. 705–737.

Limayem, M., Khalifa, M. and Frini, A. (2000) ‘What makes consumers buy from Internet? A longitudinal study of online shopping’, *IEEE Transactions on Systems, Man, and Cybernetics Part A:Systems and Humans.*, 30(4), pp. 421–432. doi: 10.1109/3468.852436.

Liu, T. C. *et al.* (2003) ‘Wireless and mobile technologies to enhance teaching and learning’, *Journal of Computer Assisted Learning*, (300), pp. 371–382.

Lokman, A. S. and Zain, J. M. (2009) ‘An architectural design of virtual dietitian (ViDi) for diabetic patients’, *Proceedings - 2009 2nd IEEE International Conference on Computer Science and Information Technology, ICCSIT 2009*, (ViDi), pp. 408–411. doi: 10.1109/ICCSIT.2009.5234671.

Lokman, A. S. and Zain, J. M. (2010a) ‘Extension and prerequisite: An algorithm to enable relations between responses in chatbot technology’, *Journal of Computer Science*, 6(10), pp. 1212–1218. doi: 10.3844/jcssp.2010.1212.1218.

Lokman, A. S. and Zain, J. M. (2010b) ‘One-match and all-match categories for keywords matching in chatbot’, *American Journal of Applied Sciences*, 7(10), pp. 1406–1411. doi: 10.3844/ajassp.2010.1406.1411.

Lwoga, E. T. and Komba, M. (2015) ‘Antecedents of continued usage intentions of web-based learning management system in Tanzania’, *Education and Training*, 57(7), pp. 738–756. doi: 10.1108/ET-02-2014-0014.

Madden, T. J., Ellen, P. S. and Ajzen, I. (1992) ‘A comparison of the theory of planned behavior and the theory of reasoned action’, *Personality and social psychology Bulletin*, 18(1), pp. 3–9.

Maddox, K. *et al.* (2019) ‘Lessons Learned from Journey Mapping in Health Care’, in *In Proceedings of the International Symposium on Human Factors and Ergonomics in Health Care*. Los Angeles: SAGE Publications. doi: 10.1177/2327857919081024.

Mafraq, H. and Kotb, Y. (2019) ‘Maarefh - Proposed MOOCs’ platform for Saudi Arabia’s higher education institutions’, *ACM International Conference Proceeding Series*, Part F1483, pp. 77–82. doi: 10.1145/3323771.3323828.

Maldonado, U. P. T. *et al.* (2009) ‘E-learning motivation and educational portal acceptance in developing countries’, *Online Information Review*, 35(1), pp. 66–85. doi: 10.1108/14684521111113597.

Malhotra, N. K., Birks, D. F. and Wills, P. (2006) *Marketing research An applied approach*. Harlow: FT/Prentice Hall. Available at: http://182.160.97.198:8080/xmlui/handle/123456789/342%0Ahttp://capitadiscovery.co.uk/cardiffmet/items/240307%0Ahttp://182.160.97.198:8080/xmlui/handle/123456789/342%0Ahttp://capitadiscovery.co.uk/cardiffmet/items/240307.

March, S. S. T. and Smith, G. F. G. (1995) ‘Design and natural science research on information technology’, *Decision Support Systems*, 15(4), pp. 251–266. doi: 10.1016/0167-9236(94)00041-2.

Markett, C. *et al.* (2006) ‘Using short message service to encourage interactivity in the classroom’, *Computers and Education*, 46(3), pp. 280–293. doi: 10.1016/j.compedu.2005.11.014.

Marquez, J. J., Downey, A. and Clement, R. (2015) ‘Walking a Mile in the User’s Shoes: Customer Journey Mapping as a Method to Understanding the User Experience’, *Internet Reference Services Quarterly*, 20(3–4), pp. 135–150. doi: 10.1080/10875301.2015.1107000.

Martin, J. and Torres, A. (2016) ‘What Is Student Engagement And Why Is It Important?’, *37*, 1, p. 2018. doi: 10.1136/bmj.322.7301.1536.

Masiero, A. A. *et al.* (2011) ‘Multidirectional Knowledge Extraction Process for Creating Behavioral Personas’.

Mauldin, M. L. (1994) ‘ChatterBots, TinyMuds, and the Turing Test: Entering the Loebner Prize Competition’, *Aaai*, pp. 16–21. Available at: http://www.aaai.org/Papers/AAAI/1994/AAAI94-003.pdf.

Mayisela, T. (2013) ‘The potential use of mobile technology: enhancing accessibility and communication in a blended learning course’, *South African Journal of Education*, 33(1), pp. 1–18. doi: 10.15700/saje.v33n1a629.

Mazman, S. G. and Usluel, Y. K. (2010) ‘Modeling educational usage of Facebook’, *Computers and Education*, 55(2), pp. 444–453. doi: 10.1016/j.compedu.2010.02.008.

McGinn, J. (Jen) and Kotamraju, N. (2008) ‘Data-driven persona development’, *Proceeding of the twenty-sixth annual CHI conference on Human factors in computing systems - CHI ’08*, (January 2008), p. 1521. doi: 10.1145/1357054.1357292.

McKinsey & Company (2016) *Winning the expectations game in customer care;* Available at: https://www.mckinsey.com/business-functions/operations/our-insights/winning-the-expectations-game-in-customer-care. (Accessed: 30 June 2020).

Mechlih, H. and Mechlih, M. M. (2015) ‘NEURAL NETWORK BASED MEDICAL

DECISION MAKING USING WEARABLE TECHNOLOGY', *2th Learning and Technology Conference, 2015. 35752 2015.*, pp. 36–38.

Meffert, K. (2006) 'Supporting design patterns with annotations', *13th Annual IEEE International Symposium and Workshop on Engineering of Computer-Based Systems (ECBS'06)*. doi: 10.1109/ECBS.2006.67.

Mehta, B. and Bhandari, B. (2016) 'Engaging medical undergraduates in question making: A novel way to reinforcing learning in physiology', *Advances in Physiology Education*, 40(3), pp. 398–401. doi: 10.1152/advan.00068.2016.

Miaskiewicz, T. and Kozar, K. A. (2011) 'Personas and user-centered design: How can personas benefit product design processes?', *Design Studies*. Elsevier Ltd, 32(5), pp. 417–430. doi: 10.1016/j.destud.2011.03.003.

Mikic, F. A. *et al.* (2009) 'CHARLIE: An AIML-based chatterbot which works as an interface among INES and humans', *20th EAEEIE Annual Conference, EAEEIE 2009 - Formal Proceedings*. doi: 10.1109/EAEEIE.2009.5335493.

Miller, N. E. and Dollard, J. (1941) *Social Learning and Imitation*. New Haven: Yale University Press. Available at: Moi.gov.jo.

Milligan, G. and Cooper, M. (1985) 'An Examination Of Procedures For Determining The Number Of Clusters In A Data Set', 50(2), pp. 159–160.

Mohadis, H. M. and Ali, N. M. (2018) 'Smartphone application for physical activity enhancement at workplace: Would office workers actually use it?', *Proceedings - International Conference on Information and Communication Technology for the Muslim World 2018, ICT4M 2018*. IEEE, pp. 144–149. doi: 10.1109/ICT4M.2018.00035.

Moon, J. W. and Kim, Y. G. (2001) 'Extending the TAM for a World-Wide-Web context', *Information and Management*, 38(4), pp. 217–230. doi: 10.1016/S0378-7206(00)00061-6.

Moore, G. and Benbasa, I. (1991) 'Development of an Instrument to Measure the Perceptions of Adopting an Information Technology Innovation', *Quality in Higher Education*, 15(2), pp. 192–222. doi: 10.1080/13538320902995758.

Mulder, S. and Yaar, Z. (2006) *The user is always right: A practical guide to creating and using personas for the web.* New Riders.

Naismith, L. *et al.* (2004) 'Literature Review in Mobile Technologies and Learning', 11, p. 48. doi: Retrived 13th March, 2014.

Nargundkar, R. (2003) *Marketing Research-Text & Cases 2E.* Tata McGraw-Hill Education.

Narkwilai, M., Funilkul, S. and Supasitthimethee, U. (2015) 'Factors influencing the Thai elderly's intention to use social network for Quality of Life: A case study LINE application', *Proceedings - 2015 7th International Conference on Information Technology and Electrical Engineering: Envisioning the Trend of Computer, Information and Engineering, ICITEE 2015*. IEEE, pp. 593–598. doi: 10.1109/ICITEED.2015.7409016.

Nenonen, S., Rasila, H. and Junnonen, J. M. (2008) 'Customer Journey – a method to investigate user experience', *W111 Research Report Usability of Workplaces Phase 2*, (Schmitt 1999), pp. 54–63. Available at: www.irbnet.de/daten/icoda/CIB8909.pdf.

Newell, A. and Simon, H. (1976) 'Computer Science as Empirical Inquiry: Symbols and Search', *Yale Law Journal*, 108(3), pp. 573–599. doi: 10.1145/360018.360022.

Ng, R. T. and Han, J. (1994) 'Efficient and Effective Clustering Methods for Spatial Data Mining', in *International Conference on Very Large Data Bases*, pp. 144–155. doi: 10.1.1.13.4395.

Nicol, D. and MacFarlane-Dick, D. (2006) 'Formative assessment and selfregulated learning: A model and seven principles of good feedback practice', *Studies in Higher Education*, 31(2), pp. 199–218. doi: 10.1080/03075070600572090.

Nielsen, L. *et al.* (2015) 'A template for design personas: Analysis of 47 persona descriptions from Danish industries and organizations', *International Journal of Sociotechnology and Knowledge Development*, 7(1), pp. 45–61. doi: 10.4018/ijskd.2015010104.

Nieters, J., Ivaturi, S. and Ahmed, I. (2007) ‘Making Personas Memorable’, *In CHI’07 extended abstracts on Human factors in computing systems*, pp. 1817–1823.

Nishiuchi, N. and Shiga, A. (2015) ‘A Method for Creating Persona Using Bayesian Network Analysis’, 9(2), pp. 69–74.

North-Samardzic, A. and Jiang, B. (2015) ‘Acceptance and use of Moodle by students and academics’, *2015 Americas Conference on Information Systems, AMCIS 2015*, (2003), pp. 1–13.

Norušis, M. (2012) ‘chapter16 Cluster Analysis’, in *IBM SPSS Statistics 19 Statistical Procedures Companion:* Prentice Hall, pp. 361–392. doi: 10.4135/9781412983648.

Nunamaker, J., Chen, M. and Purdin, T. (1991) ‘Systems development in Information Systems research’, *Journal of Management Information Systems*, pp. 89–106. doi: 10.1109/ISIE.1992.279627.

Nunamaker, J., Minder, J. and Purdin, T. (1990) ‘System development in information systems research’, *Journal of Management Information Systems*, 7, pp. 147–158. doi: 10.1016/B978-1-876938-42-0.50016-2.

Nunes, F., Silva, P. A. and Abrantes, F. (2010) ‘Human-computer interaction and the older adult’, *Proceedings of the 3rd International Conference on PErvasive Technologies Related to Assistive Environments - PETRA ’10*, (May 2014), p. 1. doi: 10.1145/1839294.1839353.

Nunnally, J. and Bernstein, I. (1995) *Psychometric theory*, *New York, NY*.

Nunnally, J. C. (1970) *Introduction to psychological measurement.* New York: McGraw-Hill.

Oeste, S.0 Lehmann, K.0 Janson, A.0 Söllner, M. & Leimeister, J. M. (2015) ‘REDESIGNING UNIVERSITY LARGE SCALE LECTURES: HOW TO ACTIVATE THE LEARNER’, *" In Academy of Management Proceedings*, 2015(1), p. 14650.

Oinas-Kukkonen, H. and Harjumaa, M. (2008) ‘A systematic framework for designing and evaluating persuasive systems’, *Lecture Notes in Computer*

Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), 5033 LNCS, pp. 164–176. doi: 10.1007/978-3-540-68504-3-15.

Ortbal, K., Frazzette, N. and Mehta, K. (2016) 'Stakeholder journey mapping: An educational tool for social entrepreneurs', *Procedia Engineering*. The Author(s), 159(June), pp. 249–258. doi: 10.1016/j.proeng.2016.08.170.

Ortiz, O. *et al.* (2015) 'M-Learning Tools: The Development of Programming Skills in Engineering Degrees', *Revista Iberoamericana de Tecnologias del Aprendizaje*, 10(3), pp. 86–91. doi: 10.1109/RITA.2015.2452531.

Özgür, H. (2016) 'Adapting the media and technology usage and attitudes scale to Turkish', *Kuram ve Uygulamada Egitim Bilimleri*, 16(5), pp. 1711–1735. doi: 10.12738/estp.2016.5.0085.

Palmatier, R. (1974) 'Notetaking Habits of College Students.', *Journal of Reading*, 18(3), pp. 215–218.

Park, S. Y. (2009) 'An analysis of the technology acceptance model in understanding University students' behavioral intention to use e-Learning', *Educational Technology and Society*, 12(3), pp. 150–162.

Parsons, J. and Taylor, L. (2011) 'Improving Student Engagement', *Current Issues in education*, 14(1), pp. 4–33.

Pereira, J. (2016) 'Leveraging chatbots to improve self-guided learning through conversational quizzes', *Proceedings of the Fourth International Conference on Technological Ecosystems for Enhancing Multiculturality - TEEM '16*, pp. 911–918. doi: 10.1145/3012430.3012625.

Pereira, M. J. and Coheur, L. (2013) 'Just . Chat - a platform for processing information to be used in chatbots', pp. 1–10.

Perlibakas, V. (2004) 'Distance measures for PCA-based face recognition', *Pattern Recognition Letters*, 25(6), pp. 711–724. doi: 10.1016/j.patrec.2004.01.011.

Pheeraphuttharangkoon, S. (2015) *The Adoption , Use and Diffusion of Smartphones among Adults over Fifty in the UK*. University of Hertfordshire.

Pickett, L. L. *et al.* (2012) ‘Ajzen’s Theory of Planned Behavior as it Relates to Eating Disorders and Body Satisfaction’, *North American Journal of Psychology*, 14(2), pp. 339–354.

Polst, S. and Stüpfert, P. (2019) ‘A Comprehensive Persona Template to Understand Citizens’ Mobility Needs.’, in *In International Conference on Human-Computer Interaction (pp. 295-306). Springer, Cham.* Cham: Springer, pp. 295–306. doi: 10.1007/978-3-030-22666-4_31.

Presser, S. *et al.* (2004) ‘Methods for Testing and Evaluating Survey Questions’, *Public Opinion Quarterly*, 68(1), pp. 109–130.

Pruitt, J. and Grundin, J. (2003) ‘Personas : Practice and Theory’, *Proceedings of the 2003 conference on Designing for user experiences*, pp. 1–15. doi: 10.1145/997078.997089.

Putnam, C., Kolko, B. and Wood, S. (2012) ‘Communicating about users in ICTD’, *Proceedings of the Fifth International Conference on Information and Communication Technologies and Development - ICTD ’12*, p. 338. doi: 10.1145/2160673.2160714.

Quintana, R. M. *et al.* (2017) ‘The persona party: Using personas to design for learning at scale’, *Conference on Human Factors in Computing Systems - Proceedings*, Part F1276(1), pp. 933–941. doi: 10.1145/3027063.3053355.

Raman, A. and Don, Y. (2013) ‘Preservice teachers’ acceptance of learning management software: An application of the UTAUT2 model’, *International Education Studies*, 6(7), pp. 157–164. doi: 10.5539/ies.v6n7p157.

Rideout, V. J., Foehr, U. G. and Roberts, D. F. (2010) ‘Generation M2: Media in the Lives of 8 to 18 Year-Olds’, *The Henry J. Kaiser Family Foundation*, pp. 1–79. doi: P0-446179799-1366925520306.

Robinson, J. P., Shaver, P. R. and Wrightsman, L. S. (2010) *SPSS survival manual: A step by step guide to data analysis using SPSS.*, *Open University Press.* doi: 10.1016/b978-0-12-590241-0.50005-8.

Robinson, J. P., Wrightsman, L. S. and Andrews, F. M. (1991) *Measures of* *personality and social psychological attitudes*. Academic Pr.

Rogers, E. (1983) *Diffusion of innovations*. 3rd editio, *The free press*. 3rd editio. New York. doi: 10.1002/chp.4750170109.

Rogers, E. M. (2003) *Diffusion of Innovations.* 5th editio. New York: The Free Press.

Rogers, E. M. (2010) *Diffusion and Innovation*, *Simon and Schuster*. doi: 10.4018/978-1-60566-038-7.ch005.

Rosmalen, P. van *et al.* (2012) 'Towards a Game-Chatbot: Extending the interaction in Serious Games', (October 2012), pp. 4–5.

Rousseeuw, P. (1987) 'Silhouettes: a graphical aid to the interpretation and validation of cluster analysis', *Journal of Computational North-Holland and Applied Mathematics*, 20(1987), pp. 53–65. doi: 10.1177/003754977702900403.

Roussou, M. *et al.* (2013) 'A Life of Their Own : Museum Visitor Personas Penetrating the Design Lifecycle of a Mobile Experience', pp. 547–552.

S. d. P. U. Departamento de Informaci´on Universitaria (2016) 'S´ıntesis de informaci´on estad´ısticas universitarias argentina 2014-2015'. República Argentina.

Sacharin, V., Schlegel, K. and Scherer, K. R. (2012) 'Geneva emotion wheel rating study', *Center for Person, Kommunikation, Aalborg University, NCCR Affective Sciences. Aalborg University, Aalborg*, (August).

Salminen, J. *et al.* (2020) 'Literature review of quantitative persona creation', in *In Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*, pp. 1–15.

Samaila, K. (2017) 'Learning Management System Usage with Postgraduate School : An Application of UTAUT Model', 3(12), pp. 38–49.

Samuel (1959) 'Some Studies in Machine Learning', *IBM Journal of Research and Development*, 44(1.2).

Sandler, J. (2015) 'What users want: Functional user experience', *Proceedings of*

2015 International Conference on Interactive Collaborative Learning, ICL 2015. IEEE, (September), pp. 355–360. doi: 10.1109/ICL.2015.7318053.

Sankar, R. (2018) 'Empowering Chatbots With Business Intelligence By Big Data Integration', *International Journal of Advanced Research in Computer Science*, 9(1), pp. 627–631. doi: 10.26483/ijarcs.v9i1.5398.

Sarosa, S. (2009) 'Information Technology Adoption Research : a PROPOSED THEORETICAL GUIDE', in *Proceedings of The 5th International Conference on Information and Communication Technology and Systems (ICTS)*. Surabaya, pp. 177–186.

Saunders, M., Lewis, P. & Thornhill, A. (2009) *Research Methods for Business Students.* Financial Times/Prentice Hall.

Saunders, M., Lewis, P. and Thornhill, A. (2009) *Research Methods for Business Students Fifth Edition*. Pearson Education.

See, J., Yusof, U. K. and Kianpisheh, A. (2010) 'User acceptance towards a personalised hands-free messaging application (iSay-SMS)', *CSSR 2010 - 2010 International Conference on Science and Social Research*. IEEE, (Cssr), pp. 1165–1170. doi: 10.1109/CSSR.2010.5773709.

Sekaran, U. and Bougie, R. (2011) *RESEARCH METHODS FOR BUSINESS : A SKILL BUILDING APPROACH*. 5TH ED. Wiley India Pvt. Ltd.

Shabajee, P., Hannabuss, S. and Tilsed, I. (1998) 'Book Reviews', *Interactive Learning Environments*, 6(3), pp. 281–290. doi: 10.1076/ilee.6.3.281.3600.

Shannon, S. J., Design, U. and Silva, B. De (2006) 'Why don't students attend lectures and what can be done about it through using iPod nanos?', *Proceedings of the 23rd Annual Ascilite Conference: who's teaching?*, (2), pp. 753–756.

Sharma, S. K., Joshi, A. and Sharma, H. (2016) 'A multi-analytical approach to predict the Facebook usage in higher education', *Computers in Human Behavior*. Elsevier Ltd, 55, pp. 340–353. doi: 10.1016/j.chb.2015.09.020.

Shaw, A. (2012a) 'Using Chatbots to Easily Create Interactive and Intelligent FAQ Webpages', *Journal of Applied Global Research*, 5(15), pp. 10–15.

Shaw, A. (2012b) ‘Using chatbots to teach socially intelligent computing principles in introductory computer science courses’, *Proceedings of the 9th International Conference on Information Technology, ITNG 2012*, pp. 850–851. doi: 10.1109/ITNG.2012.70.

Shawar, B. A. and Atwell, E. (2007) ‘Different measurements metrics to evaluate a chatbot system’, *Proceedings of the Workshop on Bridging the Gap: Academic and Industrial Research in Dialog Technologies*, (April), pp. 89–96. doi: http://dx.doi.org/10.3115/1556328.1556341.

Sheppard, B. H., Hartwick, J. and Warshaw, P. R. (1988) ‘The Theory of Reasoned Action : A Meta-Analysis of Past Research with Recommendations for Modifications and Future Research’, *Journal of Consumer Research*, 15(3), pp. 325–343.

Shiga, A. and Nishiuchi, N. (2013) ‘A support system for making persona using bayesian network analysis’, *Proceedings - 2013 International Conference on Biometrics and Kansei Engineering, ICBAKE 2013*. IEEE, pp. 281–284. doi: 10.1109/ICBAKE.2013.55.

Shirali-Shahreza, M. and Shirali-Shahreza, M. H. (2007) ‘Mobile banking services in the bank area’, *Proceedings of the SICE Annual Conference*, pp. 2682–2685. doi: 10.1109/SICE.2007.4421445.

Sia, P. Y. H., Iskandar, Y. H. P. and Yusuf, A. (2018) ‘Factors influencing the usage of mobile apps for travel among generation-Y in Malaysia’, *2017 IEEE Conference on e-Learning, e-Management and e-Services, IC3e 2017*. IEEE, pp. 55–60. doi: 10.1109/IC3e.2017.8409238.

Simon, H. A. (1996) *The sciences of the artificial, (third edition)*, *Computers & Mathematics with Applications*. doi: 10.1016/S0898-1221(97)82941-0.

Singh, A., Yadav, A. and Rana, A. (2013) ‘K-means with Three different Distance Metrics’, *International Journal of Computer Applications*, 67(10), pp. 13–17. doi: 10.5120/11430-6785.

Sinha, R. (2003) ‘Persona development for information-rich domains’, *CHI ’03: CHI ’03 extended abstracts on Human factors in computing systems*, pp. 830–831. doi:

10.1145/766011.766017.

Sok Foon, Y. and Chan Yin Fah, B. (2011) ‘Internet Banking Adoption in Kuala Lumpur: An Application of UTAUT Model’, *International Journal of Business and Management*, 6(4). doi: 10.5539/ijbm.v6n4p161.

Soutou, C. (1998) *Inference of aggregate relationships through database reverse engineering*, *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*. doi: 10.1007/978-3-540-49524-6_11.

Stewart, C. J. (1984) *The reflective practitioner: How professionals think in action*, *CrossRef Listing of Deleted DOIs*. New York: Basic Books. doi: 10.1007/bf02548593.

Sumak, B. and Sorgo, A. (2016) ‘The acceptance and use of interactive whiteboards among teachers: Differences in UTAUT determinants between pre- and post-adopters’, *Computers in Human Behavior*, 64, pp. 602–620. doi: 10.1016/j.chb.2016.07.037.

Syakur, M. A. *et al.* (2018) ‘Integration K-Means Clustering Method and Elbow Method for Identification of the Best Customer Profile Cluster’, *IOP Conference Series: Materials Science and Engineering*, 336(1). doi: 10.1088/1757-899X/336/1/012017.

Tabachnick and Fidell (2000) *Using multivariate statistics*. 4th editio. USA: Allyn and Bacon.

Taherdoost, H. (2018) ‘Sampling Methods in Research Methodology; How to Choose a Sampling Technique for Research’, *SSRN Electronic Journal*, (September). doi: 10.2139/ssrn.3205035.

Tan, E. *et al.* (2015) ‘Appsolutely smartphones: Usage and perception of apps for educational purposes Appsolutely smartphones: Usage and perception of apps for educational purposes’, *Asian Journal of the Scholarship of Teaching and Learning*, 5(1), pp. 55–75. Available at: http://www.ajsotl.edu.sg/wp-content/uploads/2015/03/v5n1p55_ETan.pdf.

Tarhini, A. *et al.* (2016) ‘Extending the UTAUT model to acceptance and use of internet understand the customers’ banking in Lebanon A structural equation modeling approach’, *Information Technology & People*, 29(4), pp. 830–849. doi: http://dx.doi.org/10.1207/S15327825MCS0301_03.

Tarhini, A. (2016) ‘The Effects of Individual-Level Culture and Demographic Characteristics on e-Learning Acceptance in Lebanon and England: A Structural Equation Modelling Approach’, *Ssrn*, (July). doi: 10.2139/ssrn.2725438.

Taylor, S. and Todd, P. (1995a) ‘Assessing IT usage: The role of prior experience’, *MIS Quarterly: Management Information Systems*, 19(4), pp. 561–568. doi: 10.2307/249633.

Taylor, S. and Todd, P. (1995b) ‘Decomposition and crossover effects in the theory of planned behavior: A study of consumer adoption intentions’, *International Journal of Research in Marketing*, 12(2), pp. 137–155. doi: 10.1016/0167-8116(94)00019-K.

Taylor, S. and Todd, P. (1995c) ‘Understanding Information Technology Usage: A Test of Competing Models’, *Information Systems Research*, 6(2), pp. 144–176.

Temkin, B. D. (2010) ‘Mapping The Customer Journey Best Practices For Using An Important Customer Experience Tool’, *Forrester*, p. 20. Available at: http://crowdsynergy.wdfiles.com/local--files/customer-journey-mapping/mapping_customer_journey.pdf.

Teo, T. (2009) ‘The impact of subjective norm and facilitating conditions on pre-service teachers’ attitude toward computer use: A structural equation modeling of an extended technology acceptance model’, *Journal of Educational Computing Research*, 40(1), pp. 89–109. doi: 10.2190/EC.40.1.d.

Teo, T. (2010) ‘A path analysis of pre-service teachers’ attitudes to computer use: Applying and extending the technology acceptance model in an educational context’, *Interactive Learning Environments*, 18(1), pp. 65–79. doi: 10.1080/10494820802231327.

Thompson, R. L., Higgins, C. A. and Howell, J. M. (1991) ‘Personal Computing: Toward a Conceptual Model of Utilization’, *MIS Quarterly*, 15(1), pp. 125–143. doi:

10.2307/249443.

Thorne, C. (2017) ‘Chatbots for troubleshooting: A survey’, *Linguistics and Language Compass*, 11(10), pp. 1–14. doi: 10.1111/lnc3.12253.

Tibshirani, Walther, G. and Hastie, T. (2001) ‘Estimating the number of clusters in a data set via the gap statistic’, *Journal of the Royal Statistical Society: Series B (Statistical Methodology)*, 63(2), p. 411—423.

Trade, B., Parsons, E. and Giddings, F. (1903) *The Laws of Imitation*. New York: Henry Holt and Company.

Trowler, V. (2010) ‘Student engagement literature review’, *The Higher Education Academy*, 1(11), pp. 1–15. doi: 10.1037/0022-0663.85.4.571.

Tu, N. *et al.* (2010) ‘Using cluster analysis in Persona development’, *2010 8th International Conference on Supply Chain Management and Information*, (January), pp. 1–5.

Uusitalo, O. (2014) ‘Research methodology’, in *SpringerBriefs in Applied Sciences and Technology*, pp. 25–39. doi: 10.1007/978-3-319-06829-9_3.

Vaishnavi, V. and Kuechler, B. (2004) ‘Design Science Research in Information Systems’, *Association for Information Systems*, p. 45. doi: 10.1007/978-1-4419-5653-8.

Valentim, N. M. C., Silva, W. and Conte, T. (2017) ‘The students’ perspectives on applying design thinking for the design of mobile applications’, *Proceedings - 2017 IEEE/ACM 39th International Conference on Software Engineering: Software Engineering and Education Track, ICSE-SEET 2017*, pp. 77–86. doi: 10.1109/ICSE-SEET.2017.10.

Vandenberghe, B. (2017) ‘Bot Personas as Off-The-Shelf Users’, *Proceedings of the 2017 CHI Conference Extended Abstracts on Human Factors in Computing Systems - CHI EA ’17*, pp. 782–789. doi: 10.1145/3027063.3052767.

