Mobile applications in supporting Open and Distance Learning students' research

by

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I declare that the above dissertation is my own work and that all the sources that I have used or quoted have been indicated and acknowledged by means of complete references.

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26/02/2021

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Abstract

Honours students, who are generally new to research, require support in finding, accessing and sharing information resources for conducting research**.** In open and distance learning (ODL) providing students with access to supportive information resources becomes problematic, especially in developing countries, due to the constraints introduced by the distance between the students as well as between students and their supervisors. Such constraints include isolation, lack of peer collaboration, the cost of basic technologies such as broadband, and time management for working students. Therefore, the aim of this study was to investigate the development of a usable mobile tool that provides an interface for information access, collaboration and information sharing. The mobile tool should allow students to access information resources, share research articles, share ideas, interact with each other and form study groups. Although the learning management system of the institution supports some of the students' needs; however, the support for honours students has been inadequate owing to a lack of capacity and flexibility, and frequent downtime.

Following the design science research (DSR) approach, an artefact (a mobile application) was created as a solution to meet some of the students' needs in terms of collaboration, and access to and sharing of relevant research-related information. The design requirements for the mobile application were abstracted from the literature and adapted to the context. To evaluate the usability of the mobile tool, usability testing was done with 30 honours students, which was followed by the administration of the Post-Study System Usability Questionnaire (PSSUQ) survey, and as well as the conducting of interviews.

The evaluation results show that the tool supports collaboration by allowing students to access and share relevant information. The practical contribution of this study to the body of knowledge is the design and construction of a knowledge-sharing and collaboration artefact for research students in ODL. Identifying the properties and guidelines for usable mobile application interface design that support information access, collaboration and information sharing in ODL provides a novel theoretical contribution based on which guidelines for mobile application sharing can be expanded.

Keywords: Open and distance learning, mobile application, design science research, collaboration, information sharing, information access, usability, usability testing

Summary

Honours students, who are generally new to research, require help in learning how to do research. The aim of this study was to investigate the development of a mobile tool that assists honours students with building research skills. The mobile tool was designed to allow the students to access information resources, share research articles, share ideas, interact with each other and form study groups. The study followed the design science research method in developing and evaluating the mobile application (app). The design of the app was informed by the literature on mobile interfaces. Usability testing and a survey were used to evaluate the app. The results showed that the app was considered useful by the students. In addition, the study added to the literature in the field in terms of identifying properties and guidelines for usable mobile application interface design.

Baithuti ba Kgrata ya Onase, bao ka kakaretšo ba lego ba baswa go dinyakišišo, ba nyaka go thušwa go ithuta go dira dinyakišišo. Maikemišetšo a dinyakišišo tše e bile go nyakišiša go tšweletšwa ga setlabelo sa go thetha seo se thušago baithuti ba kgrata ya onase go ba le bokgoni bja go dira dinyakišišo. Setlabelo se sa go thetha se hlametšwe go dumelela baithuti go fihlelela methopo ya tshedimošo, go abelana ka diathekele tša dinyakišišo, go fana dikgopolo, go šomišana mmogo le go hlama dihlopha tša dinyakišišo. Dinyakišišo tše di šomišitše mokgwa wa dinyakišišo wa tlhamo ya tša mahlale go tšweletša le go sekaseka lenaneotirišo go selefoune (*app*). Tlhamo ya *app* e thušitšwe ke dingwalwa tša mabapi le mafasetešana a diselefoune. Teko ya go šomišega le diphatišišo di šomišitšwe go sekaseka *app* ye. Dipoelo di laeditše gore *app* e bonwe e le mohola ke baithuti. Godimo ga fao, dinyakišišo di tlaleleditše ka go dingwalwa tša ka lekaleng le mabapi le go utolla diteng le ditlhahli tša tlhamo ya go šomišega ya lenaneotirišo la sellathekeng.

Abafundi abenza iziqu zeHonours, abasebasha ocwaningweni, badinga usizo lokufunda ukwenza ucwaningo. Inhloso yalolu cwaningo bekungukuphenya ngokwakhiwa kwethuluzi eliphathekayo elisiza abafundi abenza iziqu zeHonours ekwakheni amakhono okucwaninga. Ithuluzi eliphathekayo lenzelwe ukuba abafundi bakwazi ukufinyelela emithonjeni yolwazi, babelane ngemibhalo yocwaningo, babelane ngemibono, bahlanganyele ngabanye nomunye bakhe amaqoqo bafunde ndawonye. Ucwaningo lulandele indlela yocwaningo lwesayensi yokwakha ekusunguleni nasekuhloleni uhlelo lokusebenza oluphathekayo (i-*app*). Umklamo wohlelo lokusebenza wakheka ngenxa yezincwadi ezisezintweni ezixhumanisayo eziphathekayo. Kuhlolwe ukusebenziseka kwenziwa nenhlolovo ukuhlola ukusebenziseka kohlelo lokusebenza. Imiphumela ikhombise ukuthi uhlelo lokusebenza luthathwa ngabafundi njengolunosizo. Okunye, ucwaningo lwengeze ezincwadini ezikulo mkhakha maqondana nokuhlonza izakhiwo nemihlahlandlela yokuklanywa kohlelo lokuxhumanisayo okubambekayo okusebenzisekayo.

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Table of Contents

List of Tables

List of Figures

Abbreviations

CSET	College of Science, Engineering and Technology
DSR	Design science research
DSRM	Design science research methodology
HCI	Human computer interaction
IQ	Interface quality
IS	Information sharing
LMS	Learning management system
ODL	Open and distance learning
RPSC	Research Permission Sub-Committee
SU	System usability
UNISA	University of South Africa

The word “students” is used interchangeably with the word “participants” in Chapters 3, 4, 5 and 6.

CHAPTER 1

1. INTRODUCTION

1.1. The open and distance learning context

The aim of open and distance learning (ODL) universities is to provide access to the world of higher education by bridging the distance created by communication difficulties and economic, educational, geographical and social factors (De Beer et al., 2016). ODL provides flexible learning opportunities through learning environments that are process oriented and designed to promote discovery versus memorisation or the mere repetition of content (Bates, 2012; Odeyemi, 2012). Musingafi et al. (2015) concur that ODL provides accessibility, affordability and life-based education opportunities. However, the nature of the ODL environment requires students to manage the diverse and often conflicting demands and responsibilities of work and family, along with their commitment to further education and learning (De Beer et al., 2016; Wang & Li, 2008).

ODL institutions enhance their reach and address the educational needs of their students around the world through flexible learning methods that apply technological tools and infrastructure to assist students to study at a distance (Simpson, 2002; Towobola & Raimi, 2011). Research into teaching and learning in ODL contexts is receiving a growing amount of attention which should translate to increased knowledge on the demands and benefits of this approach to academic offerings (Schober et al., 2006; Wong et al., 2016). Consequently, many ODL institutions have higher courses in postgraduate studies, where research in various subject areas is carried out (Mohakud, 2012). Learning difficulties in research often have a negative impact on students' attitudes towards and interest in research, as well as on their academic performance (Wheeler & Elliot, 2008). Some students experience extreme

challenges in that they are unable to embrace the change from their preceding educational and cultural experience to their new learning and research environment (Wang & Li, 2008). Click (2018) concurs that new researchers experience a variety of research difficulties, from finding a gap in the literature to assessing sources. Komba (2015) reveals that most ODL students who are new to research have limitations in the development of their research proposals. The issues range from deficiencies in research and self-management skills to a lack of peer-support and access to relevant information resources (Urban & Palmer, 2014). These issues indicate the need for student support, specifically for those who are new to the ODL research environment, in activities such as information access, collaboration and information sharing.

1.2. The rationale

In view of the challenges of the ODL content, technology has always been considered to be part of the solution in providing access to information, initially through the postal service and more recently through digital technology (Al-Adwan et al., 2013; De Villiers, 2005a). With the continuous progression of mobile technology, mobile devices have developed quickly, and recently the combination of mobile technology and mobile devices has become an important information distribution channel (Chiu et al., 2014; Setiaji & Paputungan, 2018). Students and teachers use mobile devices such as tablets and smartphones to search and look for e-books, e-journals and e-resources (Parsons, 2010; Rose & Saravanan, 2018). For subsequent studies, a supportive learning function that enables students to share ideas, information and learning resources with their peers should be established (Jou et al., 2016). This is especially appropriate for ODL students who do not always have access to appropriate resources. Therefore, these arguments propose that the development of a mobile application to support

students should be considered. Against the background of the ODL context and the potential of mobile digital technology for overcoming some of the information access issues, the specific research problem will now be presented.

1.3. Research problem

1.3.1. Problem statement

At honours level, most universities including ODL universities require students to do a research project. However, some students are new to research and require support in accessing the information resources required to conduct such research. Providing students with access to information resources support becomes problematic in educational systems such as ODL, especially in developing countries, due to the information access constraints that are introduced by the distance between the students as well as between the students and their supervisors. These constraints include lack of interaction and communication among students (Dzakiria et al., 2013; Oyelere et al., 2018), expensive basic technologies such as broadband (Minnaar, 2013), and time management for working students (Landau, 2012). While a number of existing mobile applications have been developed for social interaction, none of those have been developed or tested for providing a service to ODL novice research students in terms of their information access needs. Existing mobile applications such as WhatsApp, do not have a standardized structure such as a share repository. Furthermore, there has been no opportunity to adapt those applications to students' needs. Therefore, the problem investigated here is the lack of evidence for a usable mobile tool that provides an interface for information access, collaboration and knowledge sharing for ODL honours students.

1.3.2. Research questions

The aim of the study was to answer the following research question:

To what extent can a usable mobile application serve as a supporting tool for honours research students in an ODL environment in South Africa?

The following sub-questions were investigated in the study:

RQ1 – What are the properties of a usable mobile application?

RQ2 – What are the requirements for a usable mobile application in an ODL environment?

RQ3 – How usable would such a mobile application be in supporting honours research students in an ODL environment?

Table 1.1 highlights the sub-research questions used to facilitate the main research question, together with the research action and output. A usable mobile application is an application that provides support for learning activities, learning links and platforms such as discussion forums (Mohammed et al., 2017). For the purpose of this study, the usability of the mobile application was considered in terms of the “effectiveness, efficiency, and the user satisfaction” (ISO, 1998). The effectiveness metric in usability testing refers to the ability to complete a task as measured by completion rate and the number of errors (Tullis & Albert, 2013). While that is the most important metric, we also considered the efficiency (resources required) and the users’ satisfaction with the tool.

Table 1.1: Research questions and objectives

Research questions	Research actions	Research outputs
RQ1: What are the properties of a usable mobile application?	Literature review	Identify the properties of a usable mobile application interface (section 2.5.2, specifically Table 2.2)
RQ2: What are the requirements for a usable mobile application in an ODL environment?	Literature review	Identify relevant properties and requirements for a usable mobile application in an ODL environment (sections 2.5.3 and 2.6.2, specifically Tables 2.4 and 2.5).
RQ3: How usable would a mobile application be in supporting honours research students in an ODL environment?	To develop a usable mobile application that serves as a supporting tool for honours research students in an ODL environment and to evaluate it	Evaluation results of mobile application with usability testing, observation, PSSUQ, and interviews. Chapters 3 (section 3.3), 4 and 5.

1.4. The objectives of the study

The main aim of this study was to develop a mobile application as a tool for honours research students in an ODL environment to support their activities of information access, collaboration, and information sharing. The developed mobile tool would allow students to access information resources, share research articles and share ideas, interact with each other and form study groups.

1.5. The context of the study

The context of the study was the University of South Africa (UNISA), the largest ODL institution in Africa (Pretorius et al., 2015; Queiros & De Villiers, 2016) which has over 400 000 students registered each year (De Hart et al., 2017). The target group was honours (postgraduate) research students since they are new to the research environment and are required to do a research project.

1.6. The contribution of the study

The contribution this study makes is as follows:

- The artefact provides a solution to existing research-related information-sharing and collaboration constraints that affect students in ODL.
- The contribution of this study to the body of knowledge is the design and construction of a knowledge-sharing and collaboration artefact for research students in ODL.
- The theoretical contribution includes the following:
    - identifying the properties of a usable mobile application
    - refining the guidelines for developing a usable mobile application interface, and
    - identifying the mobile applications developed for educational purposes.

1.7. The scope of the study

The scope of the solution is as follows:

- The study focused on ODL institutions such as UNISA.
- The targeted users of the mobile artefact included approximately 300 honours research students in the School of Computing at UNISA. However, owing to the ODL format the researcher only had access to 30 participants.
- This research did not specifically consider accessibility requirements.

1.8. Research design and methodology

The study was guided by pragmatism as its research philosophy; this is appropriate when the research data is generated through intervention and assessment (Goldkuhl, 2012). A pragmatic paradigm supports the use of qualitative and quantitative methods as a practical mode to experience human conduct (Kivunja & Kuyini, 2017). The methodology used in this study was the design science research (DSR) approach (Hevner et al., 2010). The aim of DSR is "to develop an artefact through a balanced process that combines the highest standards of rigour with a high level of relevance" (Naidoo & Gerber, 2012:2). Hevner et al. (2010) introduced seven guidelines that should be followed in creating and evaluating a mobile application. The seven DSR guidelines are fully discussed in Chapter 3 (section 3.3.1). The data for the study were generated using the following methods:

- Usability testing – used to evaluate the usability of the mobile application by performing the user-product interaction within managed environments.
- Observation – an unobtrusive observation method was used during this study because the focus was on watching the way the participants interacted with the mobile application.
- Post-Study System Usability Questionnaire (PSSUQ) – after the usability testing, the participants completed a 16-item survey that measures users' perceived satisfaction with a product or system.
- Interviews – after the usability testing, interviews were conducted and recorded using an audio recorder, thus allowing the participants to express their views about using the mobile application.

Quantitative and qualitative data were generated through this study. The quantitative data generated from the PSSUQ were analysed using the Statistical Package for Social Science (SPSS) version 26, while qualitative data were generated from the post-interview questions.

Qualitative data analysis involves interpreting the data by thoroughly and accurately classifying distinct characteristics within them (Gray, 2011). The researcher used thematic analysis (as described in Chapter 4), which entails “the process of identifying patterns or themes within qualitative data” (Braun & Clarke, 2014: 79), to identify special characteristics in the data.

The research commenced with a pilot study that was conducted using two honours project students in order to test the research design, determine the reliability and validity of the research methods, and clarify the instructions. During the pilot study, the participants could not complete all the given tasks because the mobile application could not upload the electronic file that formed part of this study. This was fixed by following the design science research (DSR) process. The main study involved 30 honours project students (13 females and 17 males) who participated by using the mobile application to access information, collaborate and share the information. All participants were UNISA students.

1.9. Limitations

This study focused only on one ODL institution. The target users were the honours project students in the School of Computing at UNISA.

1.10. Brief chapter overview

The first chapter serves as an introduction. Chapter 2 contains the literature review in which ODL, mobile devices, mobile learning, mobile applications, interaction design and user interfaces are discussed. Chapter 3 presents the research design and methodology, and includes a discussion of the research paradigm and the research approach, as well as an overview of the research, the research technique, the data collection methods and data

analysis, and research ethics. Chapter 4 focuses on data analysis, Chapter 5 discusses the findings and the implications these findings have for honours project students, while Chapter 6 concludes the study.

CHAPTER 2

2. LITERATURE REVIEW

2.1. Introduction

This chapter focuses on a number of topics that relate to the application context, namely ODL, as well as mobile devices, mobile learning, mobile applications, interaction design and user interfaces. Section 2.2 focuses on ODL definitions, and its potential advantages and constraints. This is followed by section 2.3 which focuses on mobile devices and mobile learning definitions, types of mobile device, components of mobile learning and disadvantages of mobile learning. Section 2.4 covers a discussion of mobile applications, while section 2.5 discusses interaction design, the properties of usable mobile applications and the requirements of mobile applications for interaction design, which relate to sub-question 1 and sub-question 2 respectively. Section 2.6 discusses user interfaces, section 2.7 focuses on usability and usability evaluation methods, while section 2.8 concludes this chapter.

2.2. Open and Distance Learning (ODL)

2.2.1. Definitions of Open and Distance Learning

As ODL is currently used in many institutions, in this section the researcher looked at how it has been defined by various authors. Furthermore, the researcher also looked at the advantages described by different authors according to how ODL is applied.

ODL is described as a method that focuses on opening an opportunity to provide education and training, freeing students from the restrictions of time and place, and presenting flexible

access to learning for individuals or a group of students (Sen, 2012). Kudryavtseva (2014) adds that ODL is a mode of supporting a learning opportunity that is characterised by the separation of teacher and student in both time and place. Swart (2013:4) emphasises that "ODL empowers the student to decide when, where, at what pace and how learning will take place and what learning will take place". ODL assists students in overcoming a variety of challenges in order to gain access to effective learning opportunities, and has progressively evolved to meet multiple and more various learning needs (O'Rourke, 2009). ODL merges the concepts of student centredness, continuation of learning, flexibility of learning provision, the avoidance of constraints to access, the acknowledgement of credit for prior learning, as well as student support services (South Africa. Council on Higher Education, 2009). ODL has a socioeconomic effect on teaching and learning, as it extends learning opportunities to students from less advantaged social groups who cannot access higher education for various reasons, including financial restrictions or domestic activities (Baloyi, 2013). Swanepoel et al. (2009) define ODL as a system that promotes social interaction by "bridging the time, and transactional distance between student and institution, student and teacher, student and peers, and student and material". In the context of student support, Msweli (2012) concurs that ODL is a social approach to education that necessitates the supplier to use all academic resources to guarantee that the entire range of students' expectations is met.

Clearly, there are diverse definitions of ODL. For the purpose of this study, ODL will be defined as a learning method that uses technological tools such as mobile devices to reach different students in remote areas. The next section discusses the potential advantages of ODL.

2.2.2. The advantage of ODL

The following advantages have been ascribed to ODL:

- ODL supports blended learning as it merges the advantages of both avenues of teaching, that is, direct teaching and teaching through the use of technological devices (Vasileiou, 2009).
- ODL is considered a cost-effective system by many governments, as it provides ways for increasing access and managing community participation in quality higher education that can be afforded by different groups of society (Zuhairi et al., 2013).
- ODL opens opportunities for people who are unable to engage in studies through direct instructional methods, or at a traditional institution, due to financial constraints (Ferreira & Venter, 2006).

In summary, ODL offers an advantage in terms of allowing students the flexibility to study in their own time while dealing with their multiple responsibilities. In addition, with open access ODL removes the barriers to education that are caused by distance and makes it possible for students to study and interact with the teachers. It expands access to academic activities for people who are restricted by work, family or physical commitments.

Studies have presented the potential of ODL in varied ways. Sen (2012) and Zuhairi et al. (2013) discuss the potential of open and distance learning systems for education as currently practised by the open universities. Such potential includes the following:

- relaxes the entry requirements and provides equal access of admission to all people regardless of age, venue or formal qualifications from around the country
- multimedia methods in the preparation of course packages
- course materials can be printed or stored in audio/video form for self-learning
- the availability of educational resources and knowledge sharing

- provides a student support services system throughout the country
- provides unceasing evaluation through study projects, and
- provides requirements for academic initiatives by engaging professional and vocational orientation through the courses.

ODL is also considered to be a system that supports students. Minnaar (2013) indicates that academic provision for ODL students is of the utmost significance. ODL promotes the provision of affordable, less expensive and flexible academic opportunities for every student (Osujio, 2010)**.** It promotes self-motivation and independence since ODL students need to "depend on their own sense of personal responsibility and independence" (Chawinga & Zozie, 2016:13). Students may be able to interact with each other through their own unique style of learning to obtain specified credits (Van Zyl et al., 2013).

2.2.3. The contributions of ODL

Given the advantages mentioned in the previous section, ODL makes the following main contributions to higher education.

Overcoming physical distance

ODL promotes a method of study that empowers students learning online or with the assistance of moveable technological devices at their own time and place (Naidu, 2008). With this mode, ODL overcomes physical distance since students' study time is not scheduled and all the study materials are accessible at the beginning of the academic year, allowing students to engage with the courses and study at their own pace (Kocdar et al., 2018).

Flexibility

The ‘open’ nature of distance learning classically includes open permission, and the freedom to choose what, when and where to study (Okebukola, 2013). Flexible learning highlights the creation of academic activities that have the following attributes: the recognition of variety in learning methods and students’ needs**,** and the promotion of continuous learning behaviour and skills in students and academic employees (Mohakud, 2012).

Expanding access

In distance learning, students obtain information on the move and their changing context needs flexible access to academic resources (Chipangura et al., 2013). Mayisela (2013) further explains that mobile device technology could support this need. Such technology is suitable when the internet and broadband growth enable courses to be distributed in ways that were never used before, and students can use mobile phones to access a massive range of educational resources, free from the restrictions of time and space (HEA, 2009).

2.2.4. The constraints of ODL

Despite the potential advantages and contributions of ODL discussed in the previous sections, ODL has constraints to consider. The most important constraint is the physical separation between the student on the one hand and the lecturer on the other, which disallows direct interaction between the lecturer and the student (Egan et al., 2013; Osujio, 2010). The physical distance can make students feel isolated, negatively affecting their interaction with other students and the lecturers (Ekwunife-Orakwue & Teng, 2014). Therefore, collaboration is considered to be among the list of inspiring academic features that shape ODL methods (Dzakiria et al., 2013). Network connection can be another challenge in distance learning, especially when learning in an online environment (Kop, 2011). ODL requires students in all

geographical locations to have constant, reliable accessible technological resources such as laptops, mobile devices and internet connections. Another constraint of ODL as a mode of teaching is that it does not offer immediate feedback, therefore students have to wait for feedback before continuing with other activities.

2.3. Mobile devices and mobile learning

2.3.1. Definition of mobile devices

Mobile devices are defined as devices that are portable in size with content that can be downloadable from the internet such as wearable and ambient sensors, mobile applications, and location tracking technology (Singh et al., 2017; Sim, 2019). Mobile devices are currently the most used means for communication, reading books and cooperating through social media. They can be found in various environments including universities, the entertainment industry, medical institutions, military organisations and so on (Huang, 2009). Mobile devices allow users to store, produce, transmit and consume information in remote places (Traxler, 2010). These devices have exceptional features that render them superior to outdated desktop and laptop platforms (Mahmoud & Popowicz, 2010). They provide access to learning in different environments with unrestricted contact (Bice et al., 2016). Forment and Guererro (2008) emphasise that mobile devices can be very useful tools and a way to access updated information in learning. As mobile devices improves, they provide advanced attributes that make them more appropriate and less expensive, and new applications are constantly available and accessible (Zydney & Warner, 2016).

Mobile devices can promote interaction among students allowing them to access and share information with each other in remote locations. Mobile devices can facilitate effective and

flexible communication among students and teachers: students can use these devices to send assignments, receive study information and view assignment feedback and examination results. That is particularly useful in overcoming some of the ODL-related challenges mentioned in section 1.2.1.

2.3.1.1. Types of mobile devices

With the development of mobile technology, mobile devices of different types emerged. The devices used in this study include the following:

Smartphones – are the movable personal computers representing the most current stage of portable information and communication technology growth using a network and the internet (Oulasvirta & Rattenbury, 2012). Smartphones merge a mobile phone and a handheld computer into a unified device, and allow users to access, store and distribute information (e.g. email) and install new software programs (applications) (Beal, 2015). According to Lin et al (2014), smartphones are used more for mobile applications (apps) with available internet than as a phone, camera, game or multimedia players. Giving an alternative means of LMS access via mobile phones enabled students to perform small tasks, such as consulting documents, accessing course information or viewing marks, with benefit of mobility (Luis et al., 2020).

Tablet – has a touchscreen or a stylus to allow the user to type on or control the screen (Galligan et al., 2008). A tablet PC "is a completely freestanding and fully functional mobile computer and is larger than a cellular phone or personal data assistant but smaller than a traditional laptop PC" (Park & Angel, 2013:3). Although the tablet operates with a physical keyboard, users may choose to use a stylus pen, or type with their fingers on a virtual digital keyboard (Go & Tsurumi, 2010).

2.3.2. Mobile learning

2.3.2.1. Definition of mobile learning

The term ‘mobile learning’ refers to study through portable technology such as mobile devices (Roshan et al., 2013). When technological devices such as smartphones are utilised to facilitate the process of teaching and learning, this concept is called mobile learning (Mishra & Chavhan, 2012). Jiugen and Ruonan (2016:700) concur that “mobile learning is a product evolved by modern education and modern science and technology”. Mobile learning is leveraged for digital content sharing given the accessibility of mobile devices among resource-limited communities (Nampijja & Birevu, 2016). According to Roshan et al. (2013), it is simply a modification of the automated learning systems that are available and accessible through wireless networks, expanding the possibility of studying from where the student is positioned. Mobile learning can provide a suitable distance learning academic environment in which learning activities can be facilitated (Mishra & Chavhan, 2012).

2.3.2.2. Components of mobile learning

The components of mobile learning include the following:

Collaborative learning

Collaborative learning has the capabilities of coaching asynchronous and synchronous conferencing using an LMS discussion forum (Mohammad, 2016). In collaborative learning, “students participate in group discussions and interact with faculty and other students to learn from each other” (Franklin et al., 2007:3). The connectivity of mobile learning enhances collaboration in real time and instant active participation that may lead to improved decision-making (Liaw et al., 2010).

