CROWDSOURCING JUST IN TIME KNOWLEDGE AT WORKPLACE

Aligned with the Evolvement of Smart Mobile Devices.

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ABSTRACT

The use of technology across a number of domains and facets is widespread. It is predicted by Forrester that almost half (42%) of the entire world's population, by the end of 2015, will own a smart phone. Furthermore, during the last ten years, there has been much development in the communication arena as a direct result of smart mobile technologies, including within the work setting, thus facilitating a greater degree of communication and information-sharing capacity in work communities. Nonetheless, it remains that not all the features and tools offered by this technology are utilised, which predominantly is owing to the lack of insight and understanding of users. Accordingly, we argue that people sharing knowledge in the workplace are sharing all the knowledge they are aware of in the most effective way, because it is shared in the situation where they naturally experience problems -at the workplace. Owing to the universal nature inherent in this technology, it is considered pivotal that smart phone technology goes hand-in-hand with intrinsic support. Importantly, however, if not altogether lacking, this is very often inadequate.

However, adopting mobile technology within the workplace setting can give rise to challenges that impact user behaviour and performance. Four studies were conducted with the aim of examining how employees address and manage problems on a smart mobile device (SMD) and accordingly aim at overcoming the issue. The first three studies considered provides valuable input for the researcher that was recognised as required in the fourth research. The third study was carried out amongst 90 participants located in two countries, using internet connectivity, as a case study. Confidence and frustration have previously been connected with technology competence, but this was not applied to a workplace scenario during problem-solving, when users are assigned an unfamiliar smart mobile device.

This research focuses on identifying the link between workplace users' levels of confidence and frustration when seeking to independently solve problems whilst completing familiar tasks on new smart mobile devices. A detailed video analysis of users' attitudes and behaviour during problem-solving was conducted, highlighting a correlation between attitudes and behaviour towards completing a task. When reviewing and considering the findings from the first researches, the criteria for a universal crowdsourcing solution were identified.

In the final of the studies, users across different levels of technology experiences and from varying job roles in different departments in a firm were brought together to form a collaborative community referred to as *YourSpace* designed and implemented for this thesis. To this end, the subjects were grouped across three progressive levels of a knowledge management framework devised for this specific study, namely Pedagogy (engagement), Andragogy (cultivation) and Heutagogy (realisation) levels. The employees of Malta International Airport were permitted to utilise *YourSpace* for a one-week period, during which time there was an assessment of its adoption within the work setting.

Methodology validation in this thesis was carried out through the considered design of a tablet-based research instrument that encompassed a characteristic facilitating knowledge-capture. This was achieved through taking *YourSpace* and accordingly utilising its peer-to-peer support communities. An innovative method is introduced through improving modern-day global technology in a number of ways: firstly, by further expanding works carried out in the social media domain, specifically by capturing Just in Time knowledge when seeking to overcome obstacles in the work environment; secondly, by providing a crowdsourcing instrument with the capacity to capture Just in Time knowledge in an organic work setting through gaining insight into individuals' characteristics and their within-community interactions throughout the process; and thirdly, by examining the behaviours and perspectives of users when seeking to overcome common issues experienced when utilising an unfamiliar device. The results highlighted provide a crowdsourced Just in Time support solution, which could prove pivotal in overcoming problems through the provision of a collaborative framework that supports the gathering of knowledge that is not dependent on technology experience.

Dedicated to my wife, Francesca and to my family

(2016)

DECLARATION

The work presented in this thesis is original work undertaken by the author between October 2010 and February 2015 at the University of Sheffield.

C. Attard, G. Mountain, and D. M. Romano, "PROBLEM SOLVING, CONFIDENCE AND FRUSTRATION WHEN CARRYING OUT FAMILIAR TASKS ON NON-FAMILIAR MOBILE DEVICES", Computers in Human Behavior, 2016 is discussed in more detail in chapter 4. This publication examines the application of mobile technology by users in the work setting, and the support provided. It examines how the subjects solve problems on an individual basis whilst completing familiar tasks on non-familiar SMDs. The focus of the study is centred on observing and accordingly annotating the knowledge held by the subjects on the activities to be carried out.

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List of Abbreviations

In this thesis the following terms will be referred to as defined below:

SMD ……………………………………………………	Smart Mobile device
PPT ……………………………………………………	Pain Points
LBS ……………………………………………………	Location Base Service
APPS ……………………………………………………	Applications typically available on smart mobile devices
TEL ……………………………………………………	Technology Enhanced Learning
MVC ……………………………………………………	Model View Controller
SNA ……………………………………………………	Social Network Analysis
CSCW ……………………………………………………	Computer Supported Cooperative Work
NFC ……………………………………………………	Near-Field Communication
ICT ……………………………………………………	Information and communications technology
JIT ……………………………………………………	Just In Time
SMN ……………………………………………………	Social mobile network

Definition of terms

Just in Time (JIT): In more recent times, along with the more wide-ranging use of smart mobile devices (SMDs) that enable users to connect anywhere and at any time, users are able to interact in such a way so as to construct learning objects Just in Time when experiencing a problem. Davenport and Glaser discuss JIT application by proposing to: *"embed it (knowledge) into the technology that knowledge workers use to do their jobs"* (Davenport & Glaser, 2002).

Network: A number of links between any types of object. Organisational MSNs (Mobile Social Networks) facilitate peer-to-peer collaboration and communication otherwise not established through common contacts or interests but also by the mobility-related context (Bellavista *et al*. 2013) The presence of a user on a social network is developed through joining a network of interest, such as through the sharing of posts and comments, for example.

Crowdsourcing: The term describes a new web-based model that harnesses the creative solutions of a distributed network of individuals through what amounts to an open call for example knowledge (Brabham, 2008).The main prerequisite is the use of a large network of potential labourers. Crowdsourcing represents the act of an organisation or institution and outsourcing it to an undefined network of people in the form of an open call. This can take the form of peer-production. In this thesis it is when the job is performed collaboratively.

In the specific context of this thesis, 'independent IT user' is a term defined as a learner with the capability to self-direct their own learning and development in relating to IT technology learning. A learner who may be considered dependent in the first instance may subsequently develop and become independent, thereby shifting away from dependency to independency (McAuliffe *et al*., 2008).

Users: This term relates to the users of mobile devices and smart mobile devices, i.e. those with smart features (SMDs). Subjects involved in the research might include non-users, on the other hand. Either way, there will be the clear identification of their level of engagement.

Technology Enhanced Learning (TEL) solutions: TEL solutions seek to eradicate more common obstacles to knowledge, for both students and faculty, through open, global access Katz, (2010). 'Technology', in this context, is utilised in an effort to explain ICT (Information and Communication Technology) application in the teaching field, for teachers and students (Price & Kirkwood, 2010). Through the effective adoption of user interfaces, and with consideration to a number of different pedagogical techniques, such solutions will undergo examination and assessment in specific consideration to the Just in Time support context.

Smart Mobile Digitally Connected Users: Those individuals in possession of a mobile phone, and who utilise mobile broadband Internet or Wi-Fi in the locations they commonly visit.

Persuasive Technology: Commonly explained as technology devised in mind of users' changing behaviours and perspectives, such as through social influence and persuasion, for example (Fogg, 2003).

Throughout the course of this paper, the terms 'ubiquitous' and 'pervasive' will be used interchangeably in reference to the global nature of the technology under examination. The term is applicable to those computer systems that are seamlessly integrated within the physical setting and that are perhaps considered by the user as invisible. Importantly, SMDs are constantly available and always connected, thus positioning them as a valuable instrument for information-sharing. In the context of this study, SMDs were adopted as an instrument whilst completing the proposed experiment.

Also in this report, the terms 'obstacles' and 'pain *points*' are also to be used interchangeably in reference to the issues and problems encountered by users. Pain points are the most prominent of obstacles experienced by users throughout the task-completing process.

Middleware applications: Computer software linking the components of software, or people and their applications.

A *Learning object*: A number of stages or practices that may be applied by a user when combined to create valuable knowledge. The use and 'abuse' of the term has been examined by Polsani, (2003 p. 1), who suggests that a learning object should have the capacity to embrace a cooperative and multidisciplinary development framework in an effort to create knowledge that is suitable for the emergency network society.

Self-determined and *self-directed* learning models: Utilised throughout the course of this study in an effort to provide an explanation for the two top levels (andragogy and heutagogy), respectively, within the pedagogical hierarchy selected and applied for this research. Those users with these particular attributes are able to identify goals and are seen to have problem-solving aptitudes that enable them to progress through task-completion on an independent basis and to partake in knowledge-sharing across their community.

CHAPTER 1 – INTRODUCTION

*"If everyone is busy doing everything how can anyone perfect anything? We start confusing convenience with joy, abundance with choice. Designing something requires **focus**. The first thing we ask is what do we want people to feel?*
*Delight, Surprise, love, **Connection …***
Then we begin to craft around our intention.
It takes time.
There are a thousand no's for every yes …"

WWDC Apple, June 10 2013

Introduction

Across all areas and sectors of professional lives, information, communication and ubiquitous technologies form a fundamental aspect. Accordingly, technology is viewed as a pivotal instrument upon which individuals depend in and around work.

Throughout the last ten years, SMDs have become not only widely available and utilised across various facets of life, but are also recognised as shaping and moulding new communication methods in the work environment. In 2012, almost half (48%) of all organisations in the EU—in particular, nine out of ten large organisations gave their employees portable devises that enables mobile internet connection for the purposes of work (Giannakouris & Smihily, 2012). SMDs are also recognised as having increased the ability to complete information-sharing within and across the work environment, as well as a method of facilitating self-development.

Nonetheless, due to the rate at which technology develops, users are facing challenges on a frequent basis, which means that devices are more difficult to use and thus require a greater degree of knowledge and support. New technology features need to be learnt; if this is not the case, the potential advantages gained through its use could affect workplace productivity. This can be observed in the levels of confidence and, conversely, frustration experienced by the user(Lazar *et al*., 2006). The need to learn new technology and the ever-evolving features of devices can also mean that face to face interactions between colleagues are limited (Lazar *et al.* 2006). In addition, increases in the need for ICT support have been witnessed (Attard *et al*. 2016).

In particular, more research needs to done by extending past works in the collaborative arena by achieving Just in Time knowledge-capture through the application of an innovative approach, applying an ubiquitous solution within the natural workplace (Bijedic *et al.,* 2012; Manske *et al.*, 2007). Social network analysis can be applied in an effort to assess individuals' roles and the ways in which they collaborate and communicate with their colleagues in order to achieve knowledge construction.

In view of the above, examining new approaches to improve efficiency of SMD use has increased the requirement to establish new methods of identifying the correct professional(s) within a firm, in an effort to easily and simply capture knowledge.

1.1 Scope of the Thesis

The majority of firms both large and small are seeking to manage the challenge concerning the development of efficient approaches that will facilitate workplace communities in completing knowledge-capturing and knowledge-sharing between colleagues. Different academic disciplines including computer science, education and organisational psychology, are providing years of study that facilitate new opportunities for examination in the work environment when implementing approaches that utilise crowdsourcing. In more recent times, along with the more wide-ranging use of SMDs that enable users to connect anywhere and at any time, users are able to interact in such a way so as to construct learning objects Just in Time (JIT) when experiencing a problem. Davenport and Glaser discuss JIT application by proposing to: "embed it (knowledge) into the technology that knowledge workers use to do their jobs" (Davenport and Glaser 2002). SMD use in an educational domain providing Just in Time solutions, as one example, have been analysed through the application of ubiquitous personal mobile devices and surface computing devices. By linking together such instruments it is possible to capture learner attributes, knowledge and preferences, as highlighted by Kay & Kummerfeld (2010). Currently, works such as these are limited to the educational domain, where subjects are seen to spend a less amount of time in the same location when working on a project.

A number of efforts have been directed towards examining users' requirements in the work environment through addressing knowledge-building; this has been achieved by making personalised solution propositions and examining the approaches of the workplace that are seen to facilitate and drive collaboration and communication (Nenonen & Gersberg, 2006; Dolog et al., 2007; Kim et al., 2009). For example, a number of solutions aimed at problem-solving have been provided, enabling independent application by users, without any need to identify and source traditional in-person support. This can be handled through social media utilisation, which provides the opportunity of connecting people across a global environment. Accordingly, new online crowdsourcing knowledge frameworks can be examined through social media. This approach could enable users to communicate on a Just in Time basis within the work setting (Bijedic *et al*., 2012). Importantly, however, knowledge-sharing captured through such solutions remains difficult.

Therefore, the present study suggests a number of solutions aimed at addressing some of the issues described above associated with knowledge-sharing. Through knowledge sharing, communication and collaboration among colleagues would improve, which would in turn increase the users' confidence to solve the problems and challenges they encounter when using their devices at the workplace.

The view is posed through business communities, such as in the forms of intranets, that new workplace communities may be established (Wenger, 2000), which then have the propensity and ability to partake in knowledge-sharing through the use of SMDs model solutions Just in Time with the objective of overcoming and managing the various requirements of subjects in a specific area. Accordingly, the present study aims at examining the way in which SMDs are adopted as a way of customising the means by which a solution is presented to users in need of support, in line with the individual's own requirements.

Varying frameworks that encourage subjects in the work environment to communicate and collaborate regarding knowledge-sharing solutions have been devised with the use of crowdsourcing, as highlighted by Weld *et al. (*2012). Such approaches have witnessed progressive development, utilising valuable approaches of data- or knowledge-collection with which individuals engage.

The initial studies that have been compiled for this thesis seek to examine the way in which smart mobile devices (SMDs) are utilised in the work setting, as well as the impact they have on the users' capacity to complete tasks. The work is than extended and seeks to investigate the opportunity of devising a new employee-oriented approach through crowdsourcing knowledge through the use of SMDs by adopting a collaborative computer solution framework in the context of a work setting.

1.2 Contribution to Knowledge

In this thesis, the following hypothesis is devised:

The adoption of crowdsourcing knowledge through the application of Just in Time collaborative solutions will help users overcome obstacles and challenges more proficiently in the work environment. We argue that people sharing knowledge in the workplace are sharing all the knowledge they are aware of in the most effective way because it is shared in the situation where they naturally experience problems: at the workplace. In the same vein, it is considered that users would garner new skills spanning beyond physical and departmental restrictions, thus aiding the organisational community in knowledge-sharing, where such knowledge can be accessed, expanded upon and developed by users, at any time, in line with the needs of users. It is recognised that this could help to overcome problems in a relatively short period of time.

Accordingly, this work aims to contributes to develop a novel method for users, allowing them to garner knowledge based on a framework, which, when applied in a business social network setting, will enable users, through the adoption of persuasive technology, to acquire and develop knowledge in an independent fashion and accordingly learn how to overcome problems. Furthermore, this thesis will aim to investigate how the implementation of a Just in Time collaborative computer solution framework is positioned to overcome obstacles within a relatively short period of time in the workplace. It further aims at examining how employees share information and experiences while utilising SMDs.

Emphasis will be placed on the intrinsic problems in a series of technical events, which are encountered by a user while seeking to complete the ultimate task. The framework is relevant to the individuals in a similar work setting community, where learning objects may be created in real time through staff involvement, all of whom collaborate and interact with one another through a common portal, and made visible through an APP (*YourSpace*). This thesis will consider three elements that model the workplace user which are awareness, knowledge sharing and confidence.

This thesis seeks to provide answers to the following research questions:

1. What is the link between workplace users' levels of confidence and frustration when they seek to independently solve problems whilst completing familiar tasks on new SMDs?

2. In what ways can users garner support, within collaborative knowledge-sharing computer solutions in the work environment, via the application of approaches utilising ubiquitous technology on a Just in Time basis?

3. Social media utilisation has stimulated innovative approaches and applications that have created a wealth of new opportunities. How can a mobile social network be utilised and exploited to empower its users in the workplace? How can we ensure that the users' knowledge construction is supported in a way that allows them to advance their level of learning autonomously?

For this thesis we make the following assumption researched in educational area. Users can progress along three different levels, namely from pedagogy through to andragogy and, finally, heutagogy, in an effort to establish a status of autonomy. An emerging framework centred on heutagogy (defined as the self-directed learning of an extension of andragogy, throughout which learners require less instructor control) is fundamental in the sharing of knowledge. The users who establish the highest level then are motivated to examine and study in-depth a subject of interest, and to utilise and apply their knowledge in order to facilitate a change in direction from pedagogy or andragogy in an effort to grow in confidence when tackling issues and seeking to overcome obstacles in the future (Canning, 2010; Blaschke, 2012).

This thesis combines methods from computer supported cooperative work, social networks, crowdsourcing Just in Time knowledge and smart mobile technology. The following are the key contributions of this thesis:

- Ubiquitous support creation through crowdsourcing Just in Time knowledge: With the application of crowdsourcing, users were able to take the opportunity to construct solutions through learning objects when facing issues in the use of SMDs.
- The introduction of an innovative approach to managing Just in Time support through a workplace collaborative solution: This work provides a study instrument that has been adopted in an organic work environment, which affords users the ability to construct learning objects whilst fulfilling their daily role and its associated tasks. A model that includes awareness, knowledge sharing and confidence elements is investigated. Workplace community members provided knowledge on how they would solve the problems encountered by annotating information through various instances on a tablet application. These were available for capture by colleagues across the workplace through the use of Just in Time.
- Garnering insight into workplace communities and the way in which users are able to construct learning objects simultaneously: Through capturing and reviewing community patterns, the behaviour of users was observed when collaborating with members of their community. Members were categorised into respective levels of progression in an effort to gather knowledge information that contributed to establishing the different roles they have taken when constructing learning objects.

The current work provides detailed understanding of the process applied by users when building learning objects, as well as the methods they utilise when interacting and collaborating with one another across the community with the aim of sharing and learning knowledge and devising solutions in mind of achieving task completion.

1.3 Overall Research methodology

The overall research methodology was to create a social mobile network (SMN) and analyse its use. In order to achieve the optimal design of the SMN a series of studies have been conducted to tease out the major elements needed in the final prototype solution, where users' involvements have been an integral part of the research work.

Various stages were applied in the designing, development and testing of an optimal learning solution:

1. A literature research was conducted with the aim of establishing state-of-the-art on crowdsourcing knowledge within an ubiquitous work setting. Moreover, it was essential to establish self-determined learning frameworks for implementation within the suggested research solution. The learning framework selected, which has the capacity to demonstrate users' autonomy progression, provides a sound method of establishing numerous different characteristics usually identified upon the engagement and interaction of subjects with problem-solving solutions. This enabled subjects to be categorised into one or any combination of two of the three main progression levels, throughout which subjects were required to solve problems on an independent basis.

2. Establishing evidence in consideration of the skills and attributes of the individuals who succeeded in solving problems related to IT, with emphasis also placed on those who were technology-proficient. In an effort to identify subjects, qualitative methods and one-to-one interviews were carried out, after which a study was carried out, in which subjects underwent observation with the objective of learning about their overall capabilities in the completion of tasks. The research served to garner more in-depth insight into the way in which subjects responded to obstacles in an effort to solve familiar problems on an independent basis, as well as how they related with IT support and their colleagues in the work setting.

3. Another study was compiled with the aim of establishing the different issues and problems experienced by workplace users in regard to knowledge-building skills when asked to complete familiar tasks with the use of unfamiliar SMDs.

4. This was followed by the design of an ultimate experiment following the examination of the previous research studies, as discussed above, with the application of an innovative method of crowdsourcing knowledge through SMDs, with workplace users to utilise the information available in this regard. It was implemented through the creation of a Just in Time solution with the capacity to capture subjects': 1) ability to share knowledge on a particular subject; and 2) the skills of subjects that would facilitate their ability to share with colleagues the solutions to problems experienced. The aim of the experiment was centred on examining the way in which work environment communities engaged with the suggested instrument, in line with the

respective roles adopted by each user within the firm. A user model was considered with data extracted from the tool used for the experiment. Lastly, categorisation was applied to the subjects in line with the three levels of progression, inherent in the learning framework adopted for the present study.

1.4 Thesis Structure

This thesis is made up of seven individual chapters.

Chapter 2 is a review of background work pertaining to the evident gathered, relating to modern-day technology and its various associated concepts.

Chapter 3 provides an account and general summary of the first two initial preparatory studies, which were carried out in June 2013. A case study and various activities are discussed as a way of providing proof of concept.

Chapter 4 details of the third study carried out in the work setting, with emphasis placed on problem-solving with the use of SMDs when seeking to fulfil familiar objectives on new SMDs.

Chapter 5 provides an overview of the tool designed and implemented for the fourth study of the proposed system *YourSpace*, which was developed in line with fulfilling the criteria identified as a result of the completion of the previous three studies. The tablet solution (*YourSpace*) design and application is described in-depth.

Chapter 6 details an evaluation of the Just in Time crowdsourcing tablet solution. An experiment was carried out within the natural workplace using the collaborative tool described in chapter 5. In addition an overall assessment pertaining to the studies' outcomes that were four tasks where given to participants at the workplace (Malta International Airport). An evaluation was made in line with a discussion on the way in which the subjects utilised the instrument. There is also the inclusion of a description of the categorisation of the subjects into the various progression levels.

Chapter 7 draws the conclusions and discusses the most valuable contributions of the overall study, in addition to the challenges, walkthrough and vision of future work that can extend the work done for this PhD. The challenges and achievements experienced throughout the course of the study are also summarised.

CHAPTER 2 – LITERATURE REVIEW

"The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it"

(Weiser, 1991)

2.1 Introduction

Information and Communication Technologies (ICT) are recognised as a fundamental aspect of a number of different work sectors, and are necessary in various work-associated tasks. Accordingly, technology has become recognised as a fundamental instrument for most staff. Owing to this, there has been a growth in IT support needs. In the view of Giannakouris & Smihily (2012), in 2012, almost half (48%) of all organisations, in addition to 90% of all large companies in the EU gave employees portable devices in order to facilitate mobile internet connections for work-related use.

Throughout the last ten years, SMDs have become more widely available, and are responsible for changes in communication, in addition to ubiquitous working, facilitating staff abilities to work from different locations. The ability to share knowledge whilst also delivering IT support is facilitated through the provision of SMDs, such as through encouraging users to solve problems in any location, or otherwise to communicate knowledge garnered through crowdsourcing in work communities. Collaborative computer solutions have been the focus of much research, and various computer tools have been proposed in consideration to automating personalisation through making recommendations of knowledge in line with the personal requirements of users. Importantly, there remains a lack of research centred on improving the area of Just in Time knowledge, which could be created in work environments with the aim of attempting to build learning objects by users themselves, which may be accessed ubiquitously.

In modern times, with technology prevalent and affecting the pace of life, there is the continuous production and introduction of new technologies, which can overwhelm staff and affect levels of productivity, in addition to their overall views of self-efficacy. The consideration is made by Lazar *et al.* (2006) that this could result in users feeling that they are lacking the necessary skills and competences to use Smart technology in the work setting, subsequently resulting in co-workers' interactions being limited. Accordingly, there is a greater need for on-going knowledge-sharing and the provision of new Just in Time approaches that can provide users with support when experiencing problems.

The key concepts to be taken into account with regards to studies on technology implementation in the workplace are considered below.

2.2 Pervasive Technologies and their Use in Just in Time Knowledge-Sharing Solutions

In the modern-day world, in which workplace environments are experiencing much change, relevant information is necessary in order to satisfy established goals. Accordingly, computer solution demands are becoming more centred on system designs that add value to providing the right workflow in order to facilitate users in interacting with colleagues in the work setting on a number of different subjects.

The term 'pervasive computing', also referred to as 'ubiquitous computing' (Weiser, 1991), is applicable in the domain of computers, which are seamlessly integrated into the physical setting and are unseen by the user. An example of such is smart technology, which are unobtrusive in their communications. In line with the personal computer age, pervasive computing is expected to become one of the most dominant paradigms of the 21st Century. In this vein, it is stated by Weiser (1993) that ubiquitous computing will change the way technology presents itself to the user; devices will be smaller, more present than ever before, and much more discreet.

Ubiquitous computing may be defined as a type of technology that combines with human behaviours in such a way that it becomes part of it. Weiser makes the statement that computation will be seen to be "in the background where it may not even be noticed"

(Weiser, 1993, p. 71). Accordingly, ‘ubiquitous computing’ has been linked with the vision proposed by Weiser of ‘calm computing’, which is seen to pertain to technology that does not absorb people’s attention; rather, it empowers the user (Weiser, 1993).

"Pervasive computing relies on the convergence of wireless technologies, advanced electronics and the internet. The goal of researchers working in pervasive computing is to create smart products that communicate unobtrusively " (Tang, 2001, p. 105).

It is also stated by Tang (2001) that one of the key objectives associated with pervasive devices is to ensure "unobtrusive" work. The key difference between traditional and pervasive devices is that pervasive devices, including SMDs, carry out their functions without the need to acquire user focus. The majority of the operations carried out by such a device are completed without the need of redirecting the attention of the user away from the task at hand.

The efforts carried out by Kay & Kummerfeld (2010) examine the potential of tablet top use within an educational environment, including in academic institutes, with the aim of constructing knowledge through collaboration. There is the presentation of a framework that provides personalisation infrastructure. This may be associated with an ubiquitous personal mobile device and the emergence of an embedded surface-computing device; however, their work is restricted to the educational setting, with experiments having been carried out with members generating knowledge in the same setting, with attention on common assigned tasks.