Venkatesh, V. *et al.* (2003) ‘User Acceptance of Information Technology: Toward a Unified View’, *MIS Quarterly*, 27(3), pp. 425–478.

Venkatesh, V. and Davis, F. D. (2000) ‘A Theoretical Extension of the Technology

Acceptance Model : Four Longitudinal Field Studies', 46(2), pp. 186–204.

Venkatesh, V., Thong, J. Y. L. T. and Xu, X. (2012) 'consumer acceptance and use of IT', 36(1), pp. 157–178.

Vrajitoru, D. (2003) 'Evolutionary Sentence Building for Chatterbots', *GECCO 2003 Late Breaking Papers*, (July 2003), pp. 315–321. Available at: http://citeseer.ist.psu.edu/596573.html.

Vrajitoru, D. and Ratkiewicz, J. (2004) 'Evolutionary Sentence combination for Chatterbots', *GECCO 2003 Late Breaking Papers*, pp. 315–321. Available at: http://citeseer.ist.psu.edu/596573.html.

Vredenburg, K. *et al.* (2002) 'A survey of User-Centered Design Practice', *the SIGCHI conference*, (1), p. 471. doi: 10.1145/503457.503460.

Wadie, N. and Lanouar, C. (2012) 'An Exploration of Facebook.Com Adoption in Tunisia Using Technology Acceptance Model (TAM) and Theory of Reasoned Action (TRA)', *Interdisciplinary Journal of Contemporary Research In Business*, 4(5), pp. 948–968. Available at: http://search.proquest.com/docview/1115314180?accountid=14645.

Wang, J. *et al.* (2017) 'Big Data Management with Incremental K-Means Trees–GPU-Accelerated Construction and Visualization', *Informatics*, 4(3), p. 24. doi: 10.3390/informatics4030024.

Wasitarini, D. E. and Tritawirasta, W. (2016) 'Assessing users' acceptance toward a closed access Library Service System using the UTAUT model: A case study at the National Library of Indonesia', *2015 International Conference on Information Technology Systems and Innovation, ICITSI 2015 - Proceedings*. IEEE, pp. 1–4. doi: 10.1109/ICITSI.2015.7437704.

Weizenbaum, J. (1966) 'ELIZA — A Computer Program For the Study of Natural Language Communication Between Man And Machine', *Communications of the ACM*, 9(1), pp. 36–45. doi: 10.5100/jje.2.3_1.

Werts, C. ., Linn, R. . and Joreskog, K. . (1974) 'INTRACLASS RELIABILITY ESTIMATES: TESTING STRUCTURAL ASSUMPTIONS', *Measurement*, 33(509), pp. 25–33.

Whitby, B. (2009) *Artificial Intelligence*. The Rosen Publishing Group.

Williams, M. *et al.* (2011) ‘Association for Information Systems AIS Electronic Library (AISeL) IS UTAUT REALLY USED OR JUST CITED FOR THE SAKE OF IT? A SYSTEMATIC REVIEW OF CITATIONS OF UTAUT’ s ORIGINATING ARTICLE Recommended Citation "IS UTAUT REALLY USED OR JUST CITED FOR TH’, in *European Conference on Information Systems(ECIS)*, p. 231. Available at: http://aisel.aisnet.org/ecis2011/231.

Wilson, V. (2014) ‘Research Methods: Triangulation’, *Online Information Review*, 9(1), pp. 74–75. doi: 10.1108/OIR-11-2011-0193.

Winkler, R. . and Söllner, M. . (2018) ‘Unleashing the Potential of Chatbots in Education : A State-Of-The-Art Analysis . In : Academy of Management’. Available at: https://www.alexandria.unisg.ch/254848/1/JML_699.pdf.

Winograd, T. (1972) ‘Understanding natural language’, *Cognitive Psychology*, 3(1), pp. 1–191. doi: 10.1016/0010-0285(72)90002-3.

Winter, R. (2008) ‘Design science research in Europe’, *European Journal of Information Systems*, 17(5), pp. 470–475. doi: 10.1057/ejis.2008.44.

Wirth, R. and Hipp, J. (2000) ‘CRISP-DM : Towards a Standard Process Model for Data Mining’, *Proceedings of the Fourth International Conference on the Practical Application of Knowledge Discovery and Data Mining*, (24959), pp. 29–39. doi: 10.1.1.198.5133.

Wöckl, B. *et al.* (2012) ‘Basic senior personas: A representative design tool covering the spectrum of european older adults’, *ASSETS’12 - Proceedings of the 14th International ACM SIGACCESS Conference on Computers and Accessibility*, pp. 25–32. doi: 10.1145/2384916.2384922.

Wong, K. K.-K. (2016) ‘Mediation Analysis, Categorical Moderation Analysis, and Higher-Order Constructs Modeling in Partial Least Squares Structural Equation Modeling (PLS-SEM): A B2B Example Using SmartPLS’, *The Marketing Bulletin*, 26(May), pp. 1–22. doi: 10.13140/RG.2.1.1643.0562.

Yan, M. *et al.* (2016) ‘Building a chatbot with serverless computing’, *Proceedings of the 1st International Workshop on Mashups of Things and APIs, MOTA 2016*, pp. 1–4. doi: 10.1145/3007203.3007217.

Yang, M. T. and Liao, W. C. (2014) ‘Computer-assisted culture learning in an online augmented reality environment based on free-hand gesture interaction’, *IEEE Transactions on Learning Technologies*, 7(2), pp. 107–117. doi: 10.1109/TLT.2014.2307297.

Yang, S. (2013) ‘Understanding Undergraduate Students’ Adoption of Mobile Learning Model: A Perspective of the Extended UTAUT2’, *Journal of Convergence Information Technology*, 8(10), pp. 969–979. doi: 10.4156/jcit.vol8.issue10.118.

Yang, S. and Evans, C. (2019) ‘Opportunities and challenges in using AI chatbots in higher education’, in *ACM International Conference Proceeding Series*, pp. 79–83. doi: 10.1145/3371647.3371659.

Yeap, J. A. L., Yapp, E. H. T. and Balakrishna, C. (2017) ‘User acceptance of on-demand services’, *International Conference on Research and Innovation in Information Systems, ICRIIS*. IEEE, pp. 1–6. doi: 10.1109/ICRIIS.2017.8002535.

Yenyuen, Y. and Yeow, P. H. P. (2009) ‘User acceptance of internet banking service in Malaysia’, in *International Conference on Web Information Systems and Technologies*. Berlin: Springer, pp. 295–306. doi: 10.1007/978-3-642-01344-7_22.

Zaldivar, A. *et al.* (2015) ‘Using Mobile Technologies to Support Learning in Computer Science Students’, *IEEE Latin America Transactions*, 13(1), pp. 377–382. doi: 10.1109/TLA.2015.7040672.

Zhang, X., Brown, H.-F. and Shankar, A. (2016) *Data-driven Personas: Constructing Archetypal Users with Clickstreams and User Telemetry*, *In Proceedings of the 2016 CHI Conference on Human Factors in Computing System*. doi: 10.1007/s11258-006-9188-2.

Zhao, Y. *et al.* (1967) ‘What We Learned from TransitionMate: A: A mobile app designed to support young people with chronic illness’, in *Annual Meeting of the Australian Special Interest Group for Computer Human Interaction*. ACM, pp. 162–166. doi: 10.1145/2838739.2838805.

Zhou, T., Lu, Y. and Wang, B. (2010) ‘Integrating TTF and UTAUT to explain mobile banking user adoption’, *Computers in Human Behavior*. Elsevier Ltd, 26(4), pp. 760–767. doi: 10.1016/j.chb.2010.01.013.

Zhu, H., Wang, H. and Carroll, J. M. (2019) ‘Creating persona skeletons from imbalanced datasets - A case study using U.S. Older Adults’ health data’, *DIS 2019 - Proceedings of the 2019 ACM Designing Interactive Systems Conference*, pp. 61–70. doi: 10.1145/3322276.3322285.

Zikmund, W. G. *et al.* (2009) *Business Research Methods.* South-Western Cengage Learning.

Appendix A – Ethical Approval

College of Engineering, Design and Physical Sciences Research Ethics Committee
Brunel University London
Kingston Lane
Uxbridge
UB8 3PH
United Kingdom

www.brunel.ac.uk

12 April 2018

LETTER OF APPROVAL (CONDITIONAL)

Applicant: Mrs Fatim Amer Jid Almahri

Project Title: Ethical approval for PhD project

Reference: 6470-LR-Apr/2018- 12424-3

Dear Mrs Fatim Amer Jid Almahri

The Research Ethics Committee has considered the above application recently submitted by you.

The Chair, acting under delegated authority has agreed that there is no objection on ethical grounds to the proposed study. Approval is given on the understanding that the conditions of approval set out below are followed:

- The agreed protocol must be followed. Any changes to the protocol will require prior approval from the Committee by way of an application for an amendment.
- Approval is granted only on the grounds that all student data is fully anonymised and checked prior to being made available. This has been agreed by David Bell as per his email to CEPDS-research received 11/4/2018.

Please note that:

- Research Participant Information Sheets and (where relevant) flyers, posters, and consent forms should include a clear statement that research ethics approval has been obtained from the relevant Research Ethics Committee.
- The Research Participant Information Sheets should include a clear statement that queries should be directed, in the first instance, to the Supervisor (where relevant), or the researcher. Complaints, on the other hand, should be directed, in the first instance, to the Chair of the relevant Research Ethics Committee.
- Approval to proceed with the study is granted subject to receipt by the Committee of satisfactory responses to any conditions that may appear above, in addition to any subsequent changes to the protocol.
- The Research Ethics Committee reserves the right to sample and review documentation, including raw data, relevant to the study.
- You may not undertake any research activity if you are not a registered student of Brunel University or if you cease to become registered, including abeyance or temporary withdrawal. As a deregistered student you would not be insured to undertake research activity. Research activity includes the recruitment of participants, undertaking consent procedures and collection of data. Breach of this requirement constitutes research misconduct and is a disciplinary offence.

Professor Hua Zhao

Chair

College of Engineering, Design and Physical Sciences Research Ethics Committee

Figure 0-1: Ethical Approval for Iteration One

Brunel University London

College of Engineering, Design and Physical Sciences Research Ethics Committee
Brunel University London
Kingston Lane
Uxbridge
UB8 3PH
United Kingdom

www.brunel.ac.uk

12 December 2019

LETTER OF APPROVAL

APPROVAL HAS BEEN GRANTED FOR THIS STUDY TO BE CARRIED OUT BETWEEN 06/01/2020AND 30/05/2020

Applicant (s): Mrs Fatima Amer jid almahri

Project Title: conversational system experiment

Reference: 19303-LR-Dec/2019- 22697-1

Dear Mrs Fatima Amer jid almahri

The Research Ethics Committee has considered the above application recently submitted by you.

The Chair, acting under delegated authority has agreed that there is no objection on ethical grounds to the proposed study. Approval is given on the understanding that the conditions of approval set out below are followed:

- The agreed protocol must be followed. Any changes to the protocol will require prior approval from the Committee by way of an application for an amendment.

Please note that:

- Research Participant Information Sheets and (where relevant) flyers, posters, and consent forms should include a clear statement that research ethics approval has been obtained from the relevant Research Ethics Committee.
- The Research Participant Information Sheets should include a clear statement that queries should be directed, in the first instance, to the Supervisor (where relevant), or the researcher. Complaints, on the other hand, should be directed, in the first instance, to the Chair of the relevant Research Ethics Committee.
- Approval to proceed with the study is granted subject to receipt by the Committee of satisfactory responses to any conditions that may appear above, in addition to any subsequent changes to the protocol.
- The Research Ethics Committee reserves the right to sample and review documentation, including raw data, relevant to the study.
- You may not undertake any research activity if you are not a registered student of Brunel University or if you cease to become registered, including abeyance or temporary withdrawal. As a deregistered student you would not be insured to undertake research activity. Research activity includes the recruitment of participants, undertaking consent procedures and collection of data. Breach of this requirement constitutes research misconduct and is a disciplinary offence.

Professor Hua Zhao

Chair of the College of Engineering, Design and Physical Sciences Research Ethics Committee

Brunel University London

Figure 0-2: Ethical Approval for Iteration Two

Appendix B – Extended UTAUT2 Survey

Survey on Student Acceptance and Use of Chatbots

Welcome

This survey is about identifying undergraduate students acceptance and use of chatbots at Brunel University London. Your responses will be used to help to study student acceptance and use of chatbots. Summarised results will be reported back to students.

Thank you very much for answering this survey

Fatima Amer Jid Almahri, PhD researcher in the Computer Science Department, Brunel University London.

Data Protection

Before you start the survey, please read this privacy statement which tells you how any personal data you submit with your response to this survey will be utilised and protected, and the rights you have about it.

Brunel University London Data Protection information (also covering privacy):

http://www.brunel.ac.uk/about/administration/information-access/data-protection

Your participation in this survey is voluntary, and you can stop at any point without your responses being included in the dataset.

If you are happy to continue, please tick the box below to confirm that you consent to any personal data you provide being used in the way described(if you do not consent, then please close this browser window to exit the survey):

Please select exactly 1 answer(s).

☐ I give my consent for my responses to this survey to be used as described in the privacy statement

Introduction:

A Chatbot (also known as Conversational Agent, Bot, IM bot, Smartbot, or Talkbot). It is a computer program designed to simulate an intelligent conversation with one or more human users via auditory or textual methods using natural language. Well-known examples of chatbots are Siri in iPhones and Amazon Alexa. The chatbot provides information about weather, schedule a meeting, search for/ track flights, get up-to-date news, send money, find restaurants, to name a few. It is important to know that you do not have to carry Alexa devices with you to use it is functions (skills), you can download the app in your phone and enjoy using Alexa functions (skills).

1. Select all the chatbots that you have used

- ◻ Siri by Apple
- ◻ Alexa by Amazon
- ◻ Cortana by
- ◻ Microsoft
- ◻ Google Assistant by Google
- ◻ None of the above
- ◻ Other, please specify

Section 1: Acceptance and use of Chatbots

1. To what extent do you agree or disagree with the following statement about Chatbots.

	Strongly Disagree	**Disagree**	**Slightly disagree**	**Neutral**	**Slightly agree**	**Agree**	**Strongly Agree**
Performance Expectancy (adapted from (Venkatesh, Thong and Xu, 2012)							
PE1. I find chatbot useful in my daily life.							
PE2. Using chatbot increases my chances of achieving							

things that are important to me.							
PE3. Using chatbot helps me accomplish things more quickly.							
PE4. Using chatbot increases my productivity.							
Effort Expectancy(adapted from (Venkatesh, Thong and Xu, 2012)							
EE1. Learning how to use chatbot is easy for me.							
EE2. My interaction with a chatbot is clear and understandable.							
EE3. I find chatbot easy to use.							
EE4. It is easy for me to become skillful at using a chatbot.							
Social Influence(adapted from (Venkatesh, Thong and Xu, 2012))							
SI1. People who are important to me think that I should use a chatbot.							
SI2. People who influence my behaviour think that I should use a chatbot.							
SI3. People whose opinions that I value prefer that I use a chatbot.							
Facilitating Conditions							

(adapted from (Venkatesh, Thong and Xu, 2012)**)**							
FC1. I have the resources necessary to use a chatbot.							
FC2. I have the knowledge necessary to use a chatbot.							
FC3. A chatbot is compatible with other technologies I use.							
FC4. I can get help from others when I have difficulties using chatbot.							
Hedonic motivation (adapted from (Venkatesh, Thong and Xu, 2012))							
HM1. Using chatbot is fun.							
HM2. Using chatbot is enjoyable.							
HM3. Using chatbot is very entertaining.							
Price Value (adapted from (Venkatesh, Thong and Xu, 2012)**)**							
PV1. A chatbot is reasonably priced.							
PV2. A chatbot is a good value for the money.							
PV3. At the current price, the chatbot provides a good value.							
Habit (adapted from (Venkatesh, Thong and Xu, 2012)**)**							

HT1. The use of chatbot has become a habit for me.							
HT2. I am addicted to using a chatbot.							
HT3. I must use a chatbot.							
Behavioural intention (adapted from (Venkatesh, Thong and Xu, 2012)**)**							
BI1. I intend to continue using a chatbot in the future.							
BI2. I will always try to use a chatbot in my daily life.							
BI3. I plan to continue to use chatbot frequently.							

Use

2. Please choose your usage frequency for each of the following **(adapted from** (Venkatesh, Thong and Xu, 2012))– **Scale adapted from** (Tan *et al.*, 2015)

	never	**Very rarely (Once a month or less)**	**Rarely (2-3 times a month)**	**Once a week**	**Occasionally (2-3 times a week)**	**Frequently (1-2 times a day)**	**Very frequently (Several times a day)**
US1.Browse websites(from (Venkatesh, Thong and Xu, 2012))							
US2.Search engine (from (Özgür, 2016))							

US3. Mobile e-mail (i.e Brunel email) (from (Venkatesh, Thong and Xu, 2012; Özgür, 2016)							
US4. SMS (from (Venkatesh, Thong and Xu, 2012; Özgür, 2016)							
US5. MMS (from (Venkatesh, Thong and Xu, 2012; Özgür, 2016)							
US6. Blackboard access (adapted from (Mayisela, 2013))							
US7. An online check of study timetable							
US8. Events reminders setting on mobile phone							
US9. University event or workshop Check							

Section 2: Persona Moderator (Age, Gender, Educational Level, Experience, Interactions with VLEs, attendance and grade)

1. I am **(adapted from** (Sok Foon and Chan Yin Fah, 2011; Yang, 2013; Ain, Kaur and Waheed, 2016; Tarhini *et al.*, 2016)
   - <18
   - 18-21
   - 22-25
   - 26-29
   - >= 30
1. I am **(from** (Sok Foon and Chan Yin Fah, 2011; Yang, 2013; Tarhini *et al.*, 2016)**)**
   - Male

- Female

1. I am:
   - Full-time
   - Part-time
2. I am
   - Master student
   - Undergraduate student
3. Educational Level (master students only) **adapted from** (Sok Foon and Chan Yin Fah, 2011; Yang, 2013; Ain, Kaur and Waheed, 2016; Tarhini *et al.*, 2016)
   - First year
   - Second year

1. Educational level (Undergraduate Student Only) (Sok Foon and Chan Yin Fah, 2011; Yang, 2013; Ain, Kaur and Waheed, 2016; Tarhini *et al.*, 2016)
   - Level 1
   - Level 2
   - Placement
   - Level 3
4. Do you use a chatbot? **(adapted from** (Sumak and Sorgo, 2016)**)**
   - Yes
   - No

   1.1 How long have you been using a chatbot? **(adapted from** (Sumak and Sorgo, 2016)**)**
   - Less than a year
   - A year or more and less than 3 years
   - Three years or more and less than 5 years
   - 5 years or more

   1.2 How often do you use a chatbot? **(adapted from** (Sumak and Sorgo, 2016)**)**
   - Daily
   - Weekly
   - Once a month
   - Several times a year

5. Experience using Chatbots (**adapted from** (Sumak and Sorgo, 2016; Tarhini *et al.*, 2016)**.**
   - No experience
   - Some experience – I have tested and tried some basic functionality of Chatbots (i.e Siri)
   - Experienced – I have tested and used advanced applications and content on Chatbots.
   - Very experienced – I have developed and tested several chatbots.

2. To what extent do you agree or disagree: On the whole, I actively use the Blackboard.
   - Strongly Disagree
   - Disagree
   - Slightly disagree
   - Neutral
   - Slightly agree
   - Agree
   - Strongly Agree
3. I attend all lectures (**from** (Shannon, Design and Silva, 2006)).
   - Strongly Disagree
   - Disagree
   - Slightly disagree
   - Neutral
   - Slightly agree
   - Agree
   - Strongly Agree
4. I attend all the labs (adapted **from** (Shannon, Design and Silva, 2006)**)**
   - Strongly Disagree
   - Disagree
   - Slightly disagree
   - Neutral
   - Slightly agree
   - Agree
   - Strongly Agree
5. I attend all the tutor meeting (adapted **from** (Shannon, Design and Silva, 2006)**)**
   - Strongly Disagree
   - Disagree
   - Slightly disagree
   - Neutral
   - Slightly agree
   - Agree
   - Strongly Agree

6. I attend all the tutorial (adapted **from** (Shannon, Design and Silva, 2006)**)**
   - Strongly Disagree
   - Disagree
   - Slightly disagree
   - Neutral
   - Slightly agree
   - Agree
   - Strongly Agree
7. What is your grade average (through your last completed academic term)?(**adapted from** (Gramzow and Willard, 2006).

○ 1.A*	○ 6. B	○ 10. C-	○ 14. E+	○ 18. Not applicable
○ 2. A+	○ 7. B-	○ 11. D+	○ 15. E	○
○ 3. A	○ 8. C+	○ 12. D	○ 16. E	○
○ A-	○ 9. C	○ 13. D-	○ 17. F	○
○ B+				

8. I have to retake some module
   - Strongly Disagree
   - Disagree
   - Slightly disagree
   - Neutral
   - Slightly agree
   - Agree
   - Strongly Agree
9. Generally, grades in all my module are typically the same.
   - Strongly Disagree
   - Disagree
   - Slightly disagree
   - Neutral
   - Slightly agree
   - Agree
   - Strongly Agree

10. Are you interested in attending a chatbot workshop ?

If yes, please write your email or email me at cspgfaa1@brunel.ac.uk

Thank you

Your responses to this survey have been submitted.

Appendix C - Pilot Study Feedback

Result of Pilot study- Minor correction
• Add one questions to tick all type of well-known chatbots that the participants are using. • Add "other" option to allow participants to write other chatbots they have been using and that are not included in the list. • Modify the educational level question- students educational levels were first, second, third and fourth, so a suggestion was made to make it as a first level, second level, placement and third level. • Modify the last question, which was compulsory about writing the email address if the student agrees to attend the upcoming chatbot workshop to either write their email or email the researcher at their email address, so participants cannot be identified by their emails. • Correct some spelling mistakes and sentence structure of some questions. • Delete repeated questions from the online survey. • Check the plural and singular word of the chatbots. • Add a brief about chatbots before launching the survey in addition to the existing explanation on the first page of the survey. • Remove unrelated questions to the survey.

Table 0-1: Pilot Study Feedback on Survey Questions

Appendix D - Pilot Study Result

It is essential to check item reliability. Reliability is about the consistency of a measure used within the research (Sekaran and Bougie, 2011). A test is considered reliable when the same result is obtained when repeating the test(Last and Abramson, 2001). A Cronbach alpha is used to check the reliability of the constructs (Croncbach, 1951). It is used to measure how a group of items measure a single latent construct. The literature shows different values for reliability. For example, Cronbach alpha should be at least 0.7 for the item to be reliable (Robinson, Wrightsman and Andrews, 1991; Devellis, 2003). Also, 0.6 is considered as a satisfactory result, and 0.8 or higher is preferable (Nunnally, 1970). The closer the value of Cronbach alpha to 1.0, the higher the reliability. SPSS (v25) was used to test the reliability of the pilot study.

Table 0-2 shows Cronbach alpha, inter-item correlation and item-to-item correlation. The result shows that all constructs have outstanding reliability ranging from 0.842 for HB to 0.956 for SI. Also, it means that all measured variables used with each construct are positively correlated. Also, the table present two internal consistency reliability indicators: inter-item correlation ad inter-to-total correlation. According to Hair *et al.* (2010), the value of inter-item correlation should exceed 0.3, and the item-to-total correlation is 0.5. The result shows that all constructs exceed the cut-off value for inter-item correlation except for USE. Therefore, after examining each item of USE, it is clear that US5 has a lower inter-item correlation (0.197). Therefore, USE5 should be removed from the survey.

Factor	**Items**	**Cronbach Alpha**	**Inter-item correlation**	**Item-to-total correlation**
PE	4	0.930	0.719- 0.821	0.822-0.868
EE	4	0.921	0.630- 0.763	0.749-0.821
SI	3	0.956	0.849-0.934	0.870-.935
FC	4	0.854	0.458 -0.900	0.528 – 0.809
HM	3	0.952	0.863-0.880	0.891-0.903
PV	3	0.920	0.760-0.855	0.790-0.862
HB	3	0.842	0.504- 0.894	0.563- 0.842

BI	3	0.898	0.623-0.827	0.739-0.896
USE	9	0.933	0.197-0.970	0.553-0.948

Table 0-2: Cronbach's Alpha, Inter-item Correlation and Item-to-total Correlation for the Pilot Study

Mann-Whitney-U-test were performed in SPSS (v25) with the first and last construct PE and HT to guarantee that respondents were severe in answering the questions and avoid misleading answers. The test was performed with the Gender category. Table 0-3 and 0-4 show a statistical difference between males and females on Habit and Performance Expectancy. The two tables show that there is a significant difference as p-value<0.05 (Robinson, Shaver and Wrightsman, 2010). Furthermore, comparing the z-sore for the measured variable of performance expectancy and habit shows that none of the two has a higher value than the other (e.g., HT1 > PE1, HT2> PE2, H3<PE3), which means that participants find the survey length is appropriate.

Test Statistics[a]

	PE1	PE2	PE3	PE4
Mann-Whitney U	744.500	785.000	623.000	684.500
Wilcoxon W	954.500	995.000	833.000	894.500
Z	-.412	-.044	-1.488	-.936
Asymp. Sig. (2-tailed)	.680	.965	.137	.349

a. Grouping Variable: GENDER

Table 0-3: Mann-Whitney Test for Performance Expectancy Construct with Gender Grouping Variable- A pilot Study

Test Statistics[a]

	HT1	HT2	HT3
Mann-Whitney U	573.000	784.000	788.000
Wilcoxon W	783.000	3944.000	3948.000
Z	-1.921	-.057	-.019
Asymp. Sig. (2-tailed)	.055	.955	.985

a. Grouping Variable: GENDER

Table 0-4: Mann-Whitney Test for Habit Construct with Gender Grouping Variable -A pilot Study

Appendix E - Descriptive Analysis Result

Gender

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	233	54.1	54.1	54.1
	Female	197	45.7	45.7	99.8
	Prefer not to say	1	.2	.2	100.0
	Total	431	100.0	100.0	

Table 0-5: Descriptive Analysis- Gender

AGE

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	<18	13	3.0	3.0	3.0
	18-21	231	53.6	53.6	56.6
	22-25	123	28.5	28.5	85.2
	26-29	43	10.0	10.0	95.1
	>= 30	21	4.9	4.9	100.0
	Total	431	100.0	100.0	

Table 0-6: Descriptive Analysis- Age

(51%) and (27.4%) were in grade As and Bs respectively, while the minority (21.6%) were in grade Cs, Ds, Fs and not applicable/prefer not to say.