Constructivism

Constructivism generally holds that information is built or constructed by specific people from within rather than being received by students from an outside source (Al Hamdani, 2013). In constructivism, students tend to internalise outer experiences in the form of inner personal meaning (Peng et al., 2009). Therefore, students learn by actively creating knowledge by combining experiences into previous knowledge (Al Hamdani, 2013). Most handheld devices are cost-effective and thus they are accessible to students and can be used to obtain knowledge in various parts of the world (Orr, 2010). Students can develop a great deal of experience through mobile learning activities when in a remote environment.

Situated learning

This mode of learning is different from traditional classroom learning methods in which knowledge is abstract and out of context (Yasin et al., 2010). In situated learning, "knowledge and understanding can be seen as the product of the learning situation and the nature of the learning activity" (Lave & Wenger, 1991:918). According to Keskin and Metcalf (2011), learning is not purely the gaining of information by individuals, but instead a procedure of social contribution. Furthermore, teachers and instructional designers can create conditions in which students can use their technological devices to resolve problems in case-based study (Orr, 2010). Situated learning can be engaged and facilitated in the classroom or through academic materials, and "computer and mobile technologies can be cost-effective ways of accessing real contexts or recreating more authentic contexts, and facilitating interaction amongst the group" (Comas-Quinn et al., 2009:12).

In summary, mobile devices play a role in encouraging and improving students' learning. In collaborative learning, students cooperate with peers and teachers through mobile learning.

The students can obtain new knowledge and integrate it with experiences gained through constructivism on mobile learning platforms. Situated learning makes it possible for students to access learning and social contents through mobile learning. This also helps teachers to engage with students in mentoring and cooperative activities such as research.

2.3.2.3. The advantages of mobile learning

Mobile learning has advantages that are affected by the mobile devices. Mobile devices can be used to great advantage to alter how students learn, moving from old classroom methods to one that is collaborative and attractive (Wang & Shen, 2008).. A number of studies have considered the advantages of mobile learning with the use of mobile devices as discussed below.

Accessibility

Mobile learning allows teachers to educate regardless of time and space restrictions, allowing continuous learning after the class is over or outside the classroom in areas where learning takes place naturally (Huang et al., 2010). The capability to interconnect at any time or in any place is an important element of the accessibility of mobile learning (Orr, 2010). Although communication via mobile devices is as convenient as making a call, they can also be considered for posting or broadcasting information that students can access instantly (Evagorou et al., 2008). Since mobile devices have the capacity to “store multiple files, applications, and course documents as well as to provide access to mobile platforms, such as Blackboard” (Bice et al., 2016:21), it becomes easier for students to access mobile learning content without being near a computer (Du, 2015). Ally and Samaka (2013) state that the provision of a mobile device to students will allow them to acquire mobile learning resources and encourage them to study effectively.

Interaction

The portability and instant communication channels of mobile devices influence learning procedures in terms of collaborating with peers, accessing academic resources and transferring the information (Lan & Sie, 2010). The use of mobile learning promotes collaboration and interaction as students are able to learn from each other and access and share required information when needed. (Ally & Samaka, 2013). In mobile learning, “there is room for interaction between students, and with their teachers” (Roshan et al., 2013:37), and this also offers teachers and students the capability to interrelate on a more personal level with mobile devices than they would normally do (Ward et al., 2013).

Cost

The cost of mobile learning can be perceived from various viewpoints and includes the cost of the technology (programs utilised for the growth of mobile based systems) and the fundamental framework or features of a system (Oasng et al., 2013). For example, students can access and prepare short assessments or quizzes on their mobile devices without travelling. There is a capacity for knowledge and information sharing among students through mobile learning that enables an increase in mobile learning activities on campuses without face-to-face interaction (Fahri & Samsudin, 2012). Mobile devices have become a natural element of many distance academic institutions due to the growth in computer-mediated learning (Sethy, 2011). Mobile learning has the advantage of enhancing many aspects of students’ lives, such as interactive learning and collaboration.

Technological connection

Students are likely to gather in various places such as campuses, restaurants and coffee shops, that typically have wireless internet connectivity and students can easily connect and

use the internet to access academic material without carrying multiple books everywhere (Bice et al., 2013). With mobile devices the facilities, connections, discussions and content – and academic activities in all of these – are not dependent on face-to-face contact at prearranged times (Traxler, 2010). Mobile devices, because of their many applications and purposes, not only inspire students to adopt lifetime learning, but also encourage them to select a mobile learning setting (Sethy, 2011).

In summary, these advantages can benefit the students in various ways, such as saving time and the cost of travelling to libraries for research. All the advantages of mobile learning take place with the use of mobile devices. This is because mobile devices are:

- small and portable, thus can be simply carried and used by anyone without environmental restrictions
- cost-effective because of the fewer resources that are related to their use
- consume less power than other technological devices such as laptops and desktop computers
- engaging, so learning can easily be facilitated continually
- flexible with connectivity mode, such as wireless connectivity.

2.3.2.4. The disadvantages of mobile learning

Studies have presented several constraints to mobile learning in terms of the features and functions. These include the following:

Size of the mobile devices

Although the primary advantage of mobile learning relies on the portability of the device, the main restrictions to mobile learning result from the small size (Orr, 2010). Small screens cause

difficulty in reading materials on mobile devices (Sethy, 2011). Huang et al. (2008) indicated that due to text input restrictions, teachers could not request substantive responses from students as they communicate with them in mobile learning settings.

Batteries of mobile devices

Battery efficiency consistently influences the experience of the students, as it limits their phone usage (Sethy, 2011). The batteries of mobile devices should be charged frequently, as information can be lost if batteries do not have power (Hashemi et al., 2011).

Connectivity

Although mobile learning uses the internet, poor broadband signals in areas such as rural environments affects mobile phone users (Wentzel & Amsterdam, 2005). Ally and Samaka (2013) concur that the cost of connecting to the internet in some areas, such as developing countries, results in barriers to mobile learning. Hashemi et al. (2011:2478) emphasise "that bandwidth may degrade with a larger number of users when using wireless networks".

Memory space

Some mobile devices have limited storage capacity and this affects the storage of mobile learning content. The small size of the memory also limits the performance and speed of the mobile device (Ickin et al., 2012), as well as restricting the "developer in terms of memory consumption and availability" (Mahmoud & Popowicz, 2010:2). The built-in default dictionary items that appear with the keyboard frustrate some mobile phone users (Wentzel & Amsterdam, 2005). Güler et al. (2014:129) emphasise that "mobile devices are not easy to use especially in typing or entering inputs". While continuous advances in technological development are overcoming some of the challenges, these challenges are still barriers to learning, especially on the more affordable devices.

In summary, ODL as a learning approach is affected by mobile learning constraints such as network connectivity that results in poor interaction, difficulty in information access, and slow internet bandwidth. The limited memory storage of some mobile devices can cause a device to malfunction as it cannot store large files. The short battery life of mobile devices means they cannot be sustained for long hours, and the small-size screen where students need to zoom and scroll are barriers to students' success in terms of sharing and accessing information through mobile learning. Paul et al. (2013:55) state that "the key factor for student success in ODL programmes is the provision of student support services". In higher education institutions (HEIs), "mobile devices communication provides students and lecturers with a variety of communication channels which are either text based email or voice channels" (Chipangura et al., 2013:1). The communication channels usually focus on social interaction which leaves a gap in terms of focusing on academic purposes.

2.4. Mobile applications

2.4.1. Definition of mobile applications

Mobile applications are application software intended and developed specifically to operate on mobile devices, for example smartphones and tablets (Wu & Chang, 2013). Mobile applications are essentially programs that can be easily and swiftly downloaded onto mobile devices and immediately engaged without rebooting the devices (Pilgrim et al., 2010). These devices have "the built-in software and can even operate with specific developed software such as mobile applications that are used for different purposes such as performing tasks for mobile phone users" (Chien et al., 2008:2026; Dewitt et al., 2017:90). These applications are usually installed

on mobile devices by manufacturers or can be installed after being downloaded from mobile software supply platforms such as Google play store, Windows market or Apple store.

Mobile applications are considered to be application software that is intentionally developed to target or fulfil the purpose of specific users. With the use of mobile applications, information is unceasingly accessible to users, a fact that increased the necessity to develop applications that respond to the appropriate change in their users (Mizouni et al., 2014). With the swift development of mobile applications, users can cooperate and use many activities such as social media, electronic communications, online shopping, online learning and life information. Users rely on these applications for a variety of tasks, from posting comments on social media to online banking (Ravindranath et al., 2012). Mobile applications are also beneficial for academic purposes. Huang (2009:2) states that mobile applications "can be found in the fields of education, entertainment, medicine, communication services, military systems" and many other institutions. Since mobile applications can also be found in the education field, they can be developed to support education where students cooperate with each other, the academic systems and the teacher. The following section discusses the use of mobile applications in academic environments.

2.4.2. Mobile applications in educational environments

Mobile applications are considered to be a useful tool for many teachers in higher academic institutions and researchers are starting to observe progress in students' motivation to study through mobile devices (Jeng et al., 2016). Many colleges and universities use mobile applications to deliver course content to their students (Ahmed et al., 2017). The following are some of the fields where mobile applications are used:

Mobile applications in the classroom

Mobile applications have been developed and used in educational institutions for the purpose of learning, both inside and outside the classroom, regardless of time and place (Ali et al., 2016; Huang et al., 2010). Mobile applications can be used in the classroom to improve the students' learning experience and promote participation and collaboration (Burd & Algarni, 2015). Kocdar et al. (2018) emphasises that the use of mobile applications in the classroom encourages a self-regulated learning mode where the students can follow the planned learning. This is directed by an academic facilitator or teacher who manages the class operation. Bomhold (2015) states that interaction through a mobile application increases the students' participation in the class.

Mobile applications in library systems

Several mobile applications have been developed for library systems (Chiu et al., 2014; Mansour & Thomsett-Scott 2016; Wei et al., 2015). Using mobile applications, the user can classify a focus area among the books and find a list of digital content once the meaning and focus area of the bookshelf are displayed (Hahn, 2012). Today, most academic and public libraries give services through mobile applications, along with their traditional services (Mansouri & Asl, 2019). Some mobile applications that are developed for the library have the following features (Connolly et al., 2011):

- enable users to locate the library catalogue
- enable users to have access to students' library accounts
- include the library's operation schedule
- include the contact information of the library
- include a collaborative library map
- enable users to ask for help from library staff members

- enable users to connect to library websites and resources.

Mobile applications in distance learning

In distance learning, mobile applications enable collaboration and provide students with increased ability to learn, and also support the varying pace of the students (Shroff et al., 2015). Mobile applications have been developed and implemented in different educational fields to encourage and facilitate distance learning (Al-Adwan et al., 2018; Hsu & Ching, 2013). In distance learning, mobile application promote self-learning where a student can learn without a help from the teacher (Singh et al., 2017). Vázquez-Cano (2014) indicates that mobile applications are used in various higher educational institutions through distance learning:

- Students use the mobile application to access their study materials, assessment feedback and their results both online and offline, and participate in class discussions, obtaining essential participation points regardless of their position.
- Mobile applications can offer the students travel schedules, an event catalogue, an online calendar, and thus provide students with an opportunity to lead case studies on mobile learning.
- Mobile applications allow students to use their mobile devices to develop, collaborate, and assess queries regarding academic subjects.
- Using mobile applications, students can search the library resources, access the available video content, and be informed regularly about sports activities.

Furthermore, Hsu and Ching (2013:119) concur that “mobile applications increase the interaction between the teachers in distance learning”. Teachers are able to monitor students’ progress through distance learning (Bicen & Kocakoyun, 2013). The application thus provides significant benefits to the education field, as it enables constant mobile learning, which enhances the educational experience, making it ubiquitous (Ahmed et al., 2017). Ojino and

Mich (2018) state that the use of mobile applications in supplementing learning presents a great advantage for academic institutions; in addition, management and other functions could benefit from students' behaviours and needs in relation to mobile technologies and apps.

In this study, the researcher considered the mobile applications developed for educational purposes in previous years. Table 2.1 indicates the names of the mobile applications and their purposes:

Table 2.1: Mobile applications developed for educational purposes.

Name	**Purpose**
UCLA	Provides access to library databases and catalogues (Chang, 2013)
Ebookmaker	Enables students to create their own mobile documents (Seol et al., 2012)
VocBlast	Helps university students learn technical vocabulary (Ali et al., 2016)
SciPro	Supports and facilitates autonomous learning in higher education (Aghaee & Larsson, 2013)
ThinknLearn	Has the educational purposes of increasing students' experience as well as deploying them in technical inquiry practices (Ahmed & Parsons, 2013).
MobileEdu	Improves the pedagogical experiences of students (Oyelere et al., 2018) .

Some of these mobile applications have been implemented and accessed in previous years to allow for the interaction of students with universities' learning management systems. See the links below:

http://learnenglish.britishcouncil.org/en/apps

http://www.gcflearnfree.org/mobileapps

http://www.bucknell.edu/mobile

https://www.osu.edu/downloads/apps/

http://www.nwu.ac.za/download-NWU-app

The given examples of mobile applications in Table 2.1 were developed and implemented to facilitate learning in various academic institutions or learning groups. Sharing information and collaborating to find appropriate resources in the ODL context is still a challenge due to the following constraints: lack of interaction and communication (Dzakiria et al., 2013), and time management for working students (Landau, 2012). Furthermore, in developing countries students also have to deal with expensive basic technologies such as broadband (Minnaar, 2013). This leaves a gap in information sharing and collaboration using mobile tools among students in ODL. The mobile application developed in this study specifically gives support only to honours project students in conducting research through ODL, especially those who are new to research; hence the application is not applicable to all university students.

In summary, with the increased use of the mobile devices, mobile applications have been introduced for the purpose of education (Bicen & Kocakoyun, 2013). With mobile applications, information is continuously available to users regardless of geographical location and time. Accordingly, students can use mobile applications to interact and collaborate with each other in terms of learning and information sharing. ODL empowers the student to decide when, where, at what pace, and how learning will proceed (Swart, 2013). Since ODL can be conducted without time and place restrictions, mobile devices with mobile applications can enable students to interact within the ODL environment. Using the mobile applications for educational purposes, an effective educational environment can be developed without boundaries. As mobile applications address students' needs for flexibility and portability, they can be considered as a learning experience that can bring together the two forms of prescribed and casual learning, in order to produce flexible collaborative learning.

2.5. Interaction design

2.5.1. Definition of interaction design

The term ‘interaction design’ is used to define various activities in designing and developing dissimilar artefacts such as “artistic objects, websites, PC applications, GPS systems, mobile applications, and web applications” (Huang, 2009:3). Interaction design involves “the analysis of technology, usability, cognitive psychology, and activities, to assist users in obtaining operating efficiency and safety” (You & Huang, 2012:3). Sharp et al. (2007) define interaction design as developing collaborative products that assist people to communicate and cooperate in their daily activities. Jones and Marsden (2006) define interaction design as the topic of defining the behaviour of developed artefacts and systems in the way they are interacting with their users.

Interaction designers give great prominence to “user goals and experience, and evaluate designs in terms of usability and affective influence” (Sharp et al., 2007:15). Involving real system users helps interaction designers to design systems that meet users’ needs. Good interaction design can accommodate all users; its purpose is to decrease frustration and expand user efficiency and satisfaction (Huang, 2009). From these definitions, we can observe a key point; that is, that the designed product or artefact should enable users to meet their needs and avoid any frustrations. In the context of a mobile application for learning, the designed application should support students with appropriate interaction through their learning system.

2.5.2. The properties of a usable mobile application

Certain properties are relevant when implementing and developing a usable mobile application. Studies have identified several properties (Baktha, 2017; De Barros et al., 2013; Huang, 2009; Ross & Gao, 2015), including the properties of the application layout, navigation images, content, hierarchical menus, and labels or captions. Rogers et al. (2012) state that the properties of system application should be designed properly as a poor design can frustrate the users and make them reject the application or tool. Table 2.2 lists the properties used for designing the artefact in this study. These identified properties were extracted from the literature. The search criteria included the keywords – mobile application/app properties; mobile application/app interface properties – as well as research papers published between the years 2013 and 2019. The databases used were IEEE, ACM, Web of Science, Scopus, and Google Scholar.

Table 2.2: Properties of a usable mobile application

Properties Identification	**Description**	**Authors**
Application layout	A simple indication on the screen of what is to be done.	Braden et al. 2017; Wang et al. 2019
Navigation	The design and implementation of the mobile application should take advantage of scrolling if required and this should be on the interface.	Flora et al. 2014; Wetzels et al. 2018
Images	The images should fit the size of the mobile device and provide general spaces between them. Icons should be used along with text when designing buttons	De Barros et al. 2013; Ross & Gao, 2015
Content	The displayed information on an interface should be clearly visible.	Kocakoyun and Bicen, 2017; Perr, Eichler, and Filho, 2018; Jeno et al. 2017
Hierarchical menus	Identified menus of the same category should be grouped together.	Bouzit et al. 2017; Antonelli et al. 2018; Hoehle et al. 2016
Colour	The perceptual guidelines for good colour usage should be followed.	Baktha, 2017; De Barros et al. 2013
Labelling/caption	These give the description of items such as buttons on the mobile application.	Brinkhoff, 2017; Shirazi et al. 2013; Ross et al. 2018; Oh et al. 2017

The requirements of mobile applications are considered against the background of the properties. The following section discusses the requirements of a usable mobile application.

2.5.3. The requirements of mobile applications for interaction design

Mobile applications can be developed in the same way as other embedded or traditional applications that run on desktop computers. The consideration of hardware, security,

performance, speed and storage requirements is also included in mobile application requirements. However, some features and issues of mobile applications differ from other traditional software applications, mobile applications present additional requirements that are less commonly found in traditional software applications. These include the following (Wasserman, 2010):

- Potential interaction with other applications – most embedded devices have software applications that are installed by the manufacturer, whereas mobile devices can run various applications from different sources, and interaction can take place among them.
- Sensor handling – most modern mobile devices have many features that can adapt to real-world operations.
- Native and hybrid (mobile web) applications – most embedded devices operate only with pre-installed software directly on the device, but mobile devices often contain applications that use services through mobile networks or connect via the internet.
- Families of hardware and software platforms – often, embedded devices run applications that are designed for and dedicated to their properties, whereas mobile devices may execute applications that are dedicated to different devices, supporting various kinds of operating systems.
- Security – most embedded devices are fully secured; there is no direct way to access their software and disturb their operation. However, mobile platforms are not fully secured as they can download and install new software, and this can lead to the installation of malware applications that can disturb the entire operation of the device such as the secret transmission of internal information.
- User interfaces – with a custom-built embedded application, the developer can control all aspects of the user experience, but a mobile application should have common user

interface requirements with other applications and must follow the developed user interface rules.

- Complexity of testing – natural applications are evaluated in the traditional way or via a computer-based emulator. However, web applications developed for mobile devices are difficult to test.
- Power consumption – the battery life of mobile devices is affected by the use of many application software features.

In terms of menus, actual interaction with a list of organised menus can be accomplished by having the menu items required in both the origin menu and the final menu structure (Amant et al., 2004). In order to design a functional system, interface designers should frequently involve users who will be interacting with the developed systems where the system will be used This will indicate how the user will interact with the system, and what the user experience will be (Huang, 2009). Interaction design encompasses interface design and contributes to the interaction between the user and the interface as part of the system development process (Takayama et al., 2016).

2.5.4. Summary

During mobile application interaction design the users' expectations are considered to be very important. Such design determines how easy potential users will find the expected service of the mobile applications. The designer's task is to create an intuitive interface that will guide users in interacting with the mobile application. This allows the users to use the mobile application functionality without problems.

2.6. User interface

2.6.1. Definition of user interface

A user interface is defined as a group of instructions or menus through which a user runs or executes a program (Binti-Ayob et al., 2009). A user interface permits users to interact with the software features in a natural and intuitive way (Binti-Ayob et al., 2009; Lumertz et al., 2016). User interfaces make a huge impact on the usability of the application (Binti-Ayob et al., 2009; Nivethika et al., 2013).

A user interface system can be used to dynamically adapt a graphical user interface (GUI) for a user (Sills, 2015). GUI refers to the platform that allows users and the system to process data in a visual form (Jin & Ji, 2010). The GUI can be a web page, a gaming screen, a login page, a document and the like. Applications with user interfaces such as GUI enable users to interact effectively with the systems.

Since demand is growing for common and unceasing access to data and for interactive and embedded devices, the “generation of user-interfaces based on the user’s situation requires advanced techniques to adapt content at run-time” (Hervás & Bravo, 2011:40). The user interface was one of the important factors to be measured when the mobile application in this study was developed. The user interface of the mobile application developed was measured by considering the three aspects of usability namely:

- More efficient to use: “takes less time to complete the task” (Rogers et al. 2012:19).
- Easier to use the system: “this refers to the effectiveness of the system. Processes can be done and learned by observing the object” (Rogers et al. 2012:19).
- Satisfaction: “meets users’ expectations and objectives” (Rogers et al. 2012:19).

ISO (1998) defines usability as “the extent to which a product can be used by specified users to achieve specific goals with effectiveness, efficiency, and satisfaction in a specified context of use”.

2.6.2. User interface design

The important area to be considered during the designing of the application interface process is that the design will enable the user to access the digital information (Ismail et al., 2016). This process involves human–computer interaction (HCI) which is concerned with the consideration of how people are related or connected to computer systems and applications (Binti-Ayob et al., 2009). The consideration concentrates on the design of the user interface which is built on the users’ requirements. The design of the user interface involves the experience on both the users’ and the systems’ side (Huang, 2009). The user interface design is tested when the users interact with the developed application (Bruno & Muzzupappa, 2010). Binti-Ayob et al. (2009) give four guidelines for mobile application interface design in meeting users’ needs and satisfaction. These are presented in Table 2.3.

Table 2.3: Guidelines for mobile application interface design (Binti-Ayobl et al., 2009)

Existing guideline	**Characteristics**
Golden rules of interface design (adjusted for mobile interface design) (Shneiderman, 2016).	Carry over four elements: 1. Enable frequent users to use shortcuts 2. Offer informative feedback 3. Design dialogue to produce closure 4. Support internal locus of control Make some modification: 1. Strive for consistency 2. Permit easy reversal of action 3. Offer simple error handling 4. Reduce short-term memory load Seven additional elements: 1. Design for multiple and dynamic contexts 2. Design for small devices 3. Design for limited and split attention 4. Design for speed and recovery 5. Design for “top-down” interaction 6. Allow for personalisation 7. Design for enjoyment
Seven usability guidelines for mobile devices (Warsi, 2007)	1. Meet users’ needs quickly 2. Don’t repeat navigation on every page 3. Clearly distinguish selected items 4. Make user input as simple as possible 5. Only show essential information 6. Place basic browsing controls on the page 7. Design mobile-friendly page layout
Human-centred design (ISO, 1999)	1. Understand and specify the context of use 2. Specify user and organisational requirements 3. Produce design and prototypes 4. Undertake user-based assessment
Mobile web best practices 1.0 (W3C)	1. Navigation and links 2. Page layout and content 3. Page definition 4. User input

In line with the guidelines presented in Table 2.3, the researcher conducted a systematic literature review with the following parameters: the search criteria included the keywords

mobile application/app interface design; mobile application/app design guidelines; mobile application/app interface for learning; as well as research papers published between January 2014 and December 2018. The databases used were IEEE, ACM, Web of Science, Scopus, and Google Scholar. The guidelines that are most relevant to this study are presented in the second column of Table 2.4. In the first column, the existing guidelines from Table 2.3 are provided. These guidelines were compared and those relevant to this study were selected as indicated in the third column.

Table 2.4: Comparison of mobile application guidelines towards selecting the most relevant for this study

Existing guideline based on mobile application (Binti-Ayob et al., 2009)	**Mobile application guidelines retrieved from literature**	**Relevance to this study**
1. Enable frequent users to use shortcuts (Shneiderman, 2016)	Reduce the number of interactions and to increase the pace of interaction (Aottiwerch & Kokaew, 2017; Nasution et al., 2016)	✓
2. Offer informative feedback (Shneiderman, 2016)	Provide feedback for every task performed (Adrianto et al., 2016)	✓
3. Design dialogue to produce closure (Shneiderman, 2016)	Organise sequence on action into group (Kascak et al., 2014)	✓
4. Support internal locus of control (Shneiderman, 2016)	"Allow your users to be the initiators of actions" (Adrianto et al., 2016)	x
5. Strive for consistency (Shneiderman, 2016)	Maintain consistency (De Paula et al., 2014; Zamri & Al Subhi, 2015)	✓
5. Permit easy reversal of action (Shneiderman, 2016)	Allows users to reverse their actions (Adinugroho et al., 2017)	✓
6. Offer simple error handling (Shneiderman, 2016)	Help to detect the error (Zamri & Al Subhi, 2015)	✓

7. Reduce short-term memory load (Shneiderman, 2016)	Design for little memorisation during the performance of tasks (Powell & Wimmer, 2015).	X
8. Design for multiple and dynamic contexts (Shneiderman, 2016)	Access the resources in different formats (video, text and voice) (Ismail et al., 2016)	X
9. Design for small devices (Shneiderman, 2016)	Consider the size of the devices (De Paula et al., 2014)	✓
10. Design for limited and split attention (Shneiderman, 2016)	Group related information together (Kascak et al., 2014)	✓
11. Design for speed and recovery (Shneiderman, 2016)	Allow applications to be stopped, started and resumed with little or no effort (De Paula et al., 2014)	✓
12. Design for “top-down” interaction (Shneiderman, 2016)	Make regular used information to be easily accessible (Ismail et al., 2016)	✓
13. Allow for personalisation (Shneiderman, 2016)	Offer personalised or tailored content and services (Powell & Wimmer, 2015)	X
14. Design for enjoyment (Shneiderman, 2016)	The concept to please the users (Merikivi et al., 2016)	X
15. Meet user’s needs quickly (Warsi, 2007)	“Allows user to meet their needs and maintain consistency” (Schnall et al., 2016::246)	✓
16. Don’t repeat navigation on every page (Warsi, 2007)	Categorise and display all required information (Zamri & Al Subhi, 2015)	✓
17. Clearly distinguish selected items (Warsi, 2007)	Allow the user to select options (Zamri & Al Subhi, 2015)	✓
18. Make user input as simple as possible (Warsi, 2007)	Reduce unnecessary user input as much as possible (Powell & Wimmer, 2015)	✓
19. Only show essential information (Warsi, 2007)	Display expected information (Schnall et al., 2016)	✓

20. Place basic browsing controls on the page (Warsi, 2007)	Provide access to your web pages from either a browser or on mobile application (Kascak et al., 2014)	x
21. Design mobile friendly page layout (Warsi, 2007)	"All users to navigate between hierarchy of screens" (Hujainah et al., 2016:6)	✓
22. Understand and specify the context of use (ISO 13407, 1999)	Includes accessibility considerations such as assistive technologies (Zamri & Al Subhi, 2015)	✓
23. Specify user and organizational requirements (ISO 13407, 1999)	Design an application that can meet users' and organisations' needs (Kascak et al., 2014)	x
24. Produce design and prototypes (ISO 13407, 1999)	Allows prototypes of an elaborated functionality to be produced (Bähr, 2017)	✓
25. Undertake user-based assessment (ISO 13407, 1999)	Elevate the content users care about (Ismail et al., 2016)	x
26. Navigation and links (W3C)	Avoid scrolling, especially horizontal scrolling (Hujainah et al., 2016)	✓
27. Page definition (W3C)	Enable users to move between pages (Kascak et al., 2014)	x

The refined guidelines for mobile application interface design

To support the design process, the guidelines selected from Table 2.4 were refined and grouped together according to the software development phases presented in Table 2.5.