The role of pervasive computing role has been examined in the works of Judd & Steenkiste (2003) and (Carmichael et al. 2005), both of which have added value to the extending user modelling, which is not limited to a user, introducing a new method of representing other buildings and rooms, devices and sensors. Implementing a ubiquitous environment in mind of constructing knowledge may be improved through adopting social computing. The study by (Martínez et al. 2003) centred on the application of social computing as a method of examining knowledge-building generates new opportunities; however, this is a subject requiring investigation. Moreover, various solutions have been examined with the aim of improving the overall quality of life associated with individuals implementing SMDs. Some study areas include health, leisure and entertainment, learning environments and the Smart home environment. The key challenges sought to be overcome by these researchers include the design of the user interface and the capacities of such devices in capturing context (Realinho *et al*., 2011; Barkhuus & Polichar, 2010; Gračanin *et al*., 2011). In order to overcome these challenges, there is the on going development of various transformative and computing technologies, including cloud (Ovidiu Vermesan, 2013).

In the past, users have been required to log-in and log-out of their systems (Saha & Mukherjee, 2003). In the modern-day world, however, these actions are not necessary, with single users remaining continuously logged on. Moreover, they are used as a computational resource, and are continuously used in the background at work, completing tasks in line with the needs of the users and preferences concerning the environment, such as at home, at work and in regard to travelling, etc.

The suggestion has been made by Weiser (1993) that pervasive systems can be applied by various people at the same time, irrespective of their technological skills. For example, the SMD may be applied in much the same way as a paper notebook, utilised by a group in order to partake in social activity or ideas exchange, for example. Consequently, more research is necessary in order to examine the potential of implementing pervasive computing, such as in work settings, which facilitate tools utilisation, including SMDs, for the aim of sharing knowledge amongst colleagues.

2.2.1 Knowledge-Sharing

Computer support collaborative systems design and development are very complicated owing to the diversity of users and the various issues experienced throughout the knowledge-sharing process. A number of researchers, both in management and academia, have considered the term 'knowledge management' (KM), which has been under examination since its introduction twenty years ago, in around 1990, and which, over time, has been oriented towards knowledge management within businesses. In actuality, a number of definitions suggest that knowledge management is more centred on business structure.

"Knowledge management is the process of capturing, distributing, and effectively using knowledge" (Davenport & Prusak , 1998).

"Knowledge management is a discipline that promotes an integrated approach to identifying, capturing, evaluating, retrieving, and sharing all of an enterprise's information assets. These

assets may include databases, documents, policies, procedures, and previously un-captured expertise and experience in individual workers" (Duhon, 1998).

"The objective of IT Knowledge Management is to create, maintain and make available concise and actionable information to users and IT support groups in order to resolve service disruptions quickly and respond to customer queries satisfactorily" (McGlynn, 2013).

The overall process model of knowledge management commonly comprises the following stages: 1) the garnering of knowledge, 2) the sharing of knowledge, 3) the transfer of knowledge, and 4) the networking of knowledge. All of these individual stages are recognised as adding value to knowledge creation and its overall application. The model further comprises a knowledge base store that captures the knowledge constructed. Knowledge management depends on the way in which knowledge-sharing process are applied in the context of the workflow of a firm, in a way that facilitates a business's goals and the achievement of such Biloslavo & Zornada, (2005). It is important that the design of IT solutions is carried out in a way that facilitates knowledge application processing, meaning users may be able to access the knowledge created. It is also important to make use of suitable model evaluations to be implemented so as to ensure the effective transfer of knowledge.

Various works have been carried out in different fields in order to develop this framework, such as through tools development, including collaborative solutions, intranet decision support systems, semantic networks and recommendation systems, all of which utilising artificial intelligence solutions, amongst others.

A number of solutions have proven themselves unsuccessful in motivating participants or engaging users in knowledge construction (Pee & Kankanhalli, 2015; Currie *et al*., 2008; Dawes *et al*., 2009; Kim & Lee, 2006). Various factors behind this failure include businesses having different structures in place, comprising a number of different skills and unskilled users attributed with various job roles in the workplace. This causes various communication differences between staff, which affects knowledge-sharing.

Despite the fact that knowledge-sharing occurs in a number of different channels, various processes have been found to enhance and empower knowledge-sharing (Wenger, 1998; Mohammed, S., & Dumville 2001; Ilgen et al. 2005). For example, the solutions centred on Just in Time enable users to garner access to the right knowledge on a specific field and then share this knowledge. The knowledge-sharing systems of Just in Time seek to provide valuable and relevant information from staff to their colleagues, when and where this is needed, as opposed to having staffs sitting through long lectures or courses.

Nonetheless, there is a lack of success stories relating to comparable instruments in the workplace setting. This thesis will focus on how colloborative computer solutions can be adopted in the workplace to address the research proposed in this PhD.

2.2.2 The Role of Context

With specific regard to an ubiquitous workplace environment, when utilising technology, including Smart mobile devices, for example, content awareness of the user should be taken into account. In this study context, logging a user's physical location when carrying out a certain task can be particularly pivotal in influencing the behaviours and attitudes of users throughout technology use for work-related tasks. Capturing a user's context can be fulfilled through gathering general information from users through various sensors. Subsequently, the information is passed to an application layer, which is responsible for making choices (Hong *et al.* 2009; Held *et al.*, 2002). Hong *et al.* (2009) provide a differentiation between two context types, namely cognitive and physical, where the former involves personalised intrinsic aspects whilst the latter includes information pertaining to a user's proximate physical environment. Furthermore, the information garnered through the cognitive context may be utilised to present highly personalised services.

SMDs are recognised as pivotal collectors of data with the capacity to capture various ambient information and accordingly map the data to the present position of the user through the adoption of LBS (location-based services). Various challenges have been examined in seeking to enhance the overall accuracy of the information gathered (Guido & Annalisa, 2010). Through applying mobile sensors as a way of gathering information, it is possible to understand the context pertaining to device use. Accordingly, there can be the automation of personalisation without the on-going need to interact with the user.

Various context-related definitions have been devised. For example, it has been suggested by Rodden *et al.* (1998) that context may be defined as the application's setting. One further definition of context takes into account the focus and emotional state of the user, i.e. by considering the area on which the user is paying attention (Dey, 2001). This may be recognised as establishing the user's location and accordingly mapping the data stored within a calendar map identified on all SMDs. Subsequently, the application would draw a comparison across all data with an existing user profile that is well aligned to the user and has the capacity to acknowledge the type of interaction expecting when engaging with the required task. It is common for a distinction to be made concerning context, breaking the area down into different types; however, thus far, there is no standard way to complete this. Such groupings are recognised as follows:

- Sensed context by sensors or reported by application: User ID, object's state, and user actions.
- Combined context calculated or aggregated from sensed context: speed, position from three sensors; aggregating context based on user ID, device ID, or service.
- Situation context: inferred by rules, namely situation (time-related), relation (static, dynamic).
- Learned context by machine learning technology: user preference, predicted use.

The first and second points make reference to sensor technology as the approach to garnering context-related data, whilst the subsequent points relate to algorithm use in an effort to convert the sensed information into valuable data.

Other studies have taken to grouping context within two key archetypes, including primary and secondary (Dey, 1999): the former considers immediately sensed data, where examples include geographic coordinate pair, light levels and temperature levels. Primary context is most easily achieved; nonetheless, value and depth are lacking. Secondary context explains the contextual data that may be gathered from a primary context, with this context considered most valuable owing to the fact it assigns more meaning to a primary context. Examples include data values and temperature values utilised in an effort to explain 'weather' (Dey & Abowd, 1999). A more wide-ranging set of categories also may be explained, including sensor technology use, where the following are identified by Riekki *et al.* (2000):

a) Computing Context: *Information describing the computing status of sensors, such as network connectivity, communication costs and remaining battery power.*

b) Sensor Context: *Relative to sensors, this form of context refers to the sensors' profile, such as the group they belong to, their location in a sensor network and a common situation that they face.*
c) Physical Context: *Context that refers to external conditions that can be measured by sensors.*
d) Time Context: *Time would refer to the time of day, week or month when sensor readings are obtained and which further describes the sensor context.*
e) Historical Context: *A history of sensor readings accumulated over a certain time span.*

In conclusion in this PhD, the above-detailed category groupings aim at accumulating data relating to different users which further adds value to monitoring the environment of the user; therefore, owing to the fact that the study is set up ubiquitously, this data is valuable when users are examined in an effort to gain understanding of the outcomes of the research in greater depth. In order to achieve this, for this thesis, a sensor log is recognised as valuable in monitoring the physical user context at the workplace when carrying out a particular task.

We aim to provide knowledge capture by using SMDs that will be adopted within a workplace domain providing Just in Time solutions. Studies described in Chapter 3 and 6 in this thesis investigate the use of SMDs as pervasive tools that are used to capture and share knowledge at the workplace. To date, there are few studies, that analyse the application of pervasive personal mobile devices when solving problems at the workplace. Accordingly, the proposed research links together such instruments with the possibility to capture learner attributes, knowledge and preferences, as highlighted by Kay & Kummerfeld (2010). Currently, works such as these are limited to the educational domain. This work will be adapted to the workplace where subjects are seen to spend less time in the same location when working on a project.

2.3 Self-Determined Learning using Smart Mobile Devices

With the widespread use of SMDs, a new pervasive learning paradigm, referred to as 'mobile learning' or m-learning, has emerged. The concept of m-learning is being researched for different uses, from pervasive learning services using near-field communication technology through to pervasive learning objects, providing multimedia information that can be adopted at the place of work (Muñoz-Organero *et al.*, 2011). Cochrane & Bateman (2010) investigated the potential of integrating mobile and Web 2.0 tools to adopt constructive methodologies through a social framework that allows students to engage in tertiary education. Sense-making (the process that connects data, creates a hypothesis and develops reasoning based on what is being observed while doing a task- based activity) also has been investigated in order to better understand the potential offered by learning on SMDs (Rogers *et al.*, 2009).

The studies reported above focus on specific elements and modes of learning to which a learner might be exposed, drawing particular attention to a function or a tool being used to facilitate information sharing or collecting and capturing information in different environments. However, these studies have not considered elements such as self-determined, self-directed learning and blended learning, as will be described below.

Blended learning is a relatively novel approach to learning through which people can combine technology-supported learning with face-to-face interactions. Claypole (2010) defines blended learning as *"a combination of real world plus in-world', where a teacher delivers a face-to-face lesson and then arranges to meet his or her student for a follow-up class in a virtual world such as 'Second Life'"* (Claypole, 2010, p. 36). Graham & Bonk (2006) define blended learning systems as those that combine face-to-face teachings with computer-mediated instructions. Furthermore, Sharma (2010), defines blended learning as "*peer-learning methods mediated and supported via computer-mediated activities*" (Sharma, 2010, p. 14). The latter definition is the one used in this thesis owing to the fact it includes blended learning mediated by mobile devices.

A number of techniques are being created for blended learning that aim at helping participants to engage better with the learning content (Tynjala & Hakkinen, 2005; Luca, 2006). For example, blended learning by means of SMDs is being developed. This has evolved from Technology-Enhanced Learning (Goodyear & Retalis, 2010) and Piaget's Peers learning (Boekaerts & Minnaert, 1999). Luca (2006) demonstrates how both technology and pedagogical tools, such as blended learning, learning theory, the role of assessment, a model for designing learning materials, new technology, online pedagogical tools and demonstration, need to be designed hand-in-hand so as to promote the engagement of users. Mobile Learning is increasingly leading to the evolvement of a blended learning approach in which face-to-face interaction also is often a technology-supported interaction (e.g. chat and internet-based discussion), whilst additional materials are delivered using digital media (e.g. videos and interactive materials, such as e-books). Smart mobiles and tablets are the primary hardware on which e-books are read. Blended learning also can be adopted at the place of work. However, research shows that there is a pressing need to provide practitioners who design learning systems with guidance on how blended learning can be implemented in workplace settings (Kim *et al.*, 2009).

Self-directed learning is the learning that takes place at the learner's initiative, where the individual has the primary responsibility for planning, implementing and evaluating the effort (Hiemstra, 1994). This is considered self-determined learning or Heutagogy, which, according to Mithaug (2013), is a function of three interacting factors: self-interest (regulates learner's interest), self-regulation (controls and regulates thinking) and the persistence of repeated adjustments to maximise learning; therefore, self-directed learning is an extension of self-determined learning, where the learner determines what to learn and also how the learning takes place.

Problem-solving is considered here as a learning process, which can be shared with others in a structured way. Some examples of this can be found in the literature. For example, Schmidt & Braun (2006) have examined how different individuals at their workplace can make use of the immediacy of purpose and real-world context learning. They argue that optimal solutions should smoothly integrate context-aware learning support systems, which should consider the awareness aspect for knowing about the learning context of the user, which should be taken into account when designing the solution.

Kravcik & Klamma (2012) specifically looked at support of self-regulation through a personal learning environment. Their aim was to provide the learner the freedom to design and compile the learning environment to their required personal preference. Kleanthous Loizou & Dimitrova (2012) have presented a novel computational research for community-tailored support. Their aim was to help knowledge-sharing that could be transferred within communities. All of the above are examples of how problem-solving contributes to learning. This research will extend this work by adopting different techniques and tools.

2.3.1 Model of Users' Progression Levels

A number of learning frameworks have been devised, the majority of which are concerned with progression levels or a combination of two levels. In the context of the current work, the comprehensive model devised by Canning (2010), and cited by Blaschke (2012), has been implemented, which classifies staff into three different autonomic levels, namely Pedagogy (engagement), Andragogy (cultivation) and Heutagogy (realisation). User characterisation is dependent on the ability and maturity of staff to independent establish autonomy in problem-solving, meaning progressing forward to the pyramid's top level, as detailed in Figure 1. This framework gives some degree of insight into the way in which users pass through the levels, and therefore has been recognised as the most appropriate framework for study participants' categorisation.

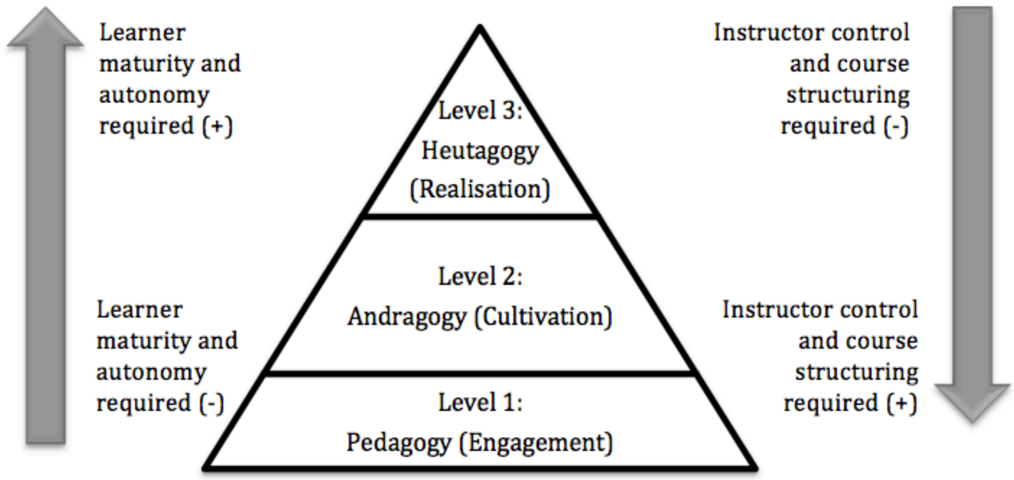


Figure 1: Ref (Blaschke, 2012, p. 60, based on Canning, 2010, p. 63) — Progression from pedagogy to andragogy then to heutagogy

The lowest level pertaining to how subjects implement learning throughout the course of a learning support framework is pedagogy (engagement). The role of user engagement in explaining technology design has been discussed by various scholars, including Rickinson, Sebba & Edwards (2011) and O'Brien & Toms (2008), who adopt the view that user engagement is critical for the creation, mediation and application of study-based knowledge. It also presents a number of different challenges to research users and researchers owing to the fact it is recognised as a problematic and complicated concept.

As recognised by Knowles (1975), andragogy is "*a process in which individuals take the initiative with or without the help of others, in diagnosing their learning needs, formulating learning goals, identifying human and material resources for learning, choosing and implementing appropriate learning strategies and evaluating learning outcomes*" (Knowles, 1975, p. 3).

Heutagogy may be described as a type of self-determined learning, where learners are considered to be notably autonomous. Emphasis is centred on capacity development and the overall capability of workers to create learners who have the ability to deal with the complexities in and around the modern-day world. The learner also has the ability to share knowledge with peers following the acquisition of learning knowledge. In heutagogy, the learner creates the learning content, and then, through self-directed approaches aimed at capturing knowledge, achieves the goal or task through carrying out a number of steps. Self-determined learning further expands the andragogy approach, where learners are required to garner both capabilities and competencies (McAuliffe *et al.*, 2008).

This thesis will extend this work through investigation to get more insight in how users can progress along three different levels, namely from pedagogy through to andragogy and, finally, heutagogy, in an effort to establish a status of autonomy. We adopt the progression learning framework researched in the educational area. Different participants may have different skills and can share knowledge in differnet ways. We identify users by adopting a novel way of identifying their progress along three different levels, namely from pedagogy through to andragogy and, finally, heutagogy. This aims to establish a status of autonomy by the way they create learning objects and actively participate to share knowlege. The users who establish the highest level are then motivated to examine and study in-depth a subject of interest, and to utilise and apply their knowledge in order to facilitate a change in direction from pedagogy or andragogy in an effort to grow in confidence when tackling issues and seeking to overcome obstacles in the future (Canning, 2010; Blaschke, 2012).

2.4 Usability Issues during Problem-Solving when Using SMDs

Despite the fact that SMDs' usage has increased and fundamentally changed how people work together, learn and communicate, there also is a need to establish more information about the attitude and behaviours of users when facing problems in the use of SMD devices. Users not only need to learn content and procedures, but also how abilities and soft skills can be developed in such a way so as to help them to solve problems and accordingly reach their goal.

The process of problem-solving, in itself, has the advantage of contributing to learning: for example, Kleanthous Loizou & Dimitrova (2012) present a novel computational research for community-tailored support, adopting the aim of helping knowledge-sharing, which could be transferred throughout communities. Through a validation study, the research examined the effects of community-adapted notifications, and accordingly showed that notification messages can improve members' awareness and perceptions of how they relate to others.

Kravcik & Klamma (2012) specifically examined the support of self-regulation through a personal learning environment. Their aim was centred on providing learners with the freedom to design and compile the learning environment in line with their required personal preferences; however, although the study involved students at a high level of education, through feedback collected for most of the learners, it was found that self-regulation was considered challenging. The proposed personal learning environment did not consider how users could tackle problems. Accordingly, more research is needed in an effort to garner deeper insight into and better understanding of attitudes and behaviours when users face difficulties.

Usability is an important aspect of SMDs. Although SMDs have become more useful, in some way, this comes at the expense of the usability of such devices (Harrison *et al.*, 2013). Nielsen identifies five attributes of usability, namely efficiency, satisfaction, learnability, memorability and errors (Nielsen, 1994).

Efficiency may be explained as how well a user achieves his/her goal in relation to accuracy and completeness. Satisfaction is the fulfilment of one's overall expectations or the pleasure derived from using a piece of software. Learnability, for Nielsen (1994), is related to the ease of the use of systems, and to the rate at which users can acquire the intended outcome. Memorability is an attribute of systems that are easy to remember, where their cognitive load impacts usability when configuring or using software. The last attribute investigated by Nielsen, (1994)and Harrison *et al*. (2013) is 'errors', which can be identified when performing an evaluation process, capturing how well the user can complete the desired tasks without mistakes, and further establishing the nature of errors and the frequency with which they occur.

Learning takes place at the learner's initiative, when s/he adopts a self-directed learning approach. Such individuals have the primary responsibility of planning, implementing and evaluating the effort (Hiemstra, 1994). In this study, a learner who can self-direct his/her progress with regards to the learning of IT technology is defined as an *independent IT user*. Other learners who initially are dependent can progress and become independent, moving from dependency to independency (McAuliffe *et al*., 2008).

Problem-solving is recognised as part of the learning process: for example, Schmidt & Braun (2006) investigated a learning process in a structured way, examining how different individuals at their workplace can make use of the immediacy of purpose and real-world context learning. They argue that optimal solutions should smoothly integrate context-aware learning support systems. Additionally, such systems should consider the awareness aspect *for knowing* about and *taking into account* the learning context of the user.

Sense-making also has been investigated in an effort to achieve better understanding of the potentials offered by learning on SMDs (Rogers *et al*., 2009). The authors argue that key aspects requiring further research are centred on investigating how users react when facing a problem, as well as their overall attitudes and behaviours, and their awareness of obstacle-solving strategies. They also argue that, in order to efficiently complete a task, the design of an application should help users to recover quickly from errors; as such, the use of error messages and system status icons also has been investigated in this thesis.

Organisational structure and workplace practices influence the way in which employees acquire knowledge, which, in turn, is shaped by the different skills needed and the level of competence required to undertake the necessary skills (Ashton, 2004). Problems can arise when there is a lack of knowledge pertaining to what action should be taken in order to solve a problem (Giannakouris & Smihily, 2012). Various studies discuss different ways of improving the way in which users interact with mobile devices: for example, Mourão & Okada (2010) showed that, in this field, there are a number of challenges when using SMD to communicate quickly, accurately and completely. The authors listed requirements to be considered, including intuitive user interface, where the user interface must provide optimised efficiency due to a high rate of user interaction and the nature of work to be done.

The proposed research investigates various challenges associated with different attributes identified in the existing models of usability. In this vein, this work particularly focuses on the last three of attributes of usability, whereby users were observed in solving problems by considering learnability, memorability and errors. An experiment is proposed to investigate how a user overcomes the above challenges and helps the workplace community solve these problems. These are desribed in detail in chapter 3 and 5.

2.5 Knowledge-Sharing in the Workplace Environment

It is common for a workplace setting to adopt a structure where staff are organised in groups where their tasks and goals are similar, with such structures and practices influencing how knowledge is acquired by employees and which subsequently is affected by the various competences and skills held by staff (Ashton, 2004). Issues may be identified when there is a lack of knowledge centred on what actions need to be implemented in order to overcome a problem (Giannakouris & Smihily, 2012).

A number of different approaches have been discussed as valuable in the work setting, such as in the work of Dolog *et al.* (2007), which are aimed at supporting knowledge-sharing amongst staff. These characterise the workplace domain as follows: 1) procedural knowledge, 2) propositional knowledge, and 3) context. *Procedural knowledge* is recognised as pivotal for those activities needing to be carried out in order to achieve the necessary results, whereas *propositional knowledge* is a concept linked with sound workplace performance (Dolog, Kravcik *et al*., 2007). *Context,* as has been discussed earlier, impacts the way in which staffs learn about workplace requirements and tasks.

In the workplace, knowledge-sharing is possible through three key approaches: training courses either in or outside of the work environment, enrolment in an e-learning environment (Payne *et al.*, 2009), or through collaboration with colleagues (Ruane & Koku, 2014).

In the present work, self-determined blended learning was also devised as a fourth knowledge-sharing model, which is an extended collaboration between peers, completed through technology, including SMDs, by constructing knowledge recognised as learning objects. Self-determined blended learning, as explained in Section 2.2, was chosen when considering the fact that this learning mode, when applied in addition to SMDs, is able to affect behavioural decisions made in real-time, during the time a user ubiquitously interacts with a device. Learning environments can be managed ‘on the go’ through the unique technology that is mobile platforms, which enable self-determined learning to be carried out anywhere within a firm.

Knowledge is constructed in the workplace in such a way that depends on how businesses operate. Some businesses encourage collaborative and self-managed teams formation, enabling experiences to be shared (Ashton, 2004), whilst others provide more formalised training opportunities (Dolog, 2007), whereas both approaches are applied by others. Studies conducted by Collins *et al.* (1997) and Greer *et al.* (1998) emphasise that training is effective Just in Time when part of an individual's regular job role. Their studies involved system development that suggests who is able to provide support when necessary.

When workplace management seek to control or otherwise monitor the exchange of information, collaboration and knowledge-sharing are key challenges (Schmidt & Braun, 2006). Nonetheless, such a challenge may be overcome through the application of technology, internet and SMD solutions that utilise the cloud owing to the fact that information may be easily accessed and processed from anywhere and by everyone, at any time, meaning the role of laptops and desktop systems can be replaced or otherwise enhanced. Various works have discussed different ways of improving the way in which users interact with mobile devices (Mourão & Okada, 2010; Hagen, Robertson, Kan & Sadler, 2005).

With regards to SMD use in the work setting, various other challenges are also recognised as potentially limiting knowledge-sharing. In 2012, as report was published by Eurostat (Giannakouris & Smihily, 2012), which made reference to various obstacles that limit the overall usage of portable devices for mobile connection to the internet. An estimated 21% of all EU27 enterprises were seen to experience connectivity issues as one key obstacle; 17% of them recognised high costs and technical issues as problematic when integrating business applications with internet mobile connections; 30% of all EU27 enterprises recognised one or more issues as preventing or limiting their business from using portable devices for internet mobile telephony (Giannakouris & Smihily, 2012).

2.5.1 Practices and Techniques in Current Research on Knowledge-Sharing

In order to gain understanding into how study tools should be designed so as to assess individuals' behaviours in the work environment in regard to knowledge-sharing, it is essential first to consider the present approaches and practices examined by different studies in regard to the workplace.

Techniques suggested by various researchers within different projects are pertinent to the work suggested for this study; these are methods that enable users to garner skills and competencies in IT throughout the completion of their daily tasks. Such skills are usually gained through methods and tools implementation that would help users to improve on the skills required to fulfil their job roles.