Degree

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	A master student	25	5.8	5.8	5.8
	An undergraduate student	406	94.2	94.2	100.0
	Total	431	100.0	100.0	

Table 0-7: Descriptive Analysis- Degree

Full-Time or Part-Time

		Frequency	Percent	Valid Percent	Cumulative Percent

Valid	Full-Time student	421	97.7	97.7	97.7
	Part-Time student	10	2.3	2.3	100.0
	Total	431	100.0	100.0	

Table 0-8:Descriptive Analysis -Mode of Study (Part or Full-time)

Educational level (Undergraduate students only)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Level 1	113	26.2	28.5	28.5
	Level 2	125	29.0	31.6	60.1
	Placement	64	14.8	16.2	76.3
	Level 3	94	21.8	23.7	100.0
	Total	396	91.9	100.0	
Missing	System	35	8.1		
Total		431	100.0		

Table 0-9: Descriptive Analysis – Educational Level

GA1. What is your Grade Average?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	A*	34	7.9	7.9	7.9
	A+	38	8.8	8.8	16.7
	A-	91	21.1	21.1	37.8
	A	57	13.2	13.2	51.0
	B+	74	17.2	17.2	68.2
	B	24	5.6	5.6	73.8
	B-	20	4.6	4.6	78.4
	C+	12	2.8	2.8	81.2
	C	3	.7	.7	81.9
	C-	2	.5	.5	82.4
	D+	1	.2	.2	82.6
	F	59	13.7	13.7	96.3
	Not applicable/prefer not to say	16	3.7	3.7	100.0
	Total	431	100.0	100.0	

Table 0-10: Descriptive Analysis - Grade

Please selects all the chatbots that you have used so far - Siri by Apple

	Frequency	Percent	Valid Percent	Cumulative Percent
Siri by Apple	297	68.9	100.0	100.0
Alexa by Amazon	205	47.6	100.0	100.0
Cortana by Microsoft	190	44.1	100.0	100.0
Google Assistant by Google	264	61.3	100.0	100.0
None of the above	15	3.5	100.0	100.0
Other, please specify	9	2.1	100.0	100.0

Table 0-11: Descriptive Analysis – Chatbots Types

If you selected Other, please specify:

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid		422	97.9	97.9	97.9
	Bixby by Samsung	6	1.4	1.4	99.3
	S Voice/Bixby	1	.2	.2	99.5
	S Voice/Bixby by Samsung	1	.2	.2	99.8
	Tmall Genie	1	.2	.2	100.0
	Total	431	100.0	100.0	

Table 0-12: Descriptive Analysis – Other Chatbots

Do you use a chatbot?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	333	77.3	77.3	77.3
	No	98	22.7	22.7	100.0
	Total	431	100.0	100.0	

Table 0-13: Descriptive Analysis – Chatbots Usage

If yes, how often do you use a chatbot?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Several times a day	55	12.8	16.5	16.5
	Daily	104	24.1	31.2	47.7
	Weekly	126	29.2	37.8	85.6
	Once a month	48	11.1	14.4	100.0
	Total	333	77.3	100.0	
Missing	System	98	22.7		
Total		431	100.0		

Table 0-14: Descriptive Analysis- Frequency of Chatbots Use

Experience in using Chabots

If yes, how long have you been using a chatbot?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Less than a year	69	16.0	20.7	20.7
	A year or more and less than 3 years	117	27.1	35.1	55.9
	Three years or more and less than 5 years	106	24.6	31.8	87.7
	5 years or more	41	9.5	12.3	100.0
	Total	333	77.3	100.0	
Missing	System	98	22.7		
Total		431	100.0		

Table 0-15: Descriptive Analysis – Experience in Using Chatbots

Experience using chatbots

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No experience	262	60.8	64.9	64.9
	Some experience- I have tested and tried some basic functionality o Chatbots (i.e Siri in iPhone)	118	27.4	29.2	94.1

	Experience - I have tested and used advanced applications and content on chatbots	24	5.6	5.9	100.0
	Total	404	93.7	100.0	
Missing	0	27	6.3		
Total		431	100.0		

Table 0-16: Descriptive Analysis – Levels of Experience in Using Chatbots

Appendix E1- Linking UTAUT2 Constructs to Chatbots Features

UTAUT2 Construct	Chatbots Features
Performance Expectancy	1) Knowledge acquisition (El-Masri and Tarhini, 2017), i.e. Additional sources of chapter
	2) Daily educational and research activities (Ameri *et al.*, 2019)
	3) Interactive quiz session (with peers) (Mehta and Bhandari, 2016)
	4) Suggestion: Presenting success stories as well as problems in the field (Indrawati and Pratomo, 2017)
	5) Getting material using the request form (Wasitarini and Tritawirasta, 2016)
	6) Goal-setting, performance monitoring, real-time feedback and competition (Oinas-Kukkonen and Harjumaa, 2008) in (Mohadis and Ali, 2018)
	7) Provide timely information (see, Yusof and Kianpisheh, 2010), accessing news and information, sharing more data and increasing the chances of communication with another person (Narkwilai, Funilkul and Supasitthimethee, 2015)
	8) Goal-oriented task: PE- beneficial usage of mobile apps because it helps them to achieve their goal-oriented tasks (Venkatesh *et al.*, 2003; Yeap, Yapp and Balakrishna, 2017)
	9) Short learning material: Limited time for knowledge transfer (Kuciapski, 2019)
Effort Expectancy	1) Grade checking (features) (Ain, Kaur and Waheed, 2016)
	2) Downloading and uploading files (Mazman and Usluel, 2010) (features)

	3) Instant messaging (feature) (Bere, 2018)
	4) Easy registration of membership in education; study group or project group(Wasitarini and Tritawirasta, 2016)
	5) Add friends/contacts (QR codes, line id and by shaking phones), free voice calls (Narkwilai, Funilkul and Supasitthimethee, 2015)
Social influence	1)Online discussion forum (Lwoga and Komba, 2015)
	2) joining the Facebook group via friend invitation (Mazman and Usluel (2010)
	3)virtual discussion forum group (Bere, 2018)
	4)posting activities on social media (Facebook, Twitter, Instagram) (Indrawati and Pratomo, 2017)
	5)Posting usage activities in social media (Indrawati and Pratomo, 2017)
	6) Questions for peers (Mehta and Bhandari, 2016) (collaboration with peers)
	7) Examples features: Timeline use to share texts, photos, videos, and stickers to exchange stories with your close friends and join the group (family or friends) (Yeap, Yapp and Balakrishna, 2017)
Facilitating conditions	1.Help (access resources) Or material available (Groves and Zemel, 2000; Teo, 2010) (software download)
	2.Help (to use the system) Mobile banking(Gharaibeh and Mohd Arshad, 2018) Or Skills training (Groves and Zemel, 2000; Teo, 2010)
	3.Technical support (Teo, 2010; Samaila, 2017)
	4. embedding visual user guide into their app(Sia, Iskandar and Yusuf, 2018)
	FAQ, help disk or individual

Hedonic motivation	1)Gamification (El-Masri and Tarhini, 2017) Or Games, stickers into online collaboration application (Indrawati and Pratomo, 2017)
	2)Instant messenger entraining features such as LINE messenger, COCOA talk messenger. Olive (Indrawati and Pratomo, 2017)
	3)Social networking site (Facebook): play games, share funny videos, praise people's achievement (Sharma, Joshi and Sharma, 2016)
	4)Crossword puzzles (Mehta and Bhandari, 2016)
	5)QR code (Indrawati and Amalia, 2019)
	6) fun activities: Hedonic motivation is achieved through activities that are fun, exciting and enjoyable that could satisfy intrinsic needs (Yeap, Yapp and Balakrishna, 2017; Indrawati and Amalia, 2019)
Habit	Habitual behaviour: 1) Meeting or collaborative activities using online collaborative activities (Indrawati and Pratomo, 2017) 2) File downloading before the test (Kiss, 2013) 3)Attending class (Dawood *et al.*, 2017)/ timetabling / Checking timetable (for today, for tomorrow, for a whole week, Exam week). 4)Submit assignment (Dawood *et al.*, 2017) 5) Note Taking (Palmatier, 1974)

Table 0-17: Chatbots Features for each UTAUT2 Construct

Appendix F – Extended Persona3D Template

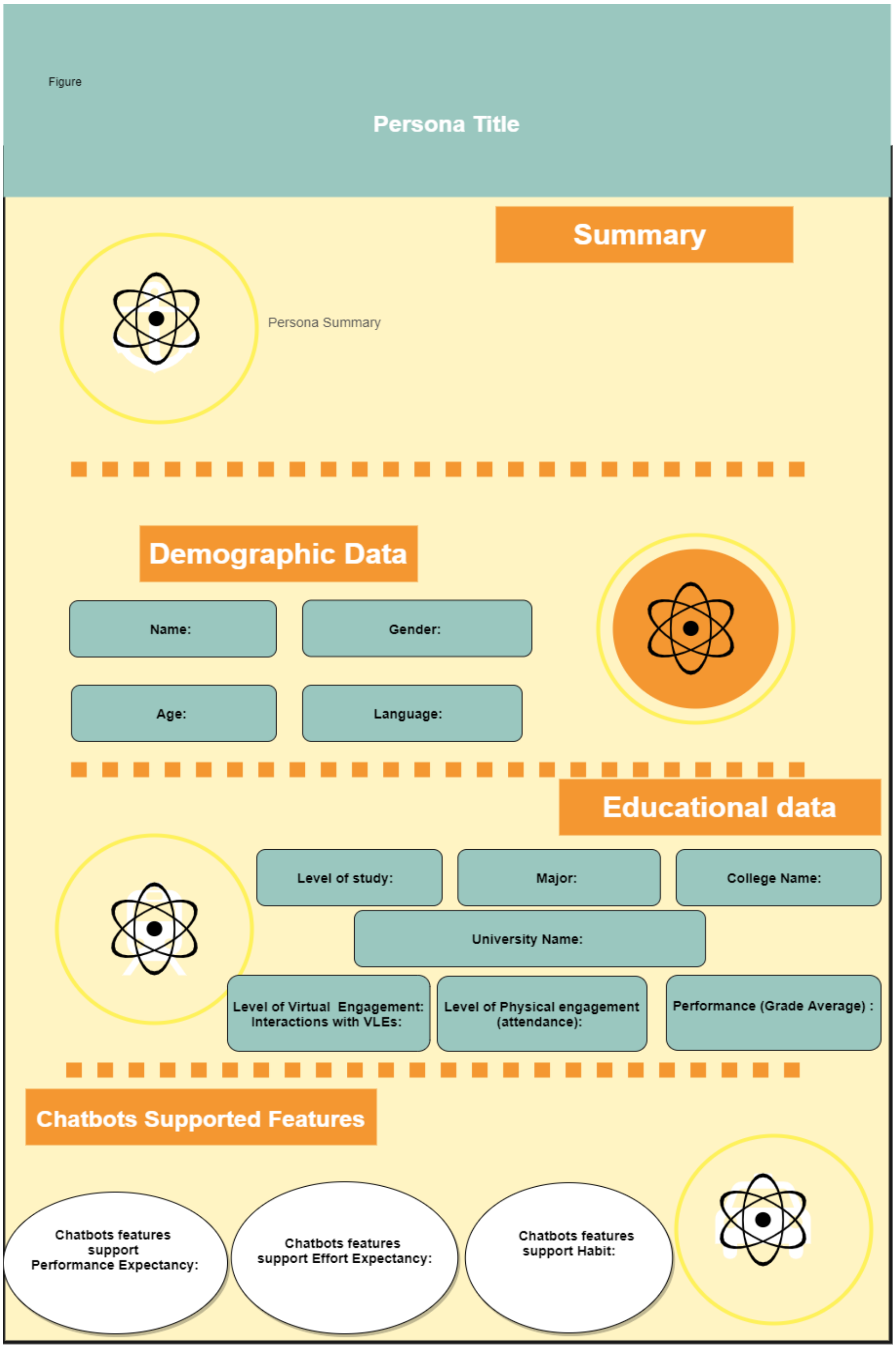


Figure 0-3: Persona3D Template

Appendix G – Initial Journey Mapping Template

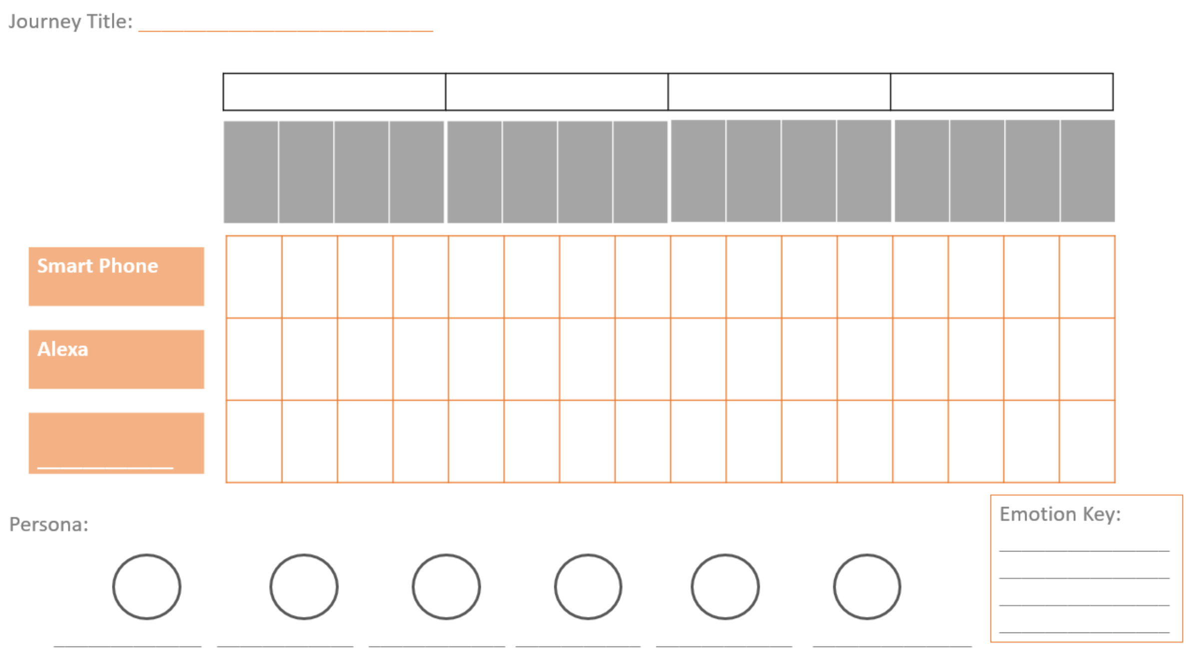


Figure 0-4: Initial Journey Map Template

Appendix H - Persona3D Model for Eight Personas

1) Persona3D for Unsuccessful Self -learner (Persona 1)

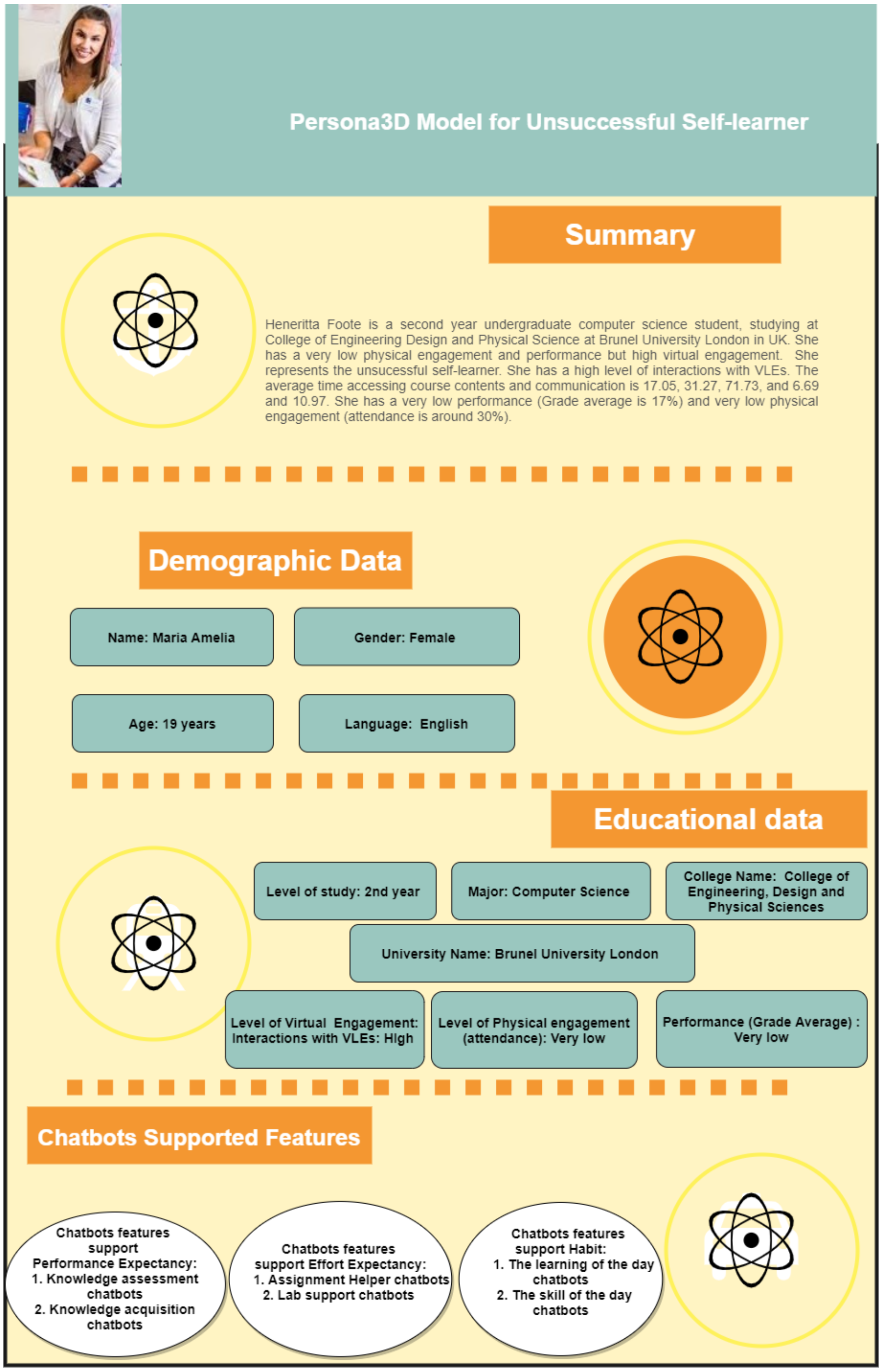


Figure 0-5: Persona3D for Unsuccessful Self-learner (Persona 1)

2) Persona3D Disengaged Student (Persona 2)

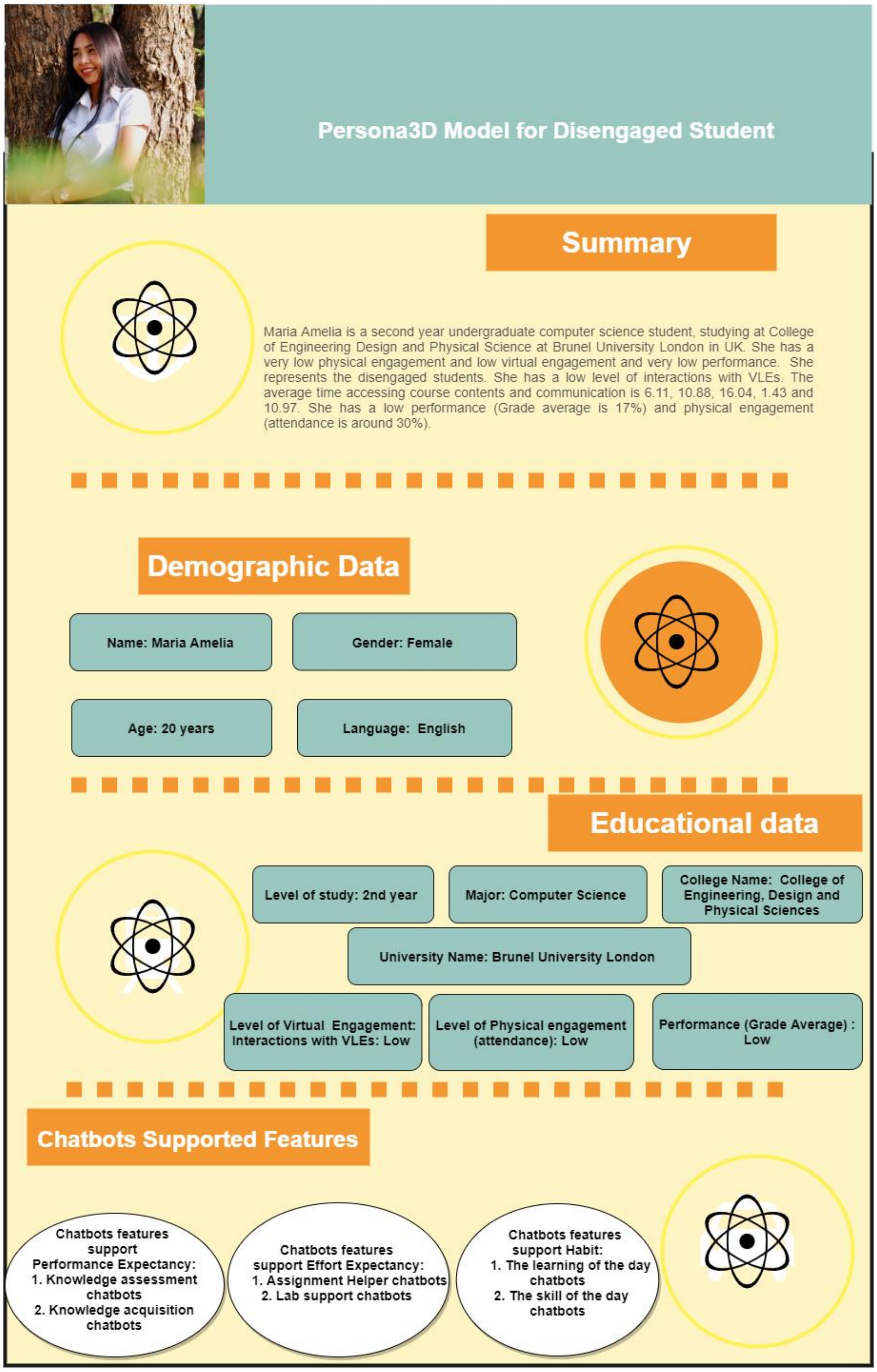


Figure 0-6: Persona3D Disengaged Student (Persona 2)

3) Persona3D for Top Student (Persona 3)

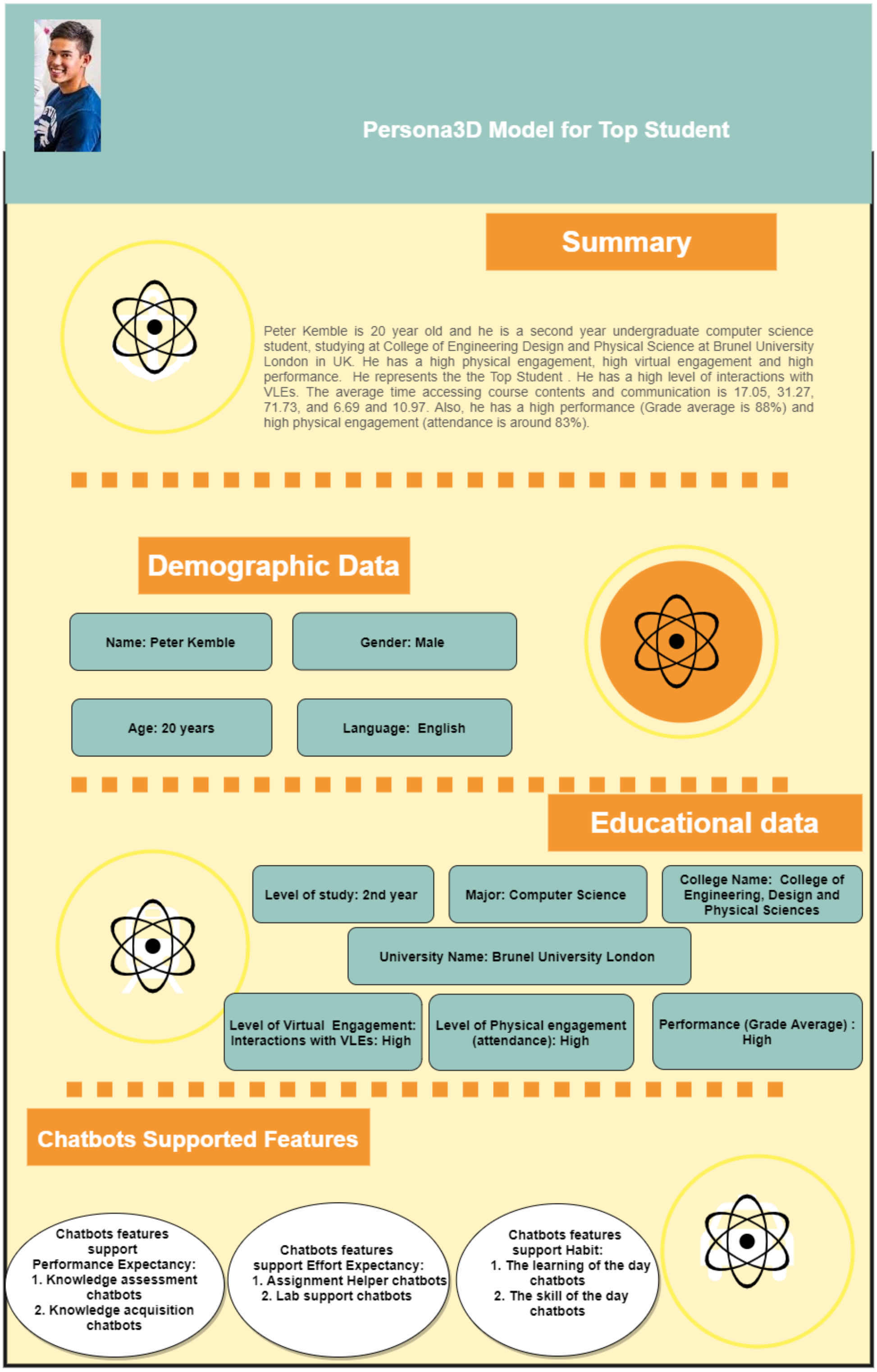


Figure 0-7: Persona3D for Top Student (Persona 3)

4) Persona3D for Successful Student (Persona 4)

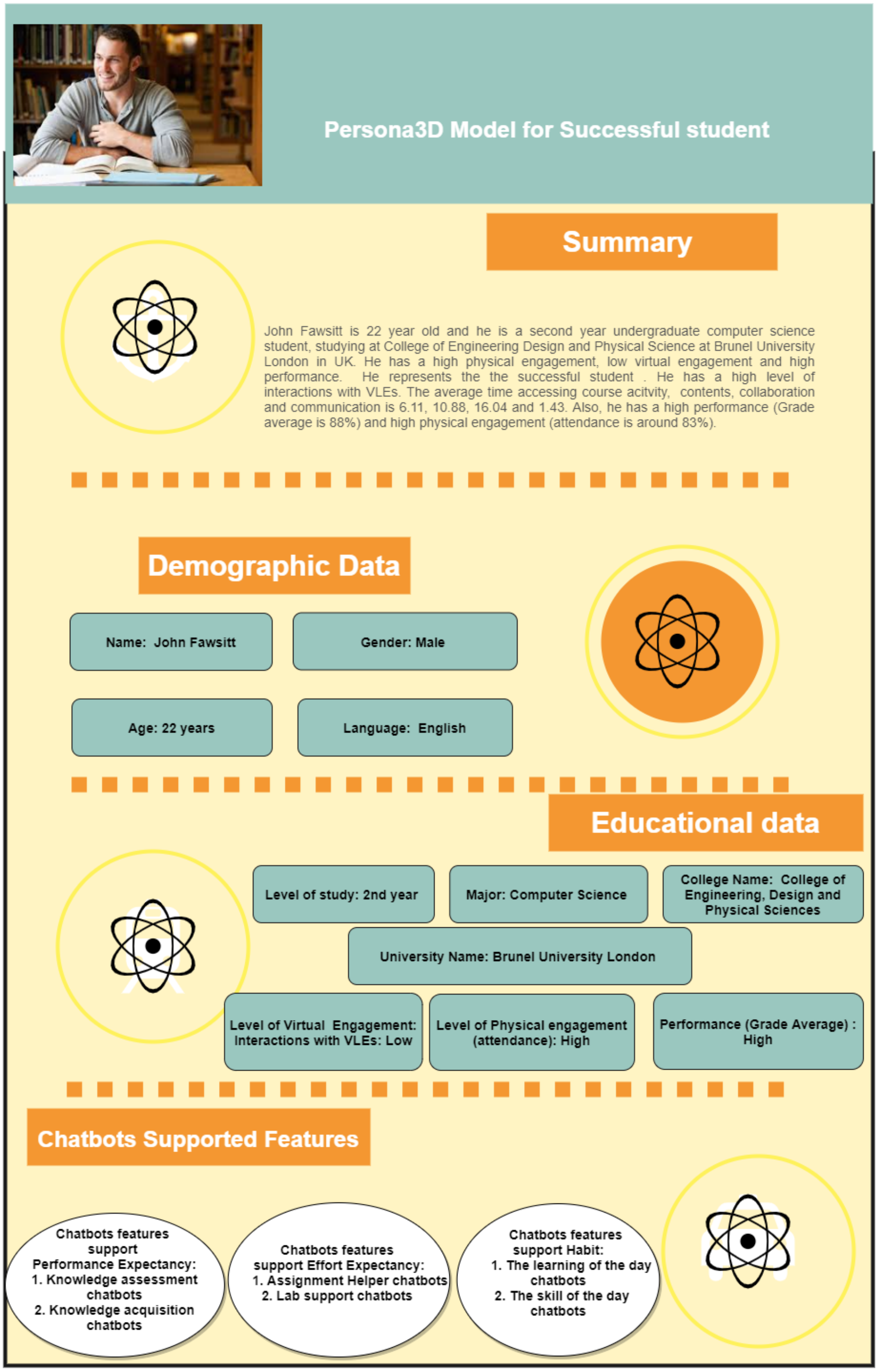


Figure 0-8: Persona3D for Successful Student (Persona 4)