Table 2.5: Selected and refined guidelines for mobile application interface design

Phases	Guidelines	Studies conducted
Analysis	**Context of use** *Specify the requirements of the target users* 1. Define the mobile application usability 2. Identify the specific tasks of the users 3. Group tasks of the same category	Karthik et al. 2014; Swearngin et al. 2018; Ahmad et al. 2018; Shneiderman, 2016
Design	**Context of medium** *Develop the application* 1. Design for portable devices 2. Design for collaboration 3. Strive for consistency 4. Simplify user input 5. Design for speed and recovery 6. Only show essential information 7. Navigation 8. Meet users' needs quickly 9. Clearly distinguish selected items	Garis & Kebolehgunaan, 2016; Hujainah et al. 2016; Khaddage and Cosío Hernández, 2014; Shneiderman, 2016; Al-nuiam, 2015; Ruzic et al. 2016; Swearngin et al. 2018
Testing and implementation	**Context of evaluation** *Evaluate design against the user requirements* 1. Usability testing 2. Observation	Becker, 2015; Desruelle and Gielen, 2015; Shneiderman, 2016; Thitichaimongkhol & Senivongse, 2016

For navigation, "all of the main categories of the applications should be displayed on the home screen to enable users to easily understand the orders of menus and system organization" (De Barros et al., 2013:377). On the other hand, "users with less experience may require an interface that is in-built and easy to navigate and which assist them to reach their need" (Harrison et al., 2013:4). Satisfaction comes when the users are able to accomplish their task through the application. This also includes collaboration where users commonly expect to

share only relevant information (Hoehle & Venkatesh, 2015). Harrison et al. (2013) indicate that during the process of application development extra features may be implemented in an application to allow the users to achieve their needs through the application. The user interface design must be clear; this will assist users to understand all elements of the application (Paz & Pow-Sang, 2014). The interface should also be in-built to allow both less experienced and expert users to use the application (Paz & Pow-Sang, 2014). The achievement of these aspects will provide a degree of usability such as that discussed in the next section.

2.7. Usability

2.7.1. Definition of usability

Usability is seen as one of several significant aspects of quality for any type of product (Paz & Pow-Sang, 2014). Usability is defined according to the International Standardisation Organisation as “the *effectiveness*, *efficiency* and *satisfaction* with which specified users can achieve specified goals in a particular environment” (ISO, 1998). According to Taylor et al. (2009), *effectiveness* is defined as the comprehensiveness and correctness with which users accomplish a certain goal. *Efficiency* refers to task completion time. Effectiveness and efficiency represent different kinds of performance measures (Sonderegger & Sauer, 2010). *Satisfaction* refers to how users react to the product; “it is a subjective measure that is typically collected in usability tests by means of questionnaires” (ISO, 1998). Tullis and Albert (2013) describe usability as having the following three themes:

- involving the users when developing the product
- the user performs tasks on the product
- user interaction with the developed product.

2.7.2. Usability evaluation methods

Usability evaluation “is one of the major bases of user interface design” (Greenberg & Buxton, 2008:2). Usability evaluation helps to assess the designed products to guarantee that their real behaviour meets the users’ needs as expected (Dix et al., 2004). Greenberg and Buxton (2008) concur that usability evaluation can be included during the acceptance test stage, where task completion time, amount of error rates, and the response of users to the system can be measured.

Usability evaluation methods are “procedures composed by a series of well-defined activities to collect data related to the interaction between the end user and a software product, in order to determine how the specific properties of a particular software contribute to achieve specific goals” (Paz & Pow-Sang, 2014:12). Usability evaluation methods were previously established to precisely assess WIMP (Window, Icon, Menu, Pointing device) interfaces, which are commonly used for the applications on desktops (Fernandez et al., 2011). Studies also show that WIMP was used to assess mobile application interfaces (Roth, 2019; Vazquez & Proctor, 2016). Rogers et al. (2012:437) classify evaluations into three groups, “depending on the setting, user involvement, and level of control”. These are discussed as follows:

Natural setting of the users

This category is used mainly to assist usage for new technologies to be classified; initiate the need to design a new system; simplify and introduce technology or reuse current technology in a new context. Approaches that are naturally used involve “observation, interviews and logging” (Rogers et al., 2012:438).

Any setting not involving users

Evaluations that operate without users' participation are directed through settings in which the researcher has to visualise or represent the way in which an interface will be used. This category includes "heuristic evaluation that applies knowledge of typical users guided by rule of thumb" (Moumane et al., 2016:4), "and walkthroughs that include stepping through a scenario or answering a set of questions for a detailed prototype" (Paz & Pow-Sang, 2014:12).

Controlled settings involving users

Controlled settings allow evaluators to regulate the task performed by users, when they should perform it, and the time they take to perform it. This group of evaluations consists of usability testing which is conducted with the users of the system that needs to be evaluated (Blecken et al., 2010). Usability testing "includes gathering data by means of a merging of methods, namely: experiments, observation, interviews and questionnaires" (Rogers et al., 2012:438). The way in which this study applied these methods is discussed in detail in Chapter 3 (section 3.5.2.)

2.7.3. Summary

In summary, there are different characteristics for mobile application interface design of which some were considered and used in this study. The characteristics that involve user input, user needs, navigation, interaction, and satisfaction were found to be very important for developing the mobile application for information access, collaboration, and information sharing.

2.8. Conclusion

The aim of this chapter was to explain the theoretical framework that formed the context for this study. This chapter presented an outline of the basic definitions and relevant issues concerning ODL, mobile devices, mobile learning, mobile applications, interaction design and user interfaces. The topics discussed in relation to the theoretical framework for this study included features of ODL, the potential and constraints of ODL, types of mobile devices, potential and constraints of mobile devices, the use of mobile applications in education, and the essence of user interface and interaction design for mobile applications. The properties of a usable mobile application were abstracted from the literature, and synthesised and presented in response to RQ1. The requirements for a usable mobile application most relevant for the ODL context were also synthesised from the literature by considering the ODL constraints mentioned and these were presented in response to RQ2. Furthermore, the usability categories and evaluation methods were discussed since they are relevant when designing a usable interface and determining whether the application designed is usable.

Despite the mobile applications that have been developed for supporting learning, there is a lack of customised tools to address ODL constraints and provide students with access to relevant information resources for conducting research. These constraints include a lack of interaction and communication, expensive basic technologies such as broadband, as well as time management for working students. The aim of this study was to investigate whether a mobile application would be useful for students in allowing access to information resources, sharing research articles, sharing ideas, interacting with each other and forming study groups. Therefore, the properties of usable mobile application interfaces identified in this chapter, together with the requirements for a usable mobile application in an ODL environment, were

used to inform the design of the mobile application developed in this study. In addition, some of the usability methods discussed were used in the evaluation of the application.

CHAPTER 3

3. RESEARCH DESIGN AND METHODOLOGY

3.1. Introduction

The purpose of this chapter is to present the strategies and techniques used to reach the objectives of this research. It begins by discussing the research paradigm and the research approach, then moves on to give an overview of the study, the research technique, data collection methods and data analysis, and to discuss research ethics.

3.2. Research paradigm

A research paradigm is the theoretical framework used by the researcher to study the approach taken to plan the investigation such as establishing the research methods to be followed and the way of analysing the data (Kivunja & Kuyini, 2017). The different research paradigms rely on different analytical basics and insights of realism that are applied by related methodological viewpoints and procedures (De Villiers, 2005b). Oates (2011) states that there are four different philosophical paradigms: critical research, positivism, interpretivism and pragmatism. Gray (2011) identifies positivism and interpretivism as the major research paradigms.

3.2.1. Critical research

Critical research is concerned with classifying balance of power, difference of opinion, and contradictions, and allowing individuals to remove them as the basis of disaffection and control (Oates, 2011). This method of investigation “is a meta-process of study, which questions currently held standards and expectations and challenges conventional social structures”

(Gray, 2011:25). Critical research aims to disclose unseen interests and programmes, leading to progress in and the arrangement of systems and to reveal the expected tasks that systems are anticipated to play in reinforcing present common structures and expanding control (Cecez-Kecmanovic, 2011). This type of research accommodates both investigators and participants allowing them to abandon what is known as ‘false consciousness’ to construct new avenues of knowledge that lead to real action (Gray, 2011). Oates (2011) states that critical research is less practised than positivism and interpretive research. These are discussed in the following sections.

3.2.2. The positivist paradigm

The positivist paradigm represents the traditional method of research and holds true more for quantitative research than qualitative research (Creswell, 2014). The positivist paradigm holds that information is complete and unbiased and confirms the existence of one unbiassed truth (De Villiers, 2005b). In terms of this paradigm, findings are largely obtained with little interference and bias on the part of the researcher through objective coding of participants’ verbatim accounts and non-participant observation (Gray, 2011). The positivist paradigm includes a research procedure that is employed to determine observations and respond to queries (Kivunja & Kuyini, 2017), and is generally conducted using quantitative methods.

3.2.3. The interpretivist paradigm

The interpretivist paradigm does not operate like the positivist paradigm to authenticate or invalidate theory, but attempts to classify, discover and enlighten the way in which all aspects in a certain cultural context are connected and interdependent (Oates, 2011). Using this paradigm, the researcher is less concerned with duplicating findings than with completing deep

assignations with the participants to obtain authentic accounts of how they develop their common certainty (Gray, 2011). All attempts are provided as a way of understanding and interpreting opinions on the observed topic (Kivunja & Kuyini, 2017). This also includes how the researcher constructs social reality through their interpretation of their findings (Gray, 2011). Interpretivists expect to observe the subject in order to provide a good understanding of the phenomenon (Oates, 2011), and this involves qualitative methods.

3.2.4. The pragmatism paradigm

The pragmatic method is adopted from mixed methods research and is based on the view that knowledge is both socially constructed and based on the reality of the world we experience and live in (Johnson et al., 2007). Mixed methods research applies when both quantitative and qualitative data are gathered and evaluated in a single study after the data have been collected and arranged simultaneously or consecutively, and involves the combination of data from several phases of the research process (Creswell et al., 2003; Flick, 2006). In terms of pragmatism, data are gathered through assessment and intervention (Goldkuhl, 2012). The pragmatic paradigm advocates the use of qualitative and quantitative research as a practical way to observe and understand people's reactions (Johnson & Onwuegbuzie, 2004; Kivunja & Kuyini, 2017). Pragmatism provides an influential view of knowledge and understanding that is used in action for making a purposeful difference in practice (Goldkuhl, 2012). Hevner (2007:91) emphasises that "pragmatism is a school of thought that considers practical consequences or real effects to be vital components of both meaning and truth". In this study, pragmatism was applied since it is the philosophy most often used for DSR (Hevner, 2007).

3.3. The research approach

3.3.1. Design science research

The method used in this study is a design science research (DSR) approach, which is "primarily concerned with research into design as science" (Hevner et al., 2010:78). The purpose of DSR is "to develop an artefact through a balanced process that combines the highest standards of rigour with a high level of relevance" (Naidoo & Gerber, 2012:2). DSR produces an innovative approach for accomplishing a common goal, which comprises an artefact as the main contribution of the research (Livari & Venable, 2009). Such new and innovative artefacts generate new certainty, besides attempting to explain the existing reality or assisting to make it understandable. In line with this definition, a DSR methodology was used to develop and test a mobile application as a tool to support students in the ODL environment. Hevner et al. (2010) present seven guidelines to assist investigators, assessors and readers to have knowledge of what establishes DSR. These guidelines are as follows:

- **Design as an artefact**: A new, practical artefact must be designed and developed as a solution to an acknowledged problem. The result of DSR is a purposeful IT artefact.
- **Problem relevance**: The solution should be very useful in resolving the exact problem; even though it need not be fully operational, DSR must construct IT-related solutions to existing problems.
- **Design evaluation**: Appropriate evaluation methods, including observational, analytical, experimental, descriptive and testing techniques should be applied. The evaluation of the DSR artefact should be based on usefulness, quality and effectiveness.
- **Research contributions**: These should be clear, verifiably innovative and interesting. DSR contributions should be based on areas of the design artefact, design fundamentals and design methods.

- **Research rigour**: Rigour is necessary but should not reduce relevance. The correct methods of DSR must be applied in both the development and the assessment of the artefact. Measurements should be linked to the assessment principles. Additionally, the human aspects should be addressed appropriately.
- **Design as search process**: Suitable methods are iteration, heuristic search, and generate-and-test cycles. A functional artefact should meet or fulfil the users' needs while operating in line with the problem environment.
- **Communication of research**: There should be a successful presentation to an audience to prove that DSR addresses the identified problem.

The reason why DSR was selected

There are three reasons why DSR was selected for this study. Firstly, DSR follows the correct process for planning and developing artefacts to resolve experiential problems, to make research contributions, to assess the plans and development of the artefact, and to present the outcomes to appropriate audiences (Hevner et al., 2010). Secondly, DSR's artefacts "include constructs, models, methods, and instantiations, and this will help in developing a mobile application as one of IT artefacts' products" (Peffers et al., 2007:101) . Thirdly, DSR includes "new properties of technical, social, or informational resources" (Peffers et al., 2007:101). In short, this definition involves any well-designed artefact with an embedded solution (Peffers et al., 2007). Furthermore, DSR is suitable for this study since the IT artefact developed was a mobile application, and this was one of the special needs in educational research projects in supporting students to address their research problems.

3.3.2. Design science research process

According to Peffers et al. (2007) DSR methodology is comprised of the following six activities in a defined sequence:

1. Identify and motivate the problem.
2. Define objectives for a solution (quantitative or qualitative).
3. Design and develop the artefact (a construct, model, method or instantiation).
4. Demonstrate use of the artefact to solve an instance of the problem (experiment, case study, proof etc.)
5. Evaluate: Use metrics and analysis to observe and measure to what extent the artefact solves the problem. If necessary, return to activity 3 to improve the artefact.
6. Communicate to the audiences.

These activities are depicted in Figure 3.1

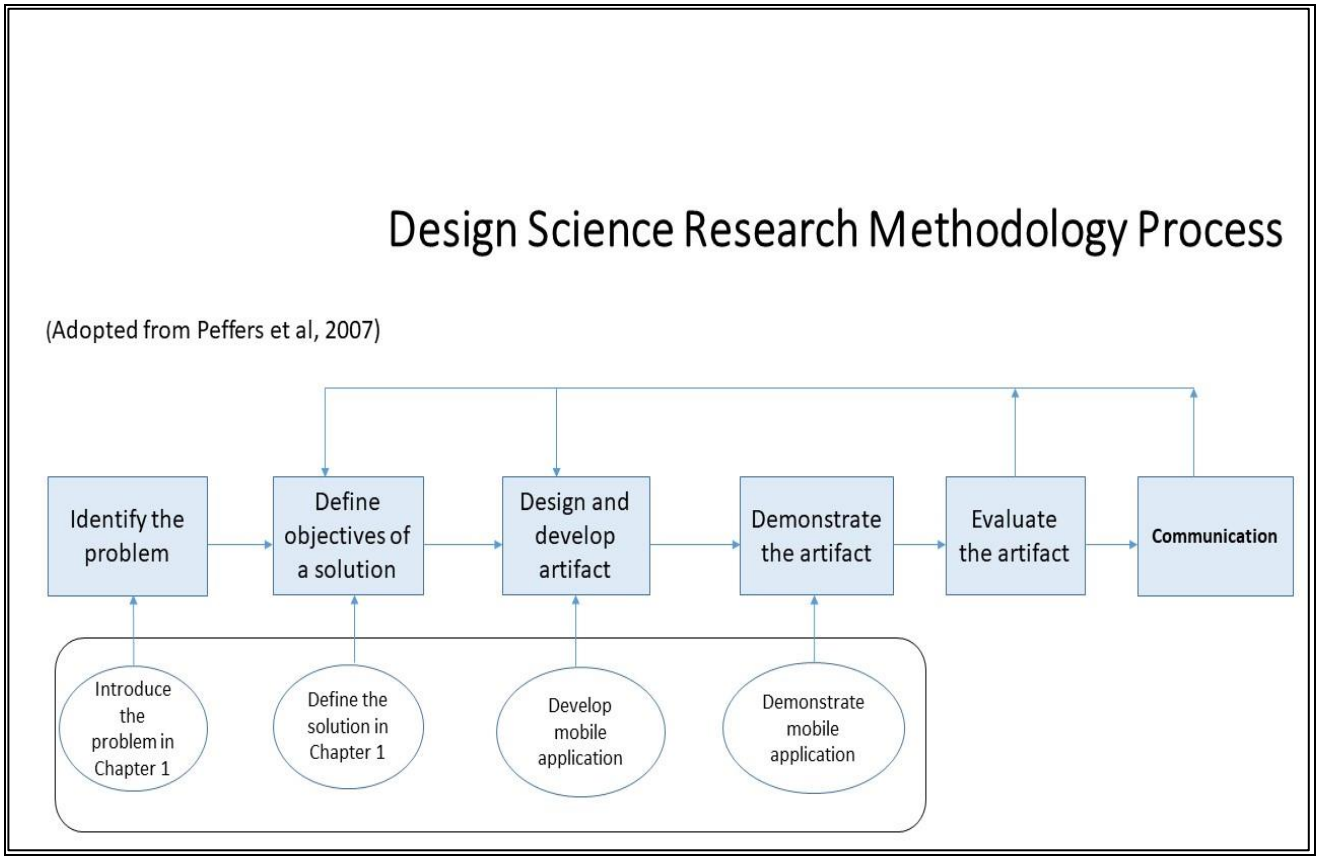

Figure 3.1 Depicts how DSRM was adopted and used in this study

The adoption and use of the DSRM is discussed below:

Problem identification

There are some students who are new to research and require support in accessing information resources to pursue research. Providing students with access to information resources support becomes a problem in ODL, especially in developing countries, due to information access constraints that are introduced by the distance between the students themselves and between students and teachers. The constraints include lack of interaction and communication (Dzakiria et al., 2013), expensive basic technologies such as broadband (Minnaar, 2013), and time management for working students (Landau, 2012). ODL students at honours level have unique needs including collaboration with peers, information access, and information sharing (see Chapter 1) that are not being met by the available support systems.

Define the solution objective

The objective was to create a mobile application that offers the honours project students a supportive environment in which they can access information resources. The mobile application provides an interface for information access, collaboration and knowledge sharing. The design and development of the mobile application is described in this chapter. This mobile application allows students to access information resources, share research articles, share ideas, interact with each other and form study groups.

Design and development

The artefact is a mobile application that supports students in information access, collaboration and knowledge sharing. The researcher developed the mobile application using the Java Android Studio, PHP, HTML, and CSS programming languages. See the code of application on Appendix M. The researcher selected only the properties and the requirements that are

suitable for the artefact of this study. The properties and requirements are discussed in detail in sections 2.5.2 and 2.5.6 respectively, and include the following:

- User input – to allow users to enter the required data
- User needs – to meet the users' expectations
- Navigation – to navigate through the different tabs of the mobile application
- Interaction – to allow users to interact with the mobile application

The researcher selected these characteristics by focusing on the purpose of the mobile application; namely, information access, collaboration and information sharing.

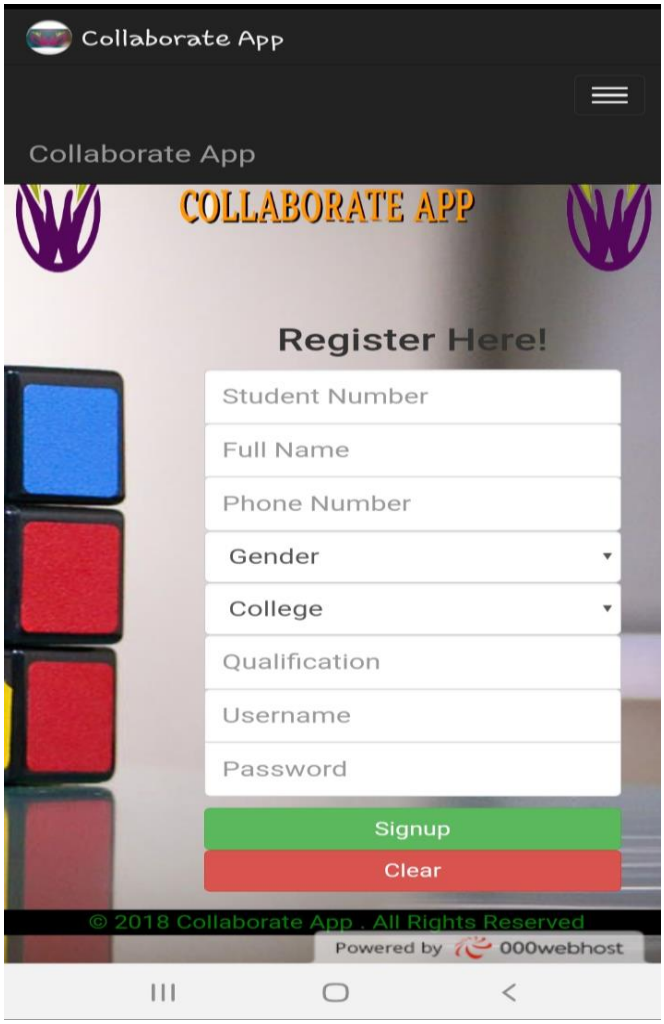

Figure 3.2: The mobile application login

Demonstration

After developing the mobile application, the researcher demonstrated to the participants how the mobile application can be used to collaborate with peers, share information and access the information. In addition, the instructions for using the mobile application were given to the participants (see Appendix F). The developed mobile application allows the students to register and log in (see Figure 3.2). After logging in successfully, they access the following tabs as indicated in Figure 3.3:

- Profile: This is used by the student to view his/her profile.
- Share Info: This is the tab where the students share information by uploading electronic articles and their links (see Figure 3.4).
- Resources: The uploaded electronic articles and their links are accessed in the resources tab. If the students cannot access electronic articles, the alternative is to access article links (see Figure 3.5).
- Discussion: This is where students collaborate and interact with each other (see Figure 3.6)

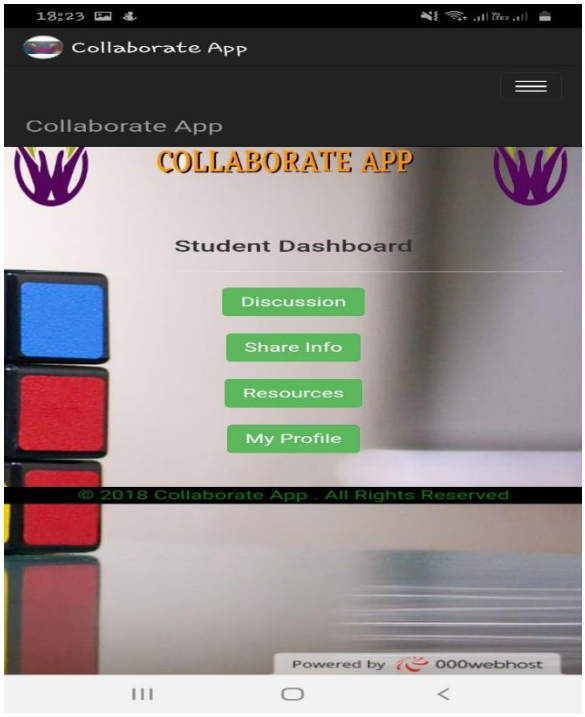

Figure 3.3: The displayed tabs of the mobile application after logging in

Figure 3.4: Sharing the resources through the mobile application.