One such project, namely ProLearn by Kieslinger & Hofer (2005)**,** aimed at bridging the gap between education and research in higher education institutions and professional training in the workplace through the application of TEL (Kieslinger & Hofer, 2005). A second project concerned with providing individuals and organisations with a new learning environment that is more efficient than what is currently available is TARGET, which integrates a learning process and a platform base comprising various services and tools with human resources management targeting communities. A knowledge model was devised within a conceptual framework, the focus of which was concerned with stimulating knowledge management and sharing across services, especially in regard to those required by users to create, package and share knowledge resources (João & Parodi, 2011). APOSDLE ("Advanced Process-Oriented Self-Directed Learning Environment") examines the different solutions available that may be applied within the workplace environment through the adoption of advanced technology.
Hannafin *et al*. (1999), Horton (2000) and Jonassen (1999) completed a review of proposals for various methods when processing an online formative action. Different solutions were discussed, with recommendations made in mind of users receiving training away from their normal work environment. It was emphasised by the authors that the preparation of such elements should be at student disposal within the learning context. Accordingly, these aspects need to be taken into account when constructing learning objects.

The study of Open Learning Environments (OLEs) was the focus of study of Hannafin *et al.* (1999) (which the present author defines as learning environments focused on the pupil), where individual investigation is predominantly encouraged. Horton *et al.* (2000) view online courses as a mixture of activities, lessons and collaborative mechanisms, where the term 'lesson' is defined as a number of experiences that achieve one of the goal's secondary goals. In contrast, however, knowledge is defined by Jonassen (1999) as being individually and socially elaborated by pupils, in line with their experiences and the interpretations of such.

Technology-enhanced learning in the work setting has been carried out, in most cases, as complements to traditional courses with the aim of improving the general learning experiences of those within a controlled learning environment: for example, online demos, support tools and short videos that are centred on demanding tasks that are one aspect of an allocated schedule course that normally would take an hour or two on a particular subject. Some examples include the studies carried out by Wang & Hannafin (2005) and Kim *et al.,* (2009).

Collaboration approaches might implement blended frameworks that facilitate users in garnering knowledge. Age Magazine published an article emphasising that individuals should be motivated to utilise social media (Hart, 2010), such as through social web content, which recently has been examined by Karanasios *et al.* (2013) on the how tagging can capture digital trace in such a way to facilitate insight into human behaviour being provided. Hart (2010) discusses various approaches to collaboration in the use of social networks, discussing those tools with the ability to enhance how users work, rather than making reference to local intranet. The individual would use tools such as Twitter and Facebook to ask for help, which would automatically update Google Docs. Establishing how such collaborative tools can be used together can facilitate communications, and thus enhance user experience in achieving day-to-day objectives.

Accordingly, the view may be posed that, when staff are utilising these tools, one additional advantage is gained at the same time owing to the fact that there is the sharing and access to knowledge through the application of a model designed for the workplace environment. Tools that may be applied for personal use outside of the workplace are utilised by Hart (2010), meaning the use of such tools could help to increase collaboration between peers and thus enhance the overall information and knowledge level surrounding work.

When implementing a peer knowledge-sharing framework, such as the one identified within an intelligent tutoring system, which is recognised as ICT-based, one of the key obstacles is centred on managing inaccurate information from colleagues. A trust model was integrated by Champaign *et al.* (2011) in order to identify the reputation of an annotation over time, meaning that such a framework examines comments to rate the trust and success of information added over time. The work was conducted through simulation, where the empirical evidence demonstrated that various learning objects were not valid knowledge sources.

When taking into account the various challenges arising in the context of SMDs, more work proposed in this thesis will ensure that experiments are designed keeping in mind the issues encountered by users in the workplace when adopting such devices, in addition to those faced by research studies when examining knowledge-sharing in the work setting. This thesis will garner insight into workplace communities and the way in which users are able to construct learning objects simultaneously. This is achieved by developing a novel method for users through a tablet–based research intrument *YourSpace,* by capturing Just in Time knowledge. Through gaining understanding of the key approaches adopted by the use of these tools, this research investigated how various aspects may be adapted to Just In Time workplace.

2.6 Persuasive Technology And Its Contribution To Knowledge-Sharing

Motivating users to contribute and share knowledge when adopting collaborative computer solutions is the main challenge different workers encounter (Pee & Kankanhalli, 2015), as discussed in Section 2.2.2. This is particularly evident in various domains, such as classroom setups for different levels of education, as well as within organisations. Various researchers have proposed model frameworks and ICT tools that contribute to obtaining more knowledge about a subject. For example, Wang & Hannafin (2005), Kieslinger & Hofer (2005), Dolog *et al.* (2004) and Mulwa et al. (2010), amongst others, propose various experiments and studies involving some form of TEL. However, it is clear that these studies did not take into consideration the role of motivation in inducing participants to independently contribute to the success of the learning experience.

One approach to increasing the motivation of users is the use of persuasive technology. The term 'persuasive' has been adopted in many fields, particularly for speeches. The Greek philosopher Aristotle (known also for his communication theory) believed that persuasion occurs when three components are represented. These include *ethos*, which refers to the overall credibility of a person, which is dependent on the experience of a person and his/her position within an organisation structure. *Logos, which* is the means of persuasion through data, logic and statistics, and *pathos, which* is the act of appealing to emotions.

In the last decade, persuasive technology has been investigated in various contexts by Fogg (2009), who coined the term "Captology", an acronym for computers as persuasive technologist. He states that, "*we have entered an era of persuasive technology, of interactive computing systems designed to change people's attitudes and behaviours*" (Fogg, 2003, p. 1).

Moreover, Davis (2012) defines persuasive technology as "*the study of computer systems designed with the intent to change people's behaviours and attitudes*" (Davis, 2012).

Fogg's (2009) "ability motivator trigger" model brings behavioural psychology within persuasive systems to provide the capability to motivate people (Fogg, 2009). This model, as well as the "Persuasive Systems Design" model by Oinas-kukkonen & Harjumaa (2008), focuses on methods for designing persuasive technology. When discussing persuasiveness of a software system, software functionalities become essential; however, a number of models suggested by Fogg (2003) have certain weaknesses. These models fail to define how designed principles should be transformed into software requirements.

Oinas-kukkonen & Harjumaa (2009) have proposed a method to evaluate the success of adopting a persuasive design. They described a number of system features that are a part of a persuasive solution. These can be categorised as *primary task support*, *dialogue support*, *system credibility* and *social support*. Each feature has a number of principles related to a specific requirement that maps to a mode of implementation. Personalisation, self-monitoring and reductions of complex behaviour are *primary task support* principles that need to be considered within such solutions. Another important feature is *dialogue support* where the main principles are praise, reminders, suggestions and social role. When a person feels useful and his/her contribution to a task is recognised, user engagement is increased. When users can share with others a problem they cannot solve or otherwise can provide support to others, they also are likely to be motivated to participate. Both characteristics are important and will be considered in the solution presented in this thesis.

System credibility features are adopted when users recognise the trustworthiness, system incorporating expertise and third-party endorsement principles from well-known respective sources. *Social support features* include principles such as social learning that increase the motivation of users to perform target behaviours (Oinas-kukkonen & Harjumaa, 2009). The use of these features contributes to increased participation in an effective way.

When developing the research tools designed for the experiment in this thesis, these features have been considered a vital part of its design and recognised as contributing to its success since those users who are engaged do not only participate to complete the study, but also feel confident and positive that the knowledge being shared with peers is effective and useful.

Social learning within a social support framework is one key way of motivating participants to perform target behaviour, where one can use a system through which s/he can observe others performing. The learning process therefore is enhanced through the cooperation and emulation principles. A system can motivate users to adopt a target attitude or behaviour by leveraging human beings natural drive. Examples of researchers who investigated similar principles include Davis (2012), Lacroix *et al.* (2009) and Seidman & Mccauley (2009).

Collaborative solutions can be applied in an organisation with the aim of motivating participants to consistently contribute to the learning objects. This would help to simplify complex problems and further ensure that peers coming from different backgrounds can understand them. The study by Fogg (2009), concerned with persuasive technology, underwent review and analysis, where the various concepts were applied in the proposed research.

The various studies proposed in this research have all adopted social media for sharing knowledge through the use of collaborative computer solutions. For this research when adopting a persuasive technology approach in a collaborative solution, it is important that stakeholders participate in the solution development, as this is recognised as leading to consistently high-quality learning objects to perform the targeted behaviour. The tools designed and implemented for the proposed methodology adopted for this thesis allow the researcher to collect data. For this PhD, this data evaluates user engagement when sharing knowledge.

2.7 Social Computing Paradigm

Social computing paradigm can play an important role when designing collaborative solutions at the workplace. A study by Carchiolo *et al.* (2010) presents PROSA a semantic peer-to-peer overlay network inspired by social dynamics that makes use of links amongst peers to resemble the way people ask other people for collaboration, help or information. This is an example of how social computing can be adopted in various ways to combined disciplines that reflect requirements. It is necessary to acknowledge these requirements in designing computer solutions with a specific goal. This phenomenon is also changing the way people interact and communicate, which have led to the term *social computing*, which various researchers in academia and industry have attempted to define:

> Vannoy and Palvia suggested that social computing consists of an "*intra-group social and business actions practised through group consensus, group cooperation, and group authority, where such actions are made possible through the mediation of information technologies, and where group interaction causes members to conform and influence others to join the group*" (Vannoy & Palvia, 2010, p. 23).
>
> Wang *et al.* defined social computing as *"computational facilitation of social studies and human social dynamics as well as the design and use of ICT technologies that consider social context"* (Wang *et al.*, 2007, p. 234).
>
> Kling defined social informatics as the *"interdisciplinary study of the design, uses and consequences of information technologies that takes into account their interaction with institutional and cultural contexts"* (Kling, 1999, p. 32).

For this thesis, the definition by Vannoy & Palvia (2010) will be adopted. Social computing will be adopted to influence participants at their workplace, to construct knowledge and actively contribute to creating learning objects. This phenomenon of social computing requires an in-depth understanding of human behaviour in the context of information technology from across a multi-disciplinary and multi-faceted context, including mobility context awareness and social technologies, amongst others. Currently, only a select few studies have investigated technology that targets individuals at the society or community level, or through a lifestyle experience (Vannoy & Palvia, 2010). Although social computing is still in its infancy, it is clear that mobile computing will play an important role in the development of societies that increasingly make use of tools to communicate. Therefore, examining technology adoption by individuals is critical to understanding social computing and the embracement of technology in people's everyday lives.

New trends allow enterprise computing within organisations to make use of technologies that are possible due to the advances in computing and networking technologies. Basole (2007), in the article "The Emergence of the Mobile Enterprise: A Value-Driven Perspective", explores the values that drive the emergence of the mobile enterprise, identifying categories of workers that can benefit from mobile ICT (Basole, 2007).

Opportunities for how organisations can employ ubiquitous computing within various domains have been identified. These domains include, for example, the workflow process with EIP system (Enterprise IT Planning), customer relationship management, and e-commerce, and further include a number of collaborative tools. However, the adoption of these tools by groups is a major problem (Crabtree *et al.*, 2002).

To conclude there is a need for other methods to involve collaborative groups in technology design. Even when designing *collaboration* tools, designers often employ methods that focus on *individuals.* This leads to tools that are not well targeted at the groups who will actually use them (Matthews *et al.*, 2011). Information systems tools that are available on SMDs may not be effectively used within such domains. Therefore this PhD investigates new ways of how social media can contribute to address problems in groups at the place of work. The proposed research makes use of SMDs as a means to capture knowledge through a social media module specifically designed for the study as described in chapter 5. Social media allow Just in Time collaborative groups to discuss and construct learning objects that encoruage subjects in the work environment to communicate through SMD while solving problems.

2.8 Frustration, Confidence and Goal-Setting in the Workplace

According to research carried out by Lazar *et al.* (2006), results indicate that, when employees face computer problems, a high percentage of their time is wasted due to frustration, which, in turn, has an impact on individuals' performance and that of their organisations. Time spent trying to solve a problem has been indicated as a key factor when measuring frustration. Frustration seems to increase when participants spend a greater amount of time trying to solve a problem without achieving satisfactory results. Error messages, connection problems, application freezes, hard-to-find features and long download time are the top five problems encountered (Lazar *et al.*, 2006b). Moreover, both confidence and frustration are influenced by the individual's own experience and circumstances surrounding their actions.

An individual's self-confidence, as well as his/her general ability to use tools, such as computer-based devices and software, play an important role in ICT-enabled workplaces since it has an influence on goal formation and sense of achievement (Pintrich, 2000). There are greater challenges when a particular goal or multiple goals need to be achieved within a short timeframe. In the digital age, due to the fast pace at which knowledge is produced, shared and consumed, there is an increased pressure to reduce the time between starting and achieving a goal.

Latham & Locke (2002) indicate that there is a strong relationship between goal commitment and performance when the user recognises his/her abilities and the importance of a task. To achieve a good performance, the goal must be specific and the individual must clearly know what is expected of him. As a result, if a learning approach within defined goals is adopted, this leads to better performance, with better results obtained than when merely focusing on what is expected from the user (Lunenburg, 2011). An important factor in relation to achieving a good performance is the manner in which a user achieves a particular goal, or multiple goals, and how this impacts on an individual. Pintrich, Conley & Kempler (2000) state that, in the last 20 years, work-related goals have evolved with different attributes and beliefs pertaining to success, failure, effort and ability. It is worth mentioning that there is a need to research and clarify the conceptual aspect of goal-setting and the influence of cognition and self-regulation, amongst others, when adopting learning techniques in the workplace.

It is argued above that mobile technology adoption in the workplace presents challenges that could affect user behaviour and performance. Therefore, there is a need to know more about users' attitudes and behaviours (such as through measuring their confidence and frustration levels prior to and following the completion of a given task) when using smart mobile devices in the workplace.

This thesis attempts to understand how a user independently manages to solve these challenges through investigation within a real environment. The outcome is a set of requirements of designed tools that can provide Just in Time support solutions. To summarise, mobile technology usage is widespread and its adoption in the workplace presents challenges that could affect user behaviour and performance, as well as confidence and frustration. Usability theories highlight several attributes (learnability, memorability and errors) that users might need to acquire in order to achieve their goal. Therefore, the need to further investigate SMDs use within the workplace environment is achieved by identifying a number of case studies that are used within the workplace while users attempt to solve problems. Being able to understand how a user independently solves these challenges helps to improve the engagement with technology. The study hypothesises that we are investigating the following: when given a task on a new SMD in the workplace environment, the majority of the users will experience obstacles; participants will attempt to overcome such obstacles in line with their own knowledge base and following their own progression level (Attard et al. 2016).

2.9 Personalisation—Definitions of Techniques Adopted at the Workplace

Today, personalisation is possible on a broader scale due to technological innovations that are increasingly making use of SMDs. Technology is becoming more and more sophisticated, and can be adapted to create personalisation within different domains. Some of these technologies are already being applied to health (Torsi *et al.*, 2010), media objects embedded into TV video play-out stream (Foss, Malheiro & Burguillo, 2012), social care activities of daily living (Zheng *et al.*, 2010) and e-marketing to direct personalised recommendations and adverts to users (Ntawanga, Calitz & Barnard, 2008), amongst others.

Fan & Poole (2006) reviewed how personalisation is adopted within various disciplines. In the article, "What is Personalisation?" they considered different domains, including personalisation in information systems. These domains included marketing/e-commerce, computer science/cognitive science, architecture/environmental psychology, information science, health and social science. The variety of fields reflects the multidisciplinary nature of research being carried out in relation to personalisation. The article is limited to the use of personalisation in e-commerce and m-commerce. Other contexts have not been tackled in depth. Moreover, ways of taking advantage of knowledge captured through mobile devices has not been discussed.

The literature provides various definitions of personalisation that have been used by different researchers within the field of computer science and information science:

> "*Personalisation is a toolbox of technologies and application features used in the design of an end-user experience*." (Kramer *et al.*, 2000, p. 44).

"Personalisation system is any piece of software that applies business rules to profiles of users and content to provide a variable set of user interfaces" (Instone, 2000, p. 15).

"Delivering to a group of individuals relevant information that is retrieved, transformed, and/or deduced from information sources" (Kim, 2002, p. 30).

"Machine-learning algorithms that are integrated into systems to accommodate individual user's unique patterns of interactions with the system" (Hirsh *et al.*, 2000).

"Unifying platform embedded in any type of computing devices that support individualized information inflow and outflow" (Riecken, 2000).

"Computer networks that provide personalized features, services and user interface portability across network boundaries and between terminals" (Tomarchio, Calvagna & DiModica, 2002, p. 128).

"Fine-tuning and prioritising information based on criteria that include timeliness, importance and relevance to the audience" (Bender, 2002).

This research will achieve personalisation by identifying criteria that reflect a relationship between individuals through computer solutions. For this PhD the definitions by Riecken (2000) and Tomarchio, Calvagna & DiModica (2002), as quoted above, fit the scope of this research when adopted to motivate users when applying one of the principles of persuasive technology described in Section 2.6. Therefore the proposed study in chapter 6, 'the potential of adopting persuasive technology' can be enhanced by the use of social computing as described in section 2.7.

2.10 Crowdsourcing

Jeff Howe and Mark Robinson coined the term crowdsourcing in June 2006 issue of Wired magazine (Howe, 2006). It was considered that, when involving users in a crowdsourcing solution, the possibilities enabling users in creating knowledge or otherwise completing a task within a short period of time could be positioned to overcome various challenges in different areas that usually would require more knowledgeable individuals or additional resources (Brabham, 2008).

The majority of businesses experience issues in needing to address the development of efficient approaches so as to enable workplace communities to share and capture knowledge effectively amongst peers. Crowdsourcing, as a new approach to business, seeks to establish solutions that may be outsourced to a larger workforce to complete tasks that normally would be performed by smaller groups (Greengard, 2011). When seeking to define crowdsourcing through the completion of a systematic literature review, 17 different definitions of the term were highlighted by Hetmank (2013), which then were categorised in different perspectives. For this particular study, three of these have been examined, namely human-centric, organisational and process perspectives. Various scholars have taken into account these perspectives, and accordingly provide a definition as follows:

Howe (2006) "*Simply defined, crowdsourcing represents the act of a company or institution taking a function once performed by employees and outsourcing it to an undefined (and generally large) network of people in the form of an open call. This can take the form of peer-production (when the job is performed collaboratively), but is also often undertaken by sole individuals.*"

Franklin *et al.* (2011): "*creates a marketplace on which requesters offer tasks and workers accept and work on the tasks*."

David *et al.* (2011): "*establish a market where a "taskmaster" can submit batches of small tasks to be completed for a small fee by any worker choosing to pick them up*."

Lofi *et al.* (2012): "*an effective tool making human skills and intelligence accessible to machines*."

Lilavati Pereira Okada *et al.* (2012): "*distribute problem-solving tasks among a group of humans*."

The aforementioned definitions have been considered valuable when considering the fact that the crowdsourcing techniques adopted in line with various others, including computing, may be adopted in an effort to push organisational staff to share problems and contribute knowledge garnered through experience. Some such issues are associated with merging quantitative and qualitative methods and data through computer-supported collaboration, in educational domains (Brabham, 2008).

In order to garner understanding into how crowdsourcing is being implemented, it is relevant to consider the development of some of the more successful platforms for designing t-shirts, developing software, testing, and support.

Threadless is web-based t-shirt organisation that implements a model whereby members compete to win work. There is usually consensus concerning fees and project specifications. Threadless is free to join, with members provided access to submit or vote on designs. Members may choose to submit designs through Adobe Photoshop or Flash templates. Members are provided with all guidelines to facilitate their submission of designs, with consideration afforded to the number of colours and the quality of the image, for example. Upon the uploading of the design, work then is assigned a score ranging 0–5, with the option voters ticking an 'I'd buy it!' box. Voting is open for a two-week period, with the highest scoring designs chosen by the website's staff for printing and sale availability.

Innocentive is another crowdsourcing platform, which is a corporate R&D (Research and Development) platform for scientific problems. Primarily, funding was assigned by a pharmaceutical giant, Eli Lilly, with *Innocentive* described as facilitating scientists in receiving financial award and professional acknowledgment for solving R&D-related challenges. Potential solvers are able to register for a free membership, with members not required to be scholars or professional scientists. Firms also can search for innovative solutions within the global scientific community. Those who join are able to submit solutions through providing a document in downloadable template form.

Crowdsourcing platforms can also be utilised by software testers and developers, as in the cases of Topcoder, mob4hire and utest, for example. The success of such platforms may be attributed to the amount of workforce in particular, in addition to the expertise attracted to a specific task (uTest.com).

Lastly, Amazon Mechanical Turk and Askville by Amazon are crowdsourcing platform-supporting functions, which are a handful of examples of community-information centric systems. These have developed and grown from being only online forums and traditional user groups. They are recognised as being the next generation of support that has incorporated social networking functions. In contrast, however, Amazon Mechanical Turk provides a micro-task marketplace, where tasks included range from micro development, testing, content-creation, etc.

The potential of Crowdsourcing in the context of a workplace environment should be investigated to gather Just in Time knowledge through the application of a collaborative model. This may be feasible through the provision of frameworks that allow crowds to be engaged with IT solutions so as to establish new ways of dealing with such challenges. Through bringing together a crowd made up of diverse individuals, highly complex problems may be overcome when more conventional methods are unsuccessful. This provides the potential to gain insight and knowledge in real time, that is at the time of the user actually experiencing the problem.

2.10.1 Explicit Collaboration through the Adoption of Social Network Analysis

Social computing principles warranting more in-depth analysis through the adoption of SNA (social network analysis) methods could be identified as underlying computer-supported collaboration. The study carried out by Kleanthous & Dimitrova (2010) emphasises the adoption of graph-based algorithms for identifying community knowledge-sharing patterns. The approach was applied in mind of examining the efficiency of personalised support provided to virtual communities centred on areas requiring support.

SNA centres on links between and amongst social groups (Wasserman & Faust, 1997). It is widely applied in behavioural and social domains, in addition to in economic, political science, organisational science, industrial engineering and animal behaviour areas (Martínez *et al.*, 2003). SNA seeks to explain patterns of relationships between different personas, patterns structure analysis, and further identifies the various elements affecting people and organisations.

Martínez *et al.* (2003) suggested an approach and collaborative tools geared towards managing the requirement for innovative methods through computer support solutions for the study of new types of interaction, as seen in the specific arena of collaborative learning environments. The work of Martínez *et al.* (2003) applied aspects similar to those found in social computing solutions within a classroom environment, which can be examined through SNA adoption with the objective to examine the collaboration between students. The findings emphasise that the fact that study subjects worked in a competitive setting did not encourage participants to publish documents; this may be taken to mean that, when applying collaborative computer solutions, it is essential that subjects are involved with these solutions and working in environments that both facilitate and encourage collaboration.

In conclusion, social computing cannot be applied without first garnering insight into the different settings and thus establishing the various challenges limiting subjects from becoming involved with the designed solutions. Identifying and addressing such challenges can be facilitated through persuasive technology; however, further research needs to be carried out in order to construct approaches that seek to develop an understanding of how the potential obstacles arising can be predicted. Such approaches can provide computer requirements with the potential to influence the overall failure or success of the solutions devised. Crowdsourcing success is dependent on user involvement, where the amount, completeness, frequency and quality of the information gathered come together to establish success.

In this PhD we hypothesise that crowdsourcing knowledge through the proposed application *YourSpace,* Just in Time collaborative solutions, that are designed by outlining the various requirements within a work setting through the use of SMDs, will help users overcome obstacles and challenges more proficiently. Through a proposed controlled experiment, we aim to exploit the possibility of crowdsourcing for Just in Time knowledge-sharing. We attempt to overcome the problems discussed in section 2.8 of this chapter, that a user comes across by supporitng the community share knowledge more efficiently and in a more relevant manner while technology evolves according to the various business processes that organisations adopt and which are becoming more and more dependent on SMD technology.

2.11 Summary

More and more users are recognised as having devices that support pervasive computing technology, although there continues to be a lack of study centred on users' behaviour and attitudes, especially in taking into consideration their confidence and frustrations when facing challenges in the work environment. The aim of this project is to provide further knowledge by investigation workplace users' levels of confidence and frustration when they seek to independently solve problems whilst completing familiar tasks on new SMDs

Knowledge-sharing is valuable in facilitating users skills to overcome the issues they experience in the work environment when utilising these technologies, without the need to seek out IT support, that might not always be of help. Accordingly, more thorough research needs to be carried out by adopting crowdsourcing in order to ensure more in-depth insight into the IT support role in this context. This PhD investigates which ways users can garner support, within collaborative knowledge-sharing computer solutions in the work environment, via the application of approaches utilising ubiquitous technology on a Just in Time basis.

Social media utilisation has stimulated innovative approaches and applications that have created a wealth of new opportunities. We aim to make use of crowdsourcing knowledge through a novel method to ensure that the users' knowledge construction is supported in a way that allows them to advance their level of learning autonomously at the workplace.

This research has attempted to identify the advantages of adopting social computing solutions such as crowdsourcing techniques, however, through this review we have demostrated that more work needs to be done within the real workplace environment in providing innovative methodologies for examining knowledge sharing solutions at the workplace. To this effect, this PhD succeeds in filling in a gap that combines knowledge sharing at the workplace by adopting Just in Time problem solving, using smart mobile devices through a novel method of crowdsourcing.

CHAPTER 3 – EXPLORATORY STUDIES

Translating Research to Practice: Putting "What Works" to Work

(Rita K. Noonan and James G. Emshoff)

Involving users in the early stages of the study increases the overall understanding of the requirements needed to design the proposed research. Therefore, preparatory workshops and user trials were carried out throughout the entire lifecycle of the research. In this chapter, two preparatory workshops will be discussed. The work presented here seeks to investigate the challenges of an employee-oriented model when users adopt SMDs in the workplace. The findings identified will serve to highlight the requirements needed in order to adopt a framework in the context of a work setting. For example, a number of solutions aimed at problem-solving have been provided in mind of enabling independent application by users, without any need to identify and source traditional in-person support.