5) Persona3D for Self-learner (Persona 5)

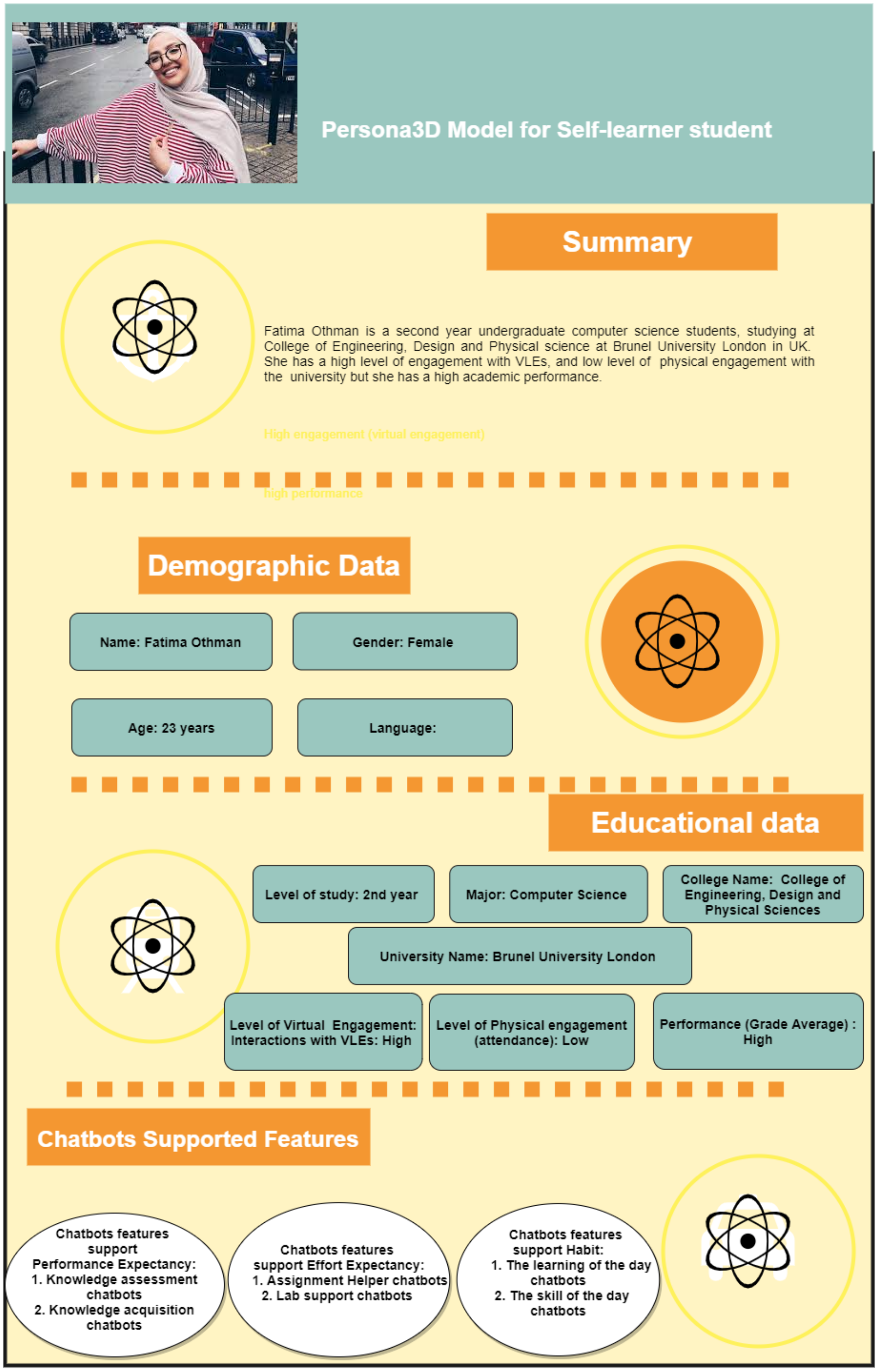


Figure 0-9: Persona3D for Self-learner (Persona 5)

6) Persona3D Model for Experienced Student (Persona 6)

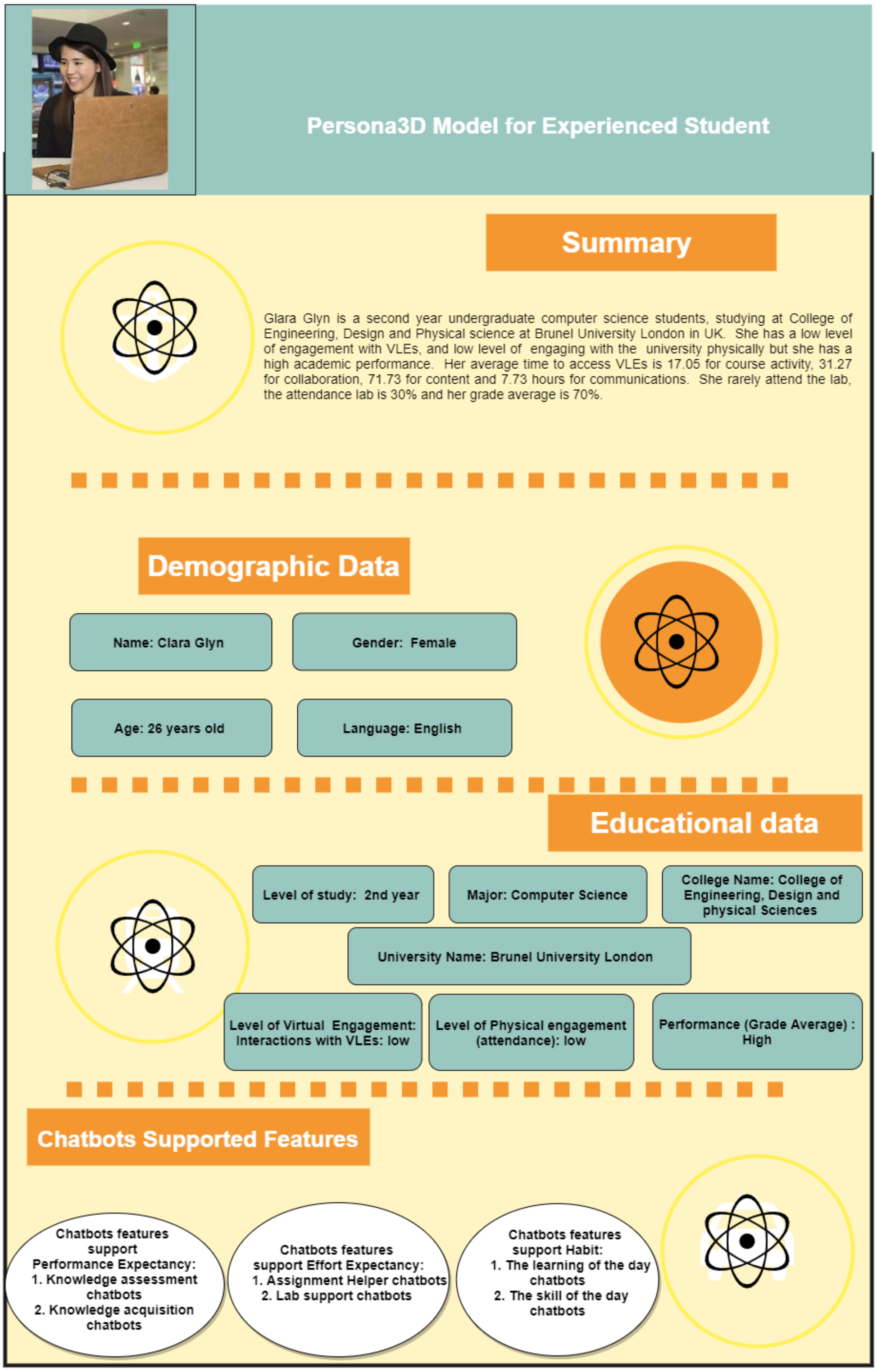


Figure 0-10: Persona3D for Experience Students (Persona 6)

7) Persona3D for Students with a Learning Difficulty (Persona 7)

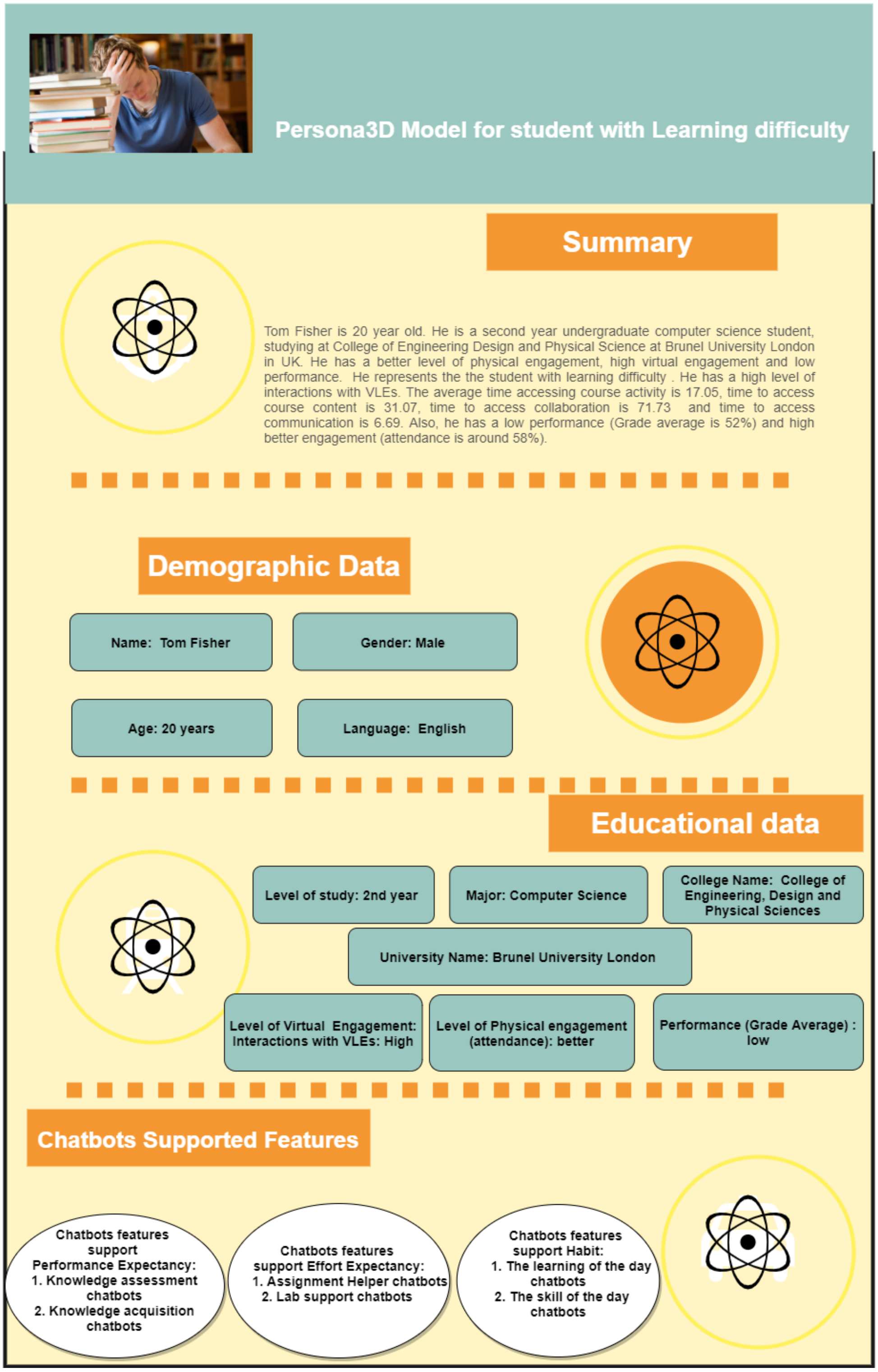


Figure 0-11: Persona3D for Students with a Learning Difficulty (Persona 7)

8) Persona3D for Unsuccessful Student (Persona 8)

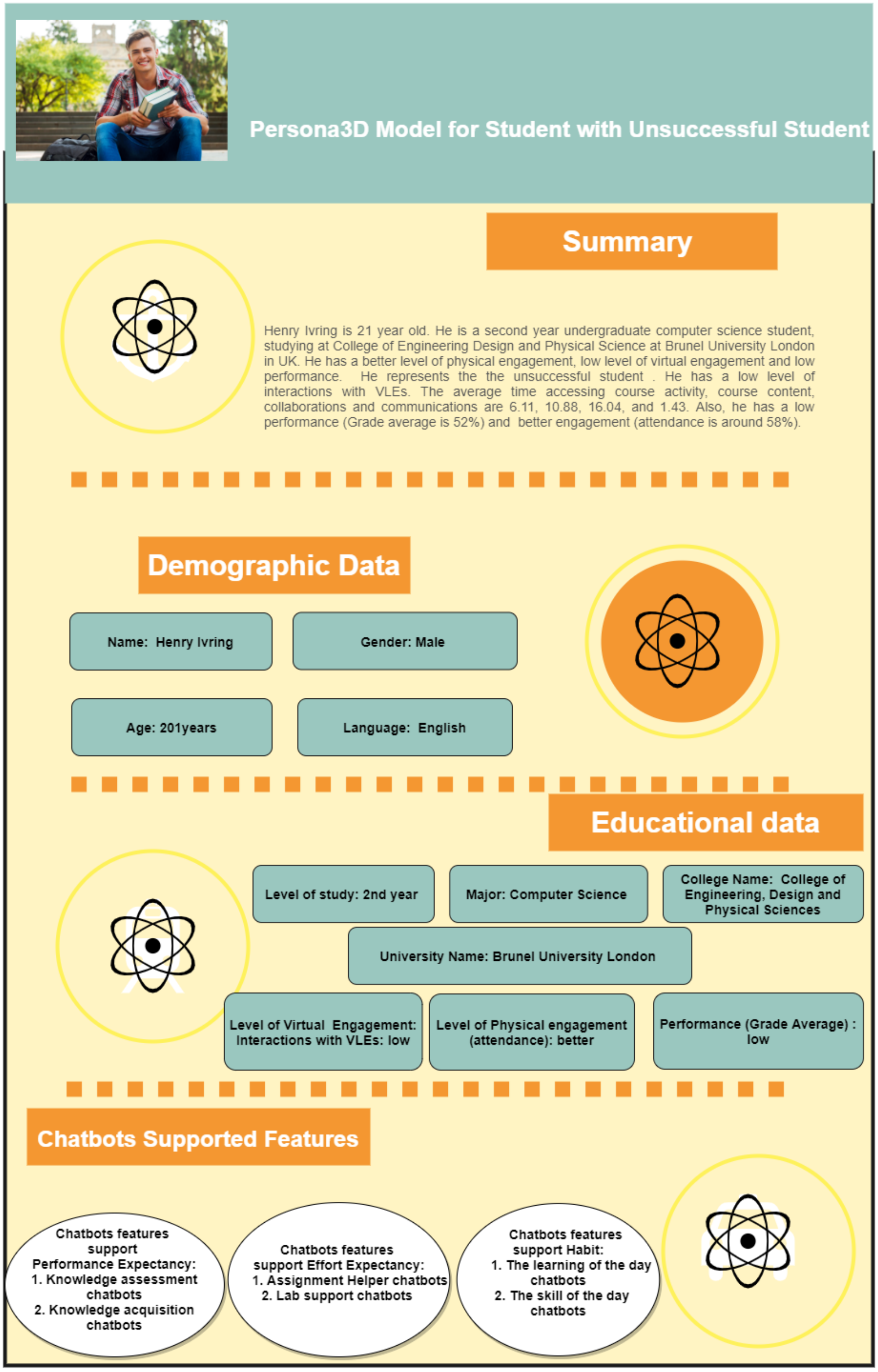


Figure 0-12: Persona3d for Unsuccessful Student (Persona 8)

Appendix I – Journey Mapping for the Eight Personas

As mentioned in Chapter 6, student emotions were extracted using the Geneva Emotion Wheel (GEW). Also, the proposed touchpoints were extracted from the literature, as covered in Section 6.1 (Table 6.1). Six touchpoints were included in each journey map, as supported by the results of the second iteration- The three main factors that affect student acceptance and use of chatbots: performance expectancy, effort expectancy and habit. For 'timetable', which supported habits, the skills were the 'learning of the day' and the 'skill of the day'. Also, 'knowledge assessment' skill supported performance expectancy. The skills 'knowledge acquisition', 'lab support' and 'assignment guider' support effort expectancy. The following sections provide the daily journey map for each persona. As shown in the figure below, the x-axis represents the time of the day, from 8 am to 11 pm, while the y-axis represents the location, including home, class, WLFB corridor, lab and Costa.

1) Journey map for persona 1

This section covers the journey map for persona 1 (Figure 0-13), who has very low physical engagement and performance and high virtual engagement, referred to as 'the unsuccessful self-learner. This persona has very low attendance of the labs and lectures; they also have very low performance (grade). However, they have high engagement with VLEs – they spend a lot of time interacting with VLEs.

At the beginning of the day, the student emotion is neutral. At 8 am, touchpoint A (the learning of the day) interacts with the student to motivate them to attend. The learning of the day skill shows the importance of the day's lecture and lab by presenting in an exciting way what the student will gain by attending, changing them from neutral to interested. The learning of the day skill briefly shows what the student is going to learn in the day. Thus, the student attends the lecture. The lecture takes place between 9 am and 11 am. After the lecture, at 11 am, the low-performance student is disappointed, as the lecture contained a lot of new concepts and terms that were too difficult for them. Touchpoint C (knowledge acquisition) interacts with the student. The skill should answer the student's questions about the lecture by explaining concepts, providing further examples and references, suggesting online courses to study, suggesting e-books, etc., which should change the student from feeling disappointed to feel pleased. At lunchtime in Costa, and before the lab session, the student is thinking that they hate going to the lab, so touchpoint A' (The Skill of the day') interacts with the student. The skill presents the usefulness of attending the lab, particularly the skills they will gain, which changes their emotion from hating to attend the lab to joy.

During the lab session, the student feels disappointed, as the lab is too challenging for them. Touchpoint C' (lab support) interacts with the user. The skill should assist the student in completing the lab successfully, which should change their emotion from disappointment to amusement. When the student gets home at 6 pm, they are afraid to start the quiz. The touchpoint B(knowledge assessment) interacts with the student. The skill assesses the student's knowledge about the day's lecture and provides feedback, which changes the student's emotion from fear to relief. At 7 pm, touchpoint C'' (assignment guider) interacts with the student. This skill provides help to the student so that they can successfully complete the assignment. It does this by breaking the assignment down into sub-tasks and providing hints and guidance in each sub-task, which changes the student's feeling from guilt to relief.

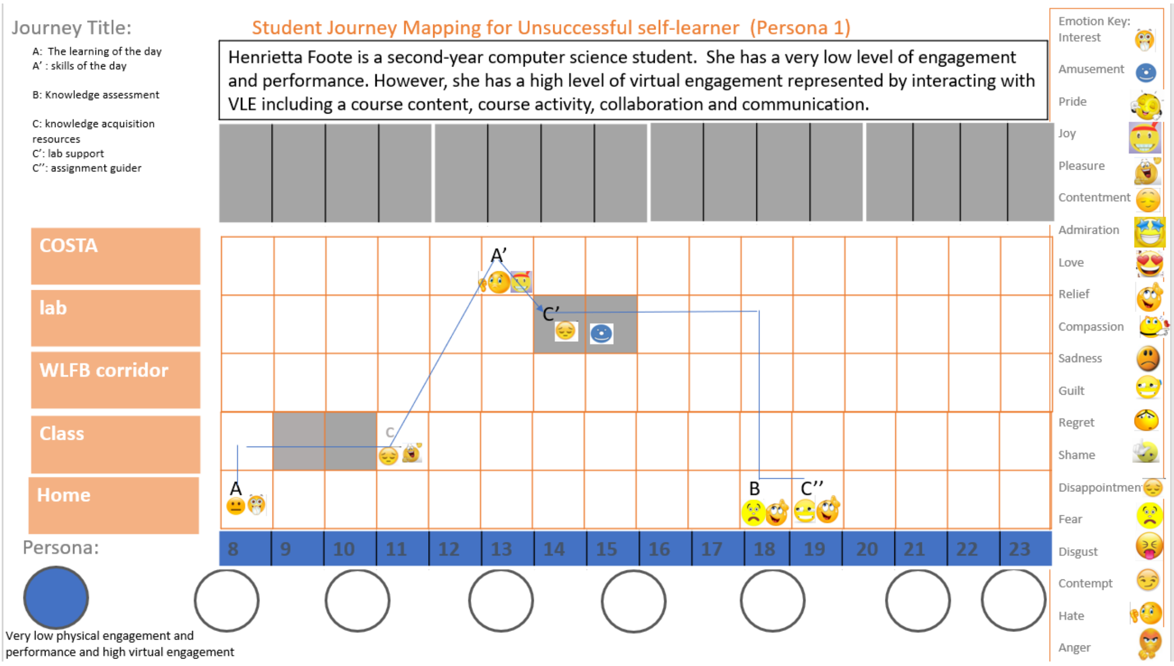


Figure 0-13: Journey Map for Persona 1

2) Journey map for persona 2

This section covers the journey map for persona 2, who has very low physical engagement and performance and low virtual engagement (Figure 0-14), also referred to as 'the disengaged student'. This student persona has very low attendance of the labs and lectures, very low performance (grade) and a low level of interaction with VLEs – they spend little time using VLEs.

At the beginning of the day, the student's emotion is neutral at 8 am. Touchpoint A (the learning of the day) interacts with the student, and the skill shows them the importance of the day's lecture and lab by telling them what they will gain by attending in an interesting way, which changes their emotion from neutral to interested. It briefly states what the student is going to learn, which encourages the student to attend the lecture. After the lecture, at 11 am, the student feels the emotion of hate, and the touchpoint (knowledge acquisition) interacts with them. The skill should answer the student's questions about the lecture by explaining concepts, providing further examples and references, suggesting online courses to study, suggesting e-books, etc., which should change the student's emotion from hate to relief. During lunchtime in Costa, at 1 pm, the student thinks that they hate to attend the upcoming lab, so the touchpoint (skill of the day) interacts with the student. The skill presents the usefulness of attending the lab, particularly the skills they will gain, which changes their emotion from hating to attend the lab to joy.

During the lab, from 2 pm to 4 pm, the student faces the challenge of solving the lab problems, and the touchpoint (lab support) interacts with the student. The skill should assist the student in completing the lab successfully, which should change their emotion from disappointment to amusement. The skill helps the student in dividing the task into sub-tasks and explains the process of solving the lab problems.

At home, at 6 pm, the touchpoint (knowledge assessment) interacts with the student. The skill assesses the student's knowledge about the day's lecture and provides feedback, which changes the student's emotion from fear to relief. At 7 pm, the touchpoint (assignment guider) interacts with the student. This skill provides help to the student so that they can successfully complete the assignment. It does this by breaking it down into sub-tasks and providing hints and guidance in each sub-task, which changes the student's feeling from guilt to relief.

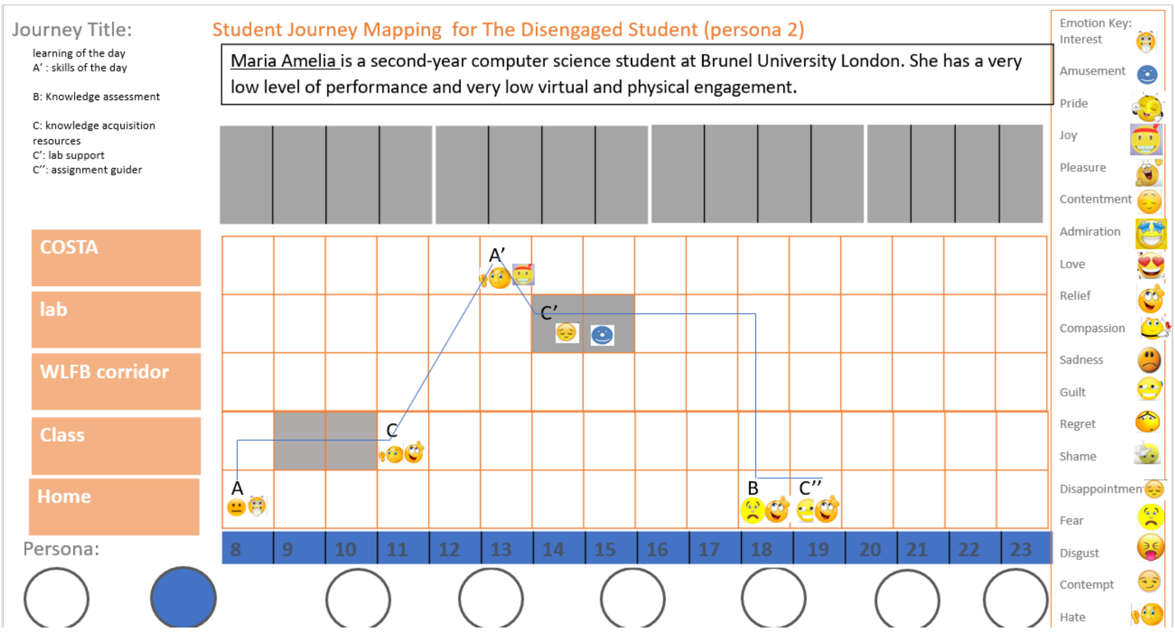


Figure 0-14: Journey Map for Persona 2

3) Journey map for persona 3

This section covers the journey map for persona 3 (Figure 0-15), who has high virtual and physical engagement and performance; it is also called 'the top student'. This student persona has high attendance of the labs and lectures, high performance (grade) and high engagement with VLEs; they spend a lot of time interacting with VLEs.

At the beginning of the day, the student feels a sense of relief at 8 am. Touchpoint A (the learning of the day) interacts with the student. The skill shows the importance of the day's lecture and lab by telling them what they will gain by attending in an interesting way, which changes their emotion from neutral to interested. In brief, it states what the student is going to learn. Thus, the student attends the lecture. After the lecture, which was from 9–11 am, the skill (get learning resources) will interact with the student. The skill should answers the student's questions about the lecture by explaining concepts, providing further examples and references, suggesting online courses to study, suggesting e-books, etc., which should change the student's feeling from contentment to amusement.

After that, at 11 am in the WLFB corridor, the student feels a sense of relief. The touchpoint (knowledge assessment) interacts with the student. The skill assesses the student's knowledge about the day's lecture and provides feedback, which changes the student's emotion from relief to pleasure. Knowledge assessment skill is a challenging quiz for the 'Top Student'. The student attends the lab and solves the lab problem without any difficulty. At home, at 7 pm, the touchpoint C''(assignment guider) interacts with the student. This skill provides help to the student so that they can successfully complete the assignment. It does this by breaking the assignment down into sub-tasks and providing hints and guidance in each sub-task, which changes their feeling from contentment to amusement.