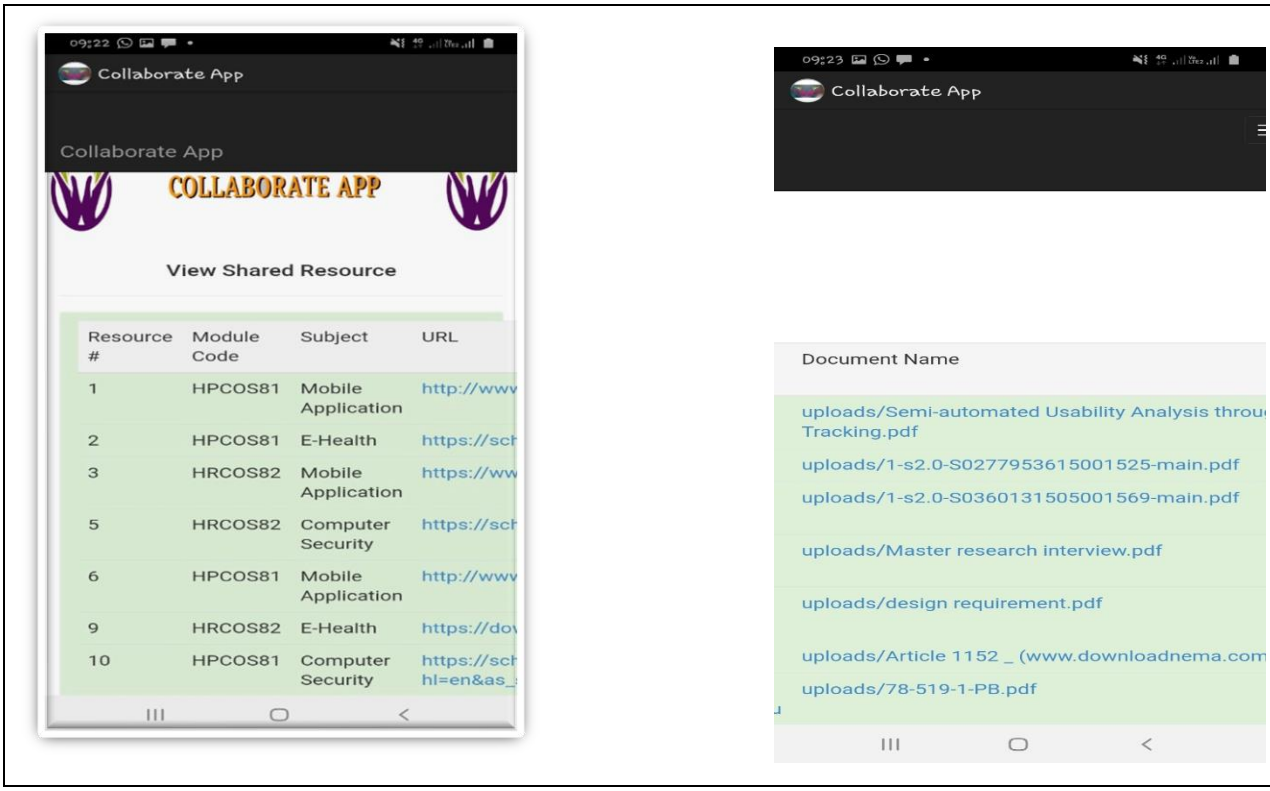

Figure 3.5: Uploaded electronic articles and their links.

Evaluation

Once the mobile application was developed, the researcher started the testing and evaluation process. This was initially conducted through a pilot study involving two participants. During the evaluation process, the mobile application failed to upload the electronic articles. Since evaluation as an activity involves an iteration process in DSRM, the researcher had to reconsider the design and development process, redesigning the mobile application to upload the electronic articles.

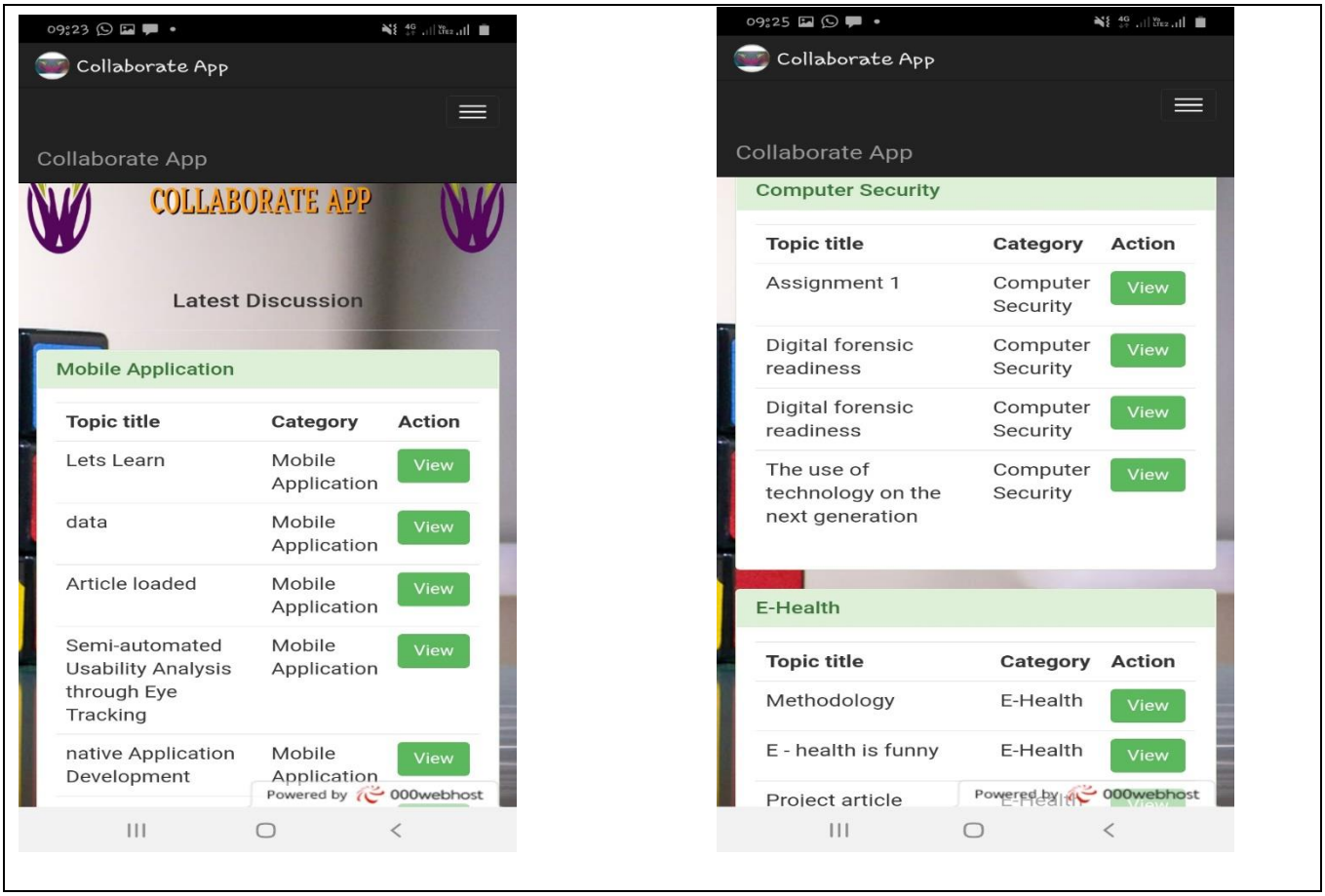

Figure 3.6: The discussions through the mobile application.

Communication

The results of this project are reported and presented as this final master's dissertation. In addition, a research conference paper has been drafted and will be included with this study.

3.4. Overview of the study

3.4.1. Pilot study

A pilot study refers to a small study used to examine the research protocols, procedures, instruments and parameters used in preparation for a full study (Bordens & Abbott, 2011). The pilot study is a way of gathering relevant information that can be employed when the full research happens. Two honours project students were involved in the pilot study for this research, which was intended to evaluate the mobile application interface using evaluation methods to determine usability. The pilot study was also conducted to examine the research design, determine the reliability and validity of the research methods, and clarify the instructions. This was done during the evaluation activity which is part of the DSRM (see Figure 3.1). During the pilot study the participants were given the instructions for using the mobile application. The application was accessed on the given smartphone and through the link provided. Subsequently, the researcher was made aware of the following important information which was pointed out by the participants:

- The mobile application did not upload the document containing the electronic article.
- The mobile application interface needed to be improved, and this was done in the design and development activity which forms part of the DSRM (see Figure 3.1)

3.4.2. Main study

Usability testing was conducted in the research area for postgraduate students (honours, master's and doctoral students) at the UNISA main campus. This enabled credible real-life participation since it was the UNISA honours students' usual study environment. The main study involved the participation of 30 honours project students using the mobile application to

tackle various tasks. All participants were briefed on how the mobile application works, and the mobile application was accessed on the given smartphone and through the link provided. Under the Discussion and Share Info tabs, the mobile application gives three categories: Mobile Application, Computer Security and E-Health. The experiment involved two stages: in stage 1, before using the mobile application, the participants had to register and login. In stage 2, after logging in, participants had to complete the following tasks:

1. Open the Google Scholar website, search and find the articles given in a list (see Appendix G), download the article and copy the URL.
2. Share the downloaded article and the copied URL on the mobile application according to the category in the Share Info tab.
3. Access and view the shared articles and their URLs under the Resources tab.
4. Open the Discussion tab to interact with other participants by adding a new message or topic or replying to the existing comments.

Only 26 of the 30 participants completed all the tasks. Three of the participants' comments in task 4 were not successfully posted on the mobile application discussion tab and one participant did not share the URL successfully on the Share Info tab in task 2, owing the fact that the mobile application could not connect to the server. In stage 2 each participant also completed the Post-Study System Usability Questionnaire (PSSUQ) for data collection purposes (see Appendix H). In stage 3, which followed immediately after stage 2, the structured interviews were held (see Appendix I). All participants completed both the PSSUQ and the structured interview questions.

3.5. Research technique

3.5.1. Sampling

When conducting research techniques, the nature of the population, categories of subjects, variables, events and concepts need to be described and represented. This is done using a sampling technique since the whole population cannot be examined at the same time. Bordens and Abbott (2011) state that the sampling process occurs when the researcher selects a small subgroup from the larger population. In selecting the sample the researcher considers the fact that it is a representation of the larger population, that is the main features of the sample are similar to or match those of the population (Gray, 2011). This means the selected subgroup has the same characteristics as the overall population (Oates, 2011). The results of a selected population of interest are generalised for the entire population. In conducting the sampling technique, the actual size of the sample needs to be determined (Gray, 2011). Sampling from a specified size of population "is much easier than drawing a random sample from the general population and greatly reduces the constraints" (Bordens & Abbott, 2011:344).

The type of sampling employed in this study was convenience sampling which is a type of non-probability sampling where the researchers select participants that are suitable for the research, because it is easy to find them and they are participating willingly (Oates, 2011). In this case, participants in the research laboratory were approached and asked to help.

Participants

The participants chosen were UNISA postgraduate students who are doing their honours research project. There were 30 participants in total, 13 females and 17 males. In this study, the participants are presented as P1 for participant 1, P2 for participant 2, and so on.

3.5.2. Data collection methods

The data collection methods used in this study included

- usability testing
- observation
- the Post-Study System Usability Questionnaire (PSSUQ)
- interviews.

Usability testing

Usability testing is regarded as an experimental method that is used mainly to analyse designed and developed artefacts (Lewis, 2006). The aim of usability testing is to evaluate the usability of an artefact by visualising the user–artefact interaction in manageable environments (Sonderegger & Sauer, 2010). Usability testing is a "method where the researcher requests the targeted users of the product to interact with it by performing specific tasks using the usability metrics approach" (Hussain et al., 2016:31).

In this study, the researcher conducted usability testing in the research area for honours, master's and doctoral students at the UNISA main campus for the following reasons: firstly, the researcher was able to define all the procedures during the usability testing; secondly, the researcher was able to measure the usability qualities and interpret the results; and thirdly, it was easy to use video or audio recordings to capture participants' reactions. Usability testing comprises technologies that help to determine and evaluate the real learning processes and reactions of the participants interacting with the designed and developed artefact (De Villiers, 2009). Usability testing includes collecting data about the usability of the developed system from users who were not participants during the system design process. Tullis and Albert (2013) describe the following basic types of usability metric, which were used in this study:

- **Effectiveness (task success)** – the most commonly employed performance measurement. This measures how successfully users can complete a task.
- **Efficiency (time-on-task)** – a general performance metric that measures resource usage, in this case expressed in terms of the time spent by users on finishing a task.
- **Satisfaction** is measured as an attitude towards the system and is an independent measure that in usability tests is usually gathered by means of surveys.

Usability metrics measure “the usability of a system regarding effectiveness, efficiency, and satisfaction” (Paz & Pow-Sang, 2016:12). In this study, the researcher observed how the participants interacted with the mobile application and recorded task success, time-on-task, errors, and efficiency.

Observation

Observation occurs not only when a researcher is observing something and making recordings, but also, as Gray (2011) states, when wishing to obtain an idea of people’s thoughts and self-interpretations of their reactions, in order to evaluate their practical behaviour. Researchers use observation to observe the reactions of participants, rather than what they report when questioned (Oates, 2011). Observation is important in qualitative studies because it permits the investigator to observe certain forms of reactions. The observation method employed in this study was unobtrusive observation, where the researcher concentrated on observing the way in which participants were interacting with the mobile application. In this case, the researcher had to refrain from asking questions of the participants during the experiment.

Questionnaires

The term ‘questionnaire’ can refer to both a data capturing method and a tool. In this discussion, the researcher is referring to the questionnaire as a tool for a predefined set of questions, assembled in a prearranged order (Oates, 2011). Gray (2011) points out that “the popularity of questionnaires is also probably based on some of their inherent advantages”. These advantages include:

- Data analysis of closed questions is relatively simple, and questions can be coded quickly.
- Respondents’ anonymity is assured.
- Questionnaires are cost-effective.
- Participants can complete the questionnaires at a time and place that suits them.

Questionnaires are commonly employed in studies because they offer a well-organised means of generating data from various participants (Oates, 2011). Since questionnaires are widely used, they should clearly define the topic of the study (Bordens & Abbott, 2011). Questionnaires reflect the designer’s view of the world.

The type of questionnaire used in this study was the Post-Study System Usability Questionnaire (PSSUQ) (see Appendix H). The PSSUQ is a 16-item survey that measures users’ perceived satisfaction with a product or system. Obtaining an overall satisfaction score is done by averaging the three subscales of System Quality (the average of items 1–6), Information Quality (the average of items 7–12), and Interface Quality (the average of items 13–16). The PSSUQ was adopted to measure the developed mobile application in order to generate the data about the concept of interest to the researcher (Oates, 2011) (see Appendix I).

Interviews

Interviews are considered to be a suitable data gathering method as they enable participants to express their feelings about complex subjects (Bowling, 2002). Interviews give the participants the freedom to respond to questions without committing themselves in writing because they sense that their responses will be confidential (Gray, 2011). The two main advantages of interviews are that they deal with complex subjects in detail, and they are flexible (Oates, 2011). The two main disadvantages of interviews as data generating methods in research is that they are time consuming, and the place where the interview takes place may affect the participants' responses (Bordens & Abbott, 2011). Oates (2011) points out that interviews can be divided into three types: structured, semi-structured, and unstructured interviews. This study focused on structured interviews because the researcher used identical pre-determined, standardised questions for every participant (see Appendix J). Gray (2011) points out that the benefit of the structured interview is that each participant has to answer the same predefined set of questions. This removes the variations in the gathered information that result from differences in time and the manner in which the questions were asked.

3.5.3. Data analysis

The reason for analysing data is to consider the types or forms of data and derive conclusions (Oates, 2011). The process of "data analysis is the most complex and mysterious of all the phases of a qualitative project, and the one that receives the least thoughtful discussion in the literature" (Thorne, 2000:70). In order to produce results that modify source data into new information, the investigator should interact in a vigorous and challenging process of analysis during all stages of the investigation (Chimbo, 2011). In this study the researcher used both quantitative and qualitative data analysis, as discussed in the next section.

3.5.3.1. Quantitative data analysis

With quantitative data analysis a large volume of data can be analysed quickly using software programs (Oates, 2011). The Statistical Package for Social Sciences (SPSS version 26) was used in this study for quantitative data analysis. One of the important attributes of analysing quantitative analysis is that if you plan the investigation instruments and the gathering of the data, data can be analysed easily (Gray, 2011). In this study, the researcher used quantitative data analysis owing to the following advantages (Oates, 2011):

- The analysis is grounded in well-established approaches and tests of significance that provide confidence in the findings. The results of the PSSUQ survey represent the way in which participants experienced how they interacted with the mobile application.
- The analysis is grounded in the quantities that are calculated, and not independent opinion, and the statistical assessment can be viewed by others. Quantitative data analysis was used to measure the data collected using the PSSUQ in this study.

The next chapter demonstrates how the quantitative data analysis was applied.

3.5.3.2. Qualitative data analysis

Analysis includes the procedures by which data are divided into small components to disclose their features and structures (Gray, 2011). Oates (2011) states that “the data and its analysis can be rich and detailed, including words, images, websites and sounds”. Qualitative data analysis entails making inferences by methodically classifying distinct features of the data (Gray, 2011). The researcher used thematic analysis as described in Chapter 4 to identify special characteristics in the data.

Thematic analysis is a process whereby forms or subjects inside the qualitative data are classified (Braun & Clarke, 2014). Unlike many qualitative methodologies, "thematic analysis is not tied to a particular epistemological or theoretical perspective" (Maguira & Delahunt, 2017:3352). Clarke and Braun (2013:121) maintain that thematic analysis is suitable for a broad variety of study interests and hypothetical viewpoints, and is useful because: (a) it operates within a broad variety of research questions, starting from participants' involvement or considerations and then moving to "those about the representation and construction of particular phenomena in particular contexts"; (b) it can be employed to analyse dissimilar forms of data, from fewer sources such as broadcasting to records of involved subgroups or interviews; (c) it operates within big or minor data sets; and (d) it is also applicable where analyses are data-driven or theory-driven. Thematic analysis was suitable for this study since interviews were used to collect data. The six-step process summarised in Table 3.1 was used as the guideline for thematic analysis (Braun & Clarke, 2014). Chapter 4 of this study describes how these guidelines were implemented to analyse the data.

Table 3.1: Phases of thematic analysis (Braun & Clarke, 2014)

Phase	***Description of the process***
1. Familiarising yourself with data	Transcribing data (if necessary), reading and re-reading the data, noting down initial ideas
2. Generating initial codes	Coding interesting features of the data in a systematic fashion across the entire data set, collating data relevant to each code
3. Searching for themes	Collating codes into potential themes, gathering all data relevant to each potential theme
4. Reviewing themes	Checking if the themes work in relation to the coded extracts (Level 1) and the entire data set (Level 2), generating a thematic 'map' of the analysis
5. Defining and naming themes	Ongoing analysis to refine the specifics of each theme, and the overall story the analysis tells, generating clear definitions and names for each theme
6. Producing the report	The final opportunity for analysis. Selection of vivid, compelling extract examples, final analysis of selected extracts, relating the analysis back to the research question and literature, producing a scholarly report of the analysis

3.5.3.3. Data triangulation

Triangulation means associating and differentiating the results from several qualitative methods or quantitative and qualitative methods (Gray, 2011). Combining methods “allows for one method compensating for the weaknesses or blind spots of the other, but the different methods remain autonomous, operating side by side” (Flick, 2006:28). The purpose of triangulation is to increase the validity of constructs by counteracting or maximizing the heterogeneity of irrelevant sources of variance attributable to inherent method bias, inquirer bias or biases in inquiry context (Gray, 2011). The advantage of triangulation is that it can be adapted for both quantitative and qualitative methods (Hanson et al., 2005; Johnson et al., 2007). As Hanson et al. (2005) propose, employing triangulation lets investigators concurrently take a broad view of a sample to people and obtain concrete, background experience of the phenomenon being investigated. The qualitative method then allows the researcher to classify relations between objects and to make summaries (Gray, 2011). Additionally, the qualitative method is relevant because it is accomplished by analysing existing cases in their temporal and local particularity (Flick, 2006), starting from people’s expressions and actions embedded within the local context.

This study used triangulation to verify and compare the findings obtained from the usability testing, PSSUQ and interviews. The results obtained from the triangulation are presented in this study.

3.5.4. Summary

In the above subsections the sampling process, data collection methods and data analysis were discussed. As it was not possible to reach all honours students in the School of

Computing at UNISA for data collection, the researcher used convenience sampling to select the participants and then make inferences to the entire population. Quantitative and qualitative data analysis were applied as discussed in the next chapter where the participants' responses to the questionnaires and in the interviews are analysed.

3.6. Research ethics

Potentially, any study that includes data collection or interaction with people should involve ethical considerations (Gray, 2011). The procedure for such ethical considerations involves the researcher explaining the purpose of the research, its funding, the protection of the participants involved, accuracy, fairness, and data collection methods (Oates, 2011).

3.6.1. Permission to conduct the study

Permission to conduct the study was authorised and granted by the College of Science, Engineering and Technology (CSET) after the researcher applied for ethical clearance and an ethics certificate was subsequently granted (see Appendix A). Permission to use UNISA students was applied for (see Appendix B), and it was authorised and granted by the Research Permission Subcommittee (RPSC) in UNISA (see Appendix C).

3.6.2. Informed consent form

The code of informed consent implies that study participants are given appropriate and available evidence about a research project, which allows them to decide whether they will become involved or not (Gray, 2011). During data collection, the researcher gave the

participants informed consent forms (see Appendix D). All participants had to read the participation information sheet (see Appendix E) before they started to participate.

3.6.3. Confidential anonymity

Regardless of the research environment chosen, the anonymity and confidentiality of the participants and their responses must be maintained (Bordens & Abbott, 2011). Participants' anonymity was guaranteed by the researcher, and they were allowed to withdraw from the study at any time without a penalty.

3.7. Conclusion

Chapter 3 set out to outline, explain and discuss the research methodology and design employed in this study. Given the fact that DSR is suitable for designing real-world artefacts in a creative way it was considered appropriate for this study. The six processes of the DSR were introduced and applied in this study and plans for collecting data were presented and described. In addition, issues relating to research ethics were explained and addressed.

The data collection employed four techniques, namely, usability testing, observation, the PSSUQ and interviews, as these techniques evaluate different yet related aspects pertaining to usability. Usability testing was applied to test the usability of the mobile application; observation was used to observe how the participants performed the given tasks on the mobile application; PSSUQ was used to test the user satisfaction with the mobile application, and a post-test interview was used to ascertain the participants' opinions of the usability of the mobile application. The next chapter presents the data analysis of the study.

CHAPTER 4

4. DATA ANALYSIS AND INTERPRETATION

4.1. Introduction

Chapter 3 discussed the design science research methodology (DSRM) used in this study. This chapter presents the results of this study in response to RQ3, namely, 'How usable will such a mobile application be in supporting honours research students in an ODL environment?' The chapter is organised as follows: In section 4.2, the usability testing and observation applied in the study is discussed by considering usability metrics. Section 4.3 discusses the quantitative data using descriptive statistics. In section 4.4, qualitative data with thematic analysis is used to discuss the data, while section 4.5 discusses data triangulation, and section 4.6 concludes this chapter.

4.2. Usability testing and observation

Usability testing and observation were discussed in Chapter 3. In this chapter, the researcher analyses the usability data that were captured during usability testing where the interaction of the participants with the mobile application was observed. As discussed in section 3.5.2, the participants were requested to perform specific tasks using the mobile application. The usability metrics are discussed below:

4.2.1. Effectiveness (task success)

Effectiveness is measured by considering task completion, as failure to complete tasks could indicate a usability issue. In this study, effectiveness was measured in terms of binary success and level of success as discussed in sections 4.2.1.1 and 4.2.1.2 respectively.

4.2.1.1. Binary success

Binary success is suitable to be employed when determining the success rate of the artefact subject to users finishing a given assignment or a set of assignments (Tullis & Albert, 2013). In binary success, each time a user performs a task, a score of value 1 is given for success or 0 for failure (see Appendix K). In consideration of the average success rate of all participants, the average of tasks completed by each participant is presented in the last column, and the average of each task is presented in the last row. Tullis and Albert (2013:67) emphasise that "the most common way to analyse and present binary success rates is by individual task". This includes effectively giving the percentage of participants who finished each task (see Figure 4.1). Figure 4.1 shows that Task 4 has the lowest completion rate where only 90 percent of participants managed to complete the task, while 97 percent of the participants completed Task 2. The cause of the failure was that the mobile application could not connect to the server. All participants completed Tasks 1 and 3 successfully. The total average of all the tasks completed by the participants was 97 percent which indicates a high task completion rate.