This chapter will discuss the different criteria contributing to the development of Study 3, problem-solving when assigned with familiar task using unfamiliar mobile device. Results will also contribute to the evolution and evaluation of the various prototypes of Study 4—the final application *YourSpace*. The following figure outlines the main objectives of the studies discussed in this chapter in relation to the studies that follow.

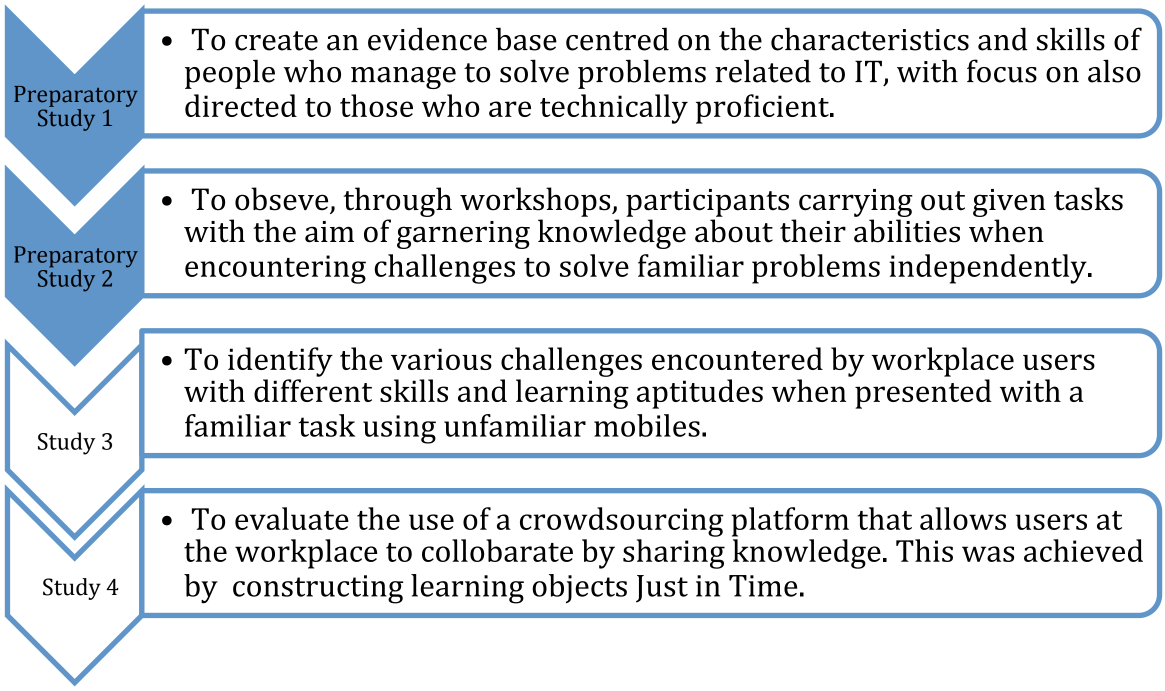


Figure 2: Two preparatory studies described in this chapter that lead to the main studies (Study 3 and Study 4)

As described in Chapter 1, the preparatory studies attempt at identifying who can contribute to knowledge within the area chosen for the research that is problem-solving using SMDs in the workplace (see figure 2). The preparatory studies are discussed in detail in the following sections.

3.1 Study 1 - One-to-One Interviews

Throughout the initial preparatory workshop, referred to as Study 1, the user role was fundamental, with emphasis centred on establishing a user group that could effectively contribute to the study. Well-designed software applications are usually successful owing to the fact they establish an intuitive experience for the individual or group making use of the application. This research has sought to identify those individuals who are more confident in the use of technology and who have the capacity to solve problems on an independent basis. It seeks to define the profiles of those individuals who can add value by sharing their experiences in solving SMD-related issues.

Study 1 Hypothesis:

H1: A greater confidence in technology and mobile technology use will be demonstrated by the younger generations of technology proficient individuals in addition to the ability to solve problems more independently when compared with older generations.

H0: There is no age or ability difference amongst mobile technology users.

3.1.1 Methodology

The aim of this study was to identify ways and modes through which users interact with SMDs. This initial study was conceived to reveal whether there was a relationship between "age" or job role of person, and whether the participant would share knowledge on IT with a community of users in such a way so as to help them solve problems when using SMDs and related technology. The knowledge captured then would be used to support others in solving problems. A one-to-one series of interviews was organised at the place of work in three locations, namely University of Malta, Mater Dei Hospital in Malta and Malta International Airport.

a) Participants

Twelve employees working at Malta International Airport, University of Malta and Mater Dei Hospital took part in the study. Half of the employees were aged between 16 and 24 years, whilst the other half were aged between 25 and 35 years. Participants were chosen purposely within these age groups in order to initially verify whether the younger generation was exposed to technology at the place of work and would be the right age group to study when seeking to understand how users deal with problems using SMDs. The participants did not have a data contract with a mobile operator and therefore used the Wi-Fi connection provided by their company. They owned a personal SMD and also ones provided by their company.

b) Instrumentation

Participants were asked to complete a short online survey. The goal of the online survey was to collect basic information about the users, in addition to the type of work and age (see Appendix D). The second part of the survey was centred on the features of mobile devices and the way they are used. The participants then held one-to-one interviews with the researcher to discuss their experiences when using SMDs.

The last part of the survey allowed participants to recommend other people who are older than 50 years of age for participation in the study. These people subsequently were enrolled in the study and given the same questionnaire.

c) Procedures

Participants with different backgrounds were invited to take part in a short study by email, which included an information sheet about the study. Users could stop participation in the study at any time. A consent form was distributed, and users were informed that they would remain anonymous (see Appendix A). A one-to-one meeting was scheduled at their place of work. Participants filled out the online form first, and a short interview was conducted. Participants shared their knowledge about their experiences when facing a problem whilst using an SMD. They were asked questions on their mobile device to explain taskbar icons found at the top part of their SMD and explain what they meant.

3.1.2 Results

Throughout the first preparatory workshop, referred to as Study 1, one of the points raised by participants was that SMDs and traditional mobile phones lack effective support information within their applications; this means that there is a lack of information that could be easily accessible on the SMDs itself and if this information were available it could guide the user using an application and inform on the general mobile platform usage.

All twelve participants completed the online form and gave feedback. Of these, 83% (n=10) had full-time paid employment and 17% (n=2) studied part-time and worked part-time (see Table 1). All participants used technology regularly and owned a mobile device (see Table 3). The participants had different roles in their work, including 1 manager, 2 lecturers, 2 doctors, 2 nurses and 5 administrative jobs.

Table 1: Participants description of employment

	Responses by %	n=12
Working full-time paid employment (35 or more hours per week)	83	10
Studying part-time, working part-time	17	2
Total	100	12

A total of 92% (n=11) own an SMD and 9% (n=1) own a normal phone that did not have smart mobile features. (Ref to Table 2)

Table 2: Type of Mobile participants owned

	Responses by %	n=12
Smartphone (e.g. Android, iPhone, Windows phone 7)	92	11
Normal Phone	8	1
Total	100	12

Table 3: How participants used their SMD. Time in hours they spent doing a particular task through their SMD

		0	1 to 6	7 to 15	16 +	Total
Using email through your Smartphone Mobile device	Count	1	6	4	0	11
Using email through your desktop computer	Count	1	5	3	3	11
How many hours a week do you spend socialising with friends using your Smartphone Mobile device excluding text and calls	Count	2	3	3	2	10
How many hours a week do you spend socialising with friends using your desktop computer?	Count	1	7	2	1	11
How many hours a week do you spend purchasing using your mobile device?	Count	4	7	0	0	11
How many hours a week do you spend purchasing using your desktop computer?	Count	2	8	1	0	11
How many hours a week do you spend reading eBooks using your mobile device?	Count	6	3	0	0	9

Table 4: When you need to do the following task how do you communicate using your SMD?

		Email using Mobile device	Social Network Using Mobile Device	SMS	Phone Call	Skype through your mobile device	Nothing of the above	Total Respondents
If you need to talk to someone about something personal, do you prefer most likely thing to do? (1st preference)	**Count**	0	1	2	7	0	1	**11**
If you need to talk to someone about something personal, do you prefer most likely thing to do? (2nd preference)	**Count**	0	3	5	2	1	0	**11**
If you need to talk to someone about something personal, do you prefer most likely thing to do? (3rd preference)	**Count**	5	1	3	2	0	1	**11**

During the interview, when participants were asked to share their experiences of using SMDs, a number of points were identified:

a) Although all users utilised technology on a regular basis, including SMDs, eight out of 12 users would not solve problem by themselves, but instead would refer to a friend for help (see Table 4). Three said they would ignore the problem and leave it unsolved. One user said he would search the Internet for a solution, but only if he really needed to make use of that particular function.

b) None of the users referred to IT support at their place of work (even if the problematic app in question was work-related, such as email or calendar) because they considered that IT support was not helpful with regard to SMDs or wireless problems. Most times, they said that IT support would actually not get back to the user when they called for support if they told them the problem was related to accessing work-related data on their personal mobile device. Support normally was said to be given to IT solutions that are accessible through a desktop computer.

Participants commented that even problems on desktop systems took time to be solved.

c) The three participants interviewed at Malta International Airport (MIA) commented that, when they experienced problems with SMDs and the problem was seen to be related to wireless connections or the internet, generally they would not immediately notice the source of the problem, and sometimes it would take a week before the app they were using would start working again. They commented that, with time, they would get used to the situation, and when a problem occurred they informed IT support, suggesting it was a wireless-related problem—even if it might be something else.

d) Participants also commented that they normally self-purchased the latest mobile devices, except for one participant, who still used a mobile device without Smart features. However, they felt they were not using the mobile to their maximum capacity and, most of the time, this was because the mobile device did not have built-in support similar to the one available on a desktop.

e) Participants explained that, when they tried to ask IT support for more information about a problem, they encountered what might have caused it. Most of the time, IT support made users feel they were doing something wrong and refrained from explaining the root cause. When users asked for advice on how to avoid the problem next time, IT support seemed to lack knowledge to explain this, or otherwise did not show any interest or did not allocate enough time to explain. IT support instead would tell them they would not understand the procedure and would give them the impression, through their language and attitude, that participants were "stupid" and "careless" in their technology use. Accordingly, participants felt they could not really take the required action to improve their performance when encountering problems with technology at the place of work.

f) Five of the users commented that most of the time problems were left unsolved for days, after which time systems suddenly would seem to start working by themselves. When asked for examples, they referred to in-house solutions that they used at work, such as portals to view the status of work forms and an email app used to access their work email through SMDs. Participants explained that the administrator of their particular section would complain when systems were not updated, as a work backlog would be created as a result of those participants from Malta International Airport and Mater Dei Hospital who are expected to log information on their in-house software regularly.

g) All participants expressed their wish to have better support. Only one participant seemed to consider taking action independently when problems arose. All participants said they spent long hours using SMDs and technology at their place of work, but admitted to not really having the necessary skills to take action when problems arose. They felt comfortable when they received advice from others, such as which app to use, or when they asked a friend to help solve a problem. Participants normally used only apps such as email, calendar, to-do lists and those containing information related to their job, which appeared appropriate in meeting their work needs. If an app proved problematic, they either uninstalled it or did not use it anymore. Those apps purchased or downloaded free from their favourite app store differed from those that were proposed by their IT workplace. When participants could choose the app themselves, they could decide whether or not they would like to use it.

h) Only eight participants stated that they liked downloading apps that could support them at their place of work. In most cases, other people recommended such apps.

When asked to interpret symbols on their SMD or mobile device, or those found in the mobile status bar normally at the top of mobile platforms, 11 out of 12 of the participants did not know how to explain them or otherwise did not know what they meant. They were asked to interpret eight icons as seen in the status bar in Figure 3. The main icon they felt they could understand was the mobile operator connection, indicating that it was possible for them to make a phone call or send and receive SMS (see Figure 3).

Figure 3: Top task bar with different symbols with information on functionality of mobile device

3.1.3 Discussion

In the current work, the author seeks to examine whether particular groups—educational background, age or job role—affect knowledge-sharing amongst colleagues in regard to problem-solving. When examining results from the preparatory study, a number of key points were highlighted, as follows:

1. A total of eleven of the study subjects personally owned sophisticated and costly technology, which predominantly were used for making phone calls and messaging (see Table 2). Accordingly, their devices were not used to their maximum potential, as was seen to be the case when seeking out apps that could add value to their working day, such as through allowing them to obtain more information or facilitate better management of their daily tasks. They experienced issues in solving problems and understanding their SMDs.
2. Feedback gathered from the subjects, especially that that had experienced problems in using their devices, emphasised that colleagues would be the usual port of call for help when experiencing device-related problems. Whenever possible, family and friends were asked rather than IT support. Generally, they were unable to or did not have the opportunity to learn how to solve the problems themselves.
3. Amongst most of the sample, most of the individuals interviewed were lacking a problem-solving attitude. This seems to be associated with feelings of incompetence

experienced by users, and IT support apparently failing to provide the information needed in order for users to overcome problems themselves.

In the suggested research, as detailed in the first chapter, the individual providing the assistance would also add to creating a learning object that could be accessed by others when seeking to gain understanding of how to solve a specific problem. Further investigation should be carried out in order to validate how knowledge may be shared, as detailed in Section 3.2.

3.1.4 Conclusion

The findings show that both educational background and age did not seem to be elements that determine whether or not users hold sound knowledge regarding SMD use, especially when solving problems at the workplace. Accordingly, the hypothesis is rejected. Accordingly, further work needs to be carried out in this area, in mind of the need to garner more understanding relating to the challenges users experience and, whenever possible, seek to define a profile of users that may be able to effectively solve a problem in order to help others through considering the collective skills of more than one person. All of the interviewed subjects demonstrated inclination to learn about technology, especially in regard to SMDs. They were aware they had not been using most of their SMD functionalities. Aiming to garner understanding of technical knowledge and accordingly learning how to communicate the necessary skills can be valuable for everyone. A number of sources could cause challenges to arise, with each individual viewing them differently. This could result in different outcomes that depend on the behaviours and/or attitudes of participants in their use of technology in the work setting. In specific consideration to this study, this is recognised as a pivotal factor needing to be investigated. The various types of challenges experienced by the participants, and the decisions made in how they are overcome, will be investigated.

More information needs to be gathered, with a second study carried out, adopting the form of two workshops, seeking to gain understanding of how subjects in the work environment attempted to gain knowledge on various challenges faced by users (see Section 3.2). The workshops, referred to as Study 2 and expanded across all subsequent studies, contributed to emphasising the behaviours and/or attitudes of users in regard to issues. The collection of information relating to users before and following the assigned task was carried out through the completion of pre- and post-studies. The task was centred on commonly used features and their associated features. Lastly, the author made the decision that subjects would be observed throughout organised workshops in order to establish how problems would be solved by users, or otherwise how they would establish the source of the problem. Study 2 centred on the completion of this stage of work.

3.2 Study 2: Study on Users' Attitudes and Behaviour when Faced with a Problem in the Workplace

The second study sought to establish the key challenges in the proposed research project, including the difficulties users of SMDs experience when using devices, and the role of IT support. A further aim was centred on identifying the most suitable way of establishing the problems experienced by users, and the needs of users, when using such devices, and accordingly striving to solve these issues. There was the completion of two different workshop sessions: the first sought to establish the competences of the participants in using SMDs, particularly when facing problems, with the first session useful in establishing various aspects for improvement throughout the second session; the second session was a replication of the first exercise, but with the additional aim of addressing various issues established in the first workshop.

For the workshop, the tasks selected were common issues experienced by those in the workplace. An external person who had experience with running workshops but who did not have experience with the topic facilitated the sessions. The researcher adopted the role of observer, and focused on making notes pertaining to subjects' behaviours and attitudes.

Study 2 Hypothesis:
H1: The majority of the users will face issues in the use of unfamiliar SMDs in the workplace, where their knowledge, behaviours and attitudes will affect their ability to solve such problems.
H0: SMD unfamiliarity, user's knowledge, behaviour and attitudes have no influence on their ability to solve problems on a smart mobile device.

In order to validate the hypothesis, two workshop sessions were carried out, the aim of which was centred on observing the subjects in solving the tasks. This research adopted the nature of a preparatory study. The results further verified whether the tasks chosen could be used for Study 3 and Study 4. The current study's findings detail the type of issues experienced by employees and how IT support was used to overcome the various challenges.

3.2.1 Methodology: Workshop 1, June 4, 2012

The first workshop was carried out in the conference room of the Malta International Airport, and lasted two and a half hours. This venue was chosen owing to the fact it was designed to cater for such events; it is well-lit, has PowerPoint facilities, is accessible, and has an air conditioning system. The chairs were arranged in a circle so that all participants could see each other whilst talking. A professional who was experienced in conducting workshops but who had limited knowledge regarding the subject under examination facilitated the workshop. The characteristics of the facilitator were ideal, as the participants were not influenced in any way. The researcher was present during the workshop, and care was taken to intervene only when probing was necessary, such as when needing to further promote a discussion on the topic or prevent deviations from a topic. The researcher's role in this workshop was also centred on clarifying any misconceptions using evidence-based research findings.

a) Participants

Participants were chosen by the Human Resources Personnel from different departments within the Malta International Airport in mind of ensuring a mixture of individuals in various roles. The only criterion for taking part in this study was that participants needed to be exposed to information technology during their work. The age of the participants varied from 21 to 45 years. Two of the participants worked within the Facilities department: one worked as a security officer and the other within the Operations department. All of them made use of a computer for writing reports. The first workshop was planned for six participants; however, only four participants attended (three males and one female). The other two were contacted but were unable to attend on the day due to unforeseen circumstances. The researcher and the facilitator had no prior knowledge as to the awareness of participants regarding smartphone devices as the participants were asked to complete the online questionnaire only at the beginning of the workshop. This aspect did not affect the planning of the session.

b) Procedures

The participants filled in an attendance sheet. The researcher and the facilitator gave a brief introduction about themselves to make the participants feel at ease. It was clearly explained that the researcher and the facilitator were interested in all responses and there were no right or wrong answers. It was emphasised to participants that they had to carry out the tasks individually, after which they would have time for group discussion. Additionally, it was explained that this group had two purposes: apart from being a workshop, it also served as a preparatory study for the subsequent study, described in Section 3.2. The main aim of this study was centred on identifying and addressing any possible problems that might arise at a stage when it still could be corrected (Wood & Ross-Kerr, 2006). Thus, these participants did not form part of the final sample. This aim of the exercise was centred on helping the researcher to identify how participants responded to the tasks being presented and to check for any problems in understanding the questions asked. Each of the participants was given a folder with a number of cards and sheets. Cards were used to facilitate understanding of the application for the participants.

The participant information sheet was read and explained by the facilitator, and the participants were allowed enough time to go through it by themselves and ask any questions to clarify any doubts they might have. After reading the participant information sheet, the participants were presented with the Informed Consent Sheet. Again, the facilitator explained every statement in the sheet. All participants gave their consent to participate and to be videotaped. Confidentiality was guaranteed by keeping participants anonymous throughout the course of the report. The participants also were asked not to disclose any of the discussed information with people outside of the group. This was done so as to provide a sense of security amongst the participants, and accordingly to encourage their participation and comments as much as possible. Throughout the course of the workshop, both English and Maltese languages were used. Since Malta is a bilingual country, participants were free to choose their language of preference. Both the facilitator and the researcher took notes. The observations on the general atmosphere, including the non-verbal cues of participants, were noted so as to be able to place the data within a context.

c) Task Undertaken

The participants were given three tasks to complete, which the facilitator explained before each one was started. When clarification was deemed necessary, the researcher provided this. The first task consisted of asking if the participants owned or had used a smartphone in the past. Only one of the participants owned and used a smartphone, whilst the others made use of an ordinary mobile phone. They then were presented with a number of different icons and, working individually, they had to match the icon with the description, such as WI-FI, Synchronisation, 3G and others, and then write down the action for that icon. This exercise had to be explained more than once for the participants to understand what they actually had to do. Those participants who were not familiar with smartphone devices seemed to encounter quite a few difficulties with the questions posed in the exercise. Participants then had to complete the following tasks by themselves:

Task 1:

Each participant was given a smartphone and was asked to create an e-mail account (to create a simulation of the task). Passwords and e-mails were given accordingly. They were asked to imagine they were at their place of work. The participants were asked to write the sequence of actions they carried out to solve the task, and they also had to report on the difficulty they experienced (from 1 to 5). The participants also were given a number of cards, such as "*Call Support*", "*Face-to-Face Support*", "*Internet Use*", "*Lost*" and "*Finished*". They were asked to indicate on the cards the time when they needed to make use of the cards. Not all of the participants understood the use and significance of these cards. The researcher represented "Support Personnel" by responding if they showed the card and when any one of the participants felt the need to ask for advice, they could make use of this card and indicate whether they required call support or face-to-face support to solve the problem (see Appendix B).

Additionally, laptops were in the room for the participants to use: for example, if they felt the need to search on the Internet on how to create an e-mail account. None of the participants opted to use the laptop to search for help or any guidance for this task. Two of the participants seemed completely lost, and their facial expressions indicated irritability and frustration since they could not master this task. One of them tried to ask his colleague, but he was reminded to carry out the task on his own, and used the card to indicate that he required support. Two of the participants managed to finish the task in about twenty minutes after using Call Support and Face-to-Face Support, whilst the other two did not manage to create an e-mail account. One of the participants experienced great difficulty in typing on the touch screen, and she was very irritated with it. In this case, a QWERTY keyboard might have helped. The participants voiced mixed reactions; those who succeeded seemed quite pleased with their achievements, whereas those who did not manage to finish the task were disappointed and wanted to know what they should have done. This indicated the need for more knowledge and information to be provided on the subject, recognising the fact that some participants will be acquainted with technology.

Task 2:

The other task given to the participants involved presenting eight sheets depicting eight screens of the application being proposed. The participants were given enough time to analyse the screens, and then they were asked to memorise the screens so that, for the second task, they had to recall what was depicted in the screens and apply it to the mobile phone. The task was to connect to the internet through Wi-Fi using the smartphone device. Due to time constraints, the participants were grouped into two groups of two people each, and it was noted that the two participants who managed to finish the first task also successfully carried out the second task, whilst the other two relied on others to finish the task for them. Both groups managed to finish the task in a short time. Overall, it seemed that recalling the application helped in completing the task successfully. The participants were asked to give comments on the application, and whether they understood each screen presented.

Task 3:

The third task consisted of a discussion between the participants on what they understood by the term "support" in relation to IT both at their workplace and at home, as well as who they called and what they did when they required support. They were asked to comment on their experience of support. They also were asked if support is something they could define and whether they could clearly explain what good support is by providing examples. Moreover, they were asked if they used particular systems at their place of work, such as particular software. Finally, they were encouraged to give suggestions on how support could be improved by using smartphone devices.

3.2.2 Results

The participants unanimously agreed that "support" is calling someone from the IT Department to solve the problem with the device being used. Those who worked night shifts mentioned that, if they could not solve the problem on their own, they would have to wait till morning for Support Staff from the IT Department to solve the problem as Support Staff have fixed working hours; thus, those who work night shifts would not be able to progress in their work. They would either have to ask a colleague to help tackle the difficulty or search online using Google or YouTube, for example. Not all of them took an interest in how Support Staff from the IT Department manages to solve the problem, as it is not their role. In their opinion, they needed the computer to work with, but they do not necessarily need to know how to solve the problem. It was mentioned that, when a difficulty arose, it would be useful to have a help sign, such as an icon, which could be accessed to get more information on how to solve the problem. When discussing the learning object/application, one of the participants mentioned that this is a concept similar to that of WIZARD, which provides guidance on how to solve the problem. Not all of the participants seemed to understand the concept of having an application on the smartphone to provide guidance in solving difficulties. One of the participants mentioned that it would be ideal to have a device that gives verbal prompts on how a problem can be solved, or making use of a video to help tackle a problem, or have pop-ups to indicate how it can be solved. It was agreed that having a task broken down into simple steps (sequence) would be valuable in solving a problem. In this way, they stated they would feel much more independent as they would not have to rely on others to solve a problem.

3.2.3 Discussion

The results can be categorised as following:

a) *Peer-to-peer learning and support.* Most often when participants encountered a difficulty whilst carrying out a task, they ask their trusted colleagues. Participants may also acquire the information from a reliable source, most often suggested by someone they trust. The concept of having an application in a smartphone device that helps you tackle difficulties was not fully understood by all participants; however, all mentioned that they learn from one another, and when they asked someone, they generally knew to help them; they felt more confident in solving the problem the next time it arose.

b) *Emerging need to carry out the study on a larger scale.* Although smartphone devices are becoming more common, after carrying out this preparatory study it was noted that two of the participants followed instructions on how to make use of the application and understood how it works and the benefits related with the application while the other two participants seemed quite lost and required the help of others to solve the second task (learning object). At the same time, the latter two participants seemed interested in acquiring more knowledge on the subject; however, due to limited time, this was not possible. This implies the need to carry out the study on a larger scale (for example, 50 participants) in order to better understand the concepts of awareness, knowledge and confidence in relation to smartphone devices and how these differ across people. Another important aspect that has emerged from this workshop was how people deal with innovative technology. This suggests that it might be interesting to analyse participants' first reactions when dealing with a novel object (in this case, smartphone devices), intuitive technology without support, and dealing with the task with support. Throughout this workshop, one could see how certain reactions of participants changed: for example, the first time they handled the phone compared to the second time; in the latter case, it was noted that participants felt more confident in using the device.

c) *Frustration due to lack of feedback.* Another important aspect voiced by the participants was that when they did not get feedback on how to solve a problem they got discouraged. They clarified that the feedback does not necessarily entail face-to-face feedback. The computer being used could provide guidelines on how to proceed with solving the difficulties encountered, such as through a step-by-step manual.

d) *Support was not always available when needed.* Since some of the participants worked 24/7 shifts, they did not always find the necessary support to solve the problems in the system, and thus they ended up being unable to progress in their work. It would appear that individuals were not being trained independently on how difficulties should be managed in relation to Information Technology. Instead, they relied on Support Staff help, and consequently ended up wasting a lot of time in finding someone to help them solve their difficulties.

e) *The will to learn and solve problems to be more productive.* During the discussion, various participants showed the will to know more. They discussed different ways of solving problems when possible, even with limited access to information. The participants highlighted that having the tasks broken down into simple steps would help them better understand how to solve each task.