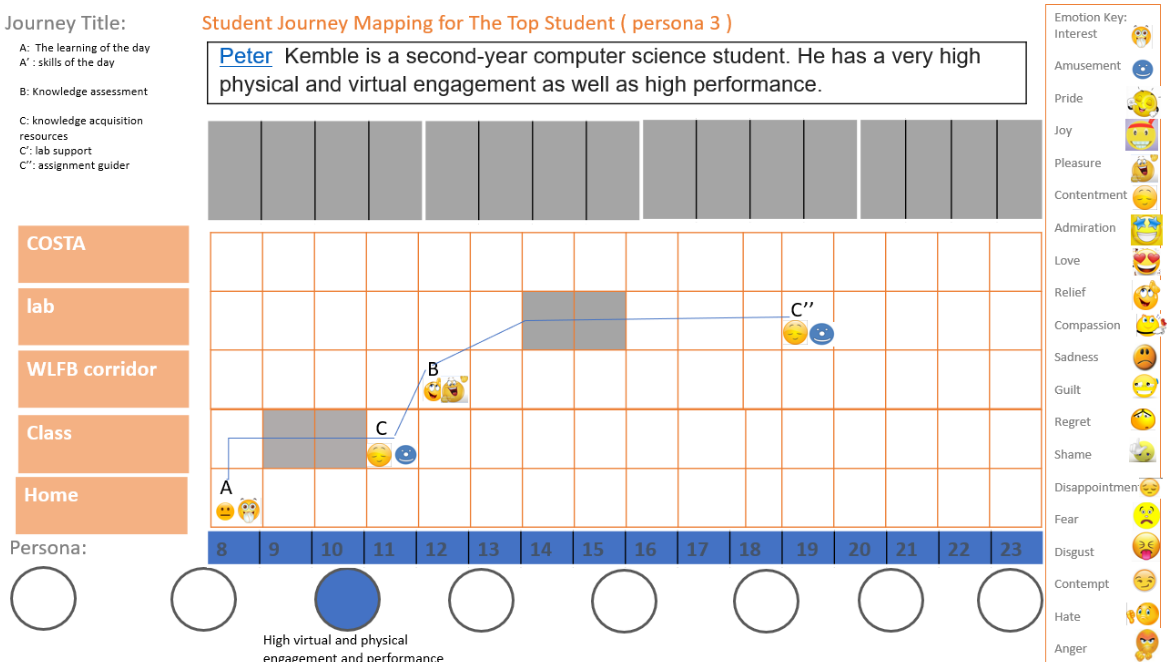


Figure 0-15: Journey Map for Persona 3

4) Journey map for persona 4

This section covers the journey map for persona 4 (Figure 0-16), who has low virtual engagement and high physical engagement and performance, also referred to as 'the successful student'. This student persona has high physical engagement, as they attend almost all of the lectures and labs and high performance (grade).

However, they have low interaction with VLEs, in terms of the number of hours they spend interacting with VLEs.

At the beginning of the day, the student is neutral at 8 am. Touchpoint A (the learning of the day) interacts with the student and motivates them to attend the day's lecture and lab by telling them what they will gain by attending in an interesting way, which changes their emotion from neutral to interested. In brief, it states what the student is going to learn. Thus, the student attends the lecture from 9 am to 11 am. After the lecture, the student is in admiration mode, and touchpoint C (knowledge acquisition) interacts with the student. The skill should answer the student's questions about the lecture by explaining concepts, providing further examples and references, suggesting online courses to study, suggesting e-books, etc., which should change the student's feeling from admiration to joy.

After that, in the WLFB corridor at 12 pm, the touchpoint B (knowledge assessment) interacts with the student. The skill assesses the student's knowledge about the day's lecture and provides feedback, which changes the student's emotion from relief to pride. The student attends the lab; after the lab, the touchpoint C''(assignment guider) interacts with the student. This skill provides help to the student so that they can successfully complete the assignment. It does this by breaking the assignment down into sub-tasks and providing hints and guidance in each sub-task, which changes their feeling from admiration to amusement.

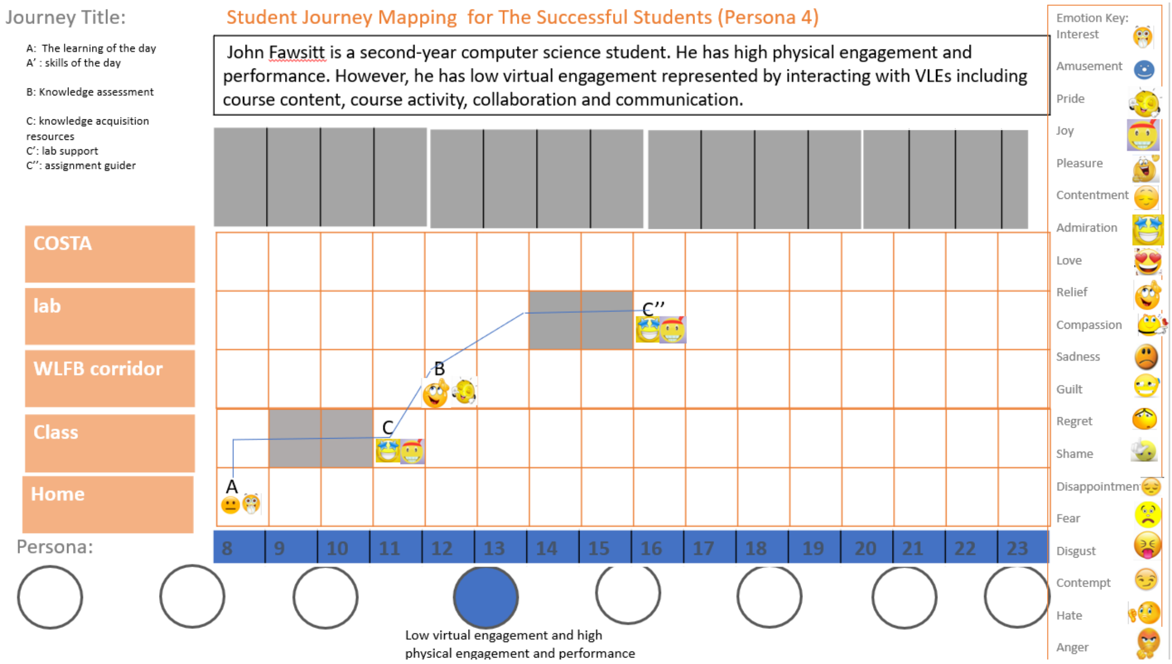


Figure 0-16: Journey Map for Persona 4

5) Journey map for persona 5

This section covers the journey map for persona 5 (Figure 0-17), who has high virtual engagement and performance and low physical engagement, also referred to as ‘the self-learner. This student persona has high virtual engagement with VLEs and high performance – they spend a lot of time interacting with VLEs and have high grades. However, they have very low attendance at the labs and lectures.

At the beginning of the day, the student’s emotion is neutral at 8 am. Touchpoint A (the learning of the day) interacts with the student. The skill shows the importance of the day’s lecture and lab by telling them what they will gain by attending in an interesting way, which changes their emotion from neutral to interested. In brief, it states what the student is going to learn; thus, the student attends the lecture from 9 am to 11 am. After the lecture, in Costa at 11 am, the touchpoint C (knowledge acquisition) interacts with the user. The skill should answer the student’s questions about the lecture by explaining concepts, providing further examples and references, suggesting online courses to study, suggesting e-books, etc., which should change the student’s feeling from compassion to amusement.

In the WLFB corridor at 12 pm, the touchpoint B (knowledge assessment) interacts with the user. The skill assesses the student’s knowledge about the day’s lecture and provides feedback, which changes the student's emotion from pleasure to pride. After that, at lunchtime, touchpoint A' (skill of the day) interacts with the student. The skill presents the usefulness of attending the lab, particularly the skills they will gain, which changes their emotion from anger to interest. Thus, the student attends the lab. After that, at 5 pm, touchpoint C''(assignment guider) interacts with the student. This skill provides help to the student so that they can successfully complete the assignment. It does this by breaking the assignment down into sub-tasks and providing hints and guidance in each sub-task, which changes their feeling from compassion to amusement.

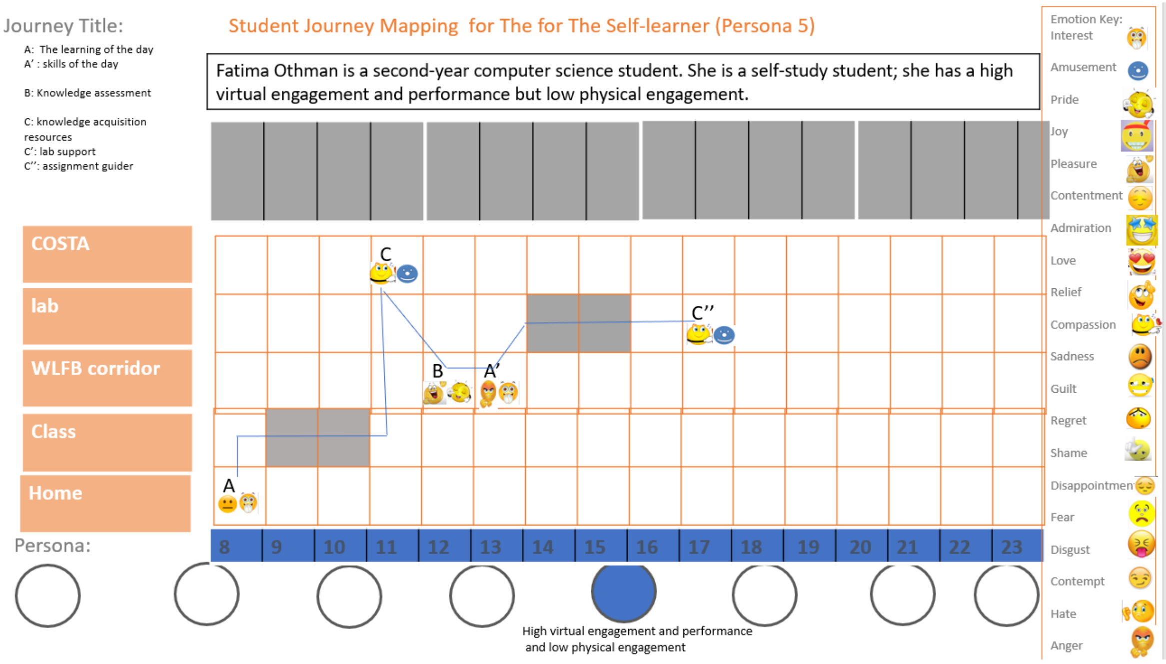


Figure 0-17: Journey Map for Persona 5

6) Journey Map for Persona 6

This section covers the journey map for persona 6 (Figure 0-18), who has low physical and virtual engagement and high performance, also referred to as 'the experienced/smart student'. This student persona has low attendance of the labs and lectures and low interaction with VLEs. However, they have high performance (grade).

At the beginning of the day, the student's emotion is neutral at 8 am. Touchpoint A (the learning of the day) interacts with the student. The skill shows the importance of the day's lecture and lab by telling them what they will gain by attending in an interesting way, which changes their emotion from neutral to interested. In brief, it states what the student is going to learn; thus, the student attends the lecture from 9 am to 11 am. After the lecture, touchpoint C (knowledge acquisition) interacts with the user. The skill should answer the student's questions about the lecture by explaining concepts, providing further examples and references, suggesting online courses to study, suggesting e-books, etc., which should change the student's feeling from relief to joy.

At 12 pm, the student is in the WLFB corridor, and touchpoint B (knowledge assessment) interacts with the user. The skill assesses the student's knowledge about the day's lecture and provides feedback, which changes the student's emotion from pleasure to pride. During lunchtime, the student stays in Costa, and the touchpoint A'(the skill of the day) interacts with the user. The skill presents the usefulness of attending the lab, particularly the skills they will gain, which changes their emotion from anger at participating in the lab to interest. Thus, the student attends the lab. At home, at around 7 pm, the touchpoint C''(assignment guider) interacts with the user. This skill provides help to the student so that they can successfully complete the assignment. It does this by breaking the assignment down into sub-tasks and providing hints and guidance in each sub-task, which changes their feeling from contentment to joy.

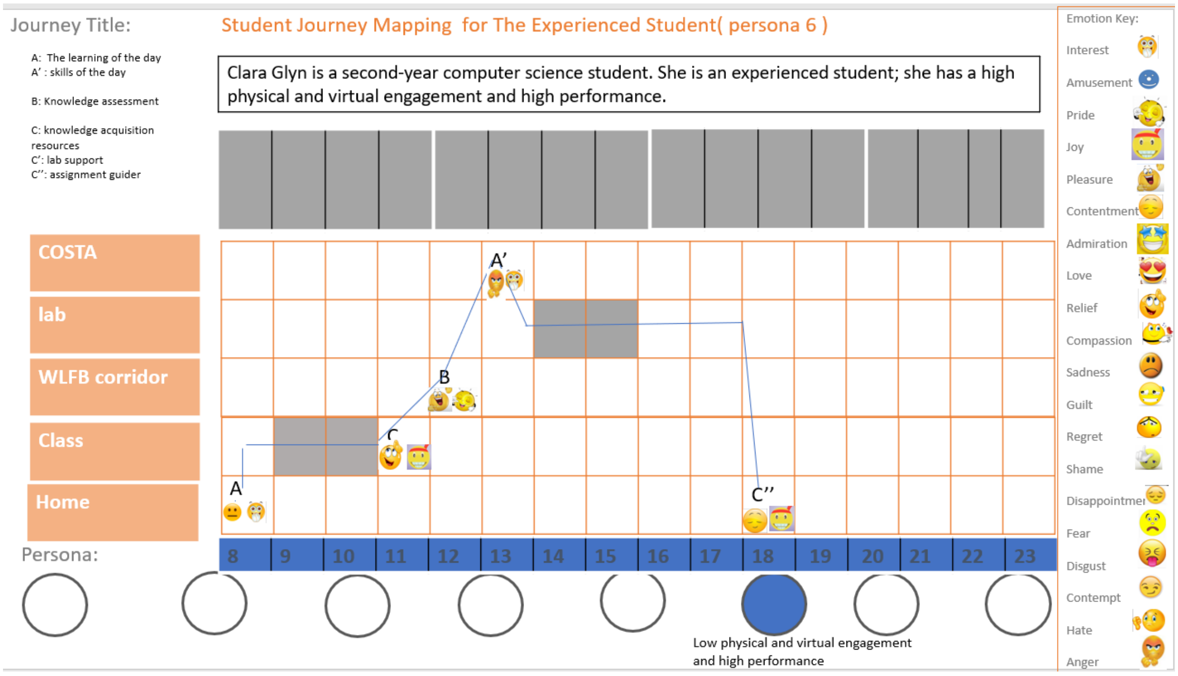


Figure 0-18: Journey Map for Persona 6

7) Journey map for persona 7

This section covers the journey map for persona 7 (Figure 0-19), who has high virtual engagement, better physical engagement and low performance, also referred to as 'the learning difficulty student'. This student persona spends a lot of time interacting with VLEs, and their attendance of the labs and lectures is quite good. However, they have low performance (grade).

At the beginning of the day, the student emotion's is neutral at 8 am. Touchpoint A (the learning of the day) interacts with the student. The skill shows the importance of the day's lecture and lab by telling them what they will gain by attending in an interesting way, which changes their emotion from neutral to interested. In brief, it states what the student is going to learn; thus, the student attends the lecture from 9 am to 11 am.

After the lecture, the student feels disgusted by the lecture, so touchpoint C (knowledge acquisition) interacts with the student. The skill should answer the student's questions about the lecture by explaining concepts, providing further examples and references, suggesting online courses to study, suggesting e-books, etc., which should change the student's feeling from disgust to joy. During lunchtime, the student stays in Costa, and the touchpoint A' (the skill of the day) interacts with the student. The skill presents the usefulness of attending the lab, particularly the skills they will gain, which changes their emotion from relief to interest in attending the lab and encourages the student to attend. In the lab, from 2 pm to 4 pm, the student finds the lab too challenging, so touchpoint C' (lab support) interacts with the student. The skill should assist the student in completing the lab successfully, which should change their emotion from fear to relief. After the lab, in the WLFB corridor, touchpoint B (knowledge assessment) interacts with the student. The skill assesses the student's knowledge about the day's lecture and provides feedback, which changes the student's emotion from sadness to admiration. At home, at around 7pm, the touchpoint C'' (assignment guider) interacts with the student. This skill provides help to the student so that they can successfully complete the assignment. It does this by breaking the assignment down into sub-tasks and providing hints and guidance in each sub-task, which changes their feeling from guilt to relief.

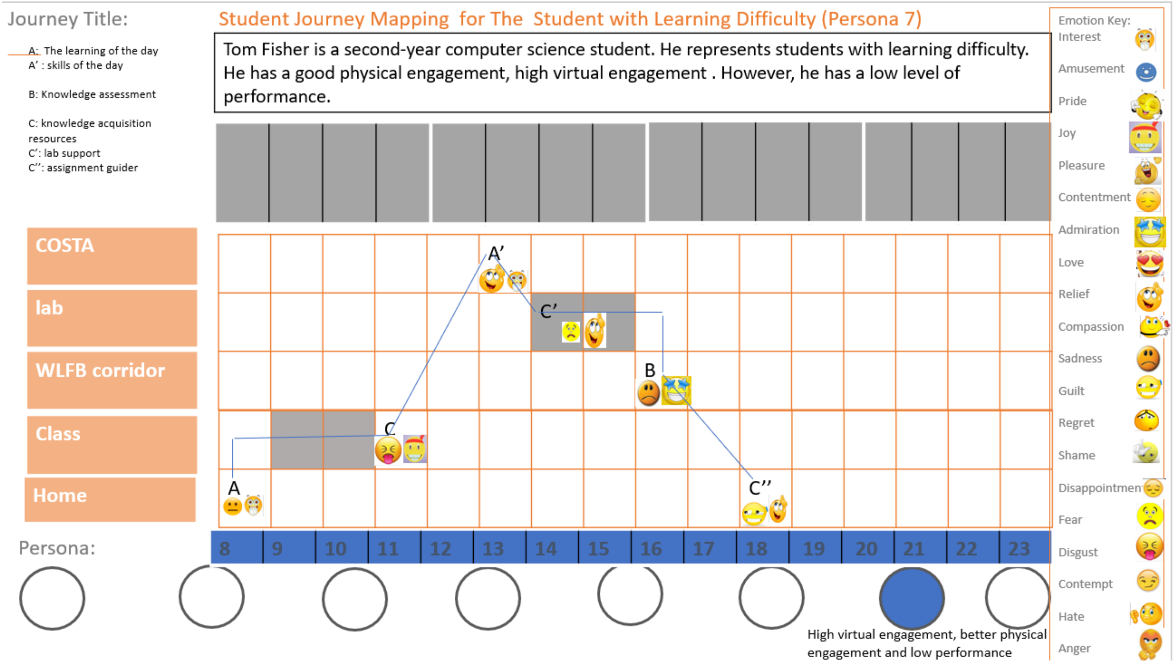


Figure 0-19: Journey Map for Persona 7

8) Journey map for persona 8

This section covers the journey map for persona 8 (Figure 0-20), who has low virtual engagement and performance and better physical engagement also referred to as ‘the unsuccessful physically engaged student’. This student persona spends a little time interacting with VLEs, and they have a low level of performance. However, their attendance is quite good in the labs and lectures.

At the beginning of the day, the student’s emotion is neutral at 8 am. Touchpoint A (the learning of the day) interacts with the student to encourage them to attend the lecture. The skill shows the importance of the day’s lecture and lab by telling them what they will gain by attending in an interesting way, which changes their emotion from neutral to interested. In brief, it states what the student is going to learn; thus, the student attends the lecture from 9 am to 11 am. After that, touchpoint C (knowledge acquisition) interacts with the user. The skill should answer the student’s questions about the lecture by explaining concepts, providing further examples and references, suggesting online courses to study, suggesting e-books, etc., which should change the student's feeling from disgust to relief.

In the WLFB corridor at 12 pm, touchpoint B (knowledge assessment) interacts with the student. The skill assesses the student's knowledge about the day's lecture and provides feedback, which changes the student's emotion from shame to pride. During lunchtime, at 1 pm in Costa, the touchpoint A' (the skill of the day) interacts with the user. The skill presents the usefulness of attending the lab, particularly the skills they will gain, which changes their emotion from anger at participating in the lab to relief. During the lab, from 2 pm to 4 pm, touchpoint C'(lab support) interacts with the student, who is finding the lab too challenging. The skill should assist the student with their learning so that they can complete the lab successfully. This should change their emotion from fear to pleasure. At home, at 6 pm, the touchpoint C''(assignment guider) interacts with the student. This skill provides help to the student so that they can successfully complete the assignment. It does this by breaking the assignment down into sub-tasks and providing hints and guidance in each sub-task, which changes their feeling from guilt to pleasure.

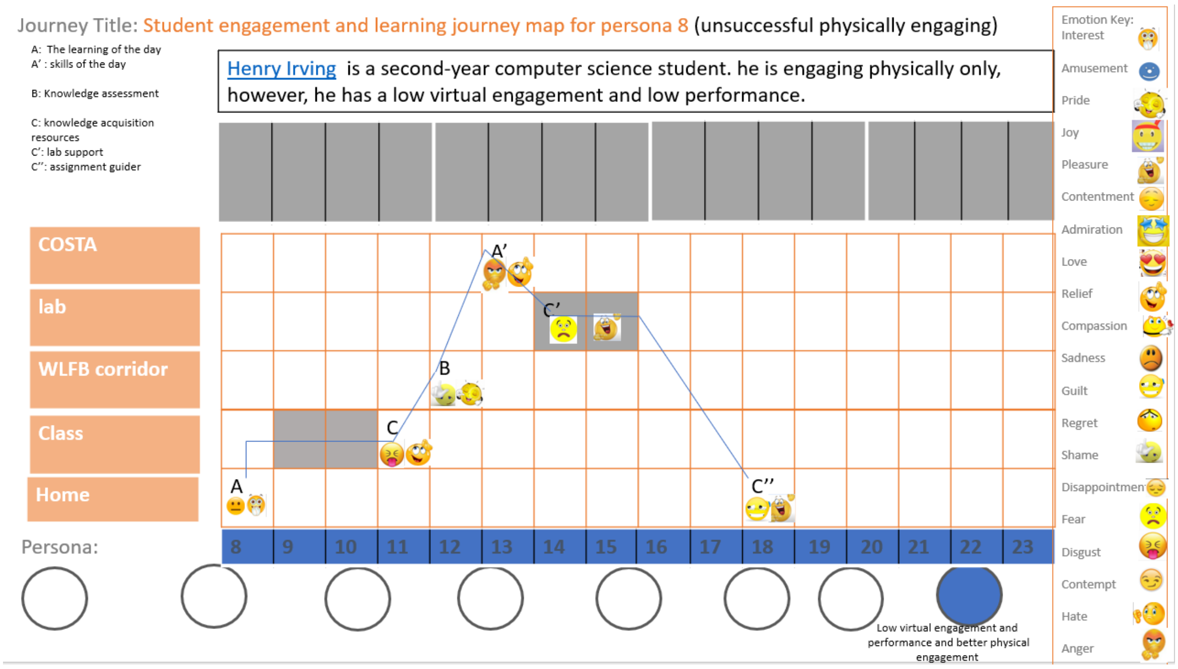


Figure 0-20: Journey Map for Persona 8

Appendix J- Implementations and Execution of Six Chatbots

1)Lab helper /Lab Support Chatbot Code

```
'use strict';

// ------------------------------------------------------------------
// APP INITIALIZATION
// ------------------------------------------------------------------

const { App } = require('jovo-framework');
const { Alexa } = require('jovo-platform-alexa');
const { GoogleAssistant } = require('jovo-platform-googleassistant');
const { JovoDebugger } = require('jovo-plugin-debugger');
const { FileDb } = require('jovo-db-filedb');

const app = new App();

const dDB = require('./dynamoDB');
const dynamoDB = new dDB()
const ses = require('./ses');
const Ses = new ses();

app.use(
    new Alexa(),
    new GoogleAssistant(),
    new JovoDebugger(),
    new FileDb()
);

// ------------------------------------------------------------------
// APP LOGIC
// ------------------------------------------------------------------
```

```
app.setHandler({
    LAUNCH() {
        return this.toIntent('SelectNumber');
    },

    SelectNumber() {
        this.setState('SelectNumberState')
        this.ask('Welcome to the lab helper! Which question number you need help with, please type the number in letters?');
    },

    SelectNumberState: {

        async whichQuestion() {
            console.log(this.$inputs.question.value)
            const number = parseInt(this.$inputs.question.value)
            const item = await dynamoDB.get(number)
            this.setSessionAttribute('item', item)
            this.setState('MoreInformation')
            this.ask(`You selected question ${item.question} ${item.answer}. Do you want more information? Yes or No?`)
        }
    },

    MoreInformation: {
        YesIntent() {
            const item = this.getSessionAttribute('item')
            Ses.email(item)
            this.setState('SelectNumberState')
            this.ask('I have sent more information to your email. What question number do you need help with?')
        },
        NoIntent() {
            this.tell('Goodbye'

module.exports.app = app;
```

Figure 0-21: Lab helper/Lab Support Chatbot Code (app.js)

```
const AWS = require('aws-sdk')

AWS.config.update({
    accessKeyId: "AKIA2NATPJN4BOYH67L6",
    secretAccessKey: "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",
    region: "us-east-1"
});

class dDB {
    constructor() {
        this.client = new AWS.DynamoDB.DocumentClient();
    }

    get(number) {
        return this.client.get({
            TableName: "LabSupport",
            Key: { number }
        }).promise().then(item => item.Item)

module.exports = dDB;
```

Figure 0-22: Lab Helper /Lab Support Chatbot Code (db.js)

```
'use strict';

var aws = require('aws-sdk');

// Provide the full path to your config.json file.
aws.config.update({
    accessKeyId: "AKIA2NATPJN4BOYH67L6",
    secretAccessKey: "xBGD4OGUva832CI4vb7l3GIgLccYpUGXfL2Fv5Mr",
    region: "us-east-1"
});

class ses {
    constructor() {
        this.client = new aws.SES();
    }
```

```
email(item) {

    var params = {
        Source: "Lab Helper <fatima.amerjidalmahri@brunel.ac.uk>",
        Destination: {
            ToAddresses: [
                "fatima.amerjidalmahri@brunel.ac.uk",
                "fatima.amerjidalmahri@outlook.com",
                "fatmam.sal@cas.edu.om",
],
        },
        Message: {
            Subject: {
                Data: "Amazon SES Test (AWS SDK for JavaScript in Node.js)",
                Charset: "UTF-8"
            },
            Body: {
                Text: {
                    Data: "Amazon SES Test (SDK for JavaScript in Node.js)\r\n"
                        + "This email was sent with Amazon SES using the "
                        + "AWS SDK for JavaScript in Node.js.",
                    Charset: "UTF-8"
                },
                Html: {
                    Data: `<html>
                    <head></head>
                    <body>
                      <h1>Question: ${item.question}</h1>
                      <h2>Answer ${item.answer} More information in this link.<a href='${item.link}'>${item.link}</a>
</h2>
                    </body>
                    </html>`,
                    Charset: "UTF-8"
    this.client.sendEmail(params, function (err, data) {
        // If something goes wrong, print an error message.
        if (err) {
            console.log(err.message);
```

```
} else {
console.log("Email sent! Message ID: ", data.MessageId);
}
module.exports = ses;
```

Figure 0-23: Lab Support Chatbot Code (ses.js)