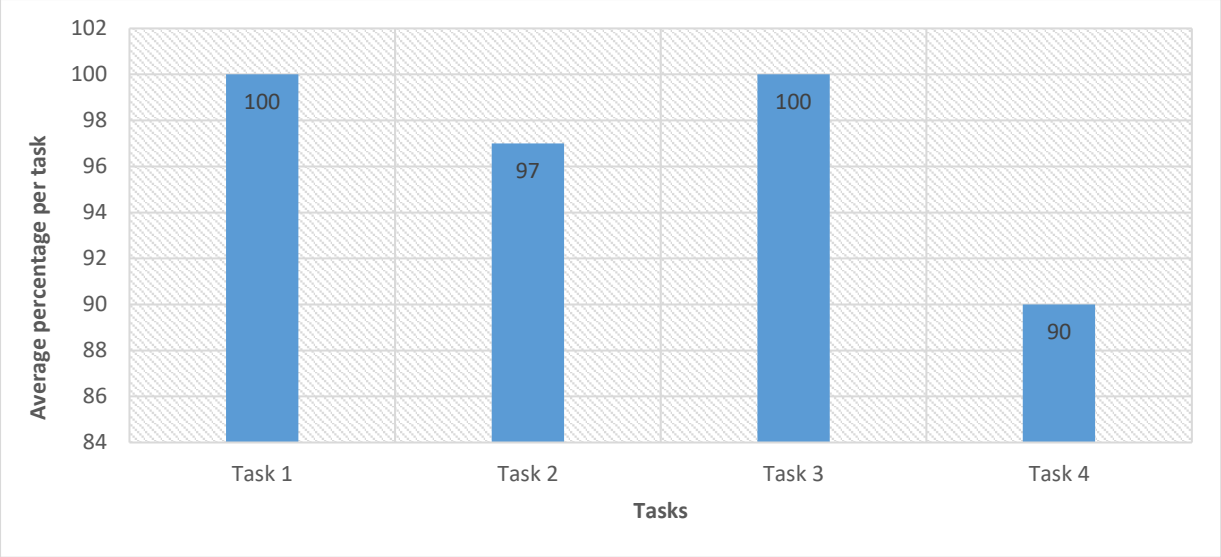

Figure 4.1: The rate of success in percentages for each task

4.2.1.2. Level of success

According to Tullis and Albert (2013), the success levels can be considered from three perspectives:

- Complete success – levels of success may rely on the amount or measures where each participant completed the task either with or without assistance.
- Partial success – levels of success may be grounded on knowledge. This may be with or without assistance.
- Failure – participant thought the task was complete, though it was not, or the participant stopped performing the task.

In this study, Tasks 1 to 4 are presented as follows: Tasks 1 and 3 were completed with 100 percent, Task 2 with 97 percent, and Task 4 with 90 percent. The completion of all tasks was in the form of partial success and failure. The results also indicate that 97 percent of Task 2 was completed with assistance (partial success), and 90 percent of Task 4 was completed with assistance (partial success). All participants completed Tasks 1 and 3 successfully without any assistance (complete success), and this shows that the participants were able to perform these tasks on the mobile application.

The number of participants who completed all the tasks successfully is presented in Figure 4.2. P27, P28, and P30 completed Task 4 with assistance, P29 completed T2 with assistance, while P1 to P26 completed all the tasks successfully without any assistance. In comparison, all participants completed Tasks 1 and 3, thus indicating the usability of the mobile application. Tasks 2 and 4 were not completed by all participants and this indicated mobile application usability issues.

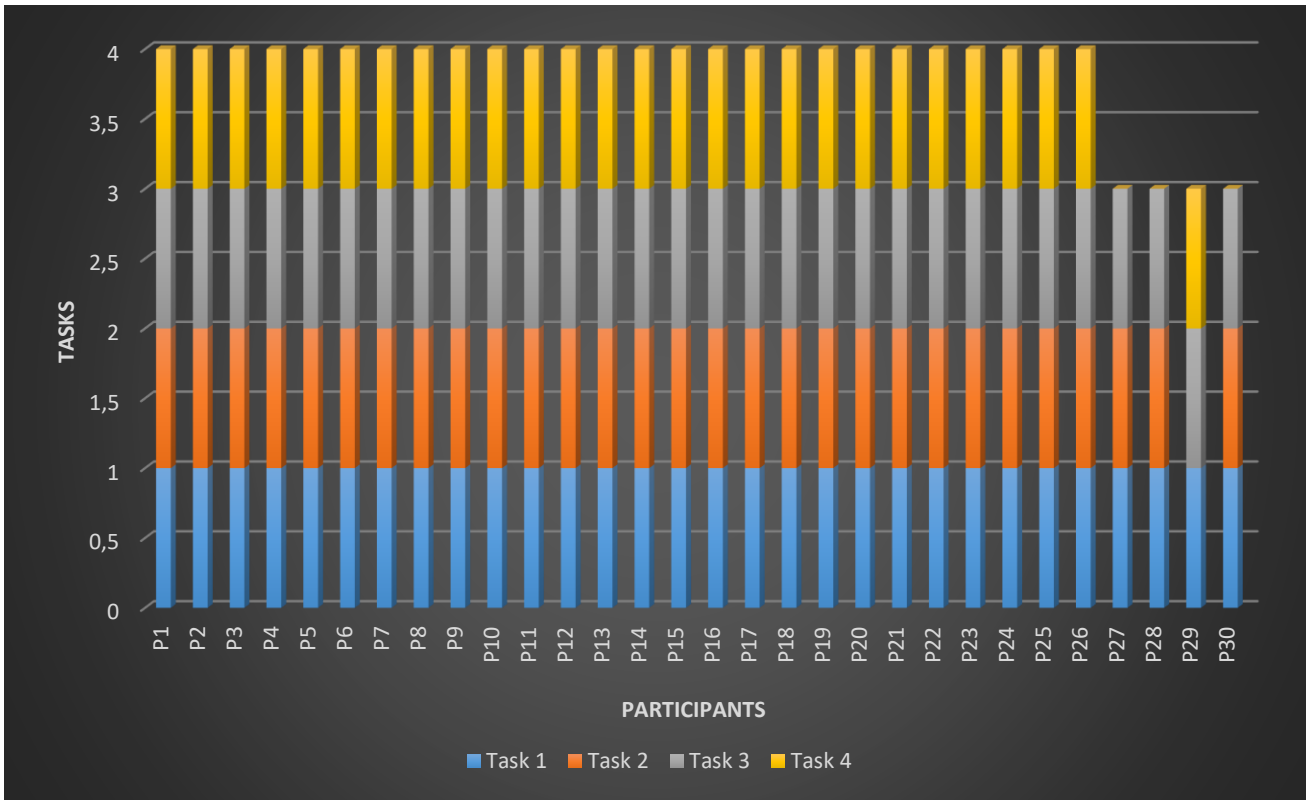

Figure 4.2: Tasks completed by all participants

4.2.2. Efficiency (time-on-task)

Efficiency measures the way in which a product enables users to accomplish their tasks (Rogers et al., 2012). It is basically “the time spent by participants between the beginning and ending of a task, usually expressed in minutes and seconds” (Tullis & Albert, 2013:74). Table 4.1 depicts the time in minutes taken by each participant to complete each task.

As indicated in the table, the total average time of the four tasks is 8.48 minutes. It would appear that Task 1 was easy to perform because it has the lowest average of 1.88 minutes, followed by Task 2 with an average of 2.18. Task 3 has an average of 2.19 minutes whereas Task 4 has the highest average of 2.22 minutes. Task 4 has a higher average than Tasks 1, 2 and 3 which indicates that Task 4 was more demanding. The standard deviation of all the tasks was calculated, accordingly the standard deviation values for Tasks 1, 2, 3, and 4 are all less than 1. This means that the time taken to complete these three tasks was similar for all participants which suggests a lack of usability issues. Therefore, this indicates that the participants performed all the tasks effectively on the mobile application.

Participants P12, P15, P21, P24, P27, P28, P29, and P30 took longer to complete tasks than other participants. P30 took the longest to complete all tasks at 11.17 minutes, followed by P27 at 11.1 minutes. P27, P28, and P30 did not complete Task 4, and P29 did not complete Task 2.

Figure 4.3 presents the average and standard deviation time on task for all four tasks. Task 4 has the highest average time, and this is where most participants took longer to complete the task.

Table 4.1: Time taken by each participant on task to complete all the tasks

Participants	Task1	Task2	Task3	Task4	Total time in minutes
P1	2,35	2,41	1,04	2,11	8,31
P2	1,56	2,39	2,36	2,02	8.33
P3	2,05	1,52	2,11	1,54	7,22
P4	1,49	2,03	2,02	2,11	8,05
P5	2,03	2,26	2,37	2,05	8,71
P6	2,07	1,47	2,03	2,07	8,04
P7	1,51	2,25	2,18	2,1	8,04
P8	1,43	2,32	2,28	2,16	8,19
P9	1,38	2,1	2,34	2,28	8,1
P10	1,37	2,45	2,19	2,07	8,08
P11	2,09	2,16	2,24	1,57	8,06
P12	2,13	2,47	2,29	2,02	9,31
P13	1,46	2,42	1,52	2,14	7,54
P14	2	2,09	2,14	2,18	8,41
P15	2,11	2,42	2,57	2,13	9,23
P16	1,26	2,14	2,49	2,06	8,35
P17	2,16	1,54	2,48	1,52	7,07
P18	2,11	2,34	2,27	2,02	8,74
P19	1,54	2,13	2,38	2,21	8,26
P20	2,18	2,24	1,53	2,09	8,04
P21	2,07	2,34	2,17	2,18	9,16
P22	1,59	2,01	2,21	2,23	8,04
P23	1,43	2,17	2,43	2,51	8,54
P24	2,02	2,01	2,17	2,46	9,1
P25	2,15	2,27	2,34	2,14	8,9
P26	2,04	2,18	2,16	2,09	8,47
P27	2,37	2,41	2,54	3,29	11,1
P28	2,01	2,51	1,49	3,41	9,42
P29	2,56	2.14	3,05	3,42	9,03
P30	2,01	2,23	2,27	2,53	11,17
Mean	**1,88**	**2,18**	**2,19**	**2,22**	**8,48**
Standard Deviation	**0,36**	**0,27**	**0,38**	**0,45**	**0,84**
Median	**2,03**	**2,24**	**2,26**	**2,12**	**8,30**

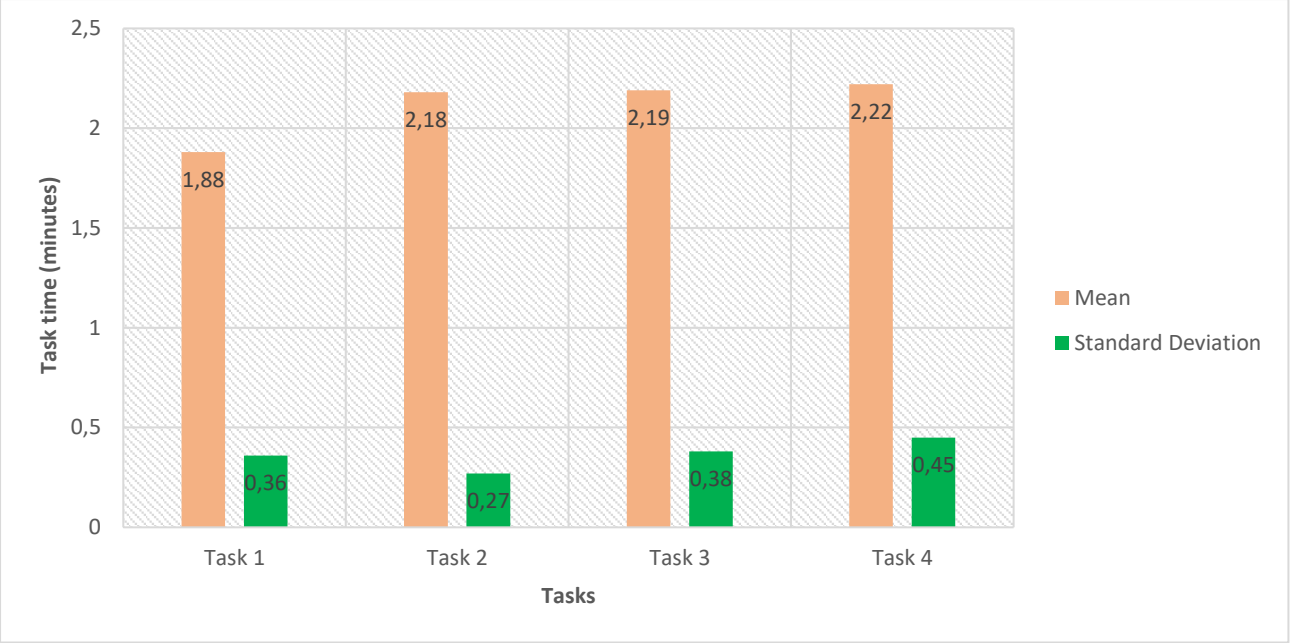

Figure 4.3: Average time on task in minutes

4.2.3. Satisfaction

Satisfaction is described the reactions of the participants towards the developed artefact. It is a particular measure which is naturally gathered in usability experiments in the form of surveys (ISO, 1998). This is discussed in section 4.3 with consideration of the PSSUQ.

4.2.4. Usability problems

A usability problem is any feature or functionality in a product that guides a user to an unwelcome outcome (Tullis & Albert, 2013). The researcher used observation as a method because it provides insight into reasons for usability problems whereas some other measures merely indicate the existence of problems. The following issues were observed and evaluated during the experiment:

Task 1 was aimed at opening the Google Scholar website, searching and finding the articles given in a list, downloading the article and copying the URL. All participants completed this task successfully without any difficulties. This indicates that Task 1 did not have usability issues.

Task 2 aimed to test whether the participants could share the downloaded article and its copied URL on the mobile application according to the category in the Share Info tab. Only one participant (P29) asked for assistance. The problem was that the mobile application could not connect to the server. This implies that Task 2 had minor usability problems regarding the mobile application.

Task 3 aimed to determine whether the participants could view and access the shared articles and their URLs or not. All participants completed this task without any struggle. This indicates that Task 3 did not have any usability problems on the mobile application. We may therefore conclude that the mobile application can be used to access shared information.

Task 4 aimed to test whether the participants could open the Discussion tab to interact with other participants by sharing or replying to comments. Only three participants (P27, P28, P30) asked for assistance on this task, as they could not post their comments on the mobile application discussion forum. During user interaction these users kept on posting their comments without success. However, while their comments were not displayed on discussion forum, but they could access other participants' posts. This indicates usability problems. Nevertheless, the other 27 participants managed to complete Task 4 without problems. These results indicate that Task 4 had usability problems since only three participants experienced the difficulties. Three participants struggled to post their comments on discussion forum. The

discussion forum tab is important since students must use it to share their views and collaborate with each other. Two participants made similar comments saying, “it is because the mobile application cannot connect to the server”. This indicates a lack of internet connectivity. However, most participants (90%) were able to use this functionality to view and post their comments. Accordingly, it was identified that the mobile application had a problem relating to internet connectivity.

In summary, the presented usability metrics show how mobile application was used during usability testing. The task success including binary success and level of success indicated how successfully the participants completed the tasks. Accordingly, 97 percent of participants completed the tasks successfully. The results of the usability measures were also discussed, and it was found that only Task 4 had usability problems. These problems relate to the effectiveness of the mobile application.

4.3. Quantitative analysis

4.3.1. Descriptive statistics

Descriptive statistics describe a number of features of data involved in research, often by means of visual analysis (Gray, 2011). The descriptive statistics used in this study include the mean, standard deviation, range of scores, Cronbach’s alpha, and correlation (Pallant, 2010). The descriptive statistics analysis is presented in the next section.

4.3.1.1. Analysis of descriptive statistics

In Table 4.3, the descriptive statistics represent the results from the Post-Study Usability Questionnaires (PSSUQ) for questions 1 to 13 respectively. The PSSUQ score starts with 1

(Strongly Agree) and ends with 7 (Strongly Disagree). The lower the score, the better the performance and satisfaction. However, 4 is neutral and does not indicate the average. The table has the min and max for each questionnaire, and these represent the scale minimum and maximum number of each question answered respectively. It also gives the mean and standard deviation for each question. The statement N = 30 represents the number of participants.

The mean, median and standard deviation

The mean and standard deviation scores for each question are presented in Table 4.2. The mean scores lie between 1.70 and 2.63, and this indicates that all the responses were in the category of high satisfaction. The minimum value for all the questions is 1, which indicates that the participants were satisfied with the usability of the mobile application. The maximum value is 6 on q3 and q12, thus indicating participants' dissatisfaction. As can be seen from the results in the table, the median values of all questions are below 4 which indicates that all responses were within the high satisfaction category. Gray (2011) states that "the standard deviation is a measure of the extent to which responses vary from the mean, and it is derived by calculating the variation from the mean". The standard deviation averages "the amount of variability in a set of scores or to put it another way, the average distance of each data value from the mean" (Oates, 2011). The standard deviation allows for a comparison to be made between the various portions of the questionnaire over the time scheduled. Furthermore, "a low standard deviation indicates that the data points tend to be very close to the mean; a high standard deviation indicates that the data points are spread out over a large range of values" (Pallant, 2010:57). As shown in Table 4.2, the standard deviation values are spread out. The questions q3, q9, q10, and q12 have standard deviation values greater than 1.0. Question q12 has the highest standard deviation value of 1.129. This indicates that few participants strongly agreed that the

mobile application has all the functions and capabilities they expected it to have, whereas other participants did not agree. The standard deviation values of the questions q1, q2, q4, q5, q6, q7, and q13 are less than 1.0. Overall, the mean and standard deviation values are not close to each other and this indicates the variation in the responses (see Table 4.2).

Table 4.2: The presentation of the descriptive statistics

Descriptive Statistics												
	1	2	3	4	5	6	7	median	Min	Max	Mean	Std. Deviation
q1	46.7%.	30.0%	20.0%.	3.3%				2.5	1	4	1.80	.887
q2	40.0%.	33.3%	26.7%					2	1	3	1.87	.819
q3	30.0%	33.3%	30.0%	3.3%		3.3%			1	6	2.20	1.126
q4	53.3%	26.7%	16.7%	3.3%				3	1	4	1.70	.877
q5	50.0%	20.0%	30.0%					2	1	3	1.80	.887
q6	50.0%	20.0%	26.7%	3.3%				2.5	1	4	1.83	.950
q7	46.7%	20.0%	33.3%					2	1	3	1.87	.900
q8	36.7%	40.0%	23.3%					2	1	3	1.87	.776
q9	46.6%	23.3%	23.3%	3.3%	3.3%			3	1	5	1.93	1.081
q10	30.0%	36.7%	23.3%	6.7%	3.3%			3	1	5	2.17	1.053
q11	30.0%	30.0%	33.3%		6.7%			2.5	1	5	2.23	1.104
q12	10.0%	43.3%	30.0%	10.0%	3.3%	3.3%		3.5	1	6	2.63	1.129
q13	53.3%	26.7%	16.7%	3.3%				2.5	1	4	1.70	.877
Valid N = 30												

4.3.1.2. The Post-Study System Usability Questionnaire (PSSUQ)

Lewis (2002:1) established guidelines for analysing the PSSUQ score and explains a universal full score and fractional scores for the subscales related to PSSUQ: i) Global: “System Utility (SysUse): average of the responses from items 1 to 6; ii) Quality of information (InfoQual): average of the responses from items 7 to 12; and iii) Interface Quality (IntQual): average of the responses from items 13 to 16”. In this study, only 13 questions of the PSSUQ were adopted to measure the developed mobile application because these were the ones deemed relevant

to the research questions of the study. The new adopted questions were grouped and selected as follows:

i. System usability (SU): average of the responses for q1, q2, q3, q4, and q5

ii. Information sharing (IS): average of the responses for q6, q7, q8, and q9

iii. Interface quality (IQ): average of the responses for q10, q11, q12 and q13

Each participant completed the PSSUQ, that is, the 13-item adapted survey, to measure the satisfaction of users with mobile application usability. The SU refers to the ease of use of the system, learning to use it, and assisting the user to become productive quickly (Lewis, 2002; Schnall et al., 2016). The IS comprises online information, onscreen communications and information that is visibly accessible (Harrati et al., 2016). Furthermore, it also measures whether the information is easy to understand, helps the user to complete the tasks effectively, and is organised (Schnall et al., 2016; Sitanggang et al., 2019). It measures whether the user likes the system, whether the system has all required functionalities, and all expected capabilities (Lewis, 2002; van der weegen et al., 2014). The mean and standard deviation of each construct are presented in Table 4.3.

Table 4.3: Overall descriptive statistic for grouped adopted PSSUQ

	N	Minimum	Maximum	Mean	Std. Deviation
SU	30	1.00	3.00	1.8667	.69536
IS	30	1.00	3.00	1.8667	.71539
IQ	30	1.00	3.60	2.1067	.73856
Valid N (listwise)	30				

As presented in the table, the SU has an average of responses of 1.8667 (SD = .69536), indicating that the usability of the mobile application was acceptable. The IS has an average of responses of 1.8667 (SD = .71539), indicating that the information sharing aspect of the mobile application was acceptable. The SU and IS have an average response of 1.8667 out of

a maximum of 3.00, thus indicating that the usability of the mobile application was acceptable The IQ has average responses of 2.1067 (SD = .73856) indicating that the users are satisfied with the interface of the mobile application. The usability of the mobile application was rated positively for all three constructs, with the standard deviation scores ranging from .69536 to .73856, for all three constructs. Based on the participants' evaluations, this study concludes that the participants were satisfied with the usability of the application.

4.3.1.3. Reliability test

A reliable measurement of scale is a standard compared to which the competence and correctness of a measurement procedure is analysed technically because "inappropriate reliability can derive unfair results and poor standard of measurement" (Jansen et al., 2003:398). The Cronbach's alpha coefficient is considered when the researcher is approximating the internal reliability quantities. This is performed through the process of determining the consistency of the questionnaires; an element analysis is done on the questions of every concept in the questionnaires to yield Cronbach's alpha values to guarantee that all questions designed for each concept assess the appropriate construct. The Cronbach's alpha value is a measure of the reliability of a measuring instrument. Its value will usually increase when the correlations between the questions of the construct increase (Jansen et al., 2003). The "Cronbach's alpha coefficient is also known as the internal consistency of the test" (Pallant, 2010:100). Cronbach's alpha can take values between negative infinity and 1 (even though only positive values are relevant) (Koo & Li, 2016). Tables 4.4, 4.5, and 4.6 indicate the reliability measurements of the constructs of the system analysis respectively.

Table 4.4: Reliability statistics of system usability

System Usability

Reliability Statistics	
Cronbach's Alpha	N of Items
.843	5

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
q1	9.40	13.283	.516	.836
q2	9.33	12.713	.689	.806
q3	9.00	12.138	.510	.847
q4	9.50	12.052	.753	.792
q5	9.40	12.041	.744	.793

Table 4.5: Reliability statistics of information sharing

Information Sharing

Reliability Statistics	
Cronbach's Alpha	N of Items
.785	4

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Q6	5.67	5.057	.588	.735
Q7	5.60	4.869	.632	.712
Q8	5.60	4.869	.793	.649
q9	5.53	4.947	.431	.834

Table 4.6: Reliability statistics of interface quality

Interface Quality

Reliability Statistics		
Cronbach's Alpha		N of Items
.777		4

Item-Total Statistics				
	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
q10	8.37	8.171	.724	.673
q11	8.30	7.666	.777	.648
q12	7.90	9.955	.338	.813
q13	8.83	9.937	.530	.744

As shown in the above tables, the Cronbach's alpha coefficient of the scale was 0.843 for system usability in Table 4.4, 0.785 for information sharing in Table 4.5, and 0.777 for interface quality in Table 4.6. Therefore, the Cronbach's alpha values are above 0.7 for all, "which can be regarded as reliable for all constructs to be used" (Churchill, 1979:65).

Based on the analysis of the reliability test, each construct has a Cronbach alpha coefficient of above 0.7. Therefore, it can be concluded that the constructs of the three variables (SU, IS and IQ) have internal consistency.

4.3.1.4. Correlation

A correlation is described as the extent of connection between objects (Fain, 2017; Oates, 2011; Shakiba et al., 2016). According to Aggarwal and Ranganathan (2016:188), "in probability theory and statistics, correlation (often measured in terms of a correlation coefficient) indicates the strength and direction of a linear relationship between two random variables". To evaluate this kind of connection, regression analysis should be applied to discover whether the correlation is substantial. A positive correlation shows that high scores on one variable are paired with high scores on the other variables and, conversely, low scores

on one variable are paired with low scores on the other variables (Fain, 2017; Gray, 2011; Oates, 2011; Pallant, 2010). Because of the predictable statement that correlation does not suggest a relationship, these correlations should not be realistically employed to conclude a relationship among underlying variables (Shipley, 2016). According to Pallant (2010:134), "a correlation of 0 indicates no relationship at all, a correlation of 1.0 indicates a perfect positive correlation, and a value of -1.0 indicates a perfect negative correlation". As shown in Table 4.7, SU is highly correlated with IQ which was to be expected. Interestingly, SU is also correlated with IS. Furthermore, IS is highly correlated with IQ which is to be expected because IQ is more likely to improve as IS improves.

Table 4.7: Correlation of system usability, information sharing, and interface quality

Correlations

		SU	IS	IQ
SU	Pearson Correlation	1	.766**	.816**
	Sig. (2-tailed)		.000	.000
	N	30	30	30
IS	Pearson Correlation	.766**	1	.684**
	Sig. (2-tailed)	.000		.000
	N	30	30	30
IQ	Pearson Correlation	.816**	.684**	1
	Sig. (2-tailed)	.000	.000	
	N	30	30	30

**. Correlation is significant at the 0.01 level (2-tailed).

4.3.2. Summary

In summary, all the variables used in the quantitative analysis presented reliable results, as indicated in the discussion in the above sections. The mean in the descriptive analysis indicated positive responses from the participants. The mean scores of the three constructs (SU, IS, and IQ) indicated that the use of the mobile application was acceptable. Furthermore, the standard deviation in the descriptive statistics and all three constructs presented positive

responses from the participants. The reliability of system analysis was indicated by Cronbach's alphas of above 0.7 for all three constructs, indicating that the questionnaire items for each construct were considered reliable in measuring the same construct. The analysis also shows significant correlation between the system usability, information sharing and interface quality of the mobile application.