At the end of the workshop, the facilitator and researcher provided a verbal summary of what was understood in an effort to ensure there were no misunderstandings.

3.2.4 Conclusion

After an analysis of the first workshop, the following recommendations were identified for improving the second workshop:

(1) To explain each task clearly and to ask the participants twice if they understand the instructions given.

(2) To give participants a less complex task since when they were asked to undertake a complex task (create an email account) it took them a long time and they felt frustrated.

(3) To ask participants to complete the online questionnaire at home or at the end of the workshop so as to save time.

(4) To allow them to carry out the second task (learning object) by themselves and not in groups.

(5) To allow more time for the discussion.

3.2.5 Methodology: Workshop Report 2, June 5, 2012

The second workshop took place in the same conference room as the first workshop, at the Malta International Airport (MIA). The researcher and facilitator agreed to make the changes described above in Section 3.1.4

a) Participants

Four participants from MIA were invited to attend the second workshop; however, only three (all males) attended. Their ages ranged from 21 to 42 years. One of them worked in the Security Department, another worked in the Fire and Safety Department, and the third participant worked in Salaries and Punching. All were eligible to take part as they all had contact with Information Technology when carrying out their work. It was decided that the facilitator would be included as part of the group. Therefore, aside from facilitating the workshop, the facilitator also carried out the exercises with the rest of the participants. Although the facilitator had limited knowledge of the topic, she had enough knowledge to allow her to use a computer to write reports and check e-mails for her work, which made her a good candidate for the group. The challenge was for her to lead the group during the workshop without influencing the outcome by stating things that might help the participants whilst completing the tasks, such as making them aware that they needed to choose a particular option or search for a particular function when configuring the assigned SMD.

b) Instrumentation

For this study, the participants were not allowed to use the mobile devices they owned; therefore, they were given mobile devices specifically for the study. In order to be able to prepare effective workshop sessions, it was important that the devices supported the right technologies. They were set up in such a way so as to monitor the user experience when using the devices. The setup included removing preconfigured setups, such as Wi-Fi and email accounts, and it was ensured that apps available had the right software to complete the task. The tasks used for this session were extended to other applications that the users would normally use at work, such as email and calendar app.

Just as in the first workshop, all participants were given a pack, which included the participant information sheet, consent form, cards and sheets with exercises.

c) Procedures

The researcher and the facilitator initiated the session by providing a brief introduction about themselves and explaining their roles in the group. The facilitator explained what was expected from them, whilst the researcher would be an observer after introducing the aim of the study. The researcher gave detailed information regarding the aim of the study. Every effort was made to make the participants feel comfortable, and they were encouraged to participate as much as possible. Their role in this group also was highlighted. Attendance was taken. The participant information sheet and the consent form were thoroughly explained by the facilitator, and any questions were clarified. All participants consented to take part and all consented to be videotaped. Both the researcher and facilitator guaranteed complete confidentially of information on the participants and all under discussion.

All participants were asked to fill in a profile regarding the mobile phone they were using at that time, and if they had ever used a smartphone device in the past. Of the four participants, only two had a smart mobile device, whilst the other two had an ordinary mobile phone. Thus, again in the second workshop, there was a mixture of awareness and confidence amongst the participants regarding the use of Smart mobile devices. The first exercise was explained, and the four participants were asked to fill in a sheet with different icons and numbers attributed to the icon (see Figure 4).

1	2	3	4	5	6		7	8	9	10	11

Figure 4: Match Icons with Description (see Appendix B)

They had to match, for example, Wi-Fi with the icon that, in their opinion, represented Wi-Fi, and then they were asked to describe the action of Wi-Fi in their own words. Participants had to be reminded to work on their own and avoid discussing the answers with their peers so as to avoid biased answers. They were reminded that they were not going to be judged on their performance but that they should focus on completing the task just as they would in the workplace environment. Only one of the participants seemed confident in carrying out this exercise as the other three felt the tasks were too challenging.

Prior to embarking on the three tasks assigned, a detailed description of what the participants were required to do was given. They were asked to put themselves in their place of work and carry out the exercise as if it was part of their job. The use of the cards, including "Face-to-face", "Call support", "Internet Use", "Lost" and "Finished", was explained, and they were asked to write a sequence of how they performed the task (see Appendix B). The cards represented different ways of how they would act if they faced a problem or completed a task. They also had to rate, using a score ranging 1–5, how easy or difficult they found each step they performed when carrying out the allocated task. The participants then were asked to connect to the internet using Wi-Fi on the smartphone device provided.

A verbal summary of the points highlighted during the workshop was given by both the facilitator and the researcher so as to ensure the points discussed were understood correctly.

3.2.6 Results

In much the same way as the first workshop, the findings suggest that all of the subjects who were able to complete the task already owned a Smart phone. This suggests that those with experience of using such devices were more likely to succeed in completing tasks using the device in the study. It was recognised that the two subjects who had their first experience with the smartphone device during the workshop were not as confidence in managing the device. If provided with more information and time, it could be that better understanding of the tasks would have been achievable. Upon completing the tasks, it was clear the subjects in question (n=2) were satisfied that they had been successful. The other two subjects needed more information on how the tasks could have been completed. It was recognised that the individuals did not download apps, but rather only preinstalled apps were used.

In contrast to the first workshop, in this case, the subjects were required to complete the tasks on their own. Three of the subjects were able to complete the task, with two of them stating that they found the application to be helpful as they had remembered how to solve the task following prior explanation, whereas the others did not remember the stages to be implemented but nonetheless still tried to complete the task on their own.

Subjects found it easier to carry out the activities when compared with those of the prior study, as discussed in Section 3.0. Regardless, however, only two of the individuals were successful in completing the tasks, whereas the others were not.

A greater amount of time was assigned to discussion in the second workshop. When questioned on their views of support services surrounding IT in their work setting and at home, the subjects discussed that they would immediately consider the person who solves their problems at their place of work when they hear the term 'Support'. Accordingly, generally, they considered face-to-face support as they depended on someone to solve their problems. In contrast, one of the subjects stated that, at home, he often made attempts to overcome obstacles through the guidelines provided by the device brand or otherwise through the Troubleshooting system. The other subjects stated online searches as ways of solving problems, such as through Google. Asking a friend for advice was also one method.

When subjects were questioned on their personal experiences with support services, two of them stated that, generally, they did not make requests of support staff, but that when the system did not response, or when other similar issues arose, this resulted in a lot of frustration. One of the subjects stated that it would be useful to be taught how to overcome problems themselves so that they did not need to rely on support staff, although it was highlighted that this was not his role. Overall, it was stated by the participants that they had to just wait for support when dealing with problems. When asked how support services could be improved in the utilisation of SMDs, the subjects stated unanimously that a system where the SMD is sensitive to establishing the problem experienced by the user would enable a solution to be achieved through completing a few simple steps. This would enable a greater degree of independence amongst the participants. Moreover, users would be able to move at their own pace without the need to wait on support staff.

3.2.7 Discussion

Generally, the second workshop derived discussion categories similar to those identified in the first workshop:

(1) *Peer-to-peer learning and support*: Through a number of examples, including asking peers how a problem could be solved, this aspect was mentioned. It was also evident throughout the course of the workshop as subjects needed to be reminded, in a number of instances, not to ask other subjects for assistance but rather to try to complete the tasks alone. The sample agreed that a collaborative system for those individuals who work together would be ideal: such a system could enable colleagues to provide suggestions for one another on how various obstacles could be overcome. It was considered that this could help all involved to make quicker, more efficient decisions.

(2) *Support services did not provide opportunities for learning but seemed to provide a black box solution:* On a number of occasions, it was mentioned that, when Support Staff established a solution, they did not explain what they had done to solve the problem. Furthermore, the subjects did not proactively seek out instructions. Accordingly, problem-solving could have been more time-efficient had Support Staff guided the participants on how the same problem could be overcome next time. With this noted, Support services do not seem to be linked with learning.

(3) *A feeling of frustration arose when users did not receive feedback on how to tackle a difficulty:* The subjects stated that they often felt discouraged from trying to solve problems themselves as they rarely received feedback from Support. In order to overcome this issue, a device could be implemented that is sensitive to the issue and guides the user in solving the problem.

(4) *The need for more independence:* Owing to the subjects' working hours, they felt a great degree of dependence on Support Staff. They had not been given training on

how different elements of the IT system could be tackled, meaning, if a problem arose, their own progress would stop until Support could find a solution.

(5) *Participants would be happy to learn how to solve problems on their own in order to be more productive:* Throughout the course of the discussion, participants showed a willingness to learn, discussing how problems could be solved, despite their very restricted access to information, such as through carrying out certain actions until they solved problems, or visiting a nearby mobile operator to get advice.

3.2.8 Conclusion

There was the validation of the workshop hypothesis, along with the identification and managing of various challenges throughout the course of the study completion. As noted in Chapter 1, this study seeks to examine knowledge-sharing, with particular emphasis on constructing learning objects centred on solving problems when given familiar task.

One specific issue experienced centred on the recruitment of subjects who fulfilled the study's inclusion criteria. A common knowledge base that can be accessed by various users in the work environment was recognised as valuable in constructing learning objects that could be customised in line with the user group's needs.

Another key factor highlighted in the completion of the study was time, with users needing adequate amounts of time to familiarise themselves with the SMD, with time affecting outcomes. When drawing a comparison between sessions in Study 2, there was some indication as to the most suitable approach to be applied when monitoring the skills and knowledge of subjects, which will be discussed in Study 3. As a result, there is a need for the approach chosen to take into account time allocation when assigning tasks with which users should be familiar.

A further challenge established throughout the completion of the studies is that Support systems are usually linked with various obstacles that can be overcome through a multitude of solutions. The study involved users from various backgrounds with differing levels of competence in the IT field. Such variations therefore were examined with consideration to the activities that would be completed in the subsequent studies. Furthermore, these outcomes were viewed as a chance to create various learning objects that would fulfil the different needs of the subjects in the next studies, with the aim of satisfying the solutions suggested in the study and thereby securing more valid findings that can be aligned with actual scenarios.

It is clear through the findings that there is a need to understand how users face challenges when seeking to overcome problems. Accordingly, a study centred on how individuals in their work environments seek to solve problems using SMDs is called for.

Through initial studies conducted in the work setting, this chapter has highlighted the various problems facing users. The tasks assigned may be used to validate the proposed research. Subsequent studies discussed in Chapter 4 and Chapter 6 will be designed in such a way so as to enable the researcher to detail and further examine the adaptation of users in line with technological advances. In order to achieve this, a larger sample of participants is necessary from different organisations. As detailed in the first chapter, the research will focus on establishing the skills required in order to independently overcome obstacles and also verify whether or not they are able to construct a set of steps to enable users to complete studies to interact with a particular tool that enables them to partake in knowledge-sharing when experiencing a problem.

CHAPTER 4—A STUDY ON WORKPLACE USERS WHEN SOLVING PROBLEMS ON MOBILE DEVICES

"To conceive of knowledge as a collection of information seems to rob the concept of all of its life… Knowledge resides in the user and not in the collection. It is how the user reacts to a collection of information that matters"

(Curchman 1971, p10)

In view of the studies 1 and 2 discussed in Chapter 3, a study was carried out with focus on the challenges arising from performing a familiar task on an unfamiliar device, which can occur, for example, when the user acquires a new device at work, either on a permanent or temporary basis, or otherwise when a user needs to learn new ways of using the device due to changes or updates in technology (such as in the case of a new operative system release or a new mobile model).

The following study examines how SMDs offer opportunities for self-directed problem-solving. The first part discusses the methodology adopted for the study, including the pre-study and post-study, whilst the second part is a video analysis of the actual study. We are more specifically interested in examining the relationship between the time the IT helpdesk takes to provide support and the way in which participants use knowledge when tackling problems when dealing with them in an independent manner. In this study, it was assumed that the adoption of mobile technology takes place within and is supported by the workplace.

The main concepts and findings considered in relation to the study and technology adoption in the workplace are discussed below.

4.1 Study 3: Problem-Solving, Confidence and Frustration when Carrying out Familiar Tasks on Non-familiar Mobile Devices

This research, which has been labelled Study 3, examines the application of mobile technology by users in the work setting, and the support provided. It examines how the subjects solve problems on an individual basis whilst completing familiar tasks on non-familiar SMDs. The focus of the study is centred on observing and accordingly annotating the knowledge held by the subjects on the activities to be carried out. Levels of confidence and frustration are also taken into account both prior to and following the completion of the study. It is recognised that issues might arise at various stages, such as when the user acquires a new device or needs to learn how to use the device as a result of technological updates, for example.

Furthermore, this research has considered how SMDs provide the opportunity to partake in self-directed learning, facilitated by technology. The chapter is broken down into two respective parts. The first details the study's pre-questionnaire and post-questionnaire, carried out before and after the tasks were assigned, respectively. More specifically, the study has centred on the link between the time taken by IT to provide assistance, and how the subjects dealt with the issues independent, with consideration to how knowledge was shared amongst the individuals. The second part centres on how users solve the tasks assigned to the study through the use of video analysis. The users own knowledge and how this is shared is observed through annotating all of the activities assigned to the participant through the reviewing of the video recorded throughout the course of the study. The results have undergone assessment in an effort to observe whether or not the users managed to overcome the issues, attempting to categorise the reasons for why they did not, if this was the case.

The various behaviours and attitudes of the users in the workplace were also captured, with the role of technology as a facilitator and the issues users faced. In other words, it sought to establish the link between the confidence and frustration experienced by users when seeking to solve problems themselves when carrying out common activities on new devices.

It was recognised that new challenges are experiencing when mobile applications are designed or expanded, such as in regard to battery usage, connectivity problems and limited resources, all of which could affect the study outcome. Accordingly, throughout the design stages of the current research, various obstacles—notably technical in nature—that were seen to be difficult to solve and that could result in the unsuccessful completion of a task, referred to as Pain Points (PPTs), were identified, as discussed in the following sections.

Study 3 Hypothesis:

H1: When given a task, on a new SMD in the workplace environment, the majority of the users will experience obstacles. They will attempt to overcome such obstacles in line with their own knowledge base and following their own progression level.

H0: Unfamiliarity with SMD does not influence task performance. People will not need to attempt to overcome obstacles, and their knowledge base will not be increased.

4.1.1 Methodology

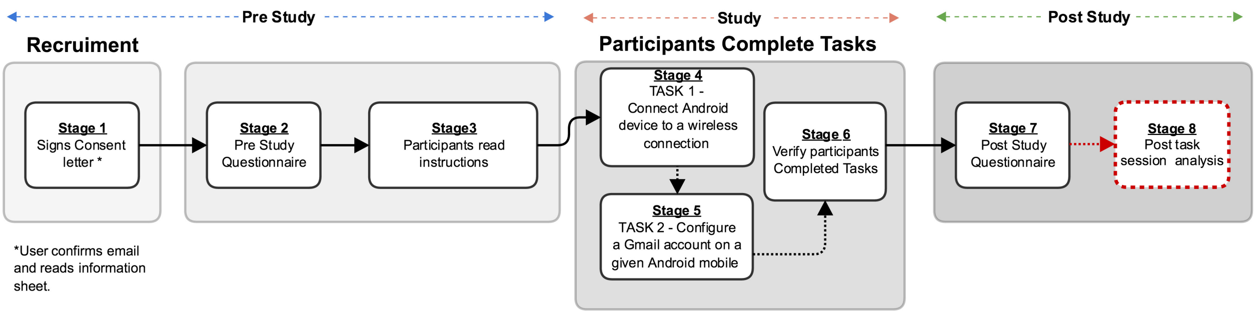


Figure 5: Description of Stages

In order to determine the level of confidence users have when using technology within the current study, an initial test was carried out in February and March 2013 with the aim of annotating the users' attitudes and behaviours, and understanding their overall knowledge base when solving problems using Smart mobile devices. The level of progressions described in Chapter 2 would be observed in the context of this research.

Three different Smart mobile platforms were utilised, each with a different operative system (OS): Android, iOS (Apple) and Windows 7. Additionally, two video cameras were utilised:

one to record users' overall behaviours (e.g., shifts in mood during the task) and time performance (via camera timer); the other to record volunteers' actions on the Smart mobile.

The study comprised a questionnaire (see Figure 5) centred on learning about users' abilities, behaviours and attitudes in trying to solve familiar problems when using a smartphone/app (see Appendix E). The questionnaire also included a test to measure user knowledge and ability when using SMDs. This was achieved by presenting a number of icons users would need to match with a specific action/meaning, which were briefly described. This icon status bar test had already been evaluated with a smaller sample in a preparatory study, carried out in July 2012, Section 3.1 and Section 3.2.

The test also measured the level of participants' confidence with technology when presenting them with two tasks, including browsing to a web page (requiring connecting to a given Wi-Fi connection). Three different platforms were used—namely Android, iOS and Windows 7—and participants were assigned SMDs with which they were not familiar. The study measured the amount of time users took to learn how to use a smartphone or a particular application, the level of frustration experienced when users were learning to use a smartphone/app, and the level of support needed from other sources. This was done by video-recording the participants. The actions were timed, and records were taken of the rates of success and at what stages the participants did not manage to achieve the tasks. These stages—which are referred to as pain points—were logged in an effort to better understand the difficulties that may have caused a change in mood.

a) Participants

Participants were recruited via either email or word of mouth in equal numbers across three locations: the University of Sheffield in UK, the University of Malta and the Malta International Airport (MIA). Those users who participated also volunteered for the study because they had an interest in knowing more about the use of SMDs.

Ninety-three (93) participants were recruited for the study. University participants came from different backgrounds, including University Lecturers and Professors, Administration Staff and paid Researchers. The selection criteria were that a university user had to receive a salary and have an allocated desk and office for their sole use within their respective university. Participants from MIA included Managers, Senior Administrators and Clerical staff.

Amongst the 60 participants recruited from the two universities, one-quarter (24) of them were in full-time employment, 5 worked part-time (less than 35 hours per week) and, from amongst the paid researchers, 25 were also studying full-time, whilst 6 were studying part-time. Amongst the 30 volunteers recruited from MIA, 22 worked full-time, 4 worked part-time and studied part-time, and 4 worked with reduced hours (less than 35 hours per week). Forty-seven (47) men and forty-three (43) women took part in the study. Participants' ages varied between 16 and 55 years, with a mean average age of 25 years. Participants were given an information sheet (also available online[1]) describing the aim of the study and its procedure. A consent form was signed by all participants prior to them taking part, and time was allocated for any questions participants might have before the study started and after the study was completed.

b) Instrumentation

The data were collected through the video-recording of users' behaviours and the administration of a pre- and post-session online questionnaire. The full questionnaires are available in Appendix F.

All participants were first asked to complete the *pre-session questionnaire* online. The first part of the pre-session questionnaire was designed to collect information on the participants, such as demographic information (age, gender, computer experience and recent workplace history etc.), the type of mobile device they owned as well as to identify the habits and the way participants used their mobile. In addition, the questionnaires included a variety of reply modes, such as value of items ranging from a 5-point Likert-like scale, closed questions (such as Boolean type, categories, multiple choice), as well as open-ended questions. The first part of the questionnaire aimed at discovering users' experiences related to their IT support needs, and enquired about workplace support in general: for example, participants were asked to rate their IT support service performance and the amount of time that elapsed between the help request and the time IT support was available. Moreover, they were asked to recall a recent problem they had experienced and to describe how this was handled. In addition, participants were asked to score, categorised by the action they performed the most

[1] www.conradattard.com/yourspace,

often on a smart mobile in their everyday life, by choosing from a number of categories shortlisted from respective top apps available. The list also included popular mobile usage functions, such as text/SMS and phone calls. A five-point Likert scale ranging between 0 and 4 was adopted to measure the score, where 4 indicated the participants used the app/task very often.

A second part of the pre-session questionnaire was adapted from the Lazar, Jones, Bessiere, Ceaparu & Shneiderman (2006a) questionnaire on user frustration with technology[2] with the aim of identifying participants' confidence levels before the session, as well as learning how they felt when they encountered problems with their mobile device and their frustration after the session. The Likert-rating scale comprised a collection of ordered categories, which were assumed to have equal scale spacing such that a rating score expressed the intensity of an effect and measured it on a numbered scale.

Immediately following the main task described in Section (c) procedure, a *post-session questionnaire* (see Appendix F.2) was distributed amongst the users in order to assess their experience, particularly with regard to their perceived mood and level of frustration when performing the given tasks. Each participant also was asked to indicate whether he or she managed to solve Task 1 or Task 2, both, or neither. Similar to the above, the participants were asked to describe the action the icon implied in order to measure users' competence and ability to recognise certain Smart mobile icons, which could have been the cause of volunteers' performance failure. In this respect, participants were asked to recognise 11 of the most typical icons found in a Smart mobile status bar (e.g., connectivity, Bluetooth, etc.). The status bar is normally found at the top of the screen, where icons are displayed almost all the time when interacting with various apps. The icons indicate the status of the respective service and also indicate the errors and actions the user may need to know, such as connectivity, battery level, errors, etc.

c) Procedure—Smart Mobile Tasks

The participants were given an SMD with a default factor configuration, and accordingly were asked to carry out two tasks in a maximum of 15 minutes: 1) connect to the internet through a Wi-Fi connection and browse to a given website; and 2) configure an existing Gmail account

[2] This questionnaire recognising the importance of self-perception of one's own abilities, confidence and determination in getting the task done

on an app, send an email to a given recipient, and check connectivity. As can be seen in Figure 6 and Figure 7, both tasks required the participant to connect to Wi-Fi and verify the connection. The second part of each task required several steps that could only be completed when Wi-Fi connectivity was achieved. The participants were allowed to proceed to the next task—but only after completing the previous one.

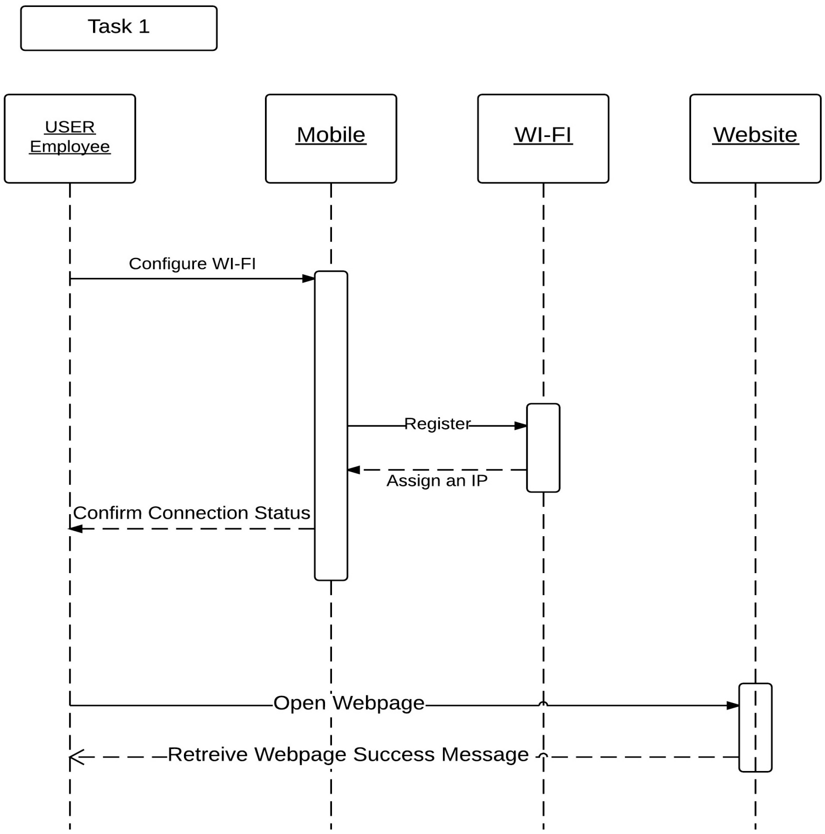


Figure 6: Sequence diagrams of tasks 1

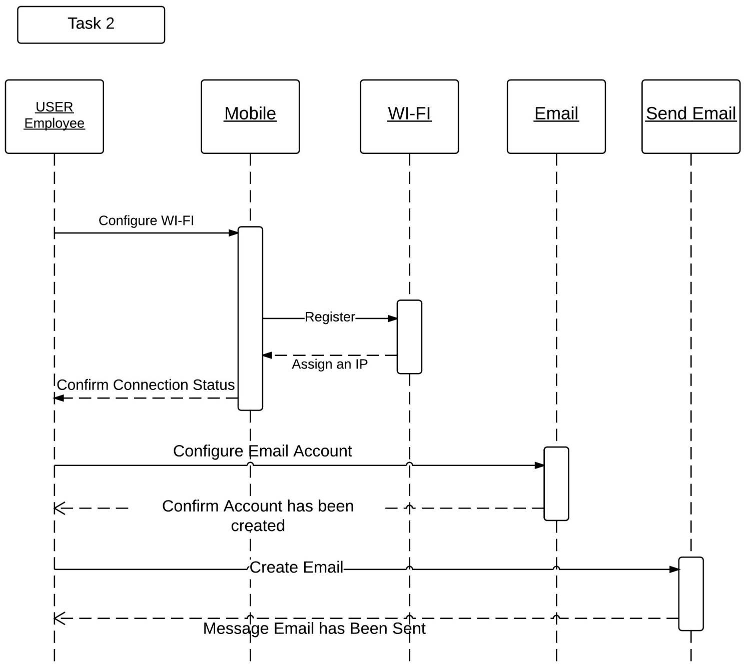


Figure 7: Sequence diagrams of tasks 2

4.1.2 Statistical Test Adopted for the Studies Carried out in this Thesis

Table 5: A list of tests that have been used for the study and reasons for choice

Test	Usage/Outcome
Kruskal-Wallis Test	Used to compare mean rating scores between several independent groups
The Kolmogorov Smirnov Test	Used to determine whether the distribution of the confidence and frustration score is normal. Since the scores distribution are fairly normal parametric test were used.
One-Way Anova	Used to compare mean frustration/confidence scores between several independent groups. E.g. groups categorised by job role within organisation
Pearson's Correlation Coefficient	Used to measure the strength of the relationship between two matric scaled variables having normal distribution. E.g. the relation between frustration and confidence.
Friedman Test	Used to compare mean rating score provided for a number of related issues.