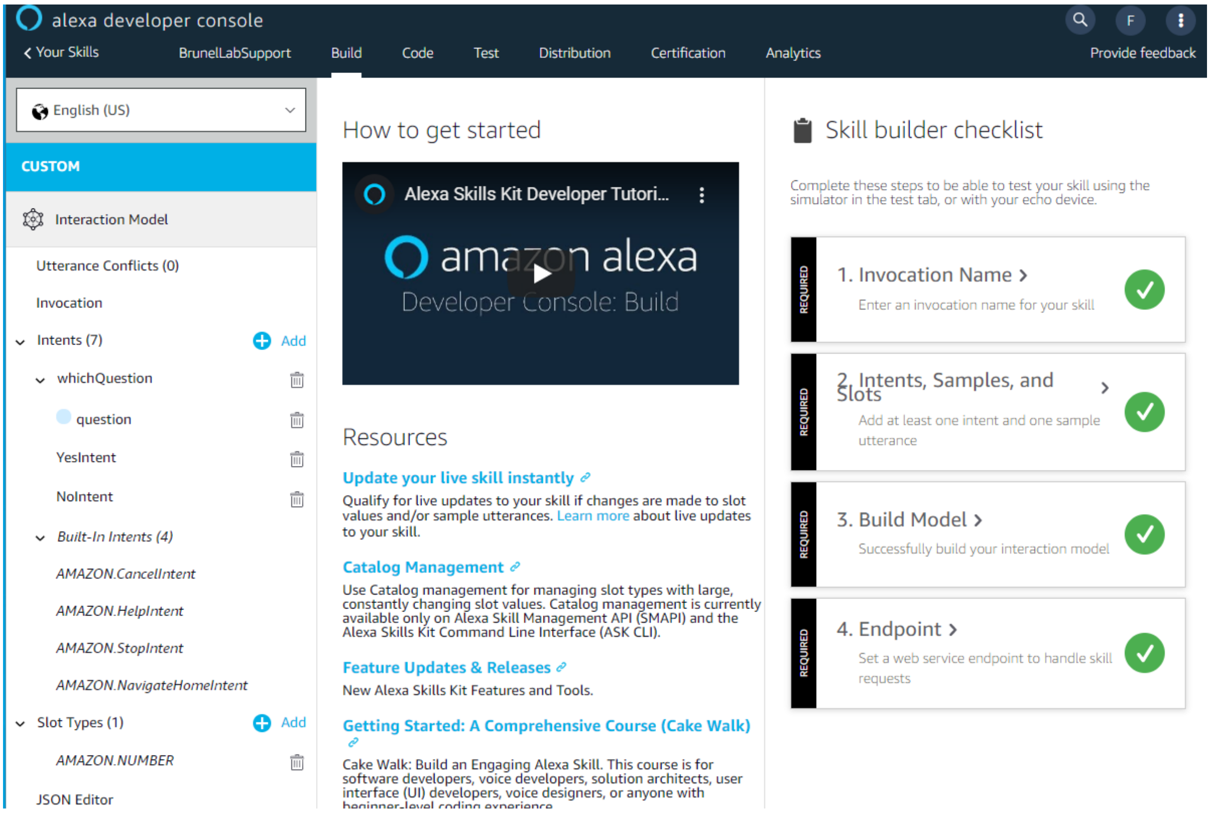


Figure 0-24: Lab Support Chatbot – Interaction Model

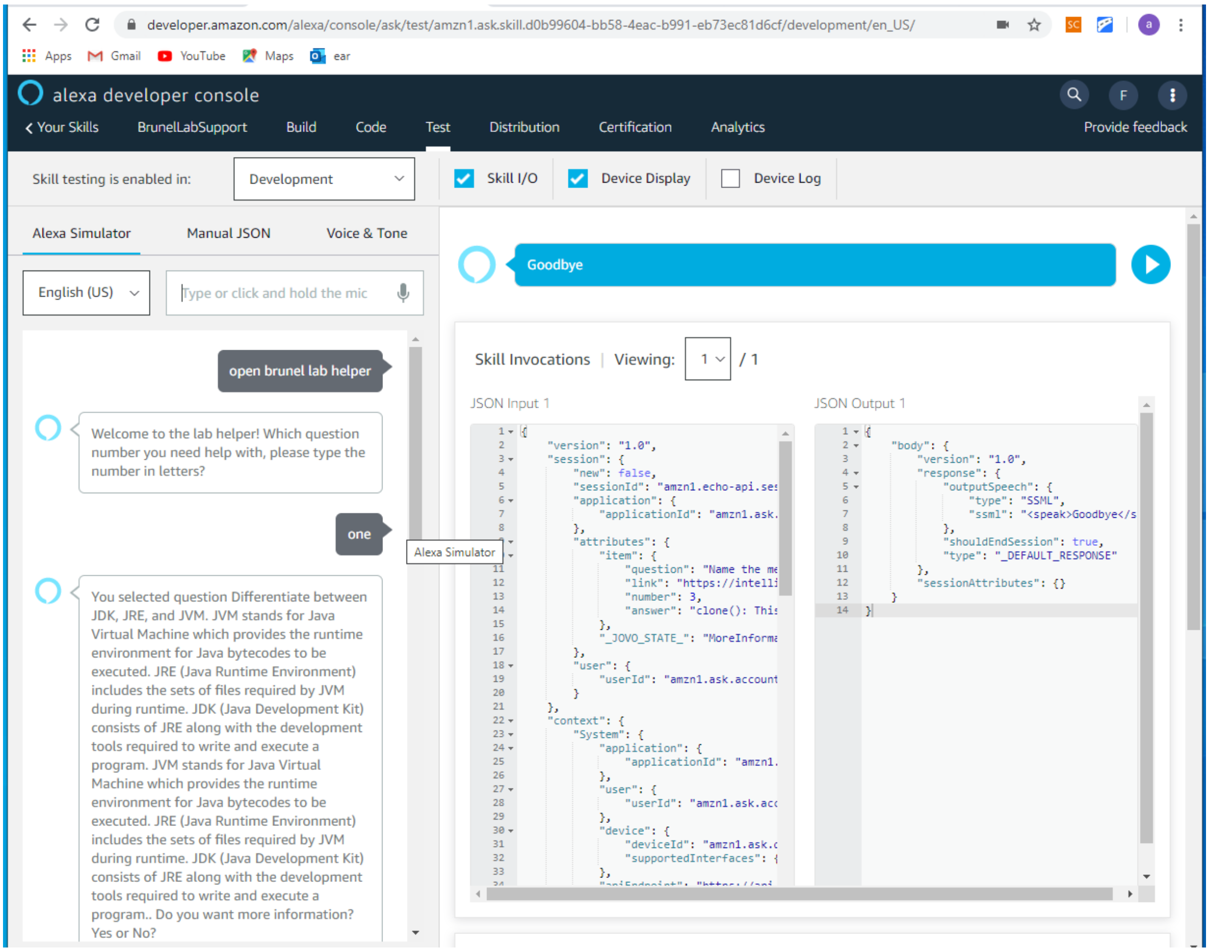


Figure 0-25: Lab Support Chatbot - Execution

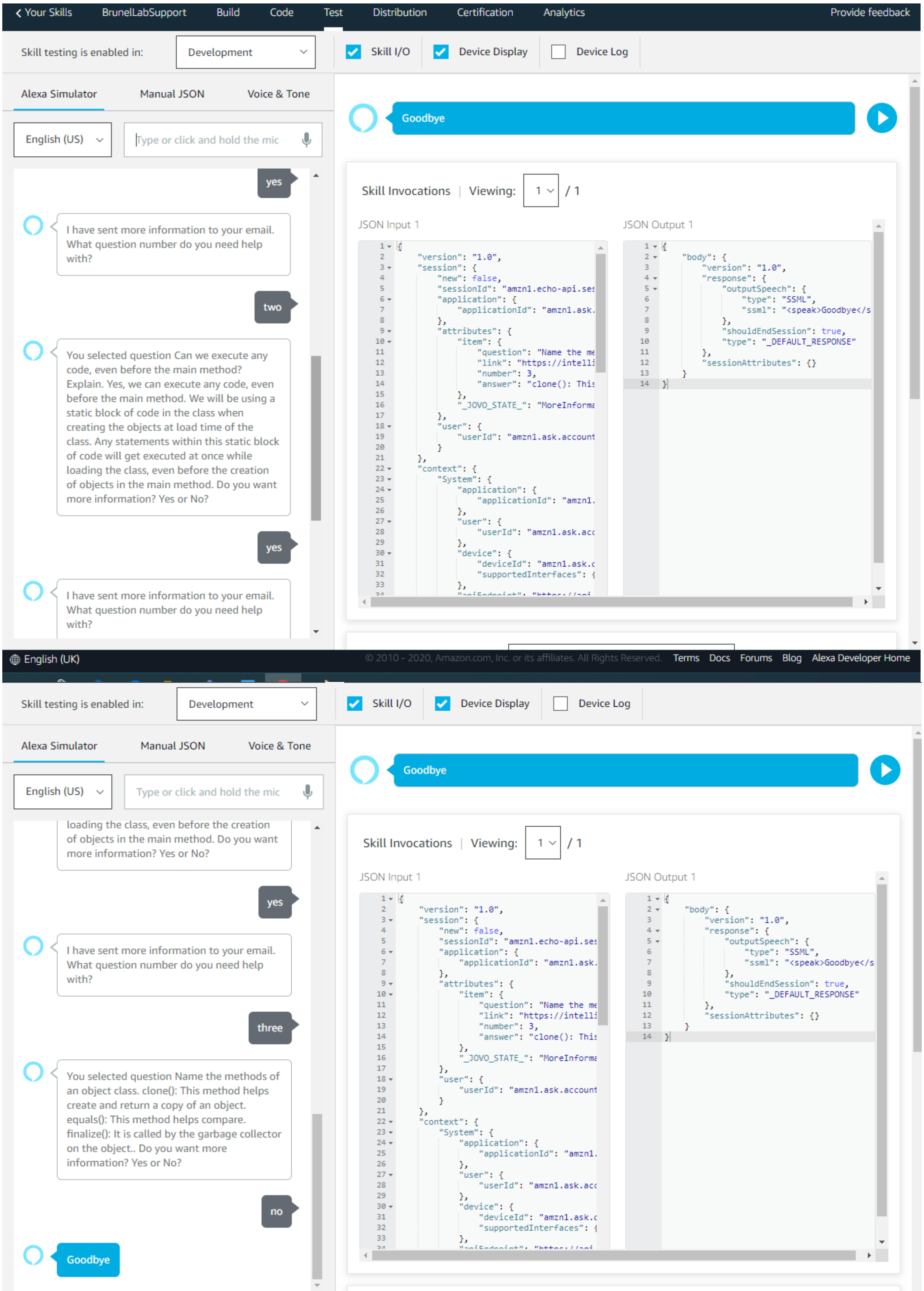


Figure 0-26: Lab Support Chatbot– Execution

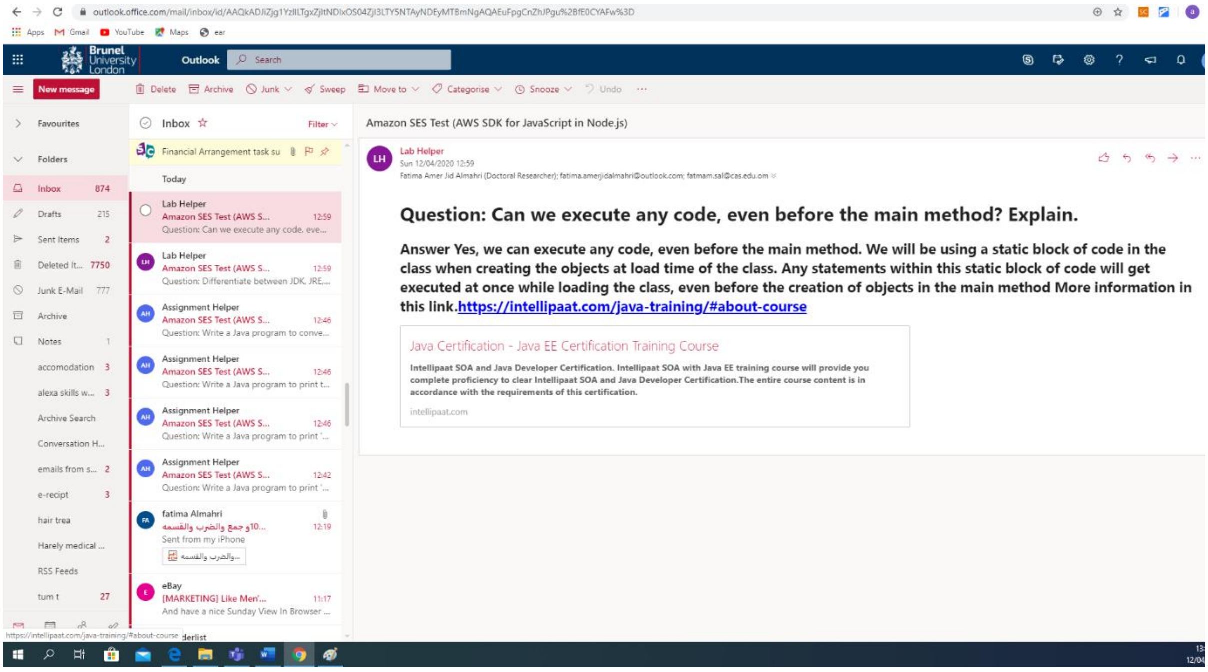


Figure 0-27: Lab Support Chatbot – Execution- Receiving Email.

2)The Learning of the Day chatbot

```
const alexaSDK = require('alexa-sdk');
const awsSDK = require('aws-sdk');
//const promisify = require('es6-promisify');
const appId = 'amzn1.ask.skill.e9cec746-442f-4c60-a723-ac27b9f028fe'; //done
//const LabTable = 'Lab';
//const docClient = new awsSDK.DynamoDB.DocumentClient();

const instructions = `Welcome to The learning of the day skill<break strength="medium" />
            Today is special you will learn something important, if you want to know say:
            <break strength="medium" /> get learning .`;

const lecture_aim = 'today you will gain a new knowledge about the importance of developing function in  java application, to  know the time and location of the lecture say: get lecture information ';

const lectureInfo =' the lecture is today from 9 to 11 am at LECT 004, now please say: get feeling';
const studentFeeling = 'are you excited to go to the lecture?, please say: add feeling' ;

const greeting = 'Thanks for letting me know your feeling, take care';
const handlers = {
```

```
/**
 * Triggered when the user says "Alexa, open today's learning.
 */
'LaunchRequest'() {
  this.emit(':ask', instructions);
},

/**
 *
 */

'getLearningOfTheDay'()
{
  this.emit(':ask', lecture_aim);

 'GetLecInfotIntent'(){
  this.emit(':ask', lectureInfo );
 },
'getFeelingIntnet'(){
  this.emit(':ask', studentFeeling);
},

'addfeelingIntent'(){

  this.emit(':tell', greeting);

},
'AMAZON.HelpIntent'() {
  const speechOutput = instructions;
  const reprompt = instructions;
  this.emit(':ask', speechOutput, reprompt);
},
'AMAZON.CancelIntent'() {
  this.emit(':tell', 'Goodbye!');
},
```

```
 'AMAZON.StopIntent'() {
   this.emit(':tell', 'Goodbye!');
 }
};

 exports.handler = function handler(event, context) {
 const alexa = alexaSDK.handler(event, context);
 alexa.APP_ID = appId;
alexa.registerHandlers(handlers);
alexa.execute();
};
```

Figure 0-28: The Learning of the Day Chatbot Code

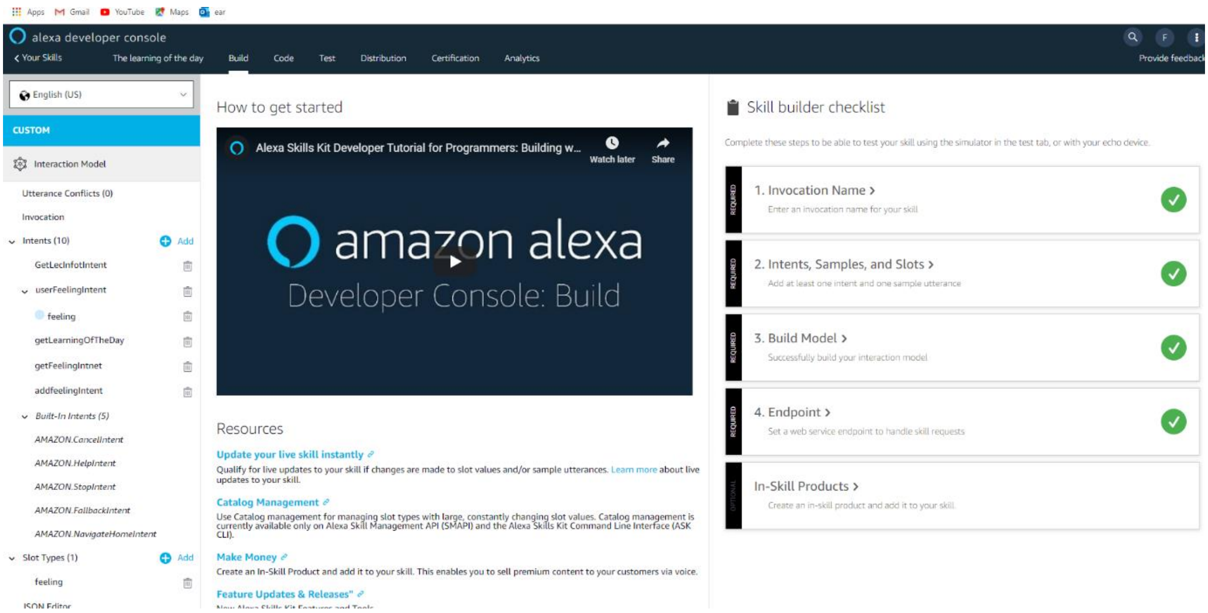


Figure 0-29: The Learning of the Day Chatbot – Execution

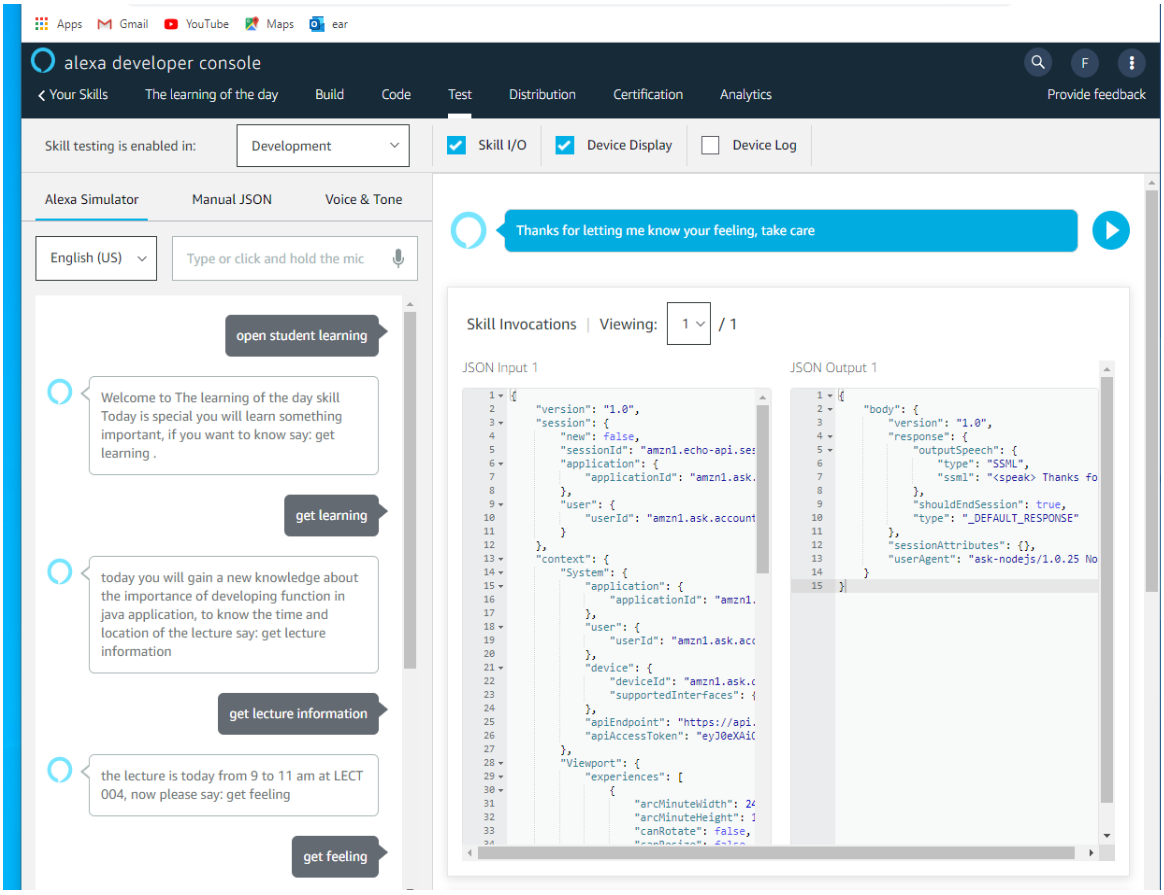


Figure 0-30: The Learning of the Day Chatbot - Execution

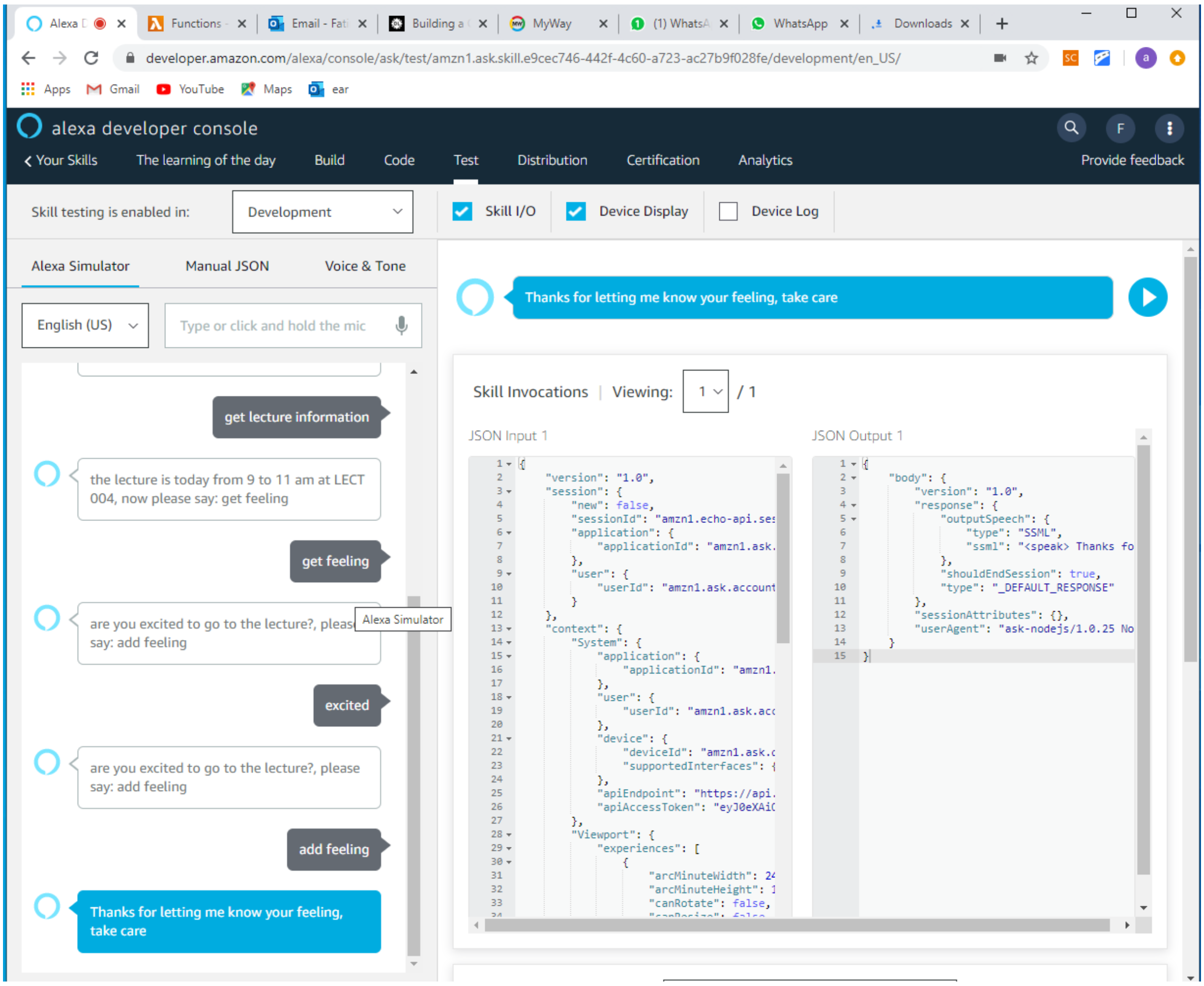


Figure 0-31: The Learning of the Day Chatbot - Execution

3) The Skill of the Day chatbot

```
const alexaSDK = require('alexa-sdk');
const awsSDK = require('aws-sdk');
//const promisify = require('es6-promisify');
const appId = 'amzn1.ask.skill.f1e89e22-8967-4199-a543-c62d263b0ffb'; //done
//const LabTable = 'Lab';
//const docClient = new awsSDK.DynamoDB.DocumentClient();

const instructions = `Welcome to The Skill of the day skill<break strength="medium" />
        Today is special you will learn something important, if you want to know say:
        <break strength="medium" /> get skill .`;
```

```
const skill_aim = 'today you will gain a new skill to create how to develop a method for any java application, to know the time and location of the lab say: get lab information ';


const labInfo =' the lab is today from 2 to 4 at lab 207, now please say :getfeeling';

const studentFeeling = 'are you excited to go to the lab?, please say: addfeeling' ;


const greeting = 'Thanks for letting me know your feeling, take care';

const handlers = {


 /**

  * Triggered when the user says "Alexa, open Brunel showcase.

  */

 'LaunchRequest'() {

   this.emit(':ask', instructions);

 },


 /**

  * Adds a opinion to the current user's saved opinions.

  * Slots: ProjectName, ProjectOpinion.

  */


 'getSkillOfTheDay'()

 {

   this.emit(':ask', skill_aim);


 },


  'getLabInfoIntent'(){

   this.emit(':ask', labInfo);

  },

 'getfeelingIntent'(){

   this.emit(':ask', studentFeeling);

 },


 'addfeelingIntent'(){


   this.emit(':tell', greeting );
```

```
  'AMAZON.HelpIntent'() {
    const speechOutput = instructions;
    const reprompt = instructions;
    this.emit(':ask', speechOutput, reprompt);
  },

  'AMAZON.CancelIntent'() {
    this.emit(':tell', 'Goodbye!');
  },

  'AMAZON.StopIntent'() {
    this.emit(':tell', 'Goodbye!');
  }
};

  exports.handler = function handler(event, context) {
  const alexa = alexaSDK.handler(event, context);
  alexa.APP_ID = appId;
  alexa.registerHandlers(handlers);
  alexa.execute();
};
```