4.4. Qualitative analysis

4.4.1. Thematic analysis

In Chapter 3, thematic analysis was discussed. In this chapter, the researcher analyses the qualitative data by implementing the six phases of thematic analysis (Braun & Clarke, 2014). The data emanated from the interview questions answered by the participants. These questions were answered after conducting the usability testing during which the researcher observed the participants' interaction with the mobile application (see Appendix J). During data analysis, the researcher scrutinised the data while keeping in mind the guiding question: To what extent can a usable mobile application serve as a supporting tool for honours research students in an ODL environment in South Africa? The six phases of thematic analysis are discussed below:

Phase 1: Familiarisation and immersion

The researcher observed and noted the interaction of the participants with the mobile application during usability testing. The researcher listened to audio recordings of the participants and read the transcripts several times.

Phase 2: Coding

Coding is not only a method for decreasing data but also for analysing data, so codes express both a semantic and theoretical interpretation of data (Braun & Clarke, 2014). In this study, the researcher coded all the data items and ended this phase by ordering every code and appropriate data extracts. The researcher generated labels for important features of the data of relevance to the main research question guiding the analysis. The generated codes are given in Table 4.8. The codes are presented to show the number of participants who mention, agree or support these. For example, two participants agreed with the notion expressed by the code “easy to understand”; hence, this is presented as “easy to understand x 2”.

Phase 3: Searching for themes

All codes that belonged together were grouped in expressive forms in the data with regard to the research question. The researcher grouped the codes together and generated the following themes:

- Share information
- Collaboration in research
- Complete task effortlessly
- Assistance in using mobile application
- Recommendations for mobile application
- Encourages use of the mobile application
- Discourages use of the mobile application
- Improvement in the mobile application

Table 4.8: Generated themes and codes for qualitative analysis

Theme: Share information **Codes** ➢ Easy to share information x 1 ➢ Cost-effective in sharing information x 1 ➢ Share electronic files and the links to videos x 4 ➢ Upload not a difficult task x 1 ➢ Share the information with other students x 30 ➢ Agree to share information x 3 0	**Theme: Collaboration in research** **Codes** ➢ Agree with collaboration in research x 30 ➢ Information (files), articles x 7 ➢ Easy to use and direct x 2 ➢ Remote area x 1 ➢ Collaborate with fellow students x 16 ➢ Access information x 27	**Theme: Complete all tasks effortlessly** **Codes** ➢ Agree that all tasks completed effortlessly x 29 ➢ Not much work to do x 5 ➢ Do not agree with completing all tasks effortlessly x 1 ➢ Server or internet connection problem x 1	**Theme: Assistance in using mobile application** **Codes** ➢ Agree that assistance is needed to use mobile application x 21 ➢ Disagree that assistance is needed to use mobile application x 9 ➢ <u>Skills</u> ➢ Computer knowledge ➢ User manual x 30
Theme: Recommendations for mobile application **Codes** ➢ Recommend that the mobile application should be used x 30 ➢ Sharing information (articles), publications, exchange of ideas x 10 ➢ Disagree x 0	**Theme: Encourages use of the mobile application** **Codes** ➢ Encourage use of the mobile application x 30 ➢ Share information x 8 ➢ Clear and straightforward x 13 ➢ Lack of internet data x 1	**Theme: Discourages use of the mobile application** **Codes** ➢ Not discouraging the use of mobile application x 3 ➢ Agree - Lack of functionality and resources x 3 ➢ Cost of data x 3 ➢ More videos x 1 ➢ Knowledge x 3 ➢ Interface x 1 ➢ Neutral x 4	**Theme: Improve mobile application** **Codes** ➢ Agree to improve mobile application x 29 ➢ Sharing of information x 2 ➢ Functionality x 19 ➢ Application good x 2 ➢ Neutral x 1 ➢ Improve servers x 1

Phase 4: Reviewing themes

In this phase, themes were reviewed and further combined based on their relationships. The researcher wanted to have a fair impression of various themes, the way they are related and the general story they express about the data. The themes were grouped as follows:

Usability – Complete task effortlessly; assistance in using mobile application; and encourages use of the mobile application

Internet connection – Discourages use of the mobile application

Knowledge and functionality – Recommendations for mobile application; and improvement of the application. The reviewed themes are presented as follows:

- **Usability** – this determines the efficiency and effectiveness of, and satisfaction with, the mobile application.
- **Information sharing** – allows the students to share the information among themselves.
- **Internet connection** – determines the functionality of the mobile application on the internet.
- **Collaboration in research** – allows students to participate through the discussion forum.
- **Knowledge and functionality** – provide the functionality of the mobile application.

Phase 5: Define the themes

Usability

The participants expressed satisfaction with the effectiveness and the following made comments about how the application helps to collaborate in the research environment. P4: "*The mobile application is effective because we can access information from our fellow students, and also to interact with them since we are studying in distance learning*"; P16: "*I like the effectiveness of mobile application because I was able to perform all required tasks."*

However, some participants indicated a problem regarding efficiency. This happened when one participant tried to share a downloaded article. P29: *"I found it difficult to share the article through mobile application"*. Participants felt that the mobile application would require a good internet connection. P5: *"The mobile application can work very efficiently if it has good connection with the network."* P16: *"The internet connection will discourage the use of the mobile application."* Significantly, it must be noted that the mobile application does not have more features as it was designed purely to serve the purpose of research. The participants acknowledged that they were encouraged to use the mobile application for research purposes and were satisfied with it. Participants identified that the mobile application is helpful for research students and suggested that it should be used by students. P8: *"Definitely, mobile application is very easy to use simply because people want some easy and direct. I am satisfied about it."* Another participant concurred by saying*: "I am content with the use of mobile application because we can manage to do our research"* (P13).

The participants expressed their dissatisfaction regarding the discussion forum on the mobile application. This was based on the fact that their comments could not be posted on the discussion forum. P27: *"I managed to perform the other tasks, but failed on the last one, I would really be happy I could have completed all the tasks."*

Information sharing

The significant part of information sharing is that the participants considered that sharing information through the mobile application is a motivation to support each other. Notably, the Share Information tab on the mobile application enables them to share relevant electronic articles and links. P12: *"I feel much supported since my fellow students can share relevant electronic articles and their links with me."* It is also clear that as the participants share

information, they are able to interact through the mobile application to overcome the distance barriers.

All shared resources are easily accessed despite the distance and time constraints. This is because the artefact provided participants with the ability to identify, retrieve, and use information effectively. It emerged that participants could access information in different formats. The main reason identified is that information can be disseminated through the mobile application in a variety of formats that are widely accessible. P21: "*I like the fact that I accessed all shared resources with different formats. It is nice to use this mobile application in ODL. The mobile application is very effective."*

Collaboration in the research environment.

Both information access and information sharing form part of collaboration. Collaboration takes place when two or more people gather and make contributions on their level of expertise to attain a common goal. This is also facilitated through the mobile application. The participants identified the mobile application interface as useful as it helped them to collaborate through the discussion forum. After the participants shared the information, they made comments about the discussion forum. P9: "*The mobile application is easy to use as it helps us to navigate and express our ideas on discussion forum platform. I believe this kind of features are needed in the space of research environment."* These participants perceived that they could conduct research in remote areas thus overcoming the distance constraints. This is because they can still share ideas, work on research papers together, and communicate with each other about the research work while in remote locations.

Lack of internet connection

The participants specified that the use of the internet is required to interact with the mobile application. They acknowledge that this type of mobile application should make use of the internet. P27: *"Improve the internet and make sure the server does not affect the students while using it".* P29: *"Resources not being easily accessible because of downtime internet."*

Functionality and knowledge

The mobile application has the functionalities that enable students to share knowledge with each other. The participants felt that the mobile application functionalities encourage collaboration and the accessibility of shared information. P29: *"Easy to access available resources to encourage collaboration amongst the users."* P26: *"I think the students will be able to interact with each other and share whatever information usable to each individual."*

For these participants, the use of mobile application functionalities was a solution as they would be able to access information and share the knowledge.

Phase 6: Writing the report

This phase comprises the entire dissertation as presented here.

4.5. Data triangulation using the usability testing, PSSUQ and the interviews

Usability testing was used to evaluate the effectiveness and efficiency of the mobile application. In terms of effectiveness, four users completed the tasks with assistance. The results indicate that there were minor usability problems on the mobile application.

The PSSUQ was used to capture data on user satisfaction. The results indicated that the participants were satisfied with the use of the mobile application in ODL. The internal consistency of the constructs as a measure of scale reliability was determined by using the Cronbach's alpha. The reliability of system analysis has Cronbach's alpha values of over 0.7 for system usability, interface quality, and information sharing. This indicates the internal consistency of the constructs as measured by the questionnaire. The usability of the mobile application was rated positively with mean scores close to each other for all three constructs. Furthermore, the quantitative analysis was statistically accepted.

Interviews were conducted after the use of the mobile application was tested. The responses to the interview questions were found to be very useful as participants indicated their concerns about the mobile application. Five themes were generated from the responses. As indicated in section 4.4, the participants expressed their satisfaction with the fact that the mobile application can be used in the research environment to collaborate and to share information.

In summary, the triangulation of the results (usability testing, PSSUQ, and post-interviews) implies that a usable mobile application for the purpose of research could be of benefit to students in an ODL environment.

4.6. Conclusion

This concludes the data analysis chapter. In this study, the researcher evaluated the use of a mobile application intended for the research environment. The results of usability testing indicated that on average 97 percent of participants completed the tasks without assistance. This indicates that the mobile application had minor usability problems in terms of efficiency and effectiveness. The results indicated positive responses to the mobile application's usability

based on the data captured using the PSSUQ. Furthermore, a significant correlation was found between System Usability, Information Sharing, and System Quality. This is not surprising as it confirms that the *Information Sharing* and *System Quality* constructs were also perceived as satisfactory. The responses from the post-interview gave further evidence that the mobile application is usable in the ODL research environment. The following chapter presents an overall discussion of this study.

CHAPTER 5

5. DISCUSSION

5.1. Introduction

The purpose of this study was to answer the main research question, which is “to what extent can a usable mobile application serve as a supporting tool for honours research students in an ODL environment in South Africa?” The mobile application was designed, implemented and investigated to determine whether it would be useful for students who are new to research in terms of information access, collaboration and information sharing. As discussed in Chapter 2, mobile application interface guidelines were used to determine the features of the designed artefact. The questionnaires and interviews used in this study to collect data were structured to ensure that they were aligned with the intention of this study. Using the research design as discussed in Chapter 3, the data were provided by the honours project students.

This chapter discusses the findings discussed in the previous chapter relating to the literature reviewed in Chapter 2. Section 5.2 of this chapter explains the pilot and the responses. This is followed by a discussion of the quantitative analysis in section 5.3. The usability tasks and their results are discussed in section 5.4 and the final results of the qualitative analysis are discussed in section 5.5, while Section 5.6 concludes this chapter.

5.2. Pilot and responses

As indicated in Chapter 3 (section 3.4.1), a pilot study was conducted with two honours project students. The intention was to evaluate the mobile application interface, test the research

design, determine the reliability and validity of the research methods, and clarify the instructions. The participants found one challenge, namely, that the mobile application did not upload the electronic article document as intended. This was resolved by improving the mobile application interface in the design and development activity of the DSRM (see Figure 4.1). The insights gained from the pilot study enhanced the integrity and usability of the mobile application considerably and the pilot study proved to be an essential step in getting to a trustworthy result.

5.3. Results of the usability testing

This section discusses the findings found during the usability testing of the mobile application where the usability metrics were used. Usability testing is fully discussed in section 4.2. The results of the usability testing were obtained from the following usability metrics:

Effectiveness (task success)

As indicated in section 4.2.1, binary success was used to determine the success of the participants in completing all the tasks. The results indicated that 97 percent of the participants completed all the tasks successfully without assistance and the rest managed to complete with assistance. As presented in Figure 4.2, it was found that only four participants required assistance with the tasks. In the ODL environment where students often work in isolation the ability to complete tasks without assistance is important. Given this binary success rate the mobile application can be considered effective for use in the ODL research environment.

Efficiency (time-on-task)

As indicated in Table 4.1 (Section 4.2.2), the total average time taken for the four tasks is 8.48 minutes. Therefore, we can conclude that the efficiency is acceptable. Furthermore, the standard deviation of all the tasks is less than 1 which implies that there were no major differences in the completion time that could indicate specific usability issues. The results are also presented in Figure 4.3.

Usability problems

Usability problems help in identifying any undesirable outcome experienced by the user. This was done through observation. One participant had a difficulty with Task 2 and three participants with Task 4. As was observed during the study, the reason for the four participants not completing the two tasks was the fact that the mobile application could not connect to the server. It is assumed that a deficient internet connection might be the reason why the mobile application could not connect to the server.

5.4. Results of the quantitative interpretation

The discussion of the results below is based on the descriptive statistics using data generated from the PSSUQ.

5.4.1. The mean and standard deviation

The analysis indicated that the mean scores lie in the high satisfaction category. This is also indicated in Figure 5.1, where the mean score lies between 1.70 and 2.63. Figure 5.1 also presents the standard deviation. According to this figure, it is clear that the standard deviation

for each question is tightly distributed around its corresponding mean. This means there was little variation in participants' responses.

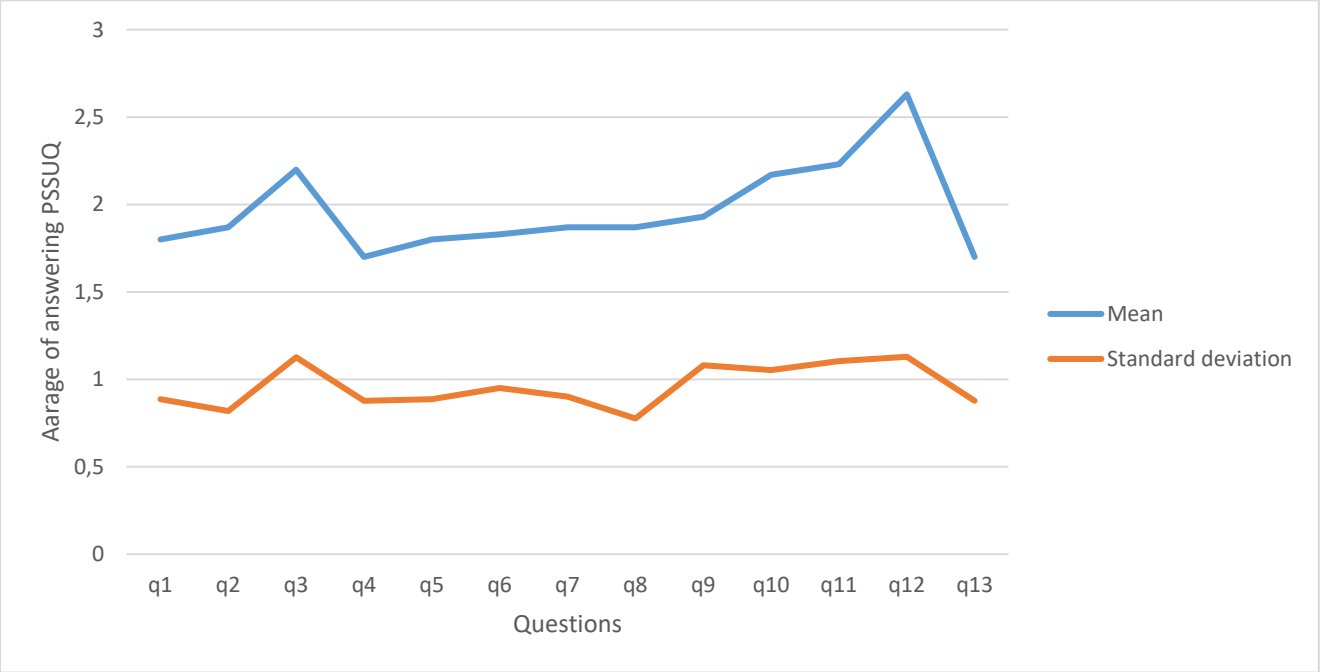

Figure 5.1: The mean and standard deviation of the PSSUQ

5.4.2. Reliability and consistency

The Cronbach's alpha (α) was calculated to estimate the internal reliability of the questionnaires. This method was used in this study to test the consistency of the participants' responses. Tables 4.5, 4.6, and 4.7 respectively indicate the three reliability measurements of the three constructs of mobile application analysis. The reliability of the mobile application analysis has Cronbach alphas above 0.7 for the groupings of SU, IS, and IQ; therefore these were considered reliable. It is clear that the values of the groupings indicate an acceptable measure of internal consistency.

5.4.3. Correlation

In a correlation, a value of 1.0 implies that two variables are perfectly related. In addition, if one variable increases, then the second variable is also increases. As indicated in Table 4.7, the R-values range from 0.684 to 0.816. This indicates a significant correlation between the constructs SU and IQ (0.816), SU and IS (0.766) and IS and IQ (0.684). This is to be expected as both IS and IQ would influence SU. The correlation between IS and IQ is less obvious, but it makes sense that the quality of the interface would influence information sharing.

5.5. Results of the qualitative interpretation

The qualitative data were analysed by implementing the six phases of thematic analysis. The data came from the interview questions answered by the participants after the usability testing where the researcher observed the interaction of the participants with the mobile application. Any additional comments which the participants felt were of importance could be included as a comment. All the interviews were audio recorded. The outcomes given in this section are grounded on the themes that were generated in phase 2 of the thematic analysis in Chapter 4 (section 4.4.1).

5.5.1. Usability

The high level of response to the “easy to use” was influenced by fact that most participants were able to use the mobile application to share information with other students. This is because the participants want a helpful tool to use for accessing information and interacting with each other. The response of “easy to use” was also influenced by the simplicity of the mobile application interface. Taylor et al. (2009:303) define simplicity as “the degree of comfort with which users find a way to accomplish tasks”. One of the participants indicated

that the mobile application interface was simple to use as it served only the purpose of research. Rogers et al. (2012:158) argue that “the style of a interface, in terms of the shapes, fonts, colours, balance, white space, and graphical elements that are used and the way they are combined can influence the use of the application”.

The participants encountered no difficulty in using the mobile application to interact with their peers. The response to “no difficulty” came from motivated participants as they could access the shared electronic articles and their URLs. They reasoned that the mobile application was effective as it allowed them to access the shared resources with different formats. This meets one of the mobile application interface design guidelines which states that mobile application page layout should be effective.

5.5.2. Information sharing

Most of the participants considered information sharing as a motivation to support each other in research. They reasoned that the information sharing part of the mobile application would help to overcome the distance barriers since all the shared information is easily accessible. Christensen and Knezek (2009) emphasise that the everyday presence of information sharing through communications technology facilitates education and knowledge sharing throughout the world today. It also assists the participants who are new to research to obtain and maintain direct access to all shared information. Information sharing encourages participation and allows students to do their work effectively.

5.5.3. Collaboration in the research environment

Although students might be located in remote environments, they can still share ideas, working on research papers together, and communicating with each other about research work. In practice, collaboration has allowed the students to study together or form small groups to accomplish common study goals (Lee & Salman, 2012). From observation, both information access and information sharing help in collaboration, as participants were able to interact with each other. Some of the participants indicated that after having shared information, they made a comment in the discussion tab to inform other participants about this.

5.5.4. Lack of internet connection

During usability testing, it was noted that some of the tasks were not completed. The participants indicated in the additional comments that the mobile application should deploy the use of the internet. Furthermore, the participants reiterated that they could not do independent research without a stable internet connection.

5.5.5. Functionality and knowledge

Functionality and knowledge were demonstrated when the participants commented that the usability of the mobile application interface helped them to share knowledge. The functionality and knowledge sharing ability of the mobile application interface are important because they help participants to focus on research and interact with each other. Participants felt that the interface had the functionality to resolve research problems. However, some participants indicated that the interface should have more functionalities.

5.6. Participants' perception of the mobile application in ODL

5.6.1. Usability of the mobile application in ODL

The results obtained in this study and discussed in Chapter 4 show that the usable mobile application in ODL can make the finding of information resources more effective and efficient and leave students who are new to research satisfied. The mobile application was appreciated and fully utilised by the participants in accordance with its research purpose of information access, collaboration and information sharing. Accordingly, the implementation of a mobile application could offer many benefits to the university learning environment, including easy, convenient, effective and accurate information access (Khaddage et al., 2011). In general, the features of the mobile application were considered usable because of their capability to assist the participants to undertake research by using the mobile application. The participants liked the mobile application interface because of its feature that allowed them to upload the electronic article document and its URL easily. The participants indicated that what they liked most about the information access provided by the mobile application interface was that it enabled them to access both the electronic article document and its URL. Notably, the current LMS provides a functionality for downloading but students do not have the functionality to upload research articles for sharing. Therefore the mobile application also helps them to access the required information when the LMS is down or not functioning. Ozdamli and Cavus (2011) state that students play an active role of learning when the information that they need is accessible. When the students struggle to find certain electronic articles, they can often find them through the shared info tab of the mobile application (see Figure 3.3). This motivates the students to interact actively in using the mobile application.

The findings of the post-interview in this study from also indicate that there are no barriers to participation by all the students. This means the students can use the mobile application to contribute to their collaborative research when they are in remote areas. Many participants liked the collaboration through the mobile application because it allowed them to become engaged and become involved in research and learn research skills from each other. According to Alnuaim et al. (2016), giving students the capability to share remarks, thoughts and perhaps favourable stories can help them to gain knowledge and various viewpoints from other students .

5.6.2. The drawbacks of the mobile application in ODL

Although the investigated mobile application was used to perform its research purpose in ODL, there are some areas where some of the participants did not find it functional. This included lack of internet connection, minimal features on the mobile application interface, and the mobile application focusing only on one module or subject. Participants suggested that the mobile application should have the potential to be utilised with other university functionalities such as submitting assignments, reviewing the assignments and examination results. However, the purpose of the mobile application investigated in this study was not to replace the LMS by providing those functionalities.

5.6.3. Recommendations made by the participants

The participants made a number of recommendations about the use of effective mobile applications in ODL. Although the mobile application investigated in this study was specifically for honours project students, the participants suggested that it should be linked to the university LMS to be used by all students. Furthermore, they expressed the view that the mobile

application should have more features including multimedia content, podcasts and videos. Luttenberger et al. (2018) indicate that learning today is often provided in the form of podcasts and videos. Involving user input during the design of a mobile application was also recommended. The information obtained from the involved “users can be implemented into the design of the technology and possibly enhance the quality of the design” (Fischer et al., 2019:513).

5.7. Summary and conclusion

The study provided evidence that the mobile application was evaluated and found to be effective, efficient and satisfactory. Although, there were participants who did not complete all the tasks, the results indicated that that the mobile application could be used effectively in the research environment.

The next chapter concludes the study. The research is reviewed, and the research questions revisited in order to confirm that the main research question and sub-questions were, indeed, answered and to summarise the way in which these answers were arrived at.

CHAPTER 6

6. CONCLUSION

6.1. Introduction

This is the concluding chapter of the study. It presents a summary of the research findings and shows how the research questions were answered. Section 6.2 presents an overview of the study, the research questions and responses. Section 6.3 explains the limitations while section 6.4 contextualises the study. The study contributions are discussed in section 6.5 and recommendations are given in section 6.6. Section 6.7 presents personal reflections.

6.2. Research questions and responses

The aim of this study was to investigate the development of a usable mobile tool that provides an interface for information access, collaboration and information sharing. To achieve this, the properties of mobile applications, and the requirements and guidelines for developing mobile applications were extracted and refined from a literature review. Furthermore, the researcher developed a mobile application and analysed its usability in the ODL environment. To evaluate the usability of the mobile application, usability testing, survey and interviews were conducted with participating honours research students to obtain their insights. A triangulation of the findings confirmed that the usability of the mobile application was acceptable for use in the ODL research environment for information access, collaboration and information sharing.

The DSR methodology was used to guide the empirical data collection methods to give answers to the main research question and sub-questions. The data were provided by the

honours project students who participated in the data capturing process during and after the usability testing. The mobile application was evaluated for the purpose of this study.

The research questions and the processes followed to answer them are briefly described below, together with the resolutions, i.e. sections where the findings are presented.

RQ1: What are the properties of a usable mobile application interface?

The properties of an effective mobile application were extracted from the literature review. These properties were discussed in Chapter 2 (section 2.5.2) and summarised in Table 2.2. The literature-based properties prioritised are as follows: layout of the application, navigation, images, content, hierarchical menus, colour, and label or caption. This gives a broad overview of desirable properties of a usable mobile application.

RQ2: What are the requirements for a usable mobile application in an ODL environment?

To answer this question, the requirements for a usable mobile application were extracted from the literature and discussed in Chapter 2 (section 2.5.3) and the relevant guidelines for considering and selecting the requirements for a usable mobile application interface design in an ODL environment were identified from the literature (Table. 2.3). These guidelines can be found in section 2.6.2, and the process for answering the question can be found in Chapter 4. This study reviewed and refined the guidelines identified in Table 2.4 to provide updated guidelines specifically for designing and implementing mobile applications that can be used in ODL research. The refined guidelines are presented in Table 2.5.

RQ3: How usable will such a mobile application be in supporting honours research students in an ODL environment?