Friedman Test

The Friedman Test was used to compare mean rating scores provided for a number of related issues. The null hypothesis specifies that the mean rating scores provided for these items are comparable and accepted if the *p* value exceeds the 0.05 level of significance. The alternative hypothesis specifies that the mean rating scores provided for the items defer significantly, and is accepted if the *p* value is less than the 0.05 criterion.

Mann Whitney Test

Mann Whitney Test was used to compare the mean rating score for a number of items between two independent groups. The null hypothesis specifies that the mean rated scores provided by the two groups are comparable and is accepted if the *p* value exceeds the 0.05 level of significance. The alternative hypothesis specifies that the mean rating scores provided by the groups differed significantly, and is accepted if the *p* value is less than the 0.05 criterion.

Most distributions of the rate scores provided was either left-skewed or right-skewed. Non-parametric test are used on the merit that most distributions are not normal.

Kruskal-Wallis Test

Kruskal-Wallis Test is an extension of the Mann Whitney Test. The latter compares mean rating scores between two independent groups. The former compares mean rating scores between several independent groups. Both tests are non-parametric owing to the fact the distribution of the rating scores provided for some statements were heavily skewed. The non-parametric tests do not rely on any distribution assumptions, whereas parametric tests (independent sample and One-Way Anova Test) rely on the assumption of normality.

The null hypothesis specifies that the mean rated scores provided by the several groups are comparable, and is accepted if the *p* value exceeds the 0.05 level of significance. The alternative hypothesis specifies that the mean rating scores provided by the groups differed significantly and is accepted if the *p* value is less than the 0.05 criterion.

Chi Square Test

The Chi Square Test is used to determine whether there exists a significant association between two categorical variables. The null hypothesis specifies that there is no association between the two categorical values and is accepted if the *p* value exceeds 0.05 level of significance.

The One-Way Anova

The One-way Anova Test is used to compare means frustration/confidence scores between several independent groups: for example, groups categories by educational level. The null hypothesis specifies that the mean scores are comparable between the groups, and is accepted if the *p* value exceeds the 0.05 level of significance.

The alternative hypothesis specifies that the mean scores differ significantly between the groups, and is accepted if the *p* value is less than the 0.05 criterion.

Kolmogorov-Smirov Test

The Kolmogorov-Smirov Test is used to determine whether the distribution of the confidence score and frustration score is normal. The null hypothesis specifies that score distribution is normal and is accepted if the *p* value level of significance is less then 0.05. The alternative hypothesis specifies that score distribution is skewed and not normal and is accepted if the *p* value is less than the 0.05 criterion.

Since Kolmogorov-Smirov Test's *p* value is of 0.536–0.737, both exceeding the 0.05 criterion, we deduce that both score distributions are fairly normal. Hence, we can use parametric tests to relate these two variables and compare them with other explanatory variables.

Pearson's Correlation Coefficient

The Pearson's Correlation Coefficient measured the strength of the relationship between two metric scaled variables having a normal distribution. Pearson's Correlation Coefficient ranges from –1 to 1, where a large negative value corresponds to a strong negative relationship, a large positive correlation corresponds to a strong negative relationship, and the correlation close to zero corresponds to a weak relationship.

The null hypothesis specifies that there is no/a weak relation between the two values, and is accepted if the *p* value exceeds the 0.05 level of significance. The alternative hypothesis specifies that there is a significant relationship between the two variables and is accepted if the *p* value is less than the 0.05 criterion.

The Pearson's Correlation Coefficient −0.225 is negative indicating a negative relationship between the frustration and confidence scores. This implies that students/participants who get the low scores in confidence get higher scores in frustration and vice versa.

This negative relationship can be generalised owing to the fact it is not attributed to chance since the *p* value 0.033 is less than the 0.05 criterion.

4.1.3 Results

Ninety-three (93) participants from 2 countries participated in the study. The performance of 90 of these was considered valid, whilst that of 3 was not. The study mainly consisted of two well-known tasks: 1) connect to the internet, and 2) configure the settings on Gmail (username and password). A total of 78 participants (87%, n=90) failed to complete Task 2, obtaining a high failure rate in relation to the three main stages: configuring a Gmail account on an app, sending an email and checking connectivity. For Task 2, 68% (n=62) participants tried various steps and attempted to understand the problems were. Altogether, 23 participants (37%, n=62) did not attempt to configure the wireless connection, and those that did attempt did not complete Task 2, with 18 of the participants who did not connect to Wi-Fi repeating the same action several times without trying different approaches.

A statistical analysis of the data was conducted. A number of tests were applied using a statistical analysis package SPSS (Field, 2009). Additionally, a qualitative analysis of the data collected from the pre- and post-session questionnaires was carried out (see Appendix E).

The majority of the participants (78%, n = 70) managed to complete Task 1. Some participants (13%, n= 12) managed to complete both Task 1 and Task 2. Only a small number of participants (7%, n = 6) failed to complete both tasks.

Table 6: Success in completing the given task

	None	Task 1 only	Task 2 only	Both	Total
All participants	6	70	2	12	90
Men	3	35	0	9	47
Women	3	35	2	3	43

The “confidence level” and “mood” of the participants was measured before and after the tasks. The “Confidence” score was generated by averaging the scores of the eight items in section 8 (questions 1 to 8) of the pre-session questionnaire, which contained questions related to how the participants were feeling at that particular moment (see Figure 8). All these items were rated on a 5-point Likert-type scale, ranging 0–4, where 0 corresponded to very low confidence and 4 corresponded to very high confidence. The question “*Do you often get upset over things*” had a value 0 for “strongly disagree” and 4 for “strongly agree”, and as such the score was inverted and added to the average confidence score (see Appendix E).

The “Frustration” score was generated by averaging the score of the 6 items (questions 6 to 11) in the post-session test. All items were rated on a 5-point Likert-like scale, ranging 0–4 (2 is the midpoint). The frustration score ranged 0–4, where 0 corresponded to very low frustration and 4 corresponded to very high frustration.

Q1 Smart mobile devices make me feel comfortable
Q2 When you run into a problem on the smart mobile device or an application you are using, do you feel relaxed?
Q3 When you encounter a problem on the smart mobile device you are using, do you feel confident about your ability to fix it?
Q4 When there is a problem with your smart mobile device that you can't immediately solve, you would stick with it until you have the answer.
Q5 If a problem was left unresolved on your smart mobile device, you would continue to think about it afterward.
Q6 Right now, are you satisfied with your life?
Q7 Do you often get upset over things?
Q8 Level of happiness before carrying out the task

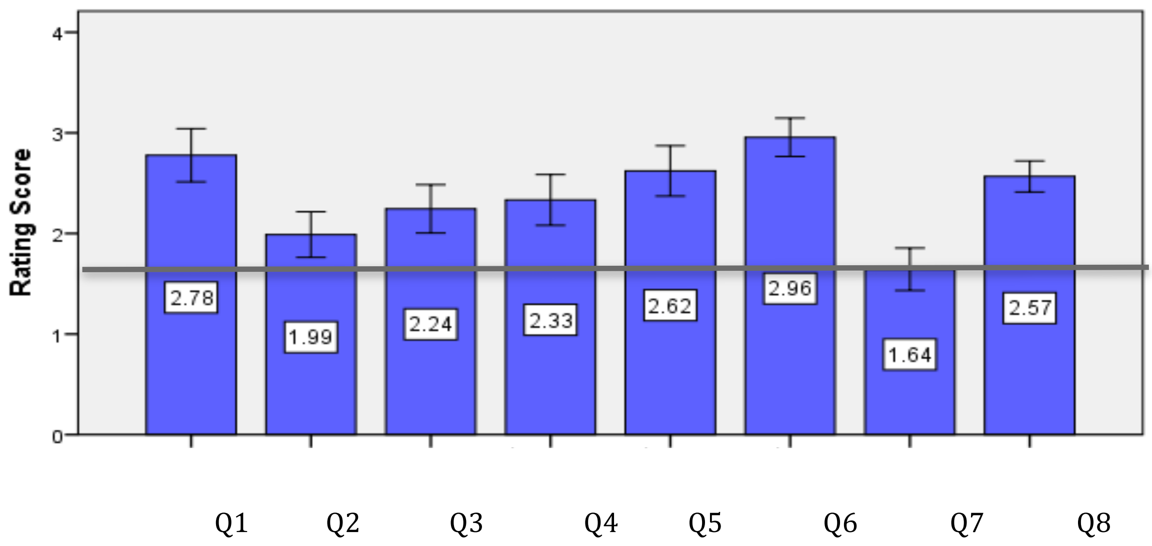


Figure 8: Pre-session "Confidence" mean score

Factor analysis was used to discover the patterns of the relationships between the eight items describing confidence and the six items related to frustration. The questions are reported below. The dominant factor, Question 7 of the pre-test, "*Do you often get upset over things*?" explained 26.97% of the total variance. This implies that respondents who provided high rating scores for Question 7 tended to provide lower rating scores for the remaining items and vice versa. This result conforms to what was expected, whereby obtaining a high score that is a high level of negativity would trigger low scores; that is, a low level of confidence in the other questions (see Figure 9).

With respect to how comfortable participants felt when using SMDs, a mean score of 2.78 was achieved, indicating that they were quite comfortable with smart mobile usage, and a score of 2.24 showing that they were confident they could fix any problem, that they would try various routes until a problem was resolved, or they would continue to think about unresolved problems. The participants, on average, were in a good mood, very satisfied with their life, and indicated they did not get often upset over things. They also indicated that, when they encountered a problem with a Smart mobile, they remained neutral; that is, neither relaxed nor anxious.

The Kolmogorov-Smirov Test was used to determine whether the distribution of the confidence score and frustration score are normal, and this proved to be true (see Figure 9). The Pearson's Correlation Coefficient was measured and gave a coefficient of –0.225, indicating a negative relationship between the frustration and confidence scores (see Figure 9). This implies that participants who gave high scores to 'confidence' had low scores in 'frustration', and vice versa. The Pearson's Correlation Coefficient is used to measure the strength of the relationship between two metric scaled variables having a normal distribution. Pearson's Correlation Coefficient ranges from –1 to 1, where a large negative value was seen to correspond to a strong negative relationship, whilst a large positive correlation corresponded to a strong positive relationship.

This negative relationship could be generalised because it is not attributed to chance since the p value is 0.033, which is less than the 0.05 criterion.

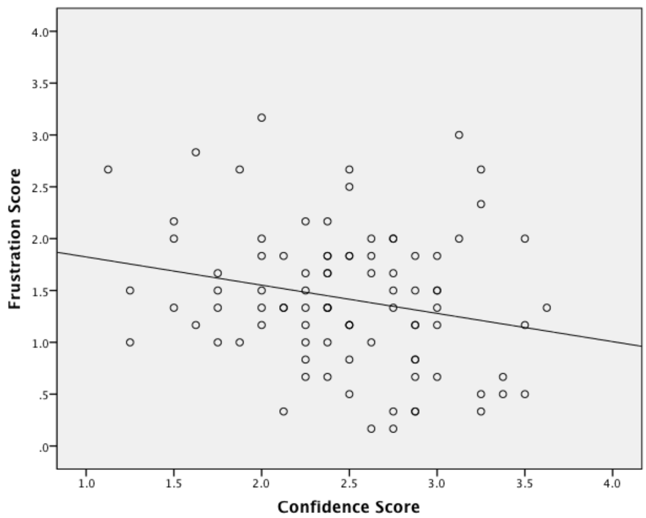


Figure 9: Frustration Score versus Confidence Score

Connectivity to the Internet is one of the main challenges identified in this study. The 39 participants (63%, n=62) who did not manage to solve the problem tried but failed to configure the Wi-Fi, whilst 14 participants (33%, n=39) identified the problem but did not know how to solve it. It was also observed that 18 participants (42%, n=39) seemed to know only one way of completing the task, and they iterated the same sequence of actions a number of times without effectively changing the actions that might have provided a solution. The study also considered how the users engaged with the mobile.

4.1.4 Job Role, Confidence and Frustration

Twenty-five (28%) of the participants had a job or studies related to computer science and therefore had a certain amount of high exposure to technology. The job types and their spread can be seen in Table 7.

Table 7: No of participants in different roles

Job Role	Frequency (No)	Percentage %
Manager of a Team	14	15.6
Administrator	17	18.9
Clerk	9	10.0
Lecturer	9	10.0
Researcher	18	20.0
IT researcher	14	15.6
IT support	9	10.0
Total	90	100.0

If we consider the relationship between confidence and frustration and job role, we observe that the highest average values in confidence levels are those of university IT researchers, followed by managers, whilst the highest scores for frustration were indicated by managers and university lecturers. The *p* values (0.098 and 0.845) for confidence and frustration scores, respectively—exceeded the 0.05 level of significance, implying that mean frustration scores did not vary much between groups of participant with different roles at the place of work. Confidence was close to 0.05, implying that the role's confidence varied for each group (see Table 8).

Table 8: Confidence and Frustration according to role in job

	Job Role	N	Mean	Std. Deviation	95% Confidence Interval for Mean		p value
					Lower Bound	Upper Bound	
Confidence Score	Manager of a Team	14	**2.68**	0.49	2.40	2.96	0.098
	Administrator	17	2.24	0.55	1.96	2.53	
	Clerk	8	2.22	0.23	2.03	2.41	
	Lecturer	9	2.46	0.56	2.03	2.89	
	Researcher	18	2.42	0.59	2.13	2.72	
	IT researcher	14	**2.76**	0.48	2.48	3.03	
	IT support	9	2.57	0.74	2.00	3.14	
Frustration Score	Manager of a Team	14	**1.67**	0.57	1.34	2.00	0.845
	Administrator	17	1.36	0.79	0.96	1.77	
	Clerk	8	1.42	0.48	1.02	1.82	
	Lecturer	9	**1.48**	0.72	0.93	2.04	
	Researcher	18	1.40	0.81	1.00	1.80	
	IT researcher	14	1.27	0.72	0.86	1.69	
	IT support	9	1.37	0.36	1.09	1.65	

4.1.5 Confidence Score and Frustration Score by Gender

A One-Way Anova Test was carried out since the variables were normally distributed. Both women and men indicated being confident (mean over 2), and had low levels of frustration (average score below 2). However, results show a significant difference between men and women in confidence, where men indicated on average more confident than women (see Table 9). This shows that there was a significant difference between men and women when rating confidence and frustration.

Table 9: Confidence and Frustration Score by gender. (*) indicates a significant result

		N	Mean	Std. Deviation	95% Confidence Interval for Mean		p value
					Lower Bound	Upper Bound	
Confidence	Men	47	**2.61**	0.60	2.44	2.79	0.018 *
	Women	43	**2.34**	0.47	2.19	2.48	
Frustration	Men	47	1.44	0.62	1.26	1.62	0.777
	Women	43	1.40	0.73	1.17	1.63	

When analysing the various items separately, we can see that women scored below 2 whilst men scored above 2 in Question 3, with $p = 0.014$, indicating a significant difference between men and women, where the latter do not feel confident when facing problems using SMDs (Table 9). Also in Question 4, men were found to be more positive in stating they would stick to a problem until they fixed it. All the other questions followed the same trend. Participants completing Task 2 were mostly men (9 out of 12 participants). These results seem to indicate that confidence might have an influence on performance when participants are faced with a more challenging task. However, there was no significant difference between genders in the level of frustration.

4.1.6 What do Users normally do with their Smart Mobile Device?

As can be seen in Table 10 below, the two most popular activities participants recalled undertaking with their smart mobile device were phone calls and text/SMS, followed by social networking, calendar use, Utility app, e-mail and news reading, whilst the least commonly adopted activity is Photography.

The 14 task categories have average values that are significantly different from one another ($X^2(24) = 810.39$, $p < 0.001$). Therefore, these task categories can stand-alone and do not need to be grouped into further large categories.

Table 10: Task Categories - types of apps sorted by average score

Table A

	Mean	Std. Deviation
Phone Calls	3.38	0.894
Text/SMS	3.34	1.051
Social Networking	2.67	1.199
Calendar	2.60	1.505
Utility App	2.34	1.317
e-mail	2.24	1.318
News BBC	2.11	1.249
References	2.04	1.18
Music	2.02	1.263
Travel	1.96	1.226
Navigation	1.76	1.221
Productivity	1.71	1.256
Photography	1.31	1.215

Table B

	Mean	Std. Deviation
Download Music	1.29	1.202
Individual player games	1.20	1.238
Sports	1.19	1.131
Books	1.10	1.039
Lifestyle	1.08	1.073
Entertainment	1.07	1.089
Educational apps	1.03	0.999
Finance	1.02	1.038
Health and Fitness	0.87	0.985
Medical	0.87	0.902
Multiplayer games	0.82	0.758
Business	0.76	0.739

4.1.7 IT Support and the Relation of Success during Task 1 and Task 2

In order to analyse whether exposure to IT has a significant effect on their abilities, those participants who have been exposed to technology and whose job descriptions are somehow related to IT were placed within a category labelled 'IT-proficient', whereas those who use technology only as tool for completing their job role were classified as 'Others'.

A one-way Anova test was carried out, providing a p-value=0.056, which exceeds the ($p < 0.05$) level of indicating that there is no significant difference between 'IT-proficient' and 'Others'. It therefore it seems that exposure to IT did not reveal any difference in the ability to resolve a task.

When correlating the replies to the question 'How long do you have to wait before an IT support representative is available?' with the completion of the tasks performed, the study showed that if one has to wait for more than ten minutes for support to be provided there is a higher probability that the person would resolve the task on their own, as can be seen in Table 11 below.

Table 11: Comparing the timeframe in which IT support was provided with the success rate in completing Task 1 and Task 2 by technology proficient or other

Question: How long do you have to wait before an IT support representative is available?

	Less than 10 minutes		10 minutes or more	
Number of users that have completed the task	Task 1	Task 2	Task 1	Task2
Technology Proficient	9 37.5%	1 25.0%	15 62.5%	3 75.0%
Other	18 31.0%	3 30.0%	40 69.0%	7 70.0%
Total	27 32.9%	4 28.6%	55 67.1%	10 71.4%

The results show that if IT support provided in the workplace is not immediately available (more than 10 minutes to respond to a query), the participant demonstrated a greater ability to resolve Task 1. There was no significant difference between participants that were IT-proficient and those that were not. The trend for Task 2 was found to be similar, although the numbers were smaller. This shows that IT support response time influences the individual's problem-solving abilities in the context of short-term tasks.

4.1.8 Recognising ICONS and Respective Status: The Visual Status Bar task

A score was assigned to the recognition task (see Figure 10), where an icon with a value of 1 was considered not difficult to recognise, a value of 2 was fairly difficult, and a value of 3 was quite difficult, with the latter requiring more in-depth knowledge of SMD usage. The maximum score one could achieve was 20, which was achieved by 5 participants (see Table 12).

1	2	3	4	5	6		7	8	9	10	11

Figure 10: Match Icons with Description

Table 12: Visual Icon SMD status bar test: score-related frequency percentage of success

Score (Maximum = 20)	Number of participants (n=90)	Percentage %	Reference
20	5	5.56	
19	1	1.11	A
18	4	4.44	
17	25	27.78	B
16	4	4.44	
15	13	14.44	
14	13	14.44	
13	7	7.78	
12	6	6.67	C
11	7	7.78	
9	2	2.22	
7	2	2.22	
0	1	1.11	
	90	**100.00**	

Only 10 people (11.11%) managed to score and identify enough icons to allow understanding of what action should be taken when interpreting the icon (see Ref A, Table 12). A total of 28% of the participants (n=17) managed to identify commonly used icons such as time, battery, symbols indicating errors, and wireless connectivity (see Ref B, Table 12). The remaining participants (n=55, 61%) failed to recognise what most icons represented and identified only a select few (see Ref C, Table 12). The latter group of participants struggled to understand which errors were associated with wireless icons and what actions needed to be taken in order to solve particular errors.

Table 13 shows the percentage of participants who succeeded in the visual status bar test with only Task 1, as well as the percentage of those who managed to complete both tasks that were assigned after the pre-session questionnaire.

Table 13: The relation of completed tasks and their ability to recognise items

		Ability to recognise items		Total
		At most 1 task was completed	Both tasks were completed	
Low	Count	23	2	25
	Percentage	29.50%	16.70%	27.80%
High	Count	55	10	65
	Percentage	70.50%	83.30%	72.20%
Total	Count	78	12	90
	Percentage	100.00%	100.00%	100.00%

$X^2(1) = 0.852$, $p = 0.356$

The results in Table 13 above show that those participants who had a good understanding of the meaning of the icons on the mobile task bar and the message status, experienced high success in task completion. This was demonstrated by a change in the task bar icons, indicating the success or failure of an action. More specifically, participants struggled to understand which error was associated with a wireless icon (either the absence or presence of wireless connectivity) and what actions were needed in order to solve such problems.

4.1.9 Designing to Inform the User: Interpreting Error Messages, Status Bar Icons and Action Taken

Independent technology users acquire knowledge to solve problems in variety of ways. As discussed in Chapter 1, Blaschke (2012) distinguishes between self-directed learning (Andragogy) and self-determined learning (Heutagogy) where, in self-directed learning, individuals take initiative with or without the help of others when diagnosing their learning needs and defining their goals. Self-determined learning extends andragogy by learners' need to acquire both competencies and capabilities (McAuliffe *et al.*, 2008).

1	2	3	4	5	6		7	8	9	10	11

Figure 11: Match Icons with Description (More info Appendix B)

Being able to interpret error messages (see Figure 11) and recognise messages represented by icons, such as the one discussed in the experiments above, highlight the importance of the user to realising that something is wrong. Following this, the user would need to know what exactly is wrong: for example, that there is a connectivity issue. If users do not encounter certain problems regularly or depend on others to acquire a solution or complete a task, tools such as SMDs might not be utilised effectively at the place of work. Results show that a lot of the problems encountered are related to the lack of knowledge regarding what actions to take to solve the problem (as also reported by Giannakouris & Smihily, 2012).

4.1.10 Pain Points Experienced by the User when Trying to Solve Problems on their SMD

A number of works have considered various methods of enhancing how users interact with SMDs (Mourão & Okada, 2010; Hagen, Robertson, Kan & Sadler, 2005). Through the observations carried out throughout the course of this work, it has been found that SMDs depend on an intuitive approach, as well as individuals' own capacity to overcome obstacles. A number of support modes and assistance can be found on popular Smart devices. One important aspect that can provide the user with guidance when experiencing problems is messages. Throughout the study's video analysis (see Section 4.2), it was found that the majority of the users either failed to try or understand how to read through the message being presenting to them when experiencing app-related problems or issues with settings. Such issues that required that the user shift their attention to performing other actions were found to be the most challenging. When recording the pain points causing the most difficulty for users, shifting attention away from the steps being carried out by the participants was found to be the most challenging. The findings show that the majority (78 participants; 87%, n=90) did not manage to solve the problem but identified it without knowing how to arrive at its solution.

4.2 Video Analysis of Participants from Study 3

In an effort to provide greater insight, video analysis was carried out with the use of scientific methods pertaining to how subjects manage SMD-related problems. Accordingly, as outlined in this study, an interpretive approach was achieved through the completion of a quantitative analysis of videos involving both counting and coding. The study's findings were fundamental in defining Study 3's criteria, as well as the criteria for the subsequent studies, in addition to helping garner better understanding of Study 2's outcomes, especially in consideration to the obstacles. Analysis was carried out across three different stages. Firstly, the formulation of what should be recorded was carried out by providing a clear definition of the criteria to be implemented throughout the observation, which involved selecting videos from three collectors. The participants selected were those found to have completed either Task 1 or Task 2, or both. The sample included a representation of at least one type of mobile device (see Section 4.2.2). Secondly, there was the logging of valid videos in line with predefined sequences, the number of iterations and the amount of time. The predefined criteria that were established in the first stage were detailed by two reviews using an Excel sheet. Thirdly, there was the checking of the videos and the updating of the log to harmonise findings established in the second stage.

4.2.1 Methodology

Various methods have been applied in examination of users' interactions with technology (Hagen *et al.,* 2005; Dourish, 2003*)*. Two of the key challenges needing to be taken into account during the design of an experiment through which users are analysed in problem-solving, when utilising an SMD, are mobility and context (Muñoz-organero *et al.,* 2011). For the present study, video camera use was necessary in order to observe the various criteria. These criteria included user observations when, for example, the problem was identified but the solution was unknown, as well as how pain points were tackled. One of the key aims was centred on observing whether the subjects would share knowledge despite not completing the task. In order to achieve this, an observation approach was devised. This is detailed in Section 4.1.1. The videos recorded during Study 3 were analyses, with discussion provided here.