Figure 0-32: The Skill of the Day Chatbot - Code

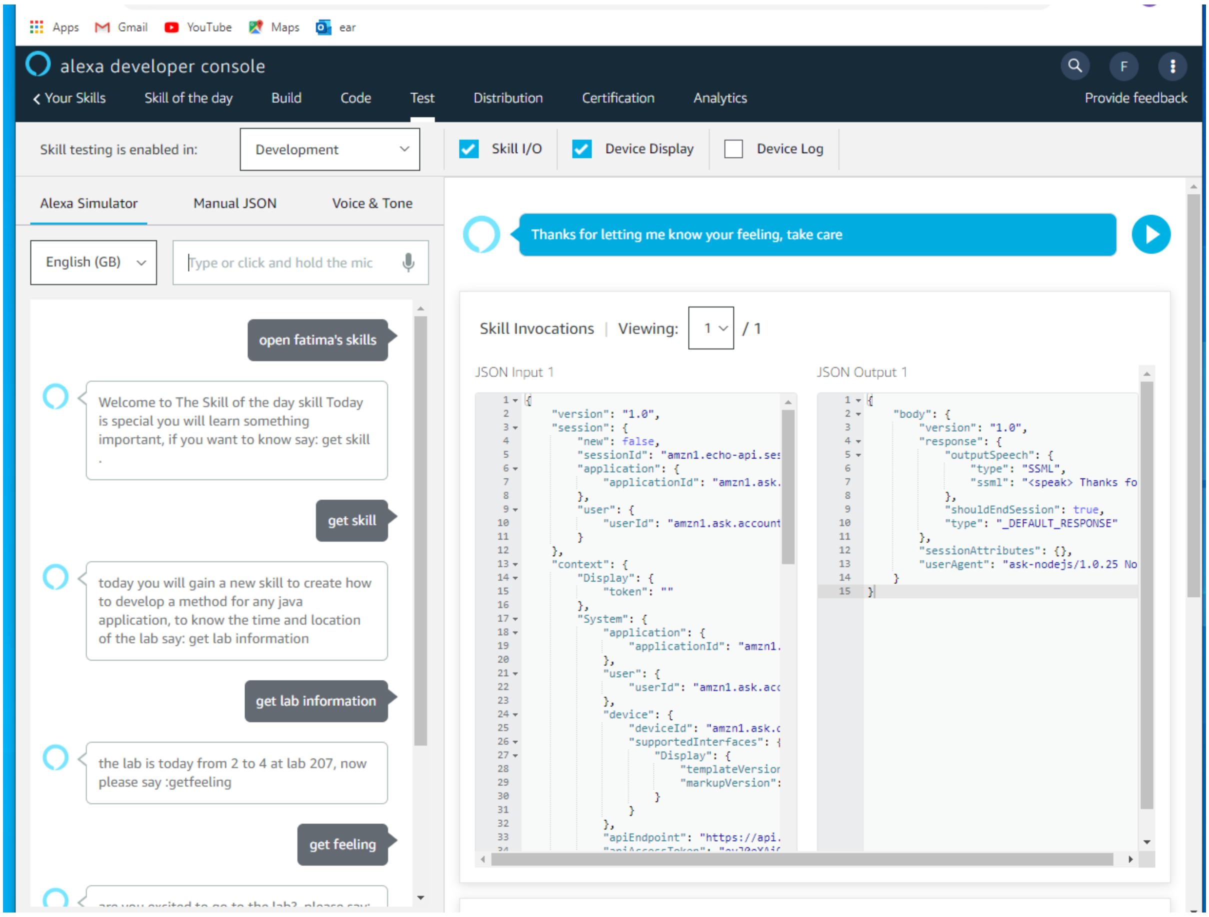


Figure 0-32: The Skill of the Day Chatbot -Execution

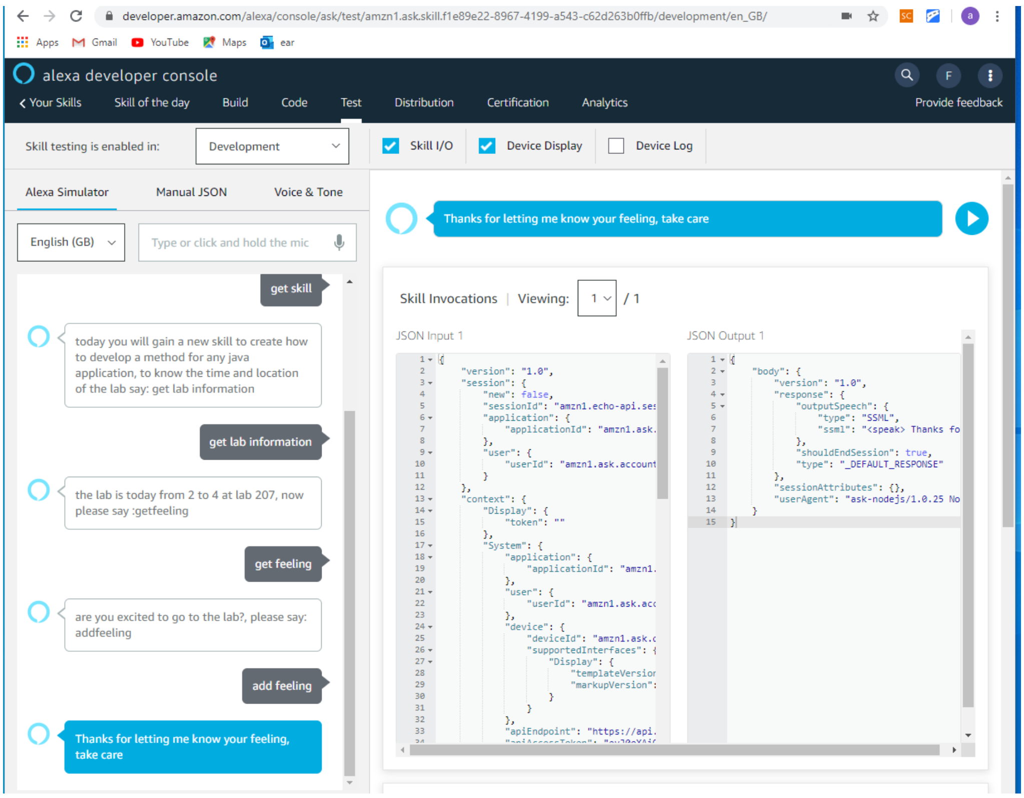


Figure 0-33: The Skill of the Day Chatbot – Execution

4) Knowledge acquisition chatbot for the Top student

```
'use strict';

// ------------------------------------------------------------------
// APP INITIALIZATION
// ------------------------------------------------------------------
const { App } = require('jovo-framework');
const { Alexa } = require('jovo-platform-alexa');
const { GoogleAssistant } = require('jovo-platform-googleassistant');
const { JovoDebugger } = require('jovo-plugin-debugger');
const { FileDb } = require('jovo-db-filedb');
const dDB = require('./dynamoDB');
const dynamoDB = new dDB();
const ses = require('./ses');
const Ses = new ses();

const app = new App();

app.use(
    new Alexa(),
    new GoogleAssistant(),
    new JovoDebugger(),
    new FileDb()
)
// ------------------------------------------------------------------
// APP LOGIC
// ------------------------------------------------------------------
app.setHandler({
    LAUNCH() {
        return this.toIntent('Welcome to the advanced knowledge acquisition');
    },
    Welcome() {
        this.setState('QuestionState')
        this.ask("You can ask me questions about any lecture by typing the lecture title.")
    },
```

```
  QuestionState: {
    async WhatQuestion() {
      const id = this.$inputs.terms.id
      if (id) {
        const javaQA = await dynamoDB.get(parseInt(id))
        this.setState('MoreInformationState')
        this.setSessionAttribute('javaQA', javaQA)
        this.ask(`${javaQA.answer} Do you want more information?`)
      } else {
        this.ask(`I did not get your question about ${this.$inputs.terms.value}. Please ask a question about Java Programming.`)
      }
    },
    Unhandled() {
      this.ask(`I did not get your question. Please ask a question about Java Programming.`)
    }
  },
  MoreInformationState: {
    YesIntent() {
      const javaQA = this.getSessionAttribute('javaQA')
      Ses.email(javaQA)
      this.setState('QuestionState')
      this.ask('I have sent more information to your email. You can ask me more questions')
    },
    NoIntent() {
      this.tell('Goodbye')
module.exports.app = app;
```

Figure 0-34: Knowledge Acquisition for Top Student – Code (app.js)

```
'use strict';

const AWS = require('aws-sdk');

AWS.config.update({
 accessKeyId: "AKIA2NATPJN4BOYH67L6",   // new
  secretAccessKey: "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", //new
  region: "us-east-1",  // new
```

```
});

class dDB {
  constructor() {
    this.client = new AWS.DynamoDB.DocumentClient();
    this.userTable = 'Java_Questions2'; // new
  }

  get(questionNumber) {
    console.log({ questionNumber })
    return this.client.get({
      TableName: this.userTable,
      Key: { questionNumber },
    }).promise()
      .then(item => item.Item);
  }

  put(data) {
    return this.client.put({
      TableName: this.userTable,
      Item: data,
    }).promise();
  }
}

module.exports = dDB;
```

Figure 0-35: Knowledge Acquisition for Top Student - Code (db.js)

```
'use strict';

var aws = require('aws-sdk');

// Provide the full path to your config.json file.
aws.config.update({
```

```
    accessKeyId: "AKIA2NATPJN4BOYH67L6",   // new
    secretAccessKey: "xBGD4OGUva832CI4vb7l3GIgLccYpUGXfL2Fv5Mr", //new
    region: "us-east-1",  // new
});


class ses {
    constructor() {
        this.client = new aws.SES();
        this.sender = "Fatima Almahri <fatima.amerjidalmahri@brunel.ac.uk>";   // new
    }

    email(item) {

        var params = {
            Source: "Knowledge Acquisition for top student<fatima.amerjidalmahri@brunel.ac.uk>",  // new
            Destination: {
                ToAddresses: [
                    "fatima.amerjidalmahri@brunel.ac.uk",  // new
                    "fatima.amerjidalmahri@outlook.com",  // new
                    "fatmam.sal@cas.edu.om",  // new


                ],
            },
            Message: {
                Subject: {
                    Data: "Amazon SES Test (AWS SDK for JavaScript in Node.js)",
                    Charset: "UTF-8"
                },
                Body: {
                    Text: {
                        Data: "Amazon SES Test (SDK for JavaScript in Node.js)\r\n"
                            + "This email was sent with Amazon SES using the "
                            + "AWS SDK for JavaScript in Node.js.",
                        Charset: "UTF-8"
                    },
                    Html: {
                        Data: `<html>
```

```
                        <head></head>
                        <body>
                          <h1>Question: ${item.question}</h1>
                          <h2>Answer ${item.answer} More information in this link.<a href='${item.link}'>${item.link}</a>
</h2>
                        </body>
                        </html>`,
                        Charset: "UTF-8"

        this.client.sendEmail(params, function (err, data) {
            // If something goes wrong, print an error message.
            if (err) {
                console.log(err.message);
            } else {
                console.log("Email sent! Message ID: ", data.MessageId);



module.exports = ses;
```

[redacted]

Figure 0-36: Knowledge Acquisition for Top Students (ses.js)

5) Knowledge Assessment Chatbot for Top Student

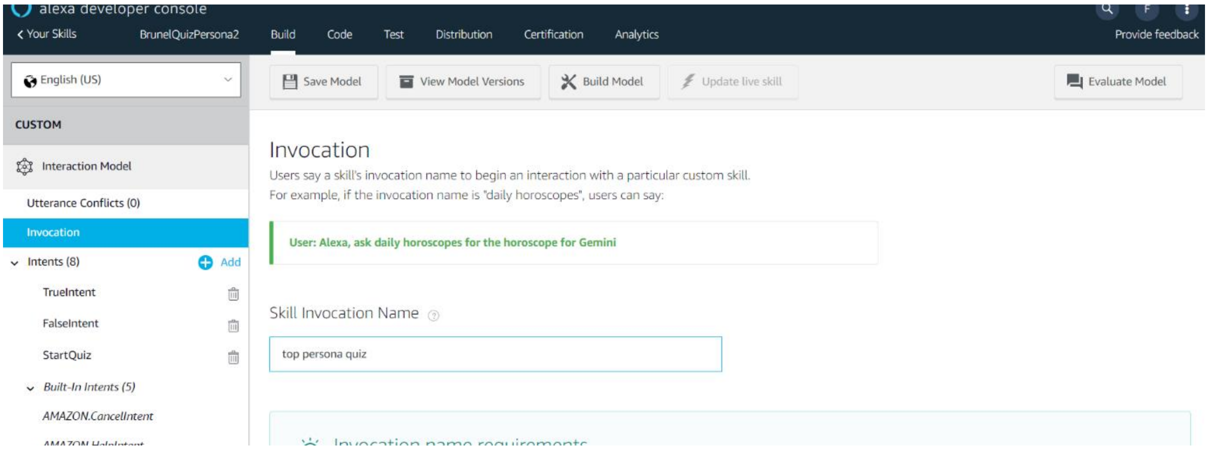
```
'use strict';

// ------------------------------------------------------------------
// APP INITIALIZATION
// ------------------------------------------------------------------

const { App } = require('jovo-framework');
const { Alexa } = require('jovo-platform-alexa');
const { JovoDebugger } = require('jovo-plugin-debugger');
const { FileDb } = require('jovo-db-filedb');

const app = new App();

app.use(
    new Alexa(),
    new JovoDebugger(),
```

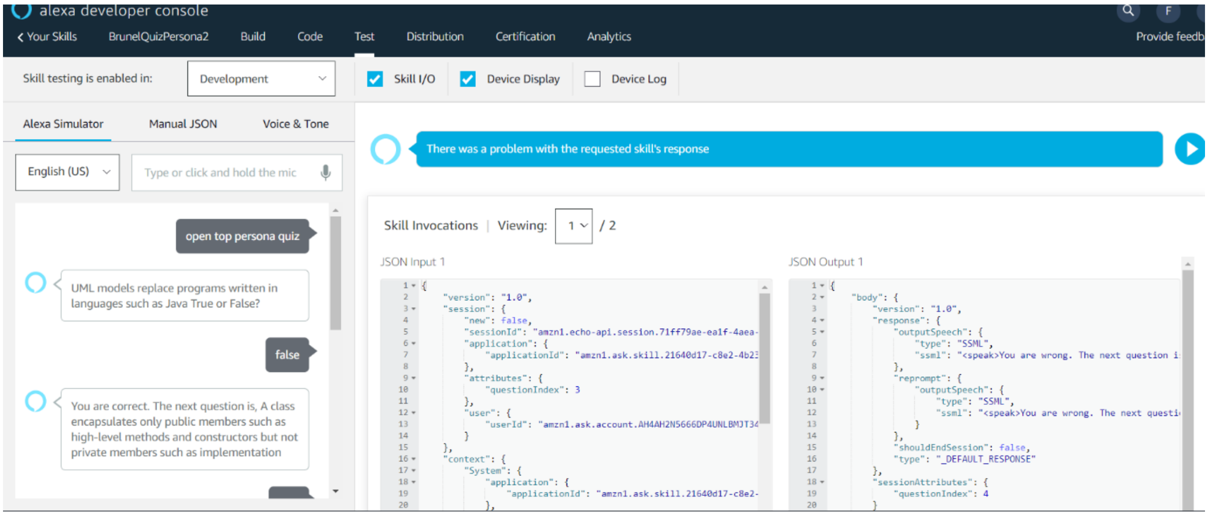
```
    new FileDb()
);

const QuestionsAnswers = [
    {
        Question: 'Every program in Java consists of at least one class definition that is defined by the programmer.',
        True: 'You are correct.',
        False: 'You are wrong sorry.'
    },
    {
        Question: 'The Java graphics package is javax.jOptionPane.',
        True: 'You are wrong sorry.',
        False: 'You are correct.'
    },
    {
        Question: `The data types short and double are included in Java's eight primitive data types.`,
        True: 'You are correct.',
        False: 'You are wrong.'
    },
    {
        Question: 'In a sentinel-controlled loop, the sentinel value must be an aceptable input value (such as a grade in a loop.',
        True: 'You are wrong.',
        False: 'You are correct.'
    },
    {
        Question: 'Too many levels of nesting can make a program difficult to understand; as a general rule, try to avoid using more.',
        True: 'You are correct.',
        False: 'You are wrong.'
    },

]

// -----------------------------------------------------------------
// APP LOGIC
// -----------------------------------------------------------------
```

```
app.setHandler({
    LAUNCH() {
        this.setSessionAttribute('questionIndex', 0)
        return this.toIntent('StartQuiz');
    },

    StartQuiz() {
        const questionIndex = this.getSessionAttribute('questionIndex')
        this.ask(QuestionsAnswers[questionIndex].Question + ' True or False?');
    },

    TrueIntent() {
        const questionIndex = this.getSessionAttribute('questionIndex')

        if (this.getSessionAttribute('questionIndex') < 4) {
            this.ask(QuestionsAnswers[questionIndex].True +
                ' The next question is, ' +
                QuestionsAnswers[questionIndex + 1].Question)
            this.setSessionAttribute('questionIndex', questionIndex + 1)

        } else {
            this.tell(QuestionsAnswers[questionIndex].True)
        }
    },

    FalseIntent() {
        const questionIndex = this.getSessionAttribute('questionIndex')

        if (this.getSessionAttribute('questionIndex') < 4) {
            this.ask(QuestionsAnswers[questionIndex].False +
                ' The next question is, ' +
                QuestionsAnswers[questionIndex + 1].Question)
            this.setSessionAttribute('questionIndex', questionIndex + 1)

        } else {
            this.tell(QuestionsAnswers[questionIndex].False)
        }
```

```
  },

  Unhandled() {
    const questionIndex = this.getSessionAttribute('questionIndex')

    this.ask("Sorry I didn't understand, " + QuestionsAnswers[questionIndex].Question + ' True or False.')
  }
});

module.exports.app = app;
```

Figure 0-37: Knowledge Assessment Chatbot for Top Students (app.js)





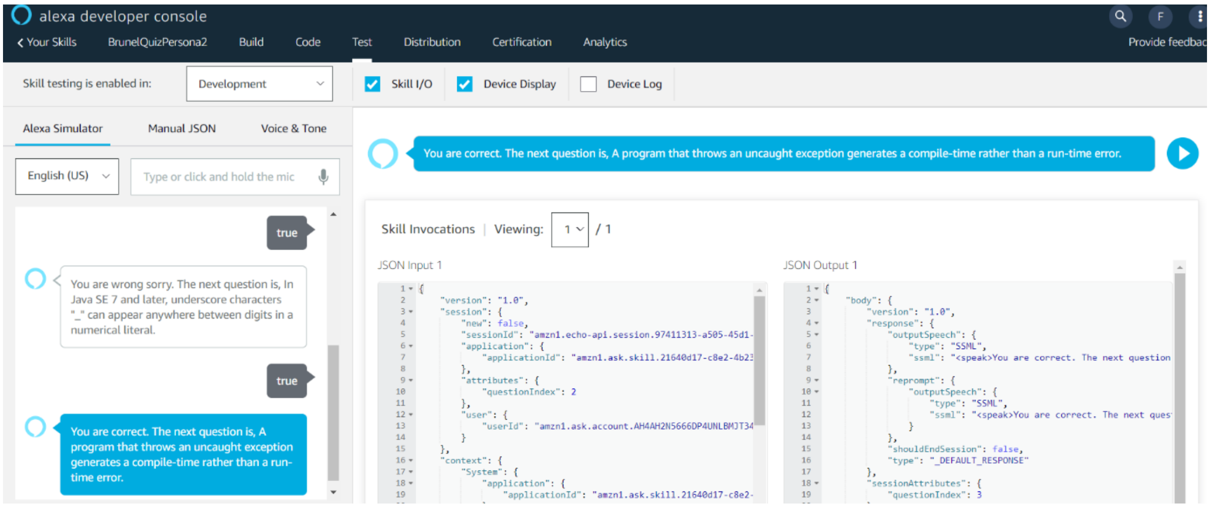


Figure 0-38 a,b,c: Knowledge Assessment Chatbot for Top Students

5) Knowledge Assessment for Disengaged Student

```
'use strict';


// -----------------------------------------------------------------

// APP INITIALIZATION

// -----------------------------------------------------------------


const { App } = require('jovo-framework');

const { Alexa } = require('jovo-platform-alexa');

const { JovoDebugger } = require('jovo-plugin-debugger');

const { FileDb } = require('jovo-db-filedb');


const app = new App();


app.use(

    new Alexa(),

    new JovoDebugger(),

    new FileDb()

);


const QuestionsAnswers = [

    {

        Question: 'Every program in Java consists of at least one class definition that is defined by the programmer.',
```

```
        True: 'You are correct.',
        False: 'You are wrong sorry.'
    },
    {
        Question: 'The Java graphics package is javax.jOptionPane.',
        True: 'You are wrong sorry.',
        False: 'You are correct.'
    },
    {
        Question: `The data types short and double are included in Java's eight primitive data types.`,
        True: 'You are correct.',
        False: 'You are wrong.'
    },
    {
        Question: 'In a sentinel-controlled loop, the sentinel value must be an aceptable input value (such as a grade in a loop.',
        True: 'You are wrong.',
        False: 'You are correct.'
    },
    {
        Question: 'Too many levels of nesting can make a program difficult to understand; as a general rule, try to avoid using more.',
        True: 'You are correct.',
        False: 'You are wrong.'
    },

]

// ------------------------------------------------------------------
// APP LOGIC
// ------------------------------------------------------------------

app.setHandler({
    LAUNCH() {
        this.setSessionAttribute('questionIndex', 0)
        return this.toIntent('StartQuiz');
    },
```

```
    StartQuiz() {
        const questionIndex = this.getSessionAttribute('questionIndex')
        this.ask(QuestionsAnswers[questionIndex].Question + ' True or False?');
    },

    TrueIntent() {
        const questionIndex = this.getSessionAttribute('questionIndex')

        if (this.getSessionAttribute('questionIndex') < 4) {
            this.ask(QuestionsAnswers[questionIndex].True +
                ' The next question is, ' +
                QuestionsAnswers[questionIndex + 1].Question)
            this.setSessionAttribute('questionIndex', questionIndex + 1)

        } else {
            this.tell(QuestionsAnswers[questionIndex].True)
        }
    },

    FalseIntent() {
        const questionIndex = this.getSessionAttribute('questionIndex')

        if (this.getSessionAttribute('questionIndex') < 4) {
            this.ask(QuestionsAnswers[questionIndex].False +
                ' The next question is, ' +
                QuestionsAnswers[questionIndex + 1].Question)
            this.setSessionAttribute('questionIndex', questionIndex + 1)

        } else {
            this.tell(QuestionsAnswers[questionIndex].False)
        }
    Unhandled() {
        const questionIndex = this.getSessionAttribute('questionIndex')

        this.ask("Sorry I didn't understand, " + QuestionsAnswers[questionIndex].Question + ' True or False.')
module.exports.app = app;
```

Figure 0-39: Knowledge Assessment Chatbot for Disengaged Student – Code

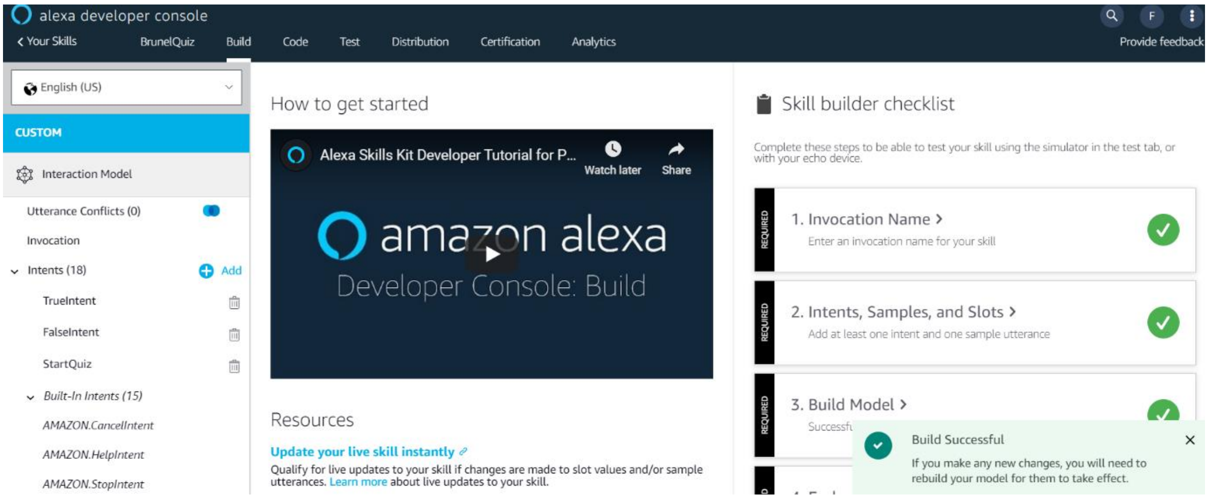


Figure0-39a: Knowledge Assessment Chatbot for Low-Performance Student– Interaction Model

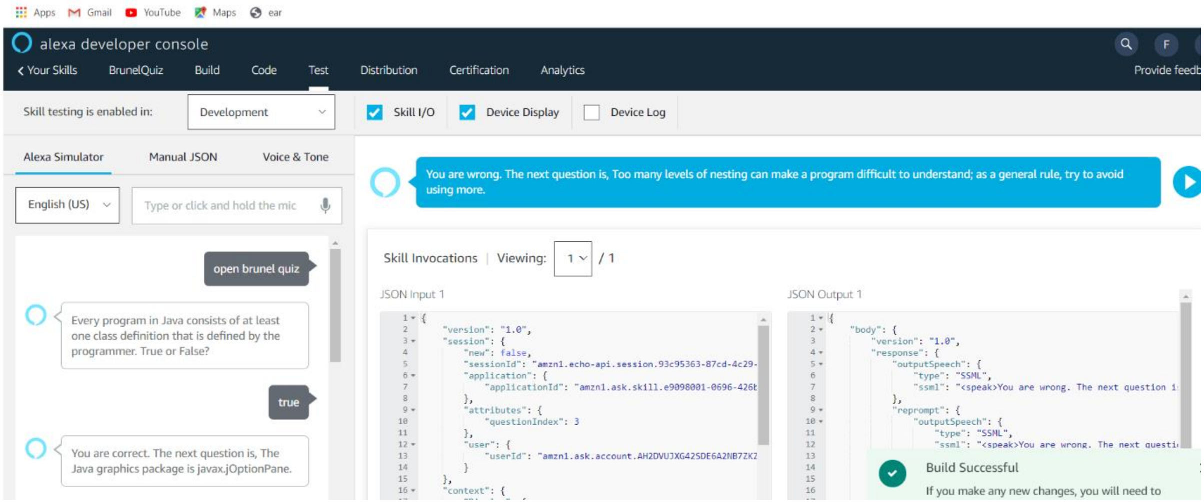


Figure 0-40: Knowledge Assessment Chatbot for Low-Performance Student – Execution

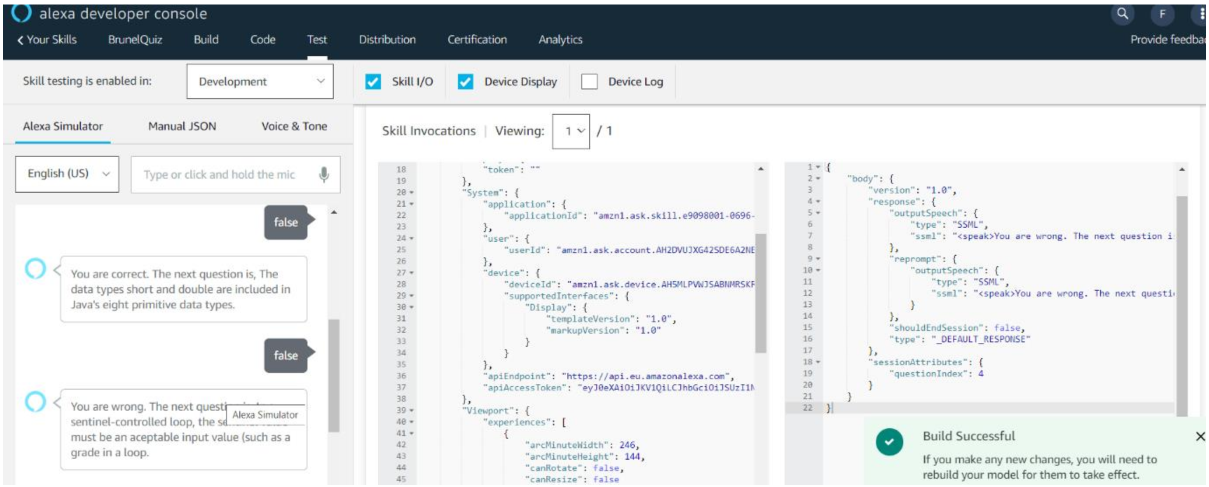


Figure 0-41: Knowledge Assessment Chatbot – Execution

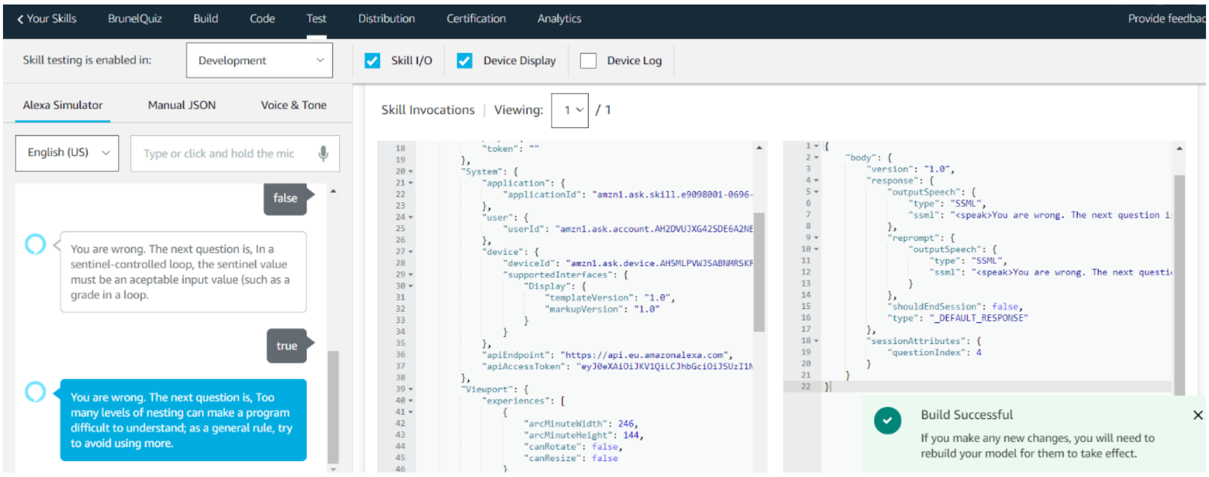


Figure 0-41: Knowledge Assessment Chatbot for Low-Performance Students- Execution