In an effort to answer this sub-question, the DSR method was used to develop an artefact and to collect the essential data by means of questionnaires and structured interviews conducted with honours project students. The usability tasks were performed as part of the usability evaluation followed by the completion of PSSUQ. The entire data gathering process was described in Chapter 3. During the usability testing, the participants were briefed on how the artefact works and asked to use it to share information, collaborate and access shared information. The generated data were analysed and interpreted as described in Chapter 4. Analysis was done on the level to which the usability of the artefact conformed. The process formed part of phase 4 of the DSRM. The results were discussed in Chapter 5 and indicate that the artefact developed in this study had a degree of impact in the ODL research environment.

The findings of the usability evaluation tasks indicated that the participants were generally of their opinion that the mobile application is usable in the ODL research environment. Effectiveness, efficiency, and satisfaction of the mobile application were evaluated during usability testing. The mobile application solved the problem relating to honours students' information access because they were able to share information, and collaborate. The students also made suggestions for improvements to the mobile application.

The contribution of each research question in relation to this study is highlighted in Table 6.1.

Table 6.1: Contribution of each research question in relation to the study

Research questions	Research action	Research output	Type of contribution
RQ1: What are the properties of a usable mobile application?	Literature review – to identify the properties of an usable mobile application	Chapter 2 (section 2.5.2). Table 2.2	Theoretical: Synthesised list of literature-based mobile application properties
RQ2: What are the requirements for a usable mobile application in an ODL environment?	Literature review – to identify the requirements for a usable mobile application in an ODL environment	Chapter 2 (sections 2.5.3 and 2.6.2) Table 2.4 and Table 2.5	Theoretical: Synthesised list of literature-based requirements
RQ3: How usable will such a mobile application be in supporting honours research students in an ODL environment?	Prototype development – to develop a usable mobile application that serves as a supporting tool for honours research students in an ODL environment. Evaluation – usability testing, observation, the PSSUQ and interviews	Chapter 3 (section 3.3) Chapter 4 and Chapter 5	Theoretical and practical: Refined list of requirements empirically validated by literature review. Evaluation of usable mobile application

6.3. Limitations

A limitation of the study was that the usability testing was conducted in the research area for masters and doctoral students only at the UNISA main campus. Since UNISA is a distance learning institution, it was difficult for researcher to get access to all the honours project students. The researcher did manage to get 30 students to participate in this study. This was considered adequate, but it would have been better to involve more students and to do so over a period of time. Each participant was evaluated only once so there is no record of usage

behaviour over a period of time. Such information could have proved useful in indicating the actual use over time and thus the potential for full adoption. The venue hosted participants in a controlled research environment, where they could interact only with the facilitator and complete tasks with only the tools provided. This might have affected the participants' behaviour. Their reactions may also have been affected by the fact that they were being observed and some of the reactions observed during usability testing may have been dissimilar from those that may have occurred in a natural environment. The mobile application requires an internet connection which limits the use in areas where the internet connection is unstable.

6.4. Contextualising the research

This section highlights recent studies on mobile applications in higher education. The researcher contextualises the contribution of the current study by considering the following contemporary studies:

- Muslimin et al. (2017) focused on presenting the stages to be considered in creating a mobile application framework for studying a topic in microeconomics. They developed an informative mobile application for microeconomics by producing study content and analysing students' satisfaction after using the app. The results indicate that the mobile informative application positively contributed as an information sharing platform to assist students to have better experience of the concepts and the course content. Furthermore, it provided teachers and students with a better or more appropriate strategy for their education and study activities. Their study is different in the focus on content versus access (this study) but both confirm the potential of the mobile application for information sharing.

- Ahmed et al. (2017) focused on designing a mobile application for university management systems and examined the interaction between students and teachers through mobile applications. The results indicated that the mobile application introduced and improved interactivity, accessibility and convenience in the learning process. The improvement of interactivity through a mobile application is beyond the scope of this study, but it will be considered for future research.
- Singh et al. (2017) examine a mobile application in a mobile learning environment. They investigated whether students who were unable to attend school could access course content through the internet by using an m-learning mobile application. The results indicate that once course content is accessed by a mobile application through the internet and stored on mobile devices, the student can study without an internet connection. While offline use is important in the ODL content; that functionality was not explored in this study but rather identified as a topic for further study.
- Ansari and Tripathi (2017) investigated the effectiveness of a mobile learning application in higher education in India. The results highlight the acceptance of mobile learning apps among students at higher academic institutions in India. In relation to this study their results also confirm that mobile learning applications can be used successfully in higher academic institutions.
- Ojino and Mich (2018) focused on mobile applications in university education. They investigated whether mobile phones and apps can be used effectively by tertiary students in educational settings. The results indicate that the use of mobile applications in supplementing learning presents a great advantage for academic institutions; in addition, management and other functions could benefit from students' behaviours and needs in relation to mobile technologies and apps. Their results show support for the use of mobile applications in higher education institutions.

- Chuchu and Ndoro (2019) studied whether mobile applications could be accepted as possible mechanisms for educational purposes in higher education institutions. They established a theoretical model from a technological integration model in order to measure certain concepts. The findings indicated that perceived functional, perceived usability, reactions towards a mobile application, and determination to deploy mobile application were all important predictors of the real usage of mobile applications for study purposes. In relation to this study the authors also identified the features of mobile applications which resonate with the properties identified in this study. The proposed mobile application features include some of the features that are identified from the findings, for example the layout of the application, navigation, images, content, hierarchical menus, colour, and label or caption.
- Luis et al. (2020) investigated the effects of using a fully integrated mobile application to access LMS in higher education. Their findings indicated that the app has eased the use of the system, the satisfaction of students with LMS has risen, and student performance has improved with increase access. In relation to this study their results also confirm that mobile applications help the students to access information on LMS.

The studies discussed mentioned certain mobile applications developed and used in higher education recently, some of them while this study was being conducted. The findings confirm the usefulness of mobile applications in supporting learning but none of these applications addressed the challenge of developing a mobile application to support students in an ODL environment.

6.5. Contribution of the study

This study encompassed designing, developing and evaluating an evidence-based artefact in the field of Computer Science. The research made both theoretical and practical contributions, as explained in the following sections.

Theoretical contribution

The findings of the literature study (section 2.5.2) contributed to the existing knowledge on the properties of a usable mobile application and making an informed choice when designing the mobile application. The theoretical contribution of this study includes the following:

- *Identifying the properties of a usable mobile application*. These can be found in section 2.5.2. This included application layout to help with providing the correct screen format, hierarchical menus that help to avoid horizontal scrolling, navigation, labels/captions, content, images and colour (see Table 2.2)
- *Identifying the requirements of mobile application for interaction design*. These are discussed in section 2.5.3.
- *The evidence-based mobile application guidelines for the ODL context.* These were developed by identifying usability-based guidelines for mobile application interface design. See Table 2.3 in section 2.6.2. Notably, interface design is a subset of interaction design.
- *The relevant guidelines were selected, refined and grouped to support the phases of the software development process.* The refined guidelines for mobile application interface design used to inform such design in this research can be found in Table 2.5. The phases include the following: define the usage mobile application; identify the specific tasks of the users; group tasks of the same category; design for small devices; design for collaboration; strive for consistency; make user input as simple as possible; design for

speed and recovery; only show essential information; navigation; meet users' needs quickly; clearly distinguish selected item; usability testing; and observation. The findings indicated that these guidelines, which were considered in this study, had an impact on the design of a usable mobile application. Furthermore, the refined guidelines were also used during the DSR process. This is represented in Table 6.2.

Table 6.2: Final guidelines with DSR process

Phases	**Guidelines**	**DSR process**
Analysis	**Context of use** *Specify the requirements of the target users*	Identify the problem
	• Define the use of the mobile application • Identify the specific tasks of the users • Group tasks of the same category	Define the objectives of a solution
Design	**Context of medium** *Develop the application*	Design and develop the artefact
	• Design for small devices • Design for collaboration • Strive for consistency • Make user input as simple as possible • Design for speed and recovery • Only show essential information • Navigation • Meet users' needs quickly • Clearly distinguish selected items	
Testing and Implementation	**Context of Evaluation** *Evaluate design against the user requirements*	Demonstrate the artefact
	• Usability testing • Observation	• Evaluate the artefact • Communicate the results

Practical contribution

The practical contribution of this study to the body of knowledge is the design and construction of a knowledge-sharing and collaboration artefact for research students in ODL. The artefact

provides a solution to existing information sharing and collaboration constraints that affect students in ODL.

With regard to the mobile application evaluation, comments and the collected quantitative and qualitative data from the participants indicated that the mobile application is usable in an ODL research environment. However, suggestions were made for the improvement of the mobile application. These suggestions include the following:

- The mobile application should be linked to the university LMS to be used by all students.
- The mobile application should have more features that include multimedia content, podcasts and videos

These suggestions would ensure further practical contributions in this study.

6.6. Recommendations for further research

This study was conducted with registered UNISA honours project students who are new to research. Accordingly, there is a need to extend the research to all postgraduate students (masters and doctoral). This could have a great advantage in that they would also participate in providing feedback to enhance the mobile application.

Furthermore, there is a need to replicate this research with larger numbers of participants and also to extend the evaluation of the mobile application. Considering the fact that the lecturers are involved as supervisors of honours project students, they could also be involved in interacting with students through the mobile application. As the participants suggested, the mobile application should have more functionalities. Hence, further studies could include more

features on the mobile application interface to provide more options for utilising the mobile application.

6.7. Personal reflection

This study has challenged and exposed me to various learning experiences and research activities. At every step I attempted to keep an open mind, trying to think about how the eventual findings would be. Considering what other researchers have discovered, I started to recognise that the outcome on this study might not necessarily provide the expected results. This is because every potential study has its unique purpose, findings and conclusions. The approach I adopted to systematically evaluate the academic literature to identify certain concepts improved my ability to recognise important facts in drafting my dissertation. Deciding on which research approach to follow was a big challenge since I am a beginner in research.

In conclusion, the opportunity to design and implement an artefact in a research context has given me a great experience. I feel humble to find myself on this journey, and to have conducted research that involved participants who sacrificed their time to help me reinforces this humility. It was also a blessing to be surrounded by academics who constantly provided guidance.

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Appendix A: Ethical clearance certificate

UNISA

UNISA COLLEGE OF SCIENCE, ENGINEERING AND TECHNOLOGY'S (CSET) RESEARCH AND ETHICS COMMITTEE

15 May 2017

Ref #: 035/SPC/2017/CSET_SOC
Name: Sonti Phillip Choshi
Student #: 33903476

Dear Sonti Phillip Choshi

Decision: Ethics Approval for 3 years (Humans Involved)

Researcher: Sonti Phillip Choshi
221 Maokeng Section, Tembisa, 1632
choshsp@unisa.ac.za, +27 11 670 9121

Supervisor (s): Prof J Van Biljon
vbiljja@unisa.ac.za, +27 11 670 9182
Prof ID Sanders
sandeid@unisa.ac.za, + 27 11 471 2858

Proposal: Developing an adaptive mobile application as a supporting tool for honours project students in an Open Distance Learning

Qualification: MSC in Computing

Thank you for the application for research ethics clearance by the Unisa College of Science, Engineering and Technology's (CSET) Research and Ethics Committee for the above mentioned research. Ethics approval is granted for a period of three years from 15 May 2017 to 15 May 2020.

1. The researcher will ensure that the research project adheres to the values and principles expressed in the UNISA Policy on Research Ethics.
2. Any adverse circumstance arising in the undertaking of the research project that is relevant to the ethicality of the study, as well as changes in the methodology, should be communicated in writing to the Unisa College of Science, Engineering and

RECEIVED
2017 -05- 16
Office of the Deputy Executive Dean
College of Science, Engineering & Technology

University of South Africa
Preller Street, Muckleneuk Ridge, City of Tshwane
PO Box 392 UNISA 0003 South Africa
Telephone: +27 12 429 [illegible] Facsimile: +27 12 429 4150
www.unisa.ac.za

Appendix B: UNISA RPSC application form

APPLICATION TO CONDUCT RESEARCH INVOLVING UNISA EMPLOYEES, STUDENTS AND DATA

Read the Standard Operating Procedure for Conducting Research involving Unisa Employees, Students and Data prior to filling out this application form (click here)

Note: Permission does not guarantee availability / access to the requested data source(s)

Incomplete applications will not be considered by the Research Permission Subcommittee (RPSC)

1. SECTION 1: APPLICANT DETAILS

1.1. INTERNAL APPLICANT *(Main Unisa Researcher)*	**TITLE**	Mr	**NAME & SURNAME** *(exactly as it should be on the letter of permission)*	Sonti Phillip Choshi		**EMPLOYEE / STUDENT NO**	33903476
	UNIT / DEPARTMENT		College of Science Engineering and Technology (CSET)	**SCHOOL**	School of Computing	**COLLEGE**	College of Science Engineering and Technology (CSET)
	WORK TEL NO		011 670 9121	**CELL NO**	072 404 1157	**EMAIL ADDRESS**	spchoshi@gmail.com
1.2. EXTERNAL APPLICANT *(Main Non-Unisa Researcher)*	**TITLE**		**NAME & SURNAME** *(exactly as it should be on the letter of permission)*			**INSTITUTION**	
	UNIT / DEPARTMENT			**FACULTY**		**POSITION / ROLE**	
	WORK TEL NO			**CELL NO**		**EMAIL ADDRESS**	

2. SECTION 2: SUPERVISOR / CO-SUPERVISOR DETAILS *(If application is made by a Student)*

2.1. UNISA SUPERVISOR / CO-SUPERVISOR	**TITLE**	Prof	**NAME & SURNAME** *(exactly as it should be on the letter of permission)*	Judy van Biljon		**EMPLOYEE NO**	1118706
	UNIT / DEPARTMENT		College of Science Engineering and Technology (CSET)	**SCHOOL**	School of Computing	**COLLEGE**	College of Science Engineering and Technology (CSET)
	WORK TEL NO		011 670 9182	**CELL NO**		**EMAIL ADDRESS**	vbiljja@unisa.ac.za
2.2. NON-UNISA SUPERVISOR / CO-SUPERVISOR	**TITLE**		**NAME & SURNAME** *(exactly as it should be on the letter of permission)*			**INSTITUTION**	
	UNIT / DEPARTMENT			**FACULTY**		**POSITION / ROLE**	
	WORK TEL NO			**CELL NO**		**EMAIL ADDRESS**	

3. SECTION 3: CO-RESEARCHER(S)' DETAILS *(If the application is relevant to a Collaborative Research Project)* *[Indicate All Co-researchers and Add More Rows If Necessary]*

1

Appendix C: Certificate of permission to conduct research involving UNISA students

UNISA university of south africa

RESEARCH PERMISSION SUB-COMMITTEE (RPSC) OF THE SENATE RESEARCH, INNOVATION, POSTGRADUATE DEGREES AND COMMERCIALISATION COMMITTEE (SRIPCC)

19 July 2017

Decision: Research Permission Approval from 19 July 2017 until 31 December 2018.

Ref #: 2017_RPSC_046
Mr. Phillip Choshi
Student #: 33903476
Staff #: N/A

Principal Investigator:
Mr. Phillip Choshi
School of Computing
College of Science, Engineering and Technology
UNISA
spchoshi@gmail.com; (011) 670-9121/ 072 404 1157

Supervisor : Prof Judy van Biljon
vbilija@unisa.ac.za, (011) 6709182

A study titled: "Developing an adaptive mobile application as a supporting tool for honours project students in an Open and Distance Learning (ODL) environment in South Africa."

Your application regarding permission to conduct research involving UNISA employees, students and data in respect of the above study has been received and was considered by the Research Permission Subcommittee (RPSC) of the UNISA Senate, Research, Innovation, Postgraduate Degrees and Commercialisation Committee (SRIPCC) on 17 July 2017.

It is my pleasure to inform you that permission has been granted for the study. You may:

1. Gain access to the MyLife email addresses of Honours Project students (HRCOS82) through the gatekeeping assistance of your supervisor, in order to invite them to participate in the Usability Lab to evaluate the mobile application usability.
2. The participating students may also participate in the post-test questionnaire.

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Appendix D: Informed consent form

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CONSENT TO PARTICIPATE IN THIS STUDY

I, _____ (participant name), confirm that the person asking my consent to take part in this research has told me about the nature, procedure, potential benefits and anticipated inconvenience of participation.

I have read (or had explained to me) and understood the study as explained in the information sheet.

I have had sufficient opportunity to ask questions and am prepared to participate in the study.

I understand that my participation is voluntary and that I am free to withdraw at any time without penalty (if applicable).

I am aware that the findings of this study will be processed into a research report, journal publications and/or conference proceedings, but that my participation will be kept confidential unless otherwise specified.

I agree to the recording of the eye tracking.

I have received a signed copy of the informed consent agreement.

Participant Name & Surname.....

Participant Signature.....Date.....

Researcher's Name & Surname.....Phillip Choshi.....

Researcher's signature..... .....Date...13/02/2017.....

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Appendix E: Participant information sheet

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PARTICIPANT INFORMATION SHEET

Ethics clearance reference number: 035/SPC/2017/CSET_SOC
Research permission reference number (if applicable):

10 February 2017

Title: Developing an adaptive mobile application as a supporting tool for honours project student in an Open and Distance Learning environment

Dear Prospective Participant

My name is Phillip Choshi and I am doing research with Prof Judy van Biljon, a professor in School of computing towards a Masters in Computing at the University of South Africa. We are inviting you to participate in a study entitled: Developing an adaptive mobile application as a supporting tool for honours project student in an Open and Distance Learning environment.

WHAT IS THE PURPOSE OF THE STUDY?

The study is conducted to investigate an adaptive mobile tool to provide an interface for information access, collaboration and knowledge sharing

WHY AM I BEING INVITED TO PARTICIPATE?

Your participation is requested in this research since; you have been identified as a UNISA honours project student.

WHAT IS THE NATURE OF MY PARTICIPATION IN THIS STUDY?

The study involves post-test questionnaires where the participants will answer after conducting the task to evaluate the mobile application usability. The Systematic Usability Scale (SUS) post-

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Appendix F: User instructions

1. Register/login on mobile application
2. Use the mobile phone to open the Google Scholar website
3. Search one of the articles listed in the table
4. Download and copy the URL of the article
5. Upload the article and paste the URL on one of the categories (Mobile application, Computer security, or E-Health) on the mobile application interface
6. Start a topic or make a comment on the discussion forum according to the categories (Mobile application, Computer security, or E-Health)
7. Exit

Appendix G: List of articles to be used during the experiment

Title	Author	Year
Mobile Application		
1. A Mobile Augmented Reality Emulator for Android	*Donald Munro, Andre Calitz, Dieter Vogts*	2017
2. The Usefulness and Ease of Use of a Mobile Simulation Application for Learning of ERP Systems	*Brenda Scholtz, Mando Kapeso, Ruth de Villiers*	2017
3. Semi-automated Usability Analysis through Eye Tracking	*Katherine Mary Malan, Jan H.P. Eloff, Jhani A. de Bruin*	2018
4. Usability Evaluation for Business Intelligence Applications: A User Support Perspective	*Chrisna Jooste, Judith Arnoldine van Biljon, Jan Mentz*	2014
5. User-centered applications: Use of mobile information technologies to promote sustainable school healthcare services	*Alida Veldsman, Darelle van Greunen, Job Mashapa*	2015
6. The level of participation during the development of a mobile care data application for home-based healthcare in a developing context: An actor-network theory perspective	*Retha de la Harpe*	2014
7. Higher Education Cloud Computing in South Africa: Towards Understanding Trust and Adoption issues	*Karl Van Der Schyff, Kirstin Krauss*	2014
8. Design Requirements for a Teledermatology Scale-up Framework	*Laticha EM Walters, Richard E Scott, Maurice Mars*	2018
9. Towards Communication and Information Access for Deaf People	*Edwin Blake, William Tucker, Meryl Glaser*	2014
10. Demarcating Mobile Phone Interface	*Karen Vera Renaud, Judy van Biljon*	2017

Design Guidelines to Expedite Selection		
Computer Security		
11. A Digital Forensic Readiness Architecture for Online Examinations	*Ivans Kigwana, H. S Venter*	2018
12. Applying long short-term memory recurrent neural networks to intrusion detection	*Ralf C. Staudemeyer*	2015
13. Burning money with firewalls	*Ralf C. Staudemeyer, James Connan*	2015
14. Growing a cyber-safety culture amongst school learners in South Africa through gaming	*Elmarie Kritzinger*	2017
15. X-Switch: An Efficient, Multi-User, Multi-Language Web Application Server	*Mayumbo Nyirenda, Hussein Suleman, Andrew Maunder, Reinhardt van Rooyen*	2009
16. Extracting salient features for network intrusion detection using machine learning methods	*Ralf C. Staudemeyer, Christian W. Omlin*	2014
17. User Authentication based on Continuous Touch Biometrics	*Christina J Kroeze, Katherine Mary Malan*	2016
18. Factors for Successful Use of Social Networking Sites in Higher Education	*L Schlenkrich, Dave Sewry*	2012
19. A model to improve the routing performance of Cognitive Radio Wireless Mesh Networks	*Lesiba Morries Kola, Mthulisi Velempini*	2017
20. An Emperical Study Of User Acceptance of Online Social Networks Marketing	*Olumayoma Mulero, Michael Adeyeye*	2013
E- Health		
21. Survival of the project: A case study of ICT innovation in health care	Hege K Adreassen, Lars Erik Kjekshus, Asksel Tjora	2015

22. A privacy preserving three-factor authentication protocol for e-Health clouds	Qi Jiang, Muhammad Khurram Khan, Xiang Lu, Jianfeng Ma & Debiao He	2016
23. Bridging e-health and the internet of things: The sphere project	*Ni Zhu, Tom Diethe, Massimo Camplani*	2015
24. Big Data, Internet of Things and Cloud Convergence – An Architecture for Secure E-Health Applications	*George Suciu, Victor Suciu, Alexandru Martian, Razvan Craciunescu, Alexandru Vulpe, Ioana Marcu, Simona Halunga & Octavian Fratu*	2015
25. Novel Cloud and SOA-Based Framework for E-Health Monitoring Using Wireless Biosensors	*Abdelghani Benharref , Mohamed Adel Serhani*	2013
26. ICTs and the challenge of health system transition in low and middle-income countries	*Gerald Bloom, Evangelia Berdou, Hilary Standing, Zhilei Guo & Alain Labrique*	2017
27. Implementation of Context Aware e-Health Environments Based on Social Sensor Networks	*Erik Aguirre, Santiago Led , Peio Lopez-Iturri , Leyre Azpilicueta , Luís Serrano & Francisco Falcone*	2016
28. Innovations in e-health	*Paul Wicks, Jon Stamford, Martha A. Grootenhuis, Lotte Haverman & Sara Ahmed*	2013
29. Big Data as an e-Health Service	*W. Liu, E.K. Park*	2014
30. A systematic review of gamification in e-Health	*Lamyae Sardi, Alildri José Luis, Fernández-Alemán*	2017

Appendix H: The PSSUQ survey

The Post-Study Usability Questionnaire	Strongly Agree	Strongly Disagree	

			1	2	3	4	5	6	7		NA
1	Overall I am satisfied with how easy it is to use this system.		○	○	○	○	○	○	○		○
2	It was simple to use this system		○	○	○	○	○	○	○		
3	I was able to complete the tasks and scenarios quickly using this system.		○	○	○	○	○	○	○		
4	I felt comfortable using this system.		○	○	○	○	○	○	○		
5	It was easy to learn to use this system.		○	○	○	○	○	○	○		
6	I believe I could become productive quickly using this system.		○	○	○	○	○	○	○		
7	The system gave error messages that clearly told me how to fix problems.		○	○	○	○	○	○	○		
8	Whenever I made a mistake using the system, I could recover easily and quickly.		○	○	○	○	○	○	○		
9	The information (such as online help, on-screen messages and other documentation) provided with system was clear.		○	○	○	○	○	○	○		
10	It was easy for me to find the information I needed.		○	○	○	○	○	○	○		
11	The information was effective in helping me complete the tasks and scenarios.		○	○	○	○	○	○	○		
12	The organization of information on the system screens was clear.		○	○	○	○	○	○	○		
13	The interface* of this system was pleasant.		○	○	○	○	○	○	○		
14	I liked using the interface of this system.		○	○	○	○	○	○	○		
15	This system has all the functions and capabilities I expect it to have.		○	○	○	○	○	○	○		
16	Overall, I am satisfied with this system.		○	○	○	○	○	○	○		

The “interface” includes those items that you use to interact with the system. For example, some components of the interface are the keyboard, the mouse, the microphone, and the screens (including their graphics and language).

Appendix I: Adopted PSSUQ for mobile application in supporting ODL students' research

Participant Number ……. Date: ____/__/__

The Post-Study Usability Questionnaire		Strongly Agree						Strongly Disagree		
		1	**2**	**3**	**4**	**5**	**6**	**7**		**NA**
1	Overall, I am satisfied with how easy it is to use this mobile application.	○	○	○	○	○	○	○		○
2	It was simple to use this mobile application	○	○	○	○	○	○	○		
3	I was able to complete the tasks and scenarios quickly using this mobile application.	○	○	○	○	○	○	○		
4	I felt comfortable using this mobile application.	○	○	○	○	○	○	○		
5	It was easy to learn to use this mobile application.	○	○	○	○	○	○	○		
6	I believe I could become productive quickly using this mobile application.	○	○	○	○	○	○	○		
7	It was easy for me to find the information I needed.	○	○	○	○	○	○	○		
8	The information was effective in helping me complete the tasks and scenarios.	○	○	○	○	○	○	○		
9	The organization of information on this mobile application was clear.	○	○	○	○	○	○	○		
10	The interface of the mobile application was pleasant.	○	○	○	○	○	○	○		
11	I liked using the interface of this mobile application.	○	○	○	○	○	○	○		
12	This mobile has all the functions and capabilities I expect it to have.	○	○	○	○	○	○	○		
13	Overall, I am satisfied with this mobile application.	○	○	○	○	○	○	○		

Appendix J: Interview questions

1. Were you able to use the mobile application to share information with other students?
2. Did you complete all the required tasks effortlessly?
3. Do you think the mobile application can be helpful for collaboration in the research environment?
4. Do you think the users will need assistance in using the mobile application?
5. Would you recommend the use of the mobile application?
6. What do you think would encourage the use of this mobile application?
7. What do you think would discourage the use this mobile application?
8. How can we improve the mobile application for learning collaboration?