4.2.2 Procedure to Annotate how Participants Attempted to Solve the Assigned Tasks by Reviewing Videos for Study 3

Two reviewers have annotated the content of the videos that were used for this study referred to session analysis (see Figure 12).

It was necessary to review the video for this study three times. The aim of the first review was to identify the iterations and to plan the way in which tasks would be annotated (as listed in Tables 14 and 15). During the second review, each reviewer independently analysed all the videos. The individual assessments were later compared during the third review (see table 16 and table 17).

During the first review a list of criteria was established to identify the most important aspects of the behaviour observed in the videos. All aspects identified were collected in an Excel template for later use.

For the first review a sample of nine videos was chosen at random, three from every collector, the University of Sheffield in the UK, the University of Malta, and the Malta International Airport (MIA). For each collector, at least one type of mobile operating system was chosen

(HTC Android, HTC Windows Mobile 7.5 and iPhone 4 iOS 6). Each video was selected from those who managed to complete only Task 1 or from those who completed both tasks. If none of the tasks were completed by any of the participants a random participant was chosen. This data was available from the pre-study and post-study questionnaire. Each reviewer suggested criteria for inclusion in the final version of the Excel template.

During the second review, the Excel template (created in review one) was used to log the various aspects of users' behaviour as observed independently by the reviewers in all videos. The videos that did not have a view of the mobile screen whilst completing the experiment at critical stages were not included in the analysis. When the screen was obstructed for a long time or where light reflected in such a way that one could not note the choices the user was making at key times, participants were excluded from the analyses. A total of 78% (n=70) of the videos were considered valid. All information observed was inserted in an Excel template by each of the reviewers, this included a log of the time, the type of approach according to the category, and the iteration completed at that particular stage. Two reviewers carried out the analyses independently at this stage using all the videos.

The third review aimed at the harmonisation of key aspects of the reviewers' independent analyses, such as main obstacles as well as key successful approaches that were completed by participants. If there was any conflict in the independent analyses a discussion took place between the two reviewers. The results presented here are the outcome of the third review.

The third review also helped to address observations that were identified as the review progressed. A total of eight videos (78%; n=70) identified differences in what was logged by both reviewers. After reviewing the video together it was agreed that they would be excluded from the study. A total of (69%; n=62) were included for further analysis.

For this study, an average time to complete tasks per sequence could be established to measure skills of the participants. Time to complete a sequence did not vary much between different SMDs used for this study. All timings to complete sequence were noted in a box plot for each SMD when extracting the results. Analysis was carried out in line with the SMD being used by participants.

The tables below list the various sequences used by participants defined in the first stage of the study. The sequences are grouped together if the final goal was the same: for example, 1a, 1b of Task 1, or 2a, 2b 2c of Task 2. In some cases, the variation was within an initial action or choosing a different application to complete the task.

Table 14: Explanation of Sequences (Task 1)

Sequence 1a Aim: Configuration of WIFI Sequence: Initial action is through Setting Icon through list menu or menu setting.
Sequence 1b Aim: Configuration of WIFI Sequence: Initial action through shortcut that pops up during specific moment
Sequence 2a Aim: Access website through browser. Initial action List Menu Screen
Sequence 2b Aim: Access website through browser. Initial action Main Menu Screen

Table 15: Explanation of Sequences (Task 2)

Sequence 1a Aim*: Configuration of Email.* Default Mail App available through OS.
Sequence 1b Aim*: Configuration of Email.* Default Browser
Sequence 1c Aim*: Configuration of Email.* Gmail App (Android - iPhone)
Sequence 2a Aim*: Send Email.* Through Default mail App.
Sequence 2b Aim: *Send Email*. Through Default Browser.
Sequence 3a Aim: Check Connection. Through Settings and verifying connection.
Sequence 3b Aim: Check Connection. By trying to browse a known website to check for Internet.
Sequence 4a Aim: Configure Connection. Setting wireless and choosing another wireless connection with Internet.
Sequence 5a No Aim: Lost.

a) Participants

As described in Section 4.1.1, 90 participants were given two tasks and were asked to complete them in 15 minutes or less. The collectors were Malta International Airport and two universities, University of Malta and Sheffield University UK. Throughout the experiment, the participants focused on solving the problems using the resources they had and any knowledge they might have gathered through experience. A total of 62 videos were shortlisted. These were chosen based a number of criteria established after reviewing the quality and validity of the video established in the first review. Only 62 participants were valid for the video analysis, as described in Section 4.2.2.

b) Instrumentation

All experiments were done at the workplace (see Figure 12 and Figure 13). Participants were asked to carry out the experiment in a familiar working environment. The studies were conducted as described in Section 4.1.1. Users were given an SMD with no configuration in order to carry out two tasks. The SMD did not support a mobile OS similar to the one the participants owned. Additionally, the participants were not familiar with the device used during the tasks. The information relating to participants' mobiles was verified from the pre-study (see Section 4.1). For both tasks, participants could not exceed 15 minutes. A video was taken whilst they completed the tasks. The two tasks were: 1) connect to a Wi-Fi connection and access a given website, and 2) configure an existing email account and send an email to a given recipient (see Appendix C). They were allowed to proceed to the next task only after completing the previous one. A video recording device was positioned at the side behind their back, allowing mobile interaction to be clearly recorded. Users were kept within a familiar workplace environment, and a similar setup was maintained within each workplace in the study.

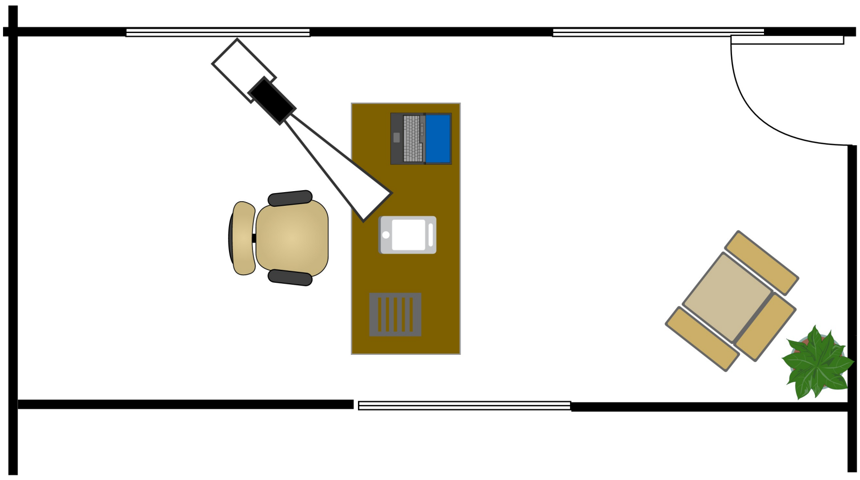


Figure 12: Setup of office where experiment was carried out

c) Procedure

The experiment was done as explained in Section 4.2.1 and setup as in Figure 10 and Figure 11. After the experiment was completed and all videos were classified anonymously, two independent viewers, including the author of this document, were involved in logging the videos taken for the study. As described early on in this chapter, a three-stage approach was adopted. Attention was assigned to anticipating a number of options the users may have chosen to solve a task. These were described as sequence (see Table 14 and Table 15). For this study, "initial time" and "end time" for each sequence of event were logged. If participants did not complete a sequence due to some difficulty, the obstacles were identified, and the time allocated by the user and numbers of iterations of sequences done were logged. After every task, a reason was logged describing the participants' approach in completing the task (see Table 16). After completing the video, the general approach of the participants during both tasks was logged (see Section 4.2.2). Information of what was logged can be viewed in Appendix C.

Figure 13: Participant completing the task for Study 3

Table 16: Description of completing or not either Task 1 or Task 2

1	Completed with confidence
2	Completed by chance
3	Lost not knowing where to go
4	Gave up
5	Know what's the problem but does not know how to solve it
6	Request support
7	Didn't read notification error message

As discussed earlier on, PPTs (obstacles) are instances caused when users experience difficulties in completing specific tasks. The experiment chosen for this study simulated a possible familiar scenario of problem that users seem to face. In the research published by Eurostat, technical problems and connectivity are amongst the reasons enterprises limit the use of mobile and the internet at the place of work. For this study, the pain points were classified as: 1) something that caused the user to change the sequence of actions he or she was following; 2) the time taken to complete an action due to lack of understanding or familiarity with task; 3) being completely stuck not knowing what to do; and 4) presented with an error message through which the user knows what is wrong but that is too complex to allow the user to identify the next action. A number of pain points were noted when reviewing the videos of participants completing the tasks. Various stages were identified, and the corresponding type of classification was noted. This helped in better understanding the difficulty related to that particular point.

A measurement frequently used (Order Scale) was adopted, as seen in Table 17. The measurement was assigned to a corresponding unique description that helped improve the logging of various pain points within the study. Kan (2003) refers to ordinal scale as a measurement operation through which subjects can be compared following an order of some sort. Using an ordinal scale, you are able not only to group subjects into categories but also to order the categories. Each category needs to be unique, and for every pain point, each participant must comply only with one.

Table 17: Pain Point – measurement and description for each score

1	Does not understand what's happening; completely lost
2	Stuck/repeats same action without trying different approach
3	Stuck/no action
4	Took time (but completed it in the end)
5	Completed

4.2.3 Results

The results detailed in this section stem from Task 2. The focus was centred on gaining insight into how participants deal with the issues they experience, especially when they have the capacity to adhere to a logical number of steps to carry out a task. Attention was directed to those results seen to be demonstrating pain points established throughout the session analysis captured on video. Table 18 details a list of pain points that were identified at a particular time during the session analysis. As described above, for this study a pain point may be defined as an event that causes the subject to stop working towards achieving their goal for one of the reasons detailed. This could affect the subject in various ways. A list of various pain points and corresponding attitudes were identified, suggesting the difficulties experienced by the participants in carrying out various events. The pain points included: (1) something that caused the user to change the sequence of actions he or she was following; (2) the time taken to complete an action due to lack of understanding or familiarity with the task; (3) being completely stuck and not knowing what to do; and (4) being presented with an error message as a result of which the user knows what is wrong but it is too complex to allow the user to identify the next action. Each of the pain points appears to be aligned with one or more stages, and the mean time (in seconds) allocated was recorded. The findings emphasise that few subjects were able to complete sequences when obstacles were experienced. This means that those participants who identified problems in the first sequence did not progress to the next stage in the task. More specifically, the majority of the sample stopped trying to complete the task. Those who continued to follow the sequence ignored the error message and made subsequent attempts to complete the task.

Table 18: List of identified Pain Point with corresponding obstacle and mean time participants spent tackling them

(Dependent Variable: Time in Seconds)

Pain Point Identified	Obstacle Type	Mean Time (SEC)	Std. Deviation	N
Configuring Email	Does not understand what's happening; Completely lost	299.00	215.179	16
	Stuck/repeats same action without trying a different approach	297.77	159.819	22
	Took time (but completed it in the end)	306.50	122.709	10
	Completed	131.00	50.192	6
Sending Email	Does not understand what's happening; Completely lost	172.86	126.518	7
	Stuck/repeats same action without trying a different approach	189.41	116.858	17
	Took time (but completed it in the end)	216.00	104.644	6
	Completed	105.50	28.991	2
Checking Connectivity	Does not understand what's happening; Completely lost	222.50	153.442	2
	Stuck/no action	89.50	101.116	2
	Stuck/repeats same action without trying a different approach	148.22	110.911	9
	Took time (but completed it in the end)	214.25	86.063	4
	Completed	28.20	25.607	5
Choosing another Wi-Fi	Completed	56.67	45.829	3
Figuring out how device works	Took time (but completed it in the end)	81.67	34.078	3

4.3 Logging Mean Time when Configuring an Email Account on Different Platforms

For this study, an average time to complete tasks per sequence could be established to measure the skills of the participants. Time to complete a sequence did not vary much between the different SMDs used for this study. All timings to complete sequence were noted for each SMD when extracting the results. Analysis was carried out in line with the SMD being used by participants.

Three different sequences are detailed in tables 19, 20 and figure 14 with the respective SMD supporting three different platforms (Windows Mobile, Android and IOS) utilised in order to complete the second task. Figure 14 details the results that show that users identified a significant difficulty when configuring the mail app using the Windows platform. Moreover, as shown in the subsequent graph, a greater portion of time was dedicated to the task when using the Windows platform, followed by IOS when configuring a mail client using the default app available on the respective SMD.

Table 19: Task 2, three different sequences and the respective SMD used to when attempting to complete first sequence and the respective mean time taken

(Dependent Variable: Time in Seconds)

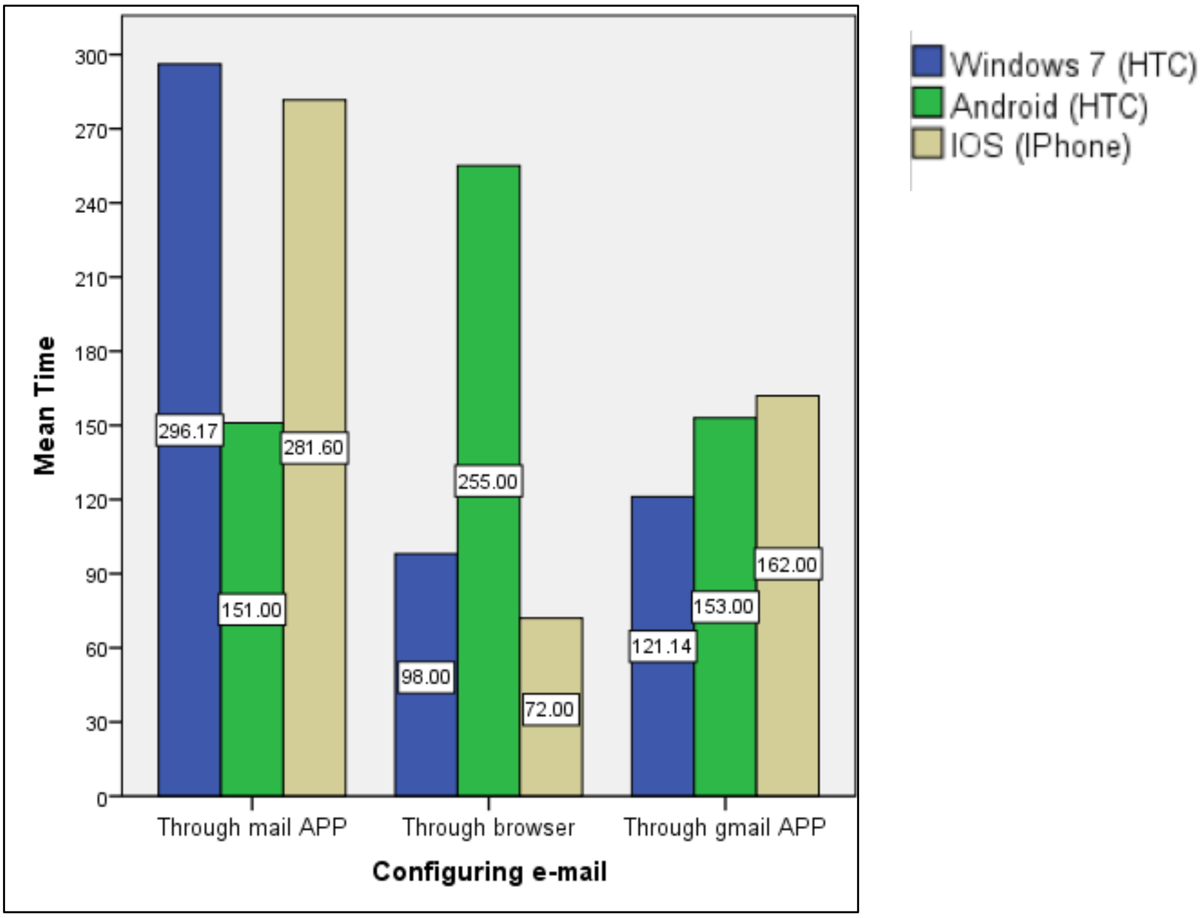
Configuring e-mail	Which smart mobile platform have you used for this study?	Sample Size	Mean Time (SEC)	Std. Deviation	P-value
Through mail app	Windows 7 (HTC)	18	296.17	155.77	0.003
	Android (HTC)	20	151.00	98.97	
	iOS (iPhone)	15	281.60	151.45	
Through browser	Windows 7 (HTC)	2	98.00	98.99	0.558
	Android (HTC)	8	255.00	280.87	
	iOS (iPhone)	2	72.00	7.07	
Through Gmail app	Windows 7 (HTC)	7	121.14	27.43	0.631
	Android (HTC)	2	153.00	147.08	
	iOS (iPhone)	2	162.00	45.25	

Table 20: Task 2, three different SMD and the repective e-mail configuration used to when attempting to complete first sequence and the respective mean time taken

(Dependent Variable: Time in Seconds)

Which smart mobile platform have you used for this study?	Configuring e-mail	Sample Size	Mean Time (SEC)	Std. Deviation	P-value
Windows 7 (HTC)	Through mail app	18	296.17	155.77	0.011
	Through browser	2	98.00	98.99	
	Through Gmail app	7	121.14	27.43	
Android (HTC)	Through mail app	20	151.00	98.97	0.340
	Through browser	8	255.00	280.87	
	Through Gmail app	2	153.00	147.08	
iOS (iPhone)	Through mail app	15	281.60	151.45	0.131
	Through browser	2	72.00	7.07	
	Through Gmail app	2	162.00	45.25	

Figure 14: Mean time (Sec) taken when configuring an email comparing three different approaches (Results are categorised according to mobile platform used)



4.3.1 The role of the users at the place of work and how it influences the way they ultimately solve the problem

As discussed earlier, Pedagogy ("*engagement*") is the lowest level of how participants adopt learning through a learning support model. We are interested in capturing user knowledge whilst users try to solve problems. Rickinson, Sebba & Edwards (2011) and O'Brien & Toms (2008) discuss the role of user engagement when designing technology and how it affects the learning process. The process of solving the problem also can be considered a learning process. The role and position of a participant in the workplace could have an impact on how they engage with technology problems. When analysing the different roles and confidence within an organisation, results show that the *p* value is very close to 0.05; however, the value is not significant. Results from the pre-study show that the mean value of confidence of managers of a team, IT researchers and IT support had a higher value than the rest, implying that the more users are exposed to problem-solving needs at the place of work, the more confident they feel when solving technology problems related to their SMD. On the other hand, lower grades, such as administrators and clerks, were seen to have lower confidence. However, when completing the tasks, many participants failed to complete both tasks, and no particular job role indicated better success in solving the problem. Therefore, it seems that certain people have the perception of having a higher confidence level, which, however, is not reflected in their actual ability to solve familiar problems.

4.3.2 Attitude, Behaviour and Obstacles in Completing the Tasks

The attitude and behaviour of the participants when completing the given tasks were also observed through video-recording, with the resulting video data broken down into categories and atomic actions according to the particular stage they were trying to complete, as described in Section 4.2.2 These actions have been identified through the video analysis of the experiment. A number of observations were logged, including whether the participant may have completed or almost completed a task, or altogether given up. When analysing the data captured through video, participants' difficulties were mostly due to the fact that the user could not correctly interpret the error message from the device, with most of the subjects, in this case, repeating the same action a number of times without trying to understand how to go about it using the information available on the smartphone (see Table 21).

Instances in which the participants found it difficult to complete a specific task are identified as "pain points". The main pain points observed through the data collected for the tasks were: 1) configuring email account; 2) connecting to the internet by configuring Wi-Fi; and 3) sending an email. Task 2 had the highest rate of failure compared with Task 1 (see Table 6).

The following are results from the analysis of video data when attempting to investigate participants' attitudes and behaviours. From the 90 participants involved in the study, 62 either attempted to complete the task, or their performance was good enough to enable us to log the events from the video recording so that the data could be processed for analysis.

Respective pain points were annotated with their atomic values according to the participant behaviour. These values were logged during the video analysis. The corresponding atomic value was measured on a 5-point scale ranging 0–4, where behaviours were categorised as follows: Participant 0) does not understand what was happening and is completely lost, 1) is stuck/no action, 2) is stuck/repeats same action without trying a different approach, 3) took time (but completed it in the end), and 4) Completed. A one-tailed test was used because a positive relationship was expected between attitudes to complete tasks with their respective atomic value. The one-tailed test gave a p value=0.035 that did not exceed the ($p < 0.05$) level, indicating that there was a significant difference when calculating the attitude to complete task, showing a correlation with atomic value in the way participants complete the tasks (see Table 21a).

Task 1 had to be completed before a participant could continue to Task 2, with both tasks independent of each other. The results show that most participants could not find a solution related to connectivity when completing Task 2. Error messages indicated the problem, but they were not easily understood. Most pain points were experienced when participants attempted to complete Task 2.

Through video analysis it was noted that most participants did not know how to change a Wi-Fi connection with no Internet to one with an Internet connection. Those participants who did not succeed in this task were not able to perform the steps normally required to complete the task (that is, configuring email, sending email and checking connectivity). From 62 participants, some failed in one, two or three of the required pain points, whilst 12 completed it and managed to send the email. The video analysis of Task 2 shows that people who perform research as part of their job role tend to achieve a higher score across all stages. This demonstrates Heutagogy compared to others. Heutagogy is a greater maturity and ability to independently acquire autonomy in problem-solving. Atomic actions of Heutagogy are, for example, actions that allowed the completion of the task or identification of the problem. These participants previously did not know how to solve the particular problem, but were able to follow a logical sequence when attempting to solve the task. On the other hand, managers of teams scored the lowest, finding it difficult to contribute when facing difficulties.

Table 21a shows how a particular pain point was tackled when participants, according to their job role, attempted to complete the task. Through the video analysis, it was observed that, at the different stages, participants followed behaviours (pain points described in Section 4.2.2) that did not allow them to complete the task. All 62 participants attempted to configure the given email account. A total of 39 participants (63%, n=62) tried to connect using a Wi-Fi and 32 participants (52%, n=62) attempted to send an email. At each of these stages, they were required to complete the task.

Table 21a: One-Way Anova Pain Point Configuring Email - Approach in solving tasks logging the reason why completed/or not

	Job Role	Sample Size	Mean	Std. Deviation	95% Confidence Interval for Mean		P-value
					Lower Bound	Upper Bound	
Attitude to complete task	IT Researcher	15	3.47	1.552	2.61	4.33	0.328
	Researcher	11	2.91	1.921	1.62	4.20	
	IT Support	6	2.17	1.722	0.36	3.97	
	Clerk	6	2.00	2.757	0.00	4.89	
	Administrator	8	2.38	2.066	0.65	4.10	
	Lecturer	8	2.38	2.066	0.65	4.10	
	Manager of a team	8	1.50	1.604	0.16	2.84	
Atomic value	IT Researcher	15	3.33	1.291	2.62	4.05	0.477
	Researcher	11	3.09	1.446	2.12	4.06	
	IT Support	6	2.67	1.862	0.71	4.62	
	Clerk	6	3.17	1.329	1.77	4.56	
	Administrator	8	2.88	1.246	1.83	3.92	
	Lecturer	8	3.75	1.389	2.59	4.91	
	Manager of a team	8	2.25	1.581	0.93	3.57	

Table 21b: Pearson Correlation

		Atomic value
Attitude to complete task	Pearson Correlation	0.231
	P-value (one-tailed)	0.035
	Sample Size	62

During the video analysis of the study, it was observed that most users either failed to understand or failed to read through the message being presented when they encountered a problem with an app or configuration of a setting. When logging the pain point with which participants experienced difficulties, it was seen that the most challenging aspect was encountered when users were required to move their focus away from the sequence of events they were tackling to another sequence of actions. The video analysis showed that the main problems participants faced were in relation to Internet connectivity due to a lack of understanding of the error messages generated, and therefore a low score was achieved when calculating the atomic value during that particular pain point.

4.3.3 Summary and Discussion

Throughout the course of this work, the hypothesis suggesting that the majority of users, when seeking to tackle obstacles independently, would experience issues when carrying out a familiar task on a new device, was confirmed. Nonetheless findings indicate that mobile users need a logical path to follow; users need to know where in an app they are, with confirmations provided to assure they are progressing forward in the right way. Through the completion of video analysis, it was found that subjects have different knowledge, and therefore, if shared with colleagues, this would constitute support.

The design of mobile apps is carried out in such a way that information is presented in a logical, easy-to-following way. Moreover, it is pivotal that mobile developers ensure the design integrates a back button, which users can use to find out where they are and accordingly retrace their steps when necessary. In the majority of instances, the need for users to follow only one path to a screen is advisable. Should a screen be accessible in different circumstances, a modal view should be considered for various contexts.

SMD use is becoming more common in the work environment; however, various issues restrict wide-ranging implementation. Despite the fact that designers of SMDs are continuously aiming at enhancing applications and operative systems in order to provide users with better support in managing and utilising their devices, problems continue to arise when a user comes to deal with unfamiliar smart mobile platforms, regardless of the familiarity of tasks.

As described in detail in sections 4.1.4 and video analysis section 4.3.2 findings show that, regardless of the position and role adopted by an individual in the work setting, and regardless of one's overall capacity to complete tasks, challenges continue to arise when people are in non-familiar settings. If there is the provision of error messages, these are not always well understood, meaning their help is limited. Should error messages not be displayed at all, only some people are able to think of the solution and try different approaches. The attitudes of individuals towards carrying out tasks are linked to their general capacity to identify a solution.

Problem-solving skills affect the time needed in order to carry out a task, with confidence seeming to affect performance. When drawing a comparison between success rates and confidence, the research has shown higher success is experienced by more confident individuals. Furthermore, the results demonstrate that those involved in the study did not experience feelings of frustration—regardless of the failing to solve the problems and the time restrictions. This could be owing to the fact that there was no personal reason for carrying out the activities.

Results show (ref to section 4.1.5) that there is some degree of gender bias in self-reported confidence, with males shown to demonstrate more confidence compared with females, but not necessarily higher problem-solving abilities. IT support efficiency in the workplace as described in section 4.1.7, has an impact on the ability of users to carry out tasks independently. In turn, this affects the confidence of the user and how they might approach a task. Confidence rate and actions of users are linked with the role they perform in the professional setting (ref to section 4.3.1); in turn, this affects their perceptions of technology and their overall self-directed problem-solving capacity.

Those individuals who carry out research as one aspect of their professional position are more likely to achieve a better performance score across all stages, meaning there is a link between attitude when carrying out a task and the atomic values assigned to the way in which activities are completed by individuals.

When recovering from challenges, error messages are not always valuable, with the role of memorability's key aspects necessitating more in-depth examination in an effort to determine whether or not users acknowledge they have experienced a particular system state before, and whether they remember the steps needed in order to overcome the problem at hand.

4.3.4 Conclusions

The present work comprised the objective to observe how people seek to carry out familiar activities on unfamiliar devices, and to establish the way in which obstacles are overcome, as well as their levels of frustration, confidence, attitudes and successes when so doing. For this study, the findings detailed in this chapter contribute in the overall design of the framework suggested: crowdsourcing individuals' knowledge and facilitating knowledge-sharing with colleagues. A model will be devised for Study 4 (see Chapter 6). The participants will be assigned activities to complete, with their behaviours and attitudes examined in an effort to address Chapter 1's outlined hypothesis.

The findings show that, despite the great effort that designers have invested in developing apps and operating systems that are easy and intuitive to use, users seems unable to transfer what they have learnt on one platform to another platform, and to guide their actions. From the results of the study we can offer various recommendations for software designers and employers considering the adoption of smart mobile devices in the workplace:

1. In the workplace, users might be more effective if allowed to use their own device or one with which they are familiar. This has been debated in Olalere et al. (2015). In this case, users might be better positioned to tackle the problem with a better attitude.
2. Self-reported technology-confident users are not exempt from experiencing problems. Technological changes, such as the use of an unfamiliar smart mobile device, seem to increase the chance of encountering problems.
3. Adopting new technology in the workplace requires a learning period with support provided during this period.

At the present time, popular Smart phones provide various modes of help and support; however, it is important to examine how SMD users can best interact with new devices and their respective functions, and how the design of support systems can be carried out in an effort to ensure self-directed approaches can be utilised, such as through the provision of collaborative or personalised support in mind of people with varying capabilities, skills and needs. So doing could mean technology will be more accessible and better positioned to increase levels of productivity, in addition to improving confidence amongst users, thus facilitating a positive attitude and experiencing when learning in the work setting.

To summarise, mobile technology usage is widespread and its adoption in the workplace presents challenges that could affect user behaviour and performances, as well as confidence and frustration. Therefore there is a need to further investigate smart mobile use within the workplace environment. Being able to understand how a user independently solves these challenges might help to improve technology engagement.

CHAPTER 5 – DESIGN AND IMPLEMENTATION OF THE PROPOSED SYSTEM

"Like all technology, social media is neutral but is best put to work in the service of building a better world"

(Simon Mainwaring)

The following step requires the provision of a model that may be applied in order to design, apply and capture Just in Time knowledge through the use of a crowdsourcing tool devised in mind of this study. Through expanding on the knowledge base already identified, as discussed in Section 2.2.1, the capture of data will be achieved from the knowledge-sharing tablet application. This PhD will seek to address the various issues and problems experienced by individuals, as highlighted in prior studies, and those discussed in Chapter 4 specifically. In order to garner evidence regarding the validity of the main hypothesis, the proposed study—as discussed in the following chapter—applied a research tool known as *YourSpace*, which is a tablet solution developed by the author of this work. The Just in Time ubiquitous tool has been designed on a foundation of social media in an effort to empower users to create knowledge that can be utilised by, and is accessibly to, the workplace as a whole.

YourSpace is a solution defined as a collaborative computer solution comprising a number of different learning objects that require an outlined time and complexity. The tool has a number of features that may be viewed as making up a support system, social media system and knowledge management system, where the use of such brings users together to construct learning objects. In a more natural setting, users are assigned various job roles and have pursued varying levels of education, and also have different areas of knowledge. Accordingly, the assumption was made that they would share different knowledge with their colleagues through the crowdsourcing tool. The objective was centred on providing a collaborative solution that could empower users to be involved in knowledge creation, in addition to completing their activities or tasks as a community in the work environment.

When designing the system interface, it was essential to ensure all of the aspects offered through the *YourSpace* solution detailed in this chapter did not overwhelm the user's short-term memory as this could affect their behaviours and attitudes through the impact on their motivation and attention. The devised solution was resident on a tablet with the aim of improving portability. Moreover, it enabled users to create tasks that could be understood and managed independently.

When applying a crowdsourcing solution for this study, a key factor identified was the need to ensure users would be involved and engaged with the tool. As considered in Section 2.9, encouraging participants to contribute and create learning objects, whilst also providing peers with support and encouraging asking for help, was pivotal to achieving project success. Accordingly, these requirements needed to be apparent in the computer solution through the adoption of principles applied by persuasive technology in order to encourage users to participate in building learning objects, as noted in the work of Oinas-kukkonen & Harjumaa (2008). Importantly, such learning objects were specific to the workplace environment in which the *YourSpace* tool was used, and was devised in line with the respective organisations' needs.

As detailed in chapters 3 and 4, Study 2 and Study 3 detailed the key aims of the *YourSpace* tool. The objectives were twofold: to establish the most effective method to gaining insight into the needs of employees; and to establish the most valuable method when providing solutions, with the aim of assisting employees in independently acquiring the necessary skills both quickly and efficiently. In the experiments of Study 2 and Study 3, the case studies used were found to be valid, and therefore may be applicable to Study 4 (discussed in Chapter 6). This chapter provides an overview of the research tool's design and application, with all of the Study 4 participants able to access the tool in their natural work setting.

5.1 Key innovation of YourSpace System

According to the requirements obtained in the previous studies the technological Just in Time collaborative solution *YourSpace* must contain the following key innovations:

- Creating Just in time solutions that are accessible through a smart mobile device.
- Real-time knowledge sharing that can allow participants within the natural workplace environment share knowledge and access learning objects from different locations.
- Support intuitive construction of knowledge by creating learning objects that allow participants to show step-by-step technical solutions allowing user to immediately focus on what has been presented.
- Capture knowledge by adopting an intuitive approach that allows user with different level of progression to share knowledge.
- Track data through a collaborative tool *YourSpace* that makes use of social media features that allow participants classifies the types of interactions in a structured way.

The key innovation concepts are described in detail in the following sections: application design (section 5.2), system architecture (section 5.3), interface modules (section 5.4) and the components of the model designed (section 5.5) for this PhD.

5.1 Background Work for Development of the Tablet Application

The first stage required a knowledge base to be created on the different areas relevant to the tasks for Malta International Airport, to which users would be able to effectively contribute in the creation of learning objects. The information garnered through the completion of Study 3 was applied in Study 4 (see Chapter 6) conduced at Malta International Airport with the aim of exploring and accordingly examining the overall efficiency of the suggested framework—a Just in Time knowledge-sharing collaborative workplace computer solution, as discussed in the current chapter.

Studies 1–3 have added much value in terms of establishing the different issues detailed in Chapter 4, sections 4.1 and 4.2, and were used to create the model adopted to the technology devised for this work. In order to satisfying the goal, there was the design and implementation of four different modules for this project:

- Module 1—Knowledge system linking android Images with *YourSpace* tablet.
- Module 2—Interface with navigation features was designed and implemented.
- Module 3—Personal Social Features, comprising various collaboration elements, enabling users to make comments and remarks for all instances by participants.
- Module 4—Data logging from *YourSpace*.

In order to satisfy Module 1, there was the design and adoption of an application through synchronising screenshots from the Android device to the corresponding tablet application. The solution then was made accessible in real time so as to allow the workplace community to both use it and create content. To satisfy the second module, there was the design and implementation of the interface with navigation features. A number of different records were kept in order to track data for later evaluation and in mind of analysing the interactions between users in creating learning objects.

In the prior study, considered in Section 4.1, subjects were required to carry out a number of tasks themselves. In the use of the *YourSpace* tool, however, subjects were expected to carry out activities through collaborative approaches, and accordingly share knowledge with the use of the computer solution (see Chapter 4 for further details). This activity was examined with the adoption of approaches similar to those applied in the social media domain. Accordingly, Module 3 comprised collaborative features, enabling users to make comments and remarks pertaining to each instance. As a result, a number of functionalities were incorporated into *YourSpace*, through which users had the ability to describe to their colleagues how certain activities could be completed. This was further enhanced by expanding Module 3 with the use of the 'drag and drop' features detailing the personal social features. This module had a number of different components that enabled the participants to add comments and remarks on the actions they needed to carry out across the different stages, in line with the ICON chosen.

One of the fundamental factors established in Study 2 throughout the course of the preparatory study, as considered in greater depth in Chapter 4, was providing users with the ability to share knowledge through the addition of information to images. Accordingly, the tool was designed to enable users to upload images that would be accessible to all of the community, where users could tag particular aspects that highlighted a certain point, with ability also to leave comments that would be helpful to overcoming the obstacle in question.

Module 4 was designed and applied so as ensure the functionalities of the tablet solution contained, which enabled the researcher to monitor data pertaining to both the learning object and the participants, would be used for assessment and analysis. These included the following high-level requirements:

1) Enable the incorporation of a logging system so as to establish users and their role within the system.
2) Ensure tasks are both accessible and explained on the tablet solution, providing online[3] assistance whenever required.
3) Enable the information collection pertaining to how users interact with the system, such as the number of interactions, time spent in creating or reading a particular instance, and the type of input given, amongst other areas.
4) Provide information as to the location of use.

Implementing an open source solution, RedPin (Bolliger, 2008) was installed as a backend service on the Android SMD assigned with the aim of logging the user's indoor location.

The datasets creation, which was considered necessary for the participants' profile definition prior to the conduction of the experiment (Study 4) was contributed to by Study 3. The video analysis was coded (throughout May 2013), which was pivotal in assessing the learning process adopted when users were involved with the use of the tool.

YourSpace assessment was conducted by employees in their natural work setting at Malta International Airport (see Chapter 6 for further details).

[3] www.conradattard.com/yourspace

5.2 Application Design

As discussed earlier, the suggested framework comprised a multi-tier model implementing an MVC model comprising a back-end and a client side. MVC is a software architecture pattern, and is not exclusive of a license or company. The design of the tablet solution was carried out with a Windows OS. In this study, there was the adoption of Microsoft ASP.NET MVC 4.0 using visual C♯ . This operating system was recognised as familiar to the users in the work setting. Three aspects available to developers in implementing applications were adopted for this application, namely Model, View and Controller: the first centres on managing data access, entity definition and the required application's business logic; the second represents where the user can see the mode-provided information, as described in Section 5.2, and the user interface; the last demonstrates how the former two components interact and communicate, and acts as a link between the two.

At the client end, upon the user logging into the system, the various topics associated with the study can be accessed, each of which comprises various learning objects that can be created by the participants. Should support be required by the user, a particular learning object can be accessed, with the user passing through the various steps to the solution. If experiencing problems, the user then can ask questions relating to the step; questions are made available to all of the community's members throughout the duration of the study. The different actions carried out by the participants were logged at the back-end of the system on a Microsoft SQL server for subsequent examination. Through the adoption of a graph-based method, there was the collection of the knowledge shared amongst the colleagues. Participants were able to access all of the updates being uploaded to *YourSpace* in real time.

All solutions required by the user were fulfilled by the back-end solution through the application of various techniques, including social network analysis, in an effort to establish a profile for different groups of people upon the completion of the study. The knowledge database was regularly updated through a local server, with all of the contributions and learning objects recorded by participants at the workplace. With the use of Google's messaging service, any information and updated were communicated to the user by a cloud service alert, which improved the overall interactive and collaborative nature of the experience without the need to frequently connect to the server. The user was able to choose what actions to do through one of the alert options.

Through the creation of tagged images within the learning objects, or otherwise by searching for present ones through the SMD, users of *YourSpace* are able to interact and share knowledge. With the use of tags, participants made comments and discussed solutions, highlighting any aspect of the image with which they were interacting. Other information, including any obstacles faced when solving the problem or the value of help given, was logged with the use of a simple scoring system.

5.3 System Architecture

The suggested solution comprised a multi-tier framework implementing a Model View Controller (MVC) model, made up of a server side and client side. The various aspects were categorised into four respective modules, all of which underwent design with the aim of gathering user data during collaboration with one another in order to create knowledge for use in a Just in Time model.

A device similar to that displayed in Figure 14 was where the tablet solution was installed for this research. The *YourSpace* application, which will be discussed further in this chapter, was installed on the tablet, with the application in question connected to a Mi-Fi device in order to facilitate achieving an internet connection at the workplace (as shown in Figure 15).

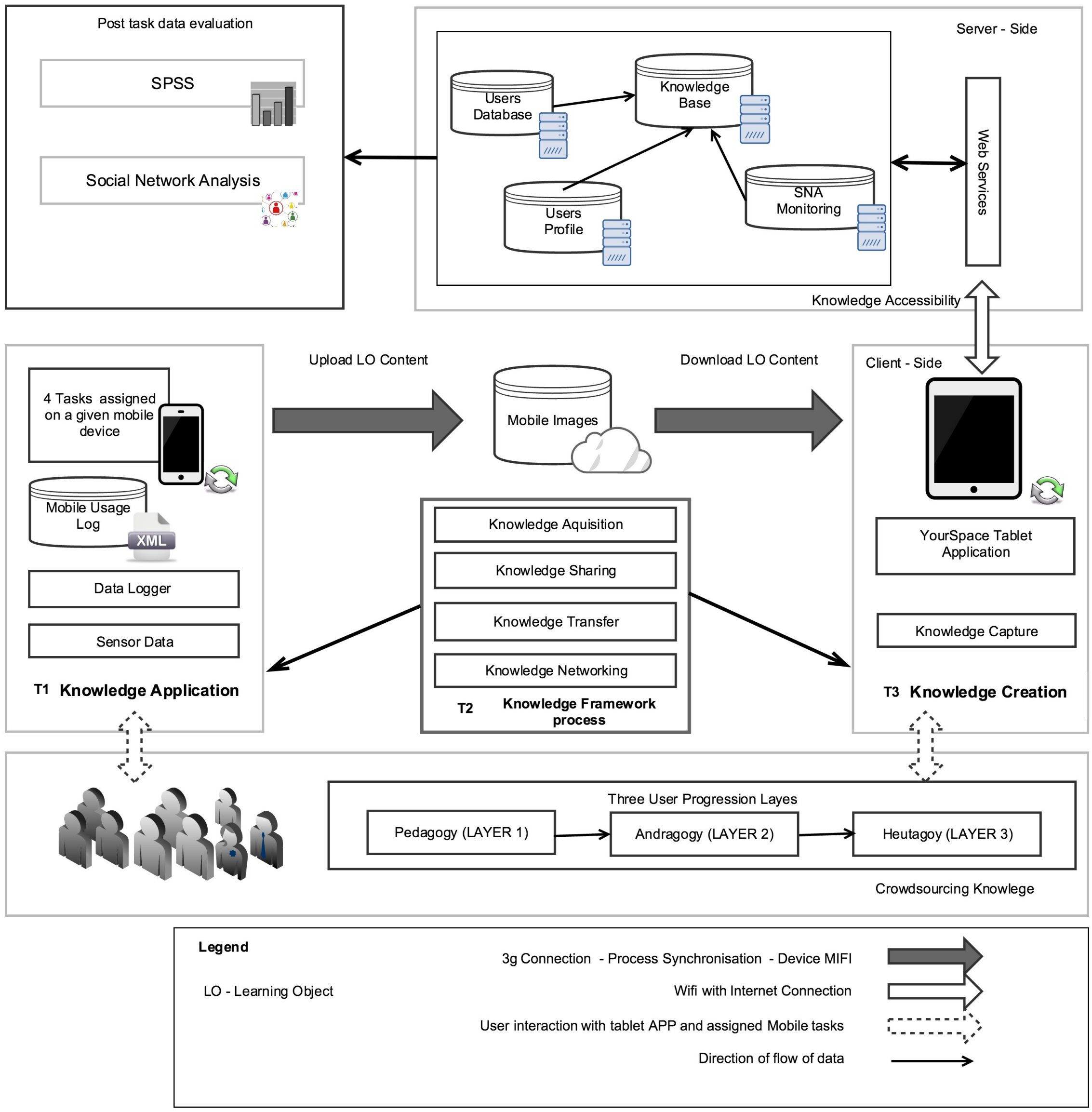


Figure 15: Multi-tier technology architecture and three levels captured through progression from pedagogy to andragogy then to heutagogy

In Figure 15 there is a technology architecture, which comprises three key tasks. Knowledge Application (T1) is made up of various elements that were installed on an Android device that was distributed amongst the subjects for the completion of the case studies. This device was installed with a data logging service and open indoor location service. Knowledge-sharing is made up of various elements that come together to form the knowledge-sharing framework (T2) , which is linked to the knowledge application and knowledge creation in the cases of T1 and T3, respectively. Lastly, knowledge creation (T3) comprises the suggested design for the tablet application for this study to crowdsource knowledge. As a method of enabling various group members to share knowledge pertaining to a particular subject, social scaffolding was suggested. Subjects involved in the study could be part of any progression level, moving from pedagogy to andragogy then to heutagogy. Taking the three respective progression levels into account, there was the design of the different elements with the objective to achieve the fundamental hypothesis underlying this study (see Chapter 1). The suggested architecture is recognised as being built on social media (T3) at its foundation, together with the knowledge framework process (T2). It is common for a knowledge framework to be adopted in order to gather valuable information that may be utilised in order to provide the user with meaning. A more in-depth description of the aspects included follows.

T1 –Knowledge Application - Through Android mobile device.

There was the installation of two background services on a mobile device, which were handed out amongst the participants for the duration of the experiment, and which were kept running throughout this time. The services were utilised to monitor and log any and all data relating to the subjects when interacting with the mobile device.

Data Logger Service was one of the services to be used, which was chosen with the objective to monitor the 5 stack apps most commonly used on the device. The service functions in a way comparable to debugger, and was designed as an Android SMD-compatible service. The service's aim is concerned with logging problems that can affect the experience of users and filtering out bugs, whilst subjects carried out the tasks assigned to them for Study 4. A log was maintained in a structured XML file on the SMD, detailing any problems or issues potentially experienced by users when carrying out the study, such as issues concerning Wi-Fi, apps failing to run, and others. This data was gathered following the conclusion of the study, upon returning the SMDs to the researcher, who then was responsible for examining each of the tasks in order to establish Study 4's success or failure (see Chapter 6). One of the more essential requirements established throughout the course of prior studies (Chapter 3) was that of differentiating between issues handled by the user on an independent basis and those deemed beyond their control. The research directed attention towards those issues that could be solved by the user in the work environment.

Another service utilised was that of *Indoor Location Positioner*, RedPin an open source project, which uses Wi-FI, GSM and Bluetooth as sensing devices. This service was utilised as a background service with the aim of garnering information pertaining to users' indoor location, such as a meeting room or office, for example. This was deemed necessary in order to establish the location for using the SMDs (see Section 5.6.1).

T2 – Knowledge Framework process.

T2 comprises the knowledge framework process, comprising knowledge acquisition, sharing, transfer and networking. Such aspects are linked with both T1 and T3, namely knowledge application and knowledge creation, respectively. T3 components capture knowledge through the suggested crowdsourced tablet application, which was accessible to group members during the collaboration process of constructing learning objects. The data is both tracked and stored on the data side, with the user profiles, knowledge base and SNA monitoring databases created to store all data relating to the tablet application. The selection of social network and SPSS analysis techniques was decided on in mind of assessing the results garnered following the completion of the study.

T3 – Knowledge Creation - Tablet Application *YourSpace*

The synchronisation of images created by the subjects through the use of the SMD was facilitated by the tablet application, where such images were automatically transferred to the corresponding device with the use of the cloud functionality. In order to achieve this operation, the participants were given a Mi-Fi device, which was configured with the use of a 3G connection between the tablet application and the SMD (see Figure 17). There was no need for the user to manually interact with any app on the tablet or app. Subjects were able to press two buttons on the Android device at one time in order to experiment with the ability to take screenshots, which were transferred automatically to the tablet application. After, users were able to view the images through the tablet application, and could select at what point they wanted to add a touch point. Figure 13 provides an overview of the various stages of the workflow deemed necessary in order to create learning objects.

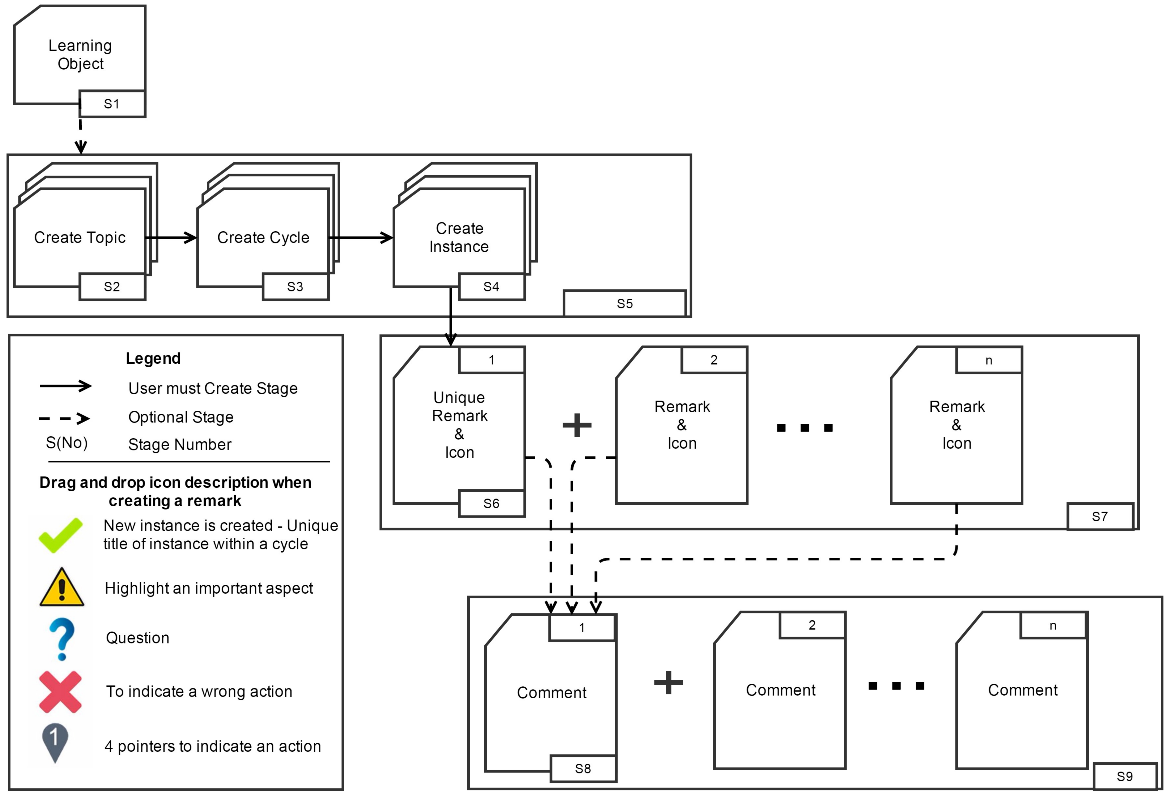


Figure 16: Workflow diagram showing the various stages that make up a learning object

Throughout the process's earlier stages (S1, S2), there was the specification and creation of learning objects by the researcher. Study 3 contributed to garnering much more in-depth insight into the tasks and associated case studies discussed in Chapter 6. Various instances come together to form cycles (S4), each of which has a unique name that has described an action. The users were given a choice of icons from which to choose (Legend figure 16 and section 5.4.4), which indicated a particular scope of use. Users would able to move the icons on the image to highlight the subject nature. All participants were able to share ideas and pose questions in the group. The tool was adopted in order to assess how knowledge was created and shared between the users in real time (see Section 5.5). Moreover, the amount of time and the type of interactions the participants had with each instance in the user profile database were recorded.

Figure 17: Android mobile (left), Windows Tablet device (Centre) and Mi-Fi (right).

5.4 Interface Modules designed to Crowdsource knowledge on assigned Tasks

The Just in Time solution is made up of four modules developed to crowdsource knowledge. The solution allows participants to access learning objects and also capture information on how participants interact when constructing learning objects:

Module 1: Knowledge System Linking Android Images with *YourSpace* Tablet.
Module 2: Interface with navigation features was designed and implemented.
Module 3: (Personal Social Features) which consisted of collaboration features allowing users creating remarks and comments for each instance by participants.
Module 4: Logging data from *YourSpace*

The effectiveness of the proposed tool was measured through an evaluation process described in Chapter 6, Section 6.4.

5.4.1 Module 1 Tablet Solution—Learning Object Material Linking Android Images with *YourSpace* Tablet

This section describes in detail the user interface of the tablet application *YourSpace*, which had a simple effective design that minimised the amount of interaction required to complete any stage described in Section 5.1.

A topic was created for each of the assigned tasks for Study 4. A total of four topics, defining the task assigned for the research project, were created before participants accessed *YourSpace* (described in detail in Chapter 6). Participants were expected to create the respective learning object for each topic by creating a new cycle. Each cycle had a number of instances that described one or more actions that needed to be carried out in order to complete a task (as shown in Figure 16).

Figure 13, shown above, is a walkthrough of the various stages participants were required to progress through in order to share their knowledge or otherwise to highlight any problems they came across whilst completing the assigned tasks through the given computer solution *YourSpace*