6) Knowledge Acquisition for Low-performance Student

```
'use strict';


// ------------------------------------------------------------------

// APP INITIALIZATION

// ------------------------------------------------------------------


const { App } = require('jovo-framework');

const { Alexa } = require('jovo-platform-alexa');

const { GoogleAssistant } = require('jovo-platform-googleassistant');

const { JovoDebugger } = require('jovo-plugin-debugger');

const { FileDb } = require('jovo-db-filedb');

const dDB = require('./dynamoDB');

const dynamoDB = new dDB();

const ses = require('./ses');

const Ses = new ses();


const app = new App();


app.use(

    new Alexa(),

    new GoogleAssistant(),

    new JovoDebugger(),

    new FileDb()
```

```
);



// ---------------------------------------------------------------
// APP LOGIC
// ---------------------------------------------------------------

app.setHandler({
    LAUNCH() {
        return this.toIntent('Welcome to the advanced knowledge acquisition');
    },

    Welcome() {
        this.setState('QuestionState')
        this.ask("You can ask me questions about any lecture by typing the lecture title.")
    },

    QuestionState: {
        async WhatQuestion() {
            const id = this.$inputs.terms.id
            if (id) {
                const javaQA = await dynamoDB.get(parseInt(id))
                this.setState('MoreInformationState')
                this.setSessionAttribute('javaQA', javaQA)
                this.ask(`${javaQA.answer} Do you want more information?`)
            } else {
                this.ask(`I did not get your question about ${this.$inputs.terms.value}. Please ask a question about
Java Programming.`)
            }
        },

        Unhandled() {
            this.ask(`I did not get your question. Please ask a question about Java Programming.`)
        }

    },

    MoreInformationState: {
```

```
    YesIntent() {
      const javaQA = this.getSessionAttribute('javaQA')
      Ses.email(javaQA)
      this.setState('QuestionState')
      this.ask('I have sent more information to your email. You can ask me more questions')
    },
    NoIntent() {
      this.tell('Goodbye')
    },

  },

});
module.exports.app = app;
```

Figure 0- 42b: Knowledge Acquisition Chatbot for Low-Performance Student (app.js) -code

```
'use strict';

const AWS = require('aws-sdk');

AWS.config.update({
  accessKeyId: "AKIA2NATPJN4BOYH67L6",   // new
    secretAccessKey: "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", //new
    region: "us-east-1",  // new
});

class dDB {
  constructor() {
    this.client = new AWS.DynamoDB.DocumentClient();
    this.userTable = 'Java_Questions'; // new
  }

  get(questionNumber) {
    console.log({ questionNumber })
    return this.client.get({
      TableName: this.userTable,
      Key: { questionNumber },
    }).promise()
      .then(item => item.Item);
  }

  put(data) {
    return this.client.put({
      TableName: this.userTable,
      Item: data,
    }).promise();
  }
}

module.exports = dDB;
```

Figure 0-42b: Knowledge Acquisition for Low Performance Student (database.js) - code

```
'use strict';

var aws = require('aws-sdk');

// Provide the full path to your config.json file.
aws.config.update({
   accessKeyId: "AKIA2NATPJN4BOYH67L6",   // new
   secretAccessKey: "xBGD4OGUva832CI4vb7l3GIgLccYpUGXfL2Fv5Mr", //new
   region: "us-east-1",  // new
});


class ses {
   constructor() {
      this.client = new aws.SES();
      this.sender = "Fatima Almahri <fatima.amerjidalmahri@brunel.ac.uk>";   // new
   }

   email(item) {

      var params = {
         Source: "Knowledge Acquisition for top student<fatima.amerjidalmahri@brunel.ac.uk>",  // new
         Destination: {
            ToAddresses: [
               "fatima.amerjidalmahri@brunel.ac.uk",  // new
               "fatima.amerjidalmahri@outlook.com",  // new
               "fatmam.sal@cas.edu.om",  // new

            ],
         },
         Message: {
            Subject: {
               Data: "Amazon SES Test (AWS SDK for JavaScript in Node.js)",
               Charset: "UTF-8"
            },
            Body: {
               Text: {
                  Data: "Amazon SES Test (SDK for JavaScript in Node.js)\r\n"
                     + "This email was sent with Amazon SES using the "
                     + "AWS SDK for JavaScript in Node.js.",
                  Charset: "UTF-8"
               },
               Html: {
                  Data: `<html>
                  <head></head>
                  <body>
                    <h1>Question: ${item.question}</h1>
                    <h2>Answer ${item.answer} More information in this link.<a href='${item.link}'>${item.link}</a>
</h2>
                  </body>
                  </html>`,
                  Charset: "UTF-8"
               }
            }
         },
      };

      this.client.sendEmail(params, function (err, data) {
         // If something goes wrong, print an error message.
         if (err) {
            console.log(err.message);
         } else {
            console.log("Email sent! Message ID: ", data.MessageId);
         }
      });
   }
```

```
}
module.exports = ses;
```

Figure 0-42c: Knowledge Acquisition for Low-Performance Student (SES.js)

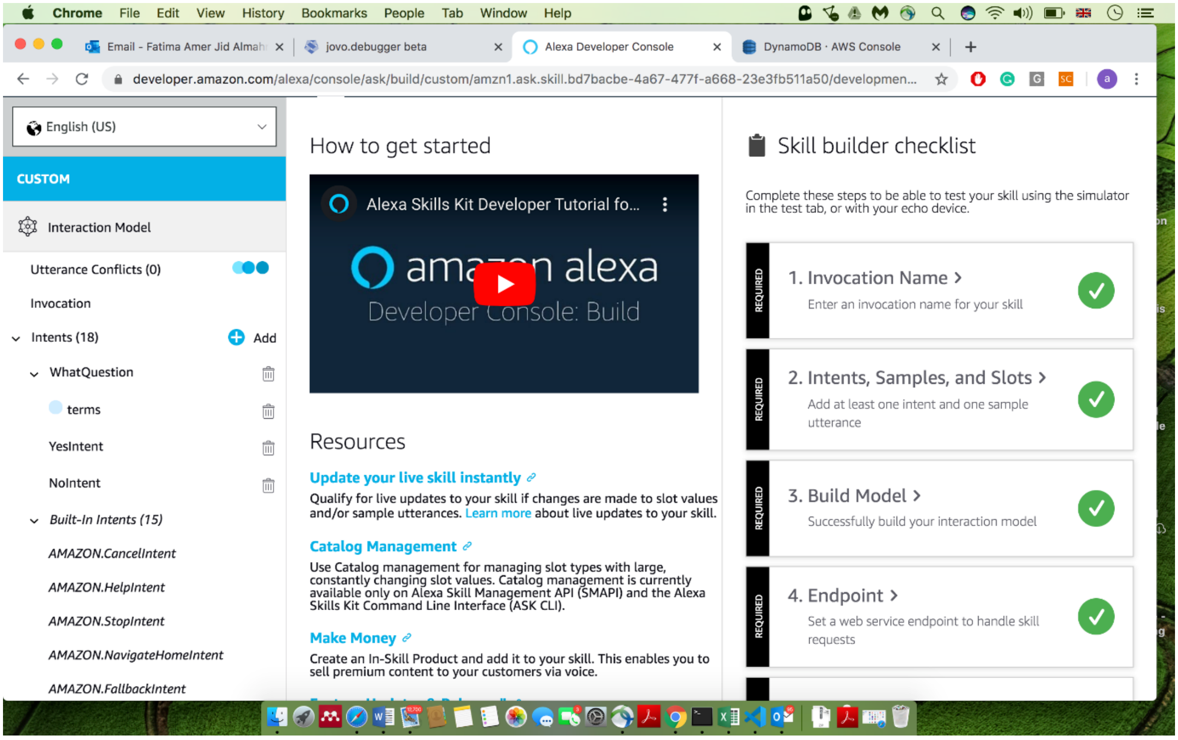


Figure 0-42: Knowledge Acquisition Chatbot for Low-Performance Student – Interaction Model

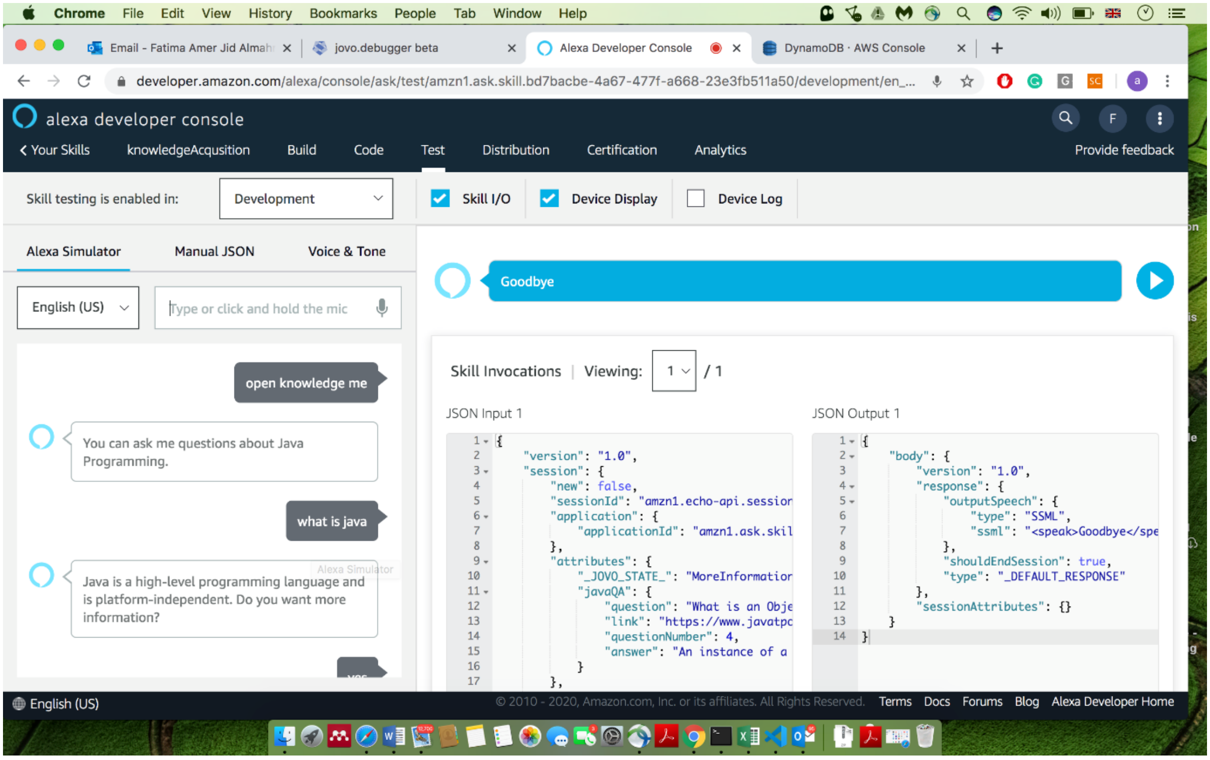


Figure 0-43: Knowledge Acquisition Chatbot for Low-Performance Student – Execution

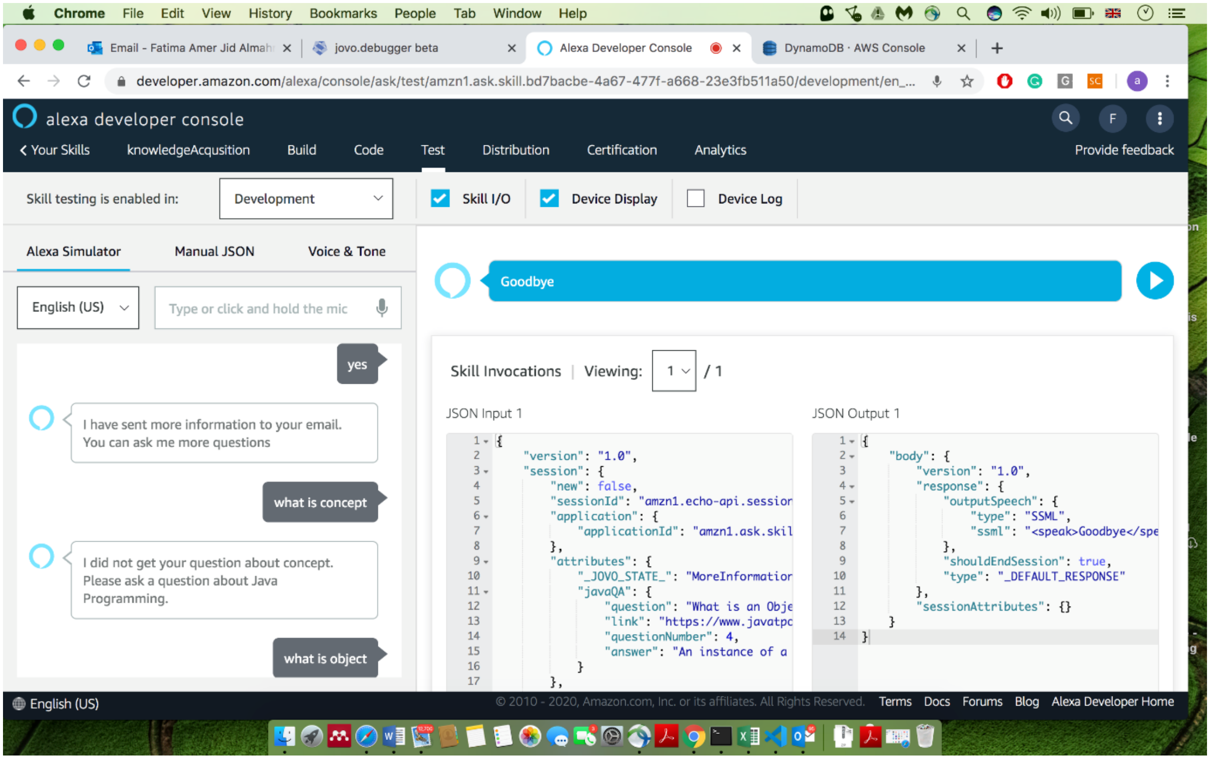


Figure 0-44: Knowledge Acquisition Chatbot for Low-Performance Student – Execution

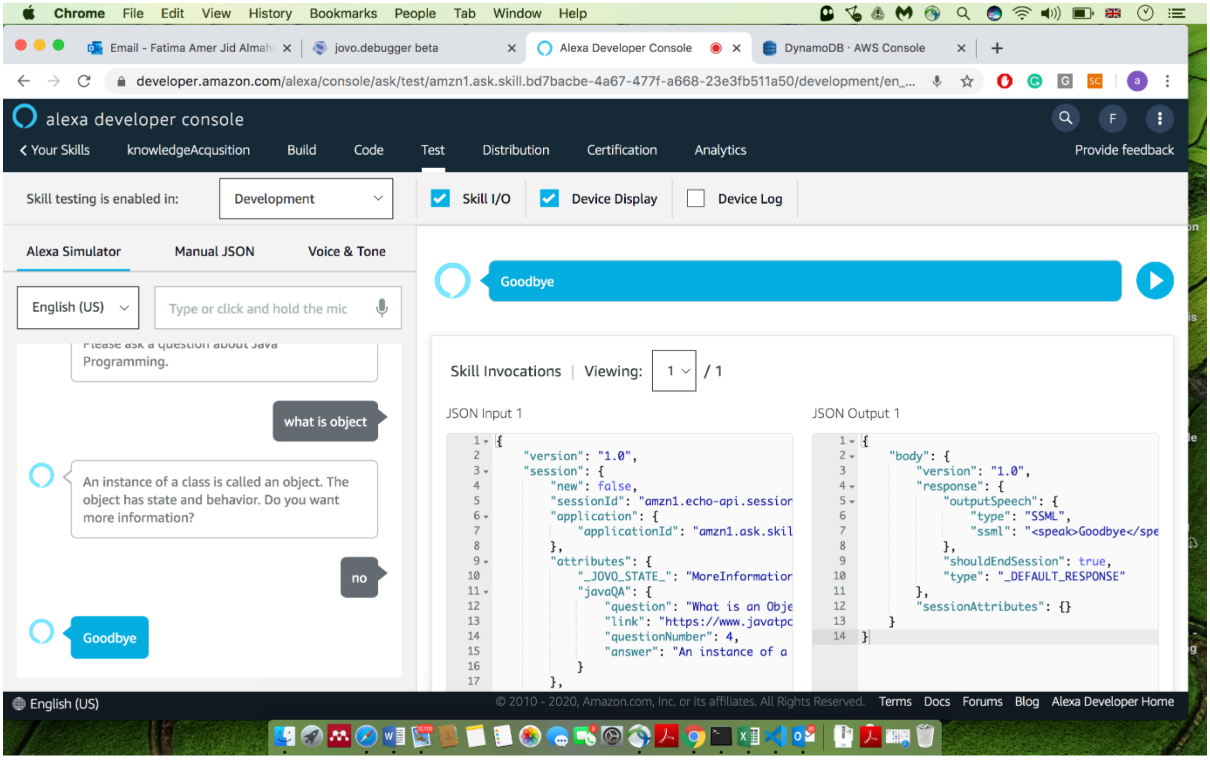


Figure 0-45: Knowledge Acquisition Chatbot for Low-Performance Student – Execution

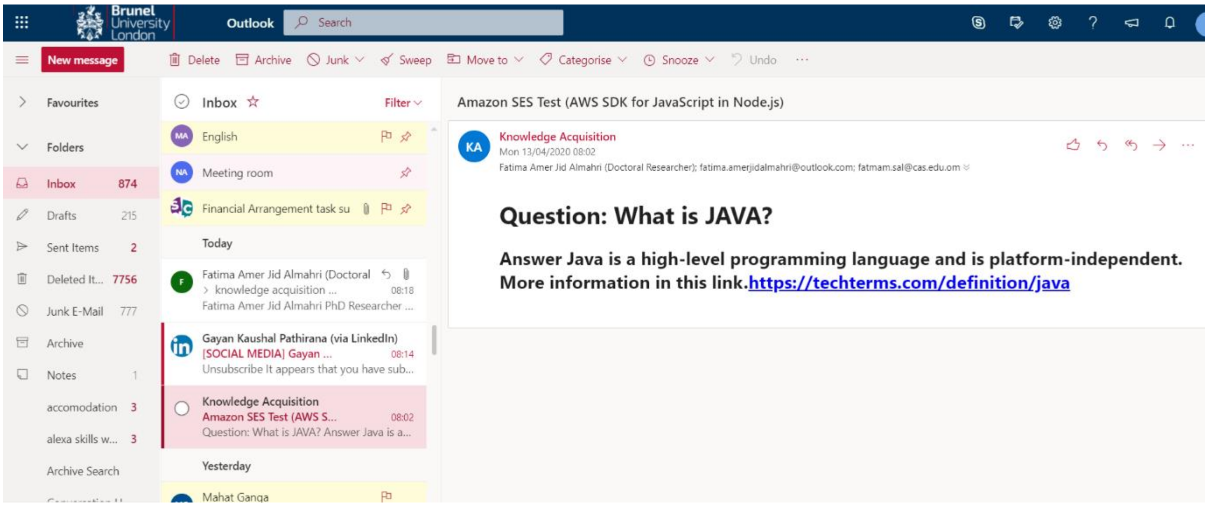


Figure 0-46: Knowledge Acquisition Chatbot for Low-Performance Student – Sending Email

Appendix K - Completeness Evaluation Method

According to Bajaj and Ram (1999), evaluating the completeness of the conceptual models can be divided into two methods: non-empirical and empirical. There are two advantages of evaluating the model using the non-empirical method: 1) the evaluation leads to absolute answers about completeness that are independent of a particular empirical situation, 2) the method requires less effort and time to perform the validation (Batini, Ceri and Navathe, 1992).

A study by Bailey and Pearson (1983) evaluate completeness. They reviewed 22 studies and identified a list of elements. Then the evaluation starts by asking three professionals to review the list. They can suggest adding more elements to the list. " the list would be assumed complete if at an = 0.01, any factor mentioned in an interview appeared on the list with a probability of 0.90".

A study by Batini, Ceri and Navathe (1992) checks the model's completeness by checking that each element of the model corresponds to a user requirement and each user requirement is represented in the model (Soutou,1998). However, Soutou (1998)states that the practical difficulty of this approach is that the sources of the user requirement exist only in people's minds, and there are no external sources of the data. Therefore, evaluating the completeness should be done with close participation of business users. The completeness review results in a list of elements that do not match user requirements, and it leads to different types of completeness mismatches (Soutou ,1998), as shown in Figure 0-47 .

- Area 1 represent elements in the data model that does not represent any user requirement and is referred to as type 1 error
- Area 2 represents user requirements elements that are not shown in the data model and are referred to as type 2 errors.
- Area 3 represents elements in the data models representing users' requirements but have not been defined accurately.

- Area 4 represents elements in the data models that represents the user model.

The objective of completeness review is to remove all items of type 1,2, and 3.

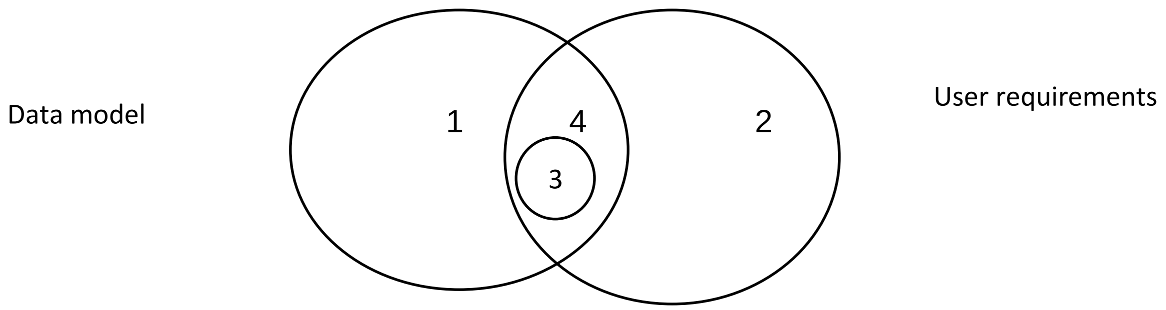


Figure 0-47: Data Model and User Requirements

Based on the above discussion, I proposed a novel way of evaluating the completeness of the model by adapting the methods proposed above to create a new one. This study target evaluating the completeness using non-empirical methods as shown in the table

Steps in the completeness evaluation method	**Source references**	**No of citation**	**Apply it on this research**
Identify the list of persona elements by reviewing the literature	Adapted from Bailey and Pearson (1983)	4013	This has been achieved in chapter 4, and the classification of these elements is shown in Table 4-8.
Check each element of the model represents a user requirement, and each user requirement represent an element in the user model	(Batini, Ceri and Navathe, 1992)	1828	1)The first user requirement is to build chatbots for different persona types. Therefore, it is important to build persona models that allow us to understand different groups of students, including their demographic data, educational data. The list of persona elements attributes is shown in Section 4.2.3. The refined list is shown in Section 4.3.3, and it is illustrated in Figure 4-17.

			2)The second user requirement is to identify these chatbots features that suit each persona. This is achieved in second and third iterations.
Evaluating the completeness should be done with the close participation of business users. In this study, the evaluation will be done by the researcher (myself)	(Soutou ,1998).	12 - Springer	Each element is evaluated
The completeness review results in a list of elements that do not match user requirements, and it leads to different types of completeness mismatches Type 1 error: Type 2 error : Type 3 error : Type 4 error:	Soutou (1998)	12 - Springer	The final list of elements in the persona3D model is evaluated to see if it supports any of the above-mentioned requirements, if not, it will be removed from the final list. The final version is shown in Chapter 6, Section 6.5.2.

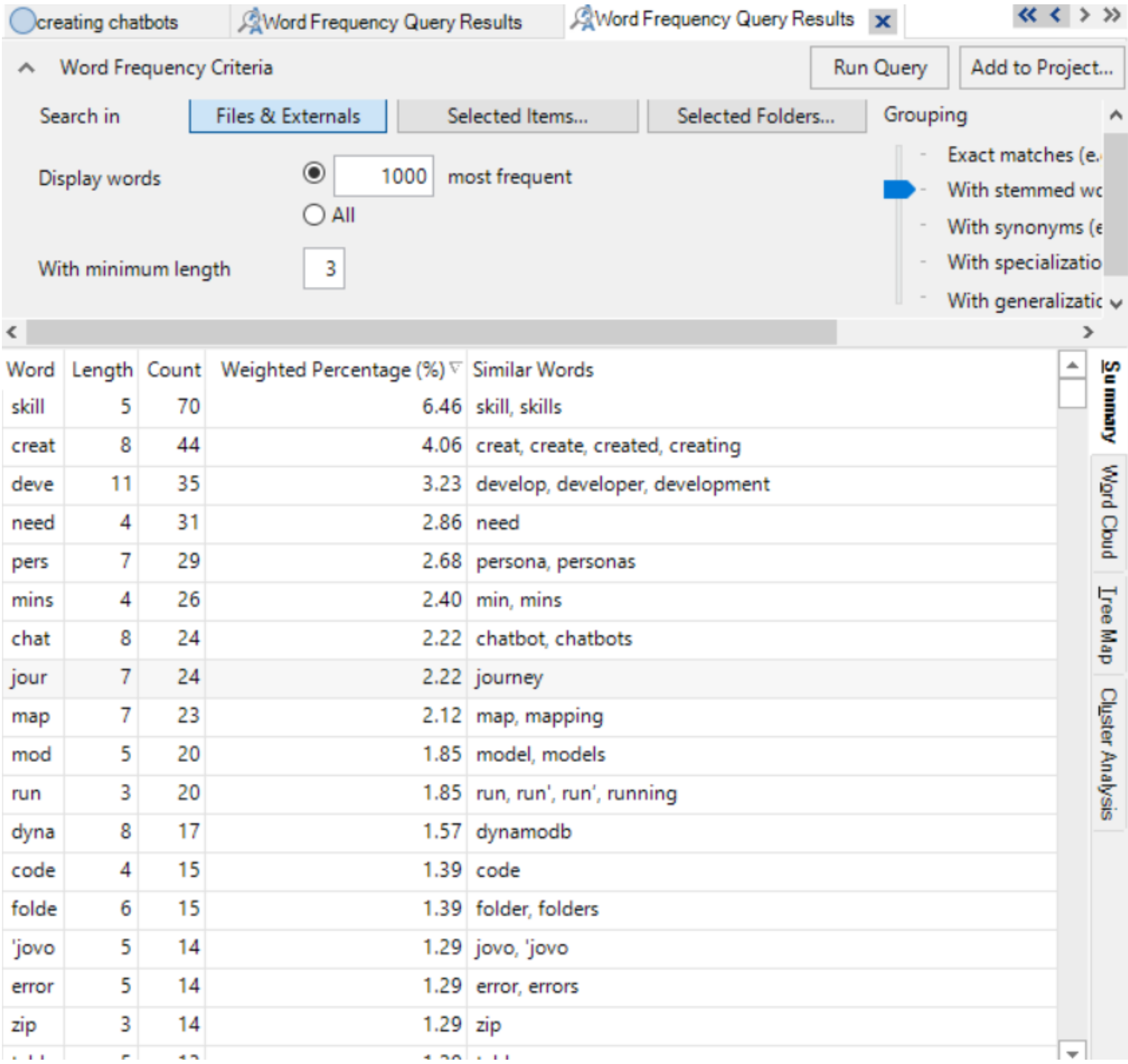
Table 0-18: Completeness Evaluation Method.

Appendix L – Logbook analysis result using NVIVO

The result of running the word frequency query in NVIVO for the logbook while creating chatbots is shown in Figure 0-48. Figure 0-49 shows the most 30 words appear in the logbooks. It is clear in Figure 0-50 that “Journey”, “Map”, “persona” and, “model” is from the most 10 words that appear in the logbook. This is confirming the effectiveness of using persona3D and journey mapping in supporting the development of chatbots.

Figure 0-48: Word Frequency Query Result

Figure 0-49: Most Word Freqency Query Resu



Word	Length	Count	Weighted Percentage (%)	Similar Words
skill	5	70	6.46	skill, skills
creat	8	44	4.06	creat, create, created, creating
deve	11	35	3.23	develop, developer, development
need	4	31	2.86	need
pers	7	29	2.68	persona, personas
mins	4	26	2.40	min, mins
chat	8	24	2.22	chatbot, chatbots
jour	7	24	2.22	journey
map	7	23	2.12	map, mapping
mod	5	20	1.85	model, models
run	3	20	1.85	run, run', run', running
dyna	8	17	1.57	dynamodb
code	4	15	1.39	code
folde	6	15	1.39	folder, folders
'jovo	5	14	1.29	jovo, 'jovo
error	5	14	1.29	error, errors
zip	3	14	1.29	zip

Figure 0-50: Summary of the Word Frequency Query Result

---

[i] **Or highest qualification**
[ii] **Or organisation**
[iii] **/place of residence**
[iv] **Either : interactive learning or classroom lecture**
[v] **Or back story**