Any comment regarding the mobile application……

Appendix K: Binary success table

Participants	Task1	Task2	Task3	Task4	Average of tasks completed by each participant
P1	1	1	1	1	100%
P2	1	1	1	1	100%
P3	1	1	1	1	100%
P4	1	1	1	1	100%
P5	1	1	1	1	100%
P6	1	1	1	1	100%
P7	1	1	1	1	100%
P8	1	1	1	1	100%
P9	1	1	1	1	100%
P10	1	1	1	1	100%
P11	1	1	1	1	100%
P12	1	1	1	1	100%
P13	1	1	1	1	100%
P14	1	1	1	1	100%
P15	1	1	1	1	100%
P16	1	1	1	1	100%
P17	1	1	1	1	100%
P18	1	1	1	1	100%
P19	1	1	1	1	100%
P20	1	1	1	1	100%
P21	1	1	1	1	100%
P22	1	1	1	1	100%
P23	1	1	1	1	100%
P24	1	1	1	1	100%
P25	1	1	1	1	100%

P26	1	1	1	1	100%
P27	1	1	1	0	75%
P28	1	1	1	0	75%
P29	1	0	1	1	100%
P30	1	1	1	0	75%
Average per task	**100%**	**97%**	**100%**	**90%**	**97%**

Appendix L: Paper accepted at IST-Africa 2021

Mobile applications in supporting Open and Distance Learning students' research

Phillip CHOSHI[1], Ian SANDERS[2], Judy VAN BILJON[3]
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Abstract: Honours students, who are mostly new to research, require support in finding, selecting and sharing information resources to conduct research. Providing students with access to information resources becomes problematic in Open and Distance Learning (ODL), especially in developing countries due to constraints that are introduced by distance among the students, and between students and the supervisors. The constraints include isolation, lack of peer collaboration, the cost of internet facilities, and time management for working students. Mobile applications could offer solution, but the extant literature offers little guidance on the functional design of such application. This design science research study presents mobile tool with an interface for information access, information sharing and collaboration. The evaluation results show that the tool supports collaboration effectively by allowing students to access and share information. Besides the proof of concept, the theoretical contribution also lies in sharing the recommendations for improving the functionality of similar applications.

Keywords: Open and Distance Learning, Mobile Application, Collaboration, Information Sharing, Information Access

1. Introduction

The introduction of Open and Distance Learning (ODL) in universities is to provide access to the world of higher education by bridging the distance created by communication difficulties, economic, educational, geographical and social factors [6]. ODL provides flexible learning opportunities through learning environments that are process oriented and designed to promote discovery versus memorisation or mere repetition of contents [2, 21]. Musingafi, Mapuranga, Chiwanza, and Zebron [19] concurs that ODL provides accessibility, affordability and life-based education opportunities. The 2020 health pandemic related to Covid-19 increased the importance of online learning and the interest in ODL. However, the nature of the ODL environment requires students to manage the diverse and often conflicting demands and responsibilities of work and family, along with their commitment to further education and learning [38; 6]. Research into teaching and learning in ODL contexts is receiving a growing amount of attention and motivates the need for a better understanding of the demands and benefits of this approach for academic offering [27, 40].

Many universities nowadays require students to complete research projects. In the South African context, this is normally done at Honours level. ODL is a learning environment and context that requires such students to take increasing responsibility for the direction and management of their research [38]. Learning difficulties in research often have a negative impact on students' attitude towards and interest in research, as well as on their academic performance [39]. Some students experienced extreme difficulty when they could not move beyond their previous educational and cultural understanding to view their new learning research environment [38]. Click [5] concurred that there are variety of research

difficulties for new researchers, from finding a gap in the literature to assessing sources. Komba [16] revealed that most ODL students who are new to research experience challenges in the development of the research proposals. The problems included not knowing where to access the information and what to include in the research proposals, and therefore, this indicates a lack of research skills. This study presents the evaluation of a mobile tool to support the students specifically those who are new to the ODL research environment. While there are a number of existing mobile applications developed for social interactions none of those were developed or tested for providing a service to ODL novice research students in terms of their information access needs and security requirements. Furthermore, the existing mobile applications do not have a standardized structure such as a share repository. The contribution of the study is to provide insight on the value added by the mobile application and recommendations for improving the functionality. Additionally, the mobile application will be useful because there is an increase of online learning and increased student isolation due to Covid-19.

2. Literature Review

2.1. Open and Distance Learning

ODL is described as an approach that focuses on opening access to education and training provision, freeing students from the constraints of time and place, and offering flexible learning opportunities to individuals or a group of students [29]. ODL is way of providing a learning opportunity that is characterized by the separation of teacher and student in both time and place [17].

ODL combines the principles of student centeredness, lifelong learning, flexibility of learning provision, the removal of barriers to access, the recognition of credit for prior learning and the provision of student support [32]. It is a socio-economic effect on teaching and learning as it extends the learning participation to students from less privileged social groups who cannot access higher education due to diverse factors, such as financial constraints or domestic arrangements [1].

ODL is also observed as a system that supports students. Minnaar [19] indicates that academic support to ODL students is of the utmost importance. Paul, Primrose, and Chrispen [24]; Tait [33] indicate the following reasons why ODL is important in supporting students: students want support (cognitive support to learning); it reduces dropout rates (affective support to promote learning and success); and learning often needs mediation of some sort (systemic support systems of the institution to encourage persistence).

ODL supports blended learning as it combines the advantages of both ways of teaching –traditional teaching and teaching with the use of technologies [36]. ODL provides affordable, cost effective and flexible educational opportunities for all [22]**.** ODL promotes self-motivation and independency since ODL students rely on their own sense of personal responsibility and independence [4]. Students may be able to interact with each other through their own unique style of learning to meet specified credits [34].

Despite the advantages discussed in the previous section, ODL has constraints such as distance and time. This occurs when the physical distance does not permit direct interaction between the teacher and the student [22, 8]. Interaction is one of the most challenging educational aspects to build into an ODL system [7]. There is a weakening of the interaction between the instructor and the student due to the student being off campus during regular time [8].

2.2. Mobile Application

Mobile applications are application software that are designed and developed specifically to run on mobile devices, e.g., smartphone, tablet, etc. [41]. Mobile applications are essentially small computer programs that can be quickly downloaded onto mobile computing devices and immediately engaged

without rebooting the devices [26]. With the rapid growth of these applications, users can interact and access many activities such as social media, electronic communications, online shopping, online learning and life information. Users rely on these applications for a variety of tasks, from posting comments on social media to online banking [27].

Mobile applications are also beneficial for academic purposes. Mobile applications can be found in the fields of education, entertainment, medicine, communication services, military systems and many other institutions [13]. Since mobile applications can also be found in the educational field, they can be developed to support education where students can interact with each other, the learning system and the teacher.

In distance learning mobile applications enable collaboration and provide students with more control over the learning process and support the varying pace of the students [30]. The studies revealed that there are mobile applications developed and implemented in different educational fields to encourage and facilitate distance learning, and this increase the interaction between the students and teachers in distance learning [12].

However, no application found was focused on the need to support information sharing for research collaboration in ODL. This need cannot be met by the existing technologies like the learning management system because of lack of capacity and frequent downtime. Furthermore, email or other means of sharing information lacks the facility of providing access to the other students in the group.

2.3. Usability

Usability is considered one of the most important aspects of quality for any kind of product [25]. Usability is defined according to the International Standardisation Organisation as ‘‘the *effectiveness*, *efficiency* and *satisfaction* with which specified users can achieve specified goals in a particular environment” [14]. *Effectiveness* refers to the extent to which a task goal is successfully achieved (e.g., the proportion of users that are able to complete a given task). Taylor, Zhang and Adipat [34] defines effectiveness as the completeness and accuracy with which users achieve a certain goal. *Efficiency* refers to the amount of resources a user spends to reach a task goal. (e.g., task completion time). Both effectiveness and efficiency represent different kinds of performance measures [31]. *Satisfaction* can be considered as an attitude towards the product and it is a subjective measure that is typically collected in usability tests by means of questionnaires [14].

3. Methodology

The study deployed pragmatism, since data was generated through assessment and intervention [9]. The pragmatism paradigm advocates the use of qualitative and quantitative methods as a pragmatic way to understand human behaviour [15]. The methodology used in this study was the design science research (DSR) approach, which is primarily concerned with research into design as science [11]. The intent of DSR is to create an artifact through a balanced process that combines the highest standards of rigour with a high level of relevance [20]. Hevner, March, Park, and Ram [11] introduced seven guidelines that were followed in developing and evaluating the mobile application.

The application (as depicted in Figure 1) was developed using Java Studio, PHP, and CSS programming languages.

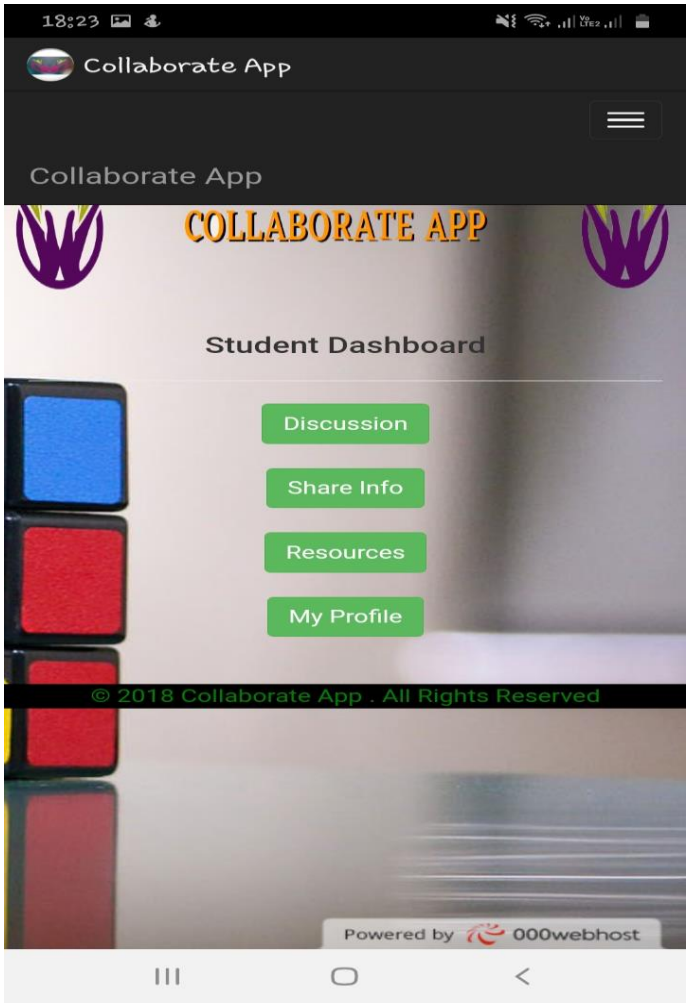

Figure 1: The displayed tabs of developed mobile application.

At first, a pilot study was conducted using two Honours project students. This pilot study was conducted to test the research design, determine the reliability and validity of the research methods, and clarify the instructions. During the pilot study, the participants could not complete the given tasks because the mobile application could not upload the electronic file as part of this study. The main study involved 30 Honours project students (13 females and 17 males) participating by using the mobile application to access information, collaborate, and share the information. All participants were University of South Africa (UNISA) students.

The quantitative data generated from the PSSUQ was analysed using the Statistical Package for Social Science (SPSS) but in this paper we discuss only the qualitative evaluation. Qualitative data was generated from the post-interview questions. Qualitative data analysis involves the making of inferences about data by systematically and objectively identifying special characteristics within them [10]. Thematic analysis is the process of identifying patterns or themes within qualitative data [3].

4. Data analysis

The quantitative data was collected, analysed, and the reliability was verified using the Cronbach's Alpha [23]. The reliability of system analysis has Cronbach alphas above 0.7 for System Usability, Interface Quality, and Information Sharing respectively and therefore, were considered reliable. Analysis using the thematic analysis involving the six phases are discussed as follows:

Phase 1: **Familiarization and Immersion**

We observed and noted the interaction of the participants with the mobile application during the usability testing. We listened to audio recordings of the participants and read the transcripts several times.

Phase 2: Coding

In this phase, we generated labels for important features of the data of relevance to the main research question guiding the analysis. The generated codes are in Table 4. Coding is not a method of data reduction, it is also analytic process, so codes capture both a semantic and conceptual reading of data [3]. We coded every data item and ended this phase by collating all codes and relevant data extracts. The codes are presented to show the number of participants who mention agree or support them. For example, two participants agreeing with the code that says, "easy to understand" is presented as "easy to understand x 2".

Theme: Share information **Codes** ➢ Easy to share information x 1 ➢ Cost-effective in share information x 1 ➢ Share electronic files and the links of videos x 4 ➢ Upload not a difficult task x 1 ➢ Share the information with other students x 30 ➢ Agree for share information x 3 0	**Theme: Collaboration in research** **Codes** ➢ Agree with collaboration in research x 30 ➢ Information (files), articles x 7 ➢ Easy to use and direct x 2 ➢ Remote area x 1 ➢ Collaborate with fellow students x 16 ➢ Access information x 27	**Theme: Complete all tasks effortlessly** **Codes** ➢ Agree with complete all task effortlessly x 29 ➢ No much work to do x 5 ➢ Not agree with complete all the task effortlessly x 1 ➢ Server or internet connection problem x 1	**Theme: Assistance use of mobile application** **Codes** ➢ Agree that assistance is needed to use mobile application x 21 ➢ Disagreeing that assistance is needed to use mobile application x 9 ➢ Skills ➢ Computer Knowledge ➢ User manual x 30
Theme: Recommendations mobile application **Codes** ➢ Recommending that mobile application can be used x 30 ➢ Sharing information (articles) publications, exchange of ideas x 10 ➢ Disagree x 0	**Theme: Encouragement use of the mobile application** **Codes** ➢ Encouraging the use of mobile application x 30 ➢ Share information x 8 ➢ Clear and straight forward x 13 ➢ Lack of internet data x 1	**Theme: Discourage use of mobile application** **Codes** ➢ Not discouraging the use of mobile application x 3 ➢ Agree - Lack of functionality and resources x 3 ➢ Cost of data x 3 ➢ More videos x 1 ➢ Knowledge x 3 ➢ Interface x 1 ➢ Neutral x 4	**Theme: Improve mobile application** **Codes** ➢ Agree to improve mobile application x 29 ➢ Sharing of information x 2 ➢ Functionality x 19 ➢ Application good x 2 ➢ Neutral x 1 ➢ Improve servers x 1

Table 4.1: Generated themes and codes for qualitative analysis

Phase 3: Searching for themes

All codes that belonged together were grouped in meaningful pattern in the data relevant to the research question. The researcher grouped the codes together and generated the following themes:

- Share information
- Collaboration in research

- Complete task effortlessly
- Assistance in using mobile application
- Recommendations mobile application
- Encouragement uses of the mobile application
- Discouragement uses of the mobile application
- Improvement of the mobile application

Phase 4: Reviewing themes

In this stage the themes were reviewed and further combined based on their relationships.
The researcher wanted to have a fair idea of different themes, how they fit together and the overall story they tell about the data. The grouped themes are:
Usability – (Complete task effortlessly, Assistance in using mobile application, and Encouragement uses of the mobile application)
Internet connection – (Discouragement uses of the mobile application)
Knowledge and functionality – (Recommendations mobile application, and Improvement of the application). The reviewed themes are presented as follows:

- **Usability** – this determines the efficiency, effectiveness, and satisfaction of the mobile application.
- **Information sharing** – allows the students to share the information amongst each other.
- **Internet connection** – determines the functionality of mobile application with internet
- **Collaboration in research** – allows students to participate through discussion forum.
- **Knowledge and functionality** – provide the functionality of the mobile application.

Phase 5: Refine the themes

Usability

The participants expressed satisfaction with the effectiveness and the following made comments about how it helps to collaborate in the research environment. *P4: "The mobile application is effective because we can access information from our fellow students, and also to interact with them since we are studying in distance learning".*

Information sharing

The significant part of information sharing is that the participants considered that sharing information through the mobile application is a motivation to support each other. This is because the share information tab of the mobile application enables them to share the relevant electronic articles and the links. *P12: "I feel much supported since my fellow students can share relevant electronic articles and their links with me."*

Internet connection

The participants indicated that the mobile application require the use of internet. They acknowledge that this type of mobile application should make use of internet. *P27: "Improve the internet and make sure the server does not affect the students while using it". P29: "Resources not being easily accessible because of downtime internet."*

Collaboration in research

Both information access and information sharing forms part of collaboration. Collaboration takes place when a group of people come together and contribute their expertise for the benefit of a shared objective. This is also facilitated through the mobile application. The participants identified the mobile application

interface as useful as it helps them to collaborate through the discussion forum. After the participants shared the information, they made comments about the discussion forum. *P9: "The mobile application is easy to use as it helps us to navigate and express our ideas on discussion forum platform. I believe this kind of features are needed in the space of research environment.".*

Knowledge and functionality

The mobile application has the functionalities that enable students to share knowledge to each other. The participants felt that the mobile application functionalities encourage collaboration and accessibilities of shared information. *P29: Easy to access available resources to encourage collaboration amongst the users. P26: I think the students will be able to interact to each other and share whatever information usable to each individual.*

For these participants, the usability of mobile application functionalities was a solution to their information access problem as they would be able to access information and share the knowledge.

5. Discussions

The results show that mobile application provides continuous information access to users regardless of geographical location and time. The evaluation of the application confirmed that students found the mobile application useful for supporting information access. Furthermore, participants indicated that the mobile application helps them to interact and collaborate with each other in terms of general support and staying connected to overcome isolation. The findings from the usability evaluation tasks indicated that the participants were generally of their opinion that the mobile application is usable in the ODL research environment.

The participants reported that using the mobile application helped in overcoming some of the research constraints in the ODL environment. The results address students' needs for information sharing and information access, and this can be considered as a learning experience that can bring together the two forms of formal and informal learning, in order to produce flexible collaborative learning in ODL research environment.

6. Conclusions

The contribution of this study to the body of knowledge is the design and construction of a knowledge sharing and collaboration artifact for research students in ODL. The artifact provides a solution to existing information sharing and collaboration constraints that affect students in ODL. The application clearly addresses specific needs such as isolation, lack of interaction, expensive technologies i.e. broadband, and time management for working students for learning not addressed by Learning Management System. Through the interview questions, participants specified that they most enjoyed sharing their own ideas and collaborate with peers. The mobile application designed in this study can be applied outside the ODL context, i.e. at residential universities. Future studies can investigate the use of mobile application for all postgraduate research students in the ODL environment.

7. References

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Appendix M: programming codes

HTML Code

```
<html>
<head>
<title>Collaborate App</title>
<!--Custom CSS-->
<link rel="stylesheet" type="text/css" href="css/global.css">
<link rel="stylesheet" type="text/css" href="css/style.css">
<style>
body{
background-image: url("./images/banner1.jpg");
background-repeat: no-repeat;
background-attachment: fixed;
background-position: center;
}
</style>

<!--Bootstrap CSS-->
<link rel="stylesheet" type="text/css" href="css/bootstrap.css">
<link rel="stylesheet" type="text/css" href="css/bootstrap.min.css">

<link href="//netdna.bootstrapcdn.com/font-awesome/4.0.3/css/font-awesome.css" rel="stylesheet">
<!--Script-->
<script src="js/jquery.js"></script>
<script src="js/bootstrap.js"></script>
<script src="js/bootstrap.min.js"></script>
</head>
<body>
<!-- Navigation -->
<nav class="navbar navbar-inverse navbar-fixed-top">
<div class="container">

<!-- Brand and toggle get grouped for better mobile display -->
<div class="navbar-header page-scroll">
<button type="button" class="navbar-toggle" data-toggle="collapse" data-target="#bs-example-navbar-collapse-1">
<span class="sr-only">Toggle navigation</span>
<span class="icon-bar"></span>
```

</button>

Collaborate App

<!-- Collect the nav links, forms, and other content for toggling -->

<!--
<ul class="nav navbar-nav navbar-left">
 Topics

-->

<form class="navbar-form navbar-right" method="POST"role="search" action="pages/login.php">

<input type="text" class="form-control" name="username"placeholder="Username">
<input type="password" class="form-control" name="password"placeholder="Password">

<button type="submit" class="btn btn-success">Login</button>
<button type="reset" class="btn btn-warning">Clear</button>
</form>

<!-- /.navbar-collapse -->

<!-- /.container-fluid -->
</nav>

<form method="POST" class="form-signin" action="functions/register.php">

```
<h3 class="text-center">Register Here!</h3>
<input type="text" name="studentno" placeholder="Student Number"class="form-control" required>
<input type="text" name="fullname" placeholder="Full Name"class="form-control" required>
<input type="number" name="phoneno" placeholder="Phone Number"class="form-control" required>
<select class="form-control" name="gender"required>
<option>Gender</option>
<option value="Male">Male</option>
<option value="Female">Female</option>
</select>
<select class="form-control" name="college"required>
<option>College</option>
<option value="Agric">Agric</option>
<option value="Science">Science</option>
</select>
<input type="text" placeholder="Qualification" name="quali"class="form-control" required>
<input type="text" placeholder="Username" name="username"class="form-control" required>
<input type="password" placeholder="Password" name="password" class="form-control" required>
<input type="submit" value="Signup" class="btn btn-success" style="width:100%;">
<input type="reset" value="Clear" class="btn btn-danger" style="width:100%;">
</form>
</div>
</div>
</div>

<div class="footer">
<p>&copy; 2018 Collaborate App . All Rights Reserved</p>
</div>

</body>
</html>
```

PHP Code

```
include "db.php";
session_start();

        if(isset($_SESSION['username'])&&$_SESSION['username']!="" ||
        isset($_SESSION['studentno'])&&$_SESSION['studentno']!=""){

        }else{
                header("Location:../index.php");
        }

        $username=$_SESSION['username'];
        $studentno=$_SESSION['studentno'];
        $fullname=$_SESSION['fullname'];
        $userid = substr($_SESSION['email'],0,8);
$comment = mysql_real_escape_string($_POST['comment']);
$userid = substr($_SESSION['email'],0,8);
$postid = $_POST['postid'];
date_default_timezone_set("Africa/Harare");
$datetime=date("Y-m-d h:i:sa");
$comment = mysql_query("INSERT INTO `tblcomment`(`comment`, `post_Id`, `datetime`, `studentno`)
                                                VALUES('$comment','$postid','$datetime','$userid') ");
$sql = mysql_query("SELECT *
                                        from tblcomment as c join tbluser as u on c.studentno=u.studentno
                                        where post_Id='$postid' and c.studentno='$userid'
and c.datetime='$datetime'");

while($row=mysql_fetch_assoc($sql)){
echo "<label>Comment by: </label> ".$row['fullname']."<br>";
echo '<label class="pull-right">'.$row['datetime'].'</label>';
echo "<p class='well'>".$row['comment']."</p>";
```

```
}
?>
```

Java Code

```
package za.unisa.collaborateapp;

import android.os.Bundle;
import android.os.Handler;
import android.app.Activity;
import android.content.Intent;
import android.view.Menu;

public class SplashActivity extends Activity {

    // Splash screen timer
    private static int SPLASH_TIME_OUT = 4000;

    @Override
    protected void onCreate(Bundle savedInstanceState) {
        super.onCreate(savedInstanceState);
        setContentView(R.layout.activity_splash);

        new Handler().postDelayed(new Runnable() {

            /*
             * Showing splash screen with a timer. This will be useful when you
             * want to show case your app logo / company
             */
```

```
            @Override
            public void run() {
                // This method will be executed once the timer is over
                // Start your app main activity
                Intent i = new Intent(SplashActivity.this, MainActivity.class);
                startActivity(i);

                // close this activity
                finish();
            }
        }, SPLASH_TIME_OUT);
    }

  @Override
   public boolean onCreateOptionsMenu(Menu menu) {
      // Inflate the menu; this adds items to the action bar if it is present.
      getMenuInflater().inflate(R.menu.splash, menu);
      return true;
   }

}
```

Android

```
<?xml version="1.0" encoding="UTF-8"?>
<manifest android:versionName="1.0" android:versionCode="1" package="za.unisa.collaborateapp"
xmlns:android="http://schemas.android.com/apk/res/android"><uses-permission
android:name="android.permission.INTERNET"/><uses-sdk android:targetSdkVersion="17"
android:minSdkVersion="8"/><application android:theme="@style/AppTheme"
android:label="@string/app_name" android:icon="@drawable/ic_launcher"
android:allowBackup="true"><activity android:name="za.unisa.collaborateapp.SplashActivity"
android:label="@string/app_name"><intent-filter><action
android:name="android.intent.action.MAIN"/><category
android:name="android.intent.category.LAUNCHER"/></intent-filter></activity><activity
android:name=".MainActivity"/></application></manifest>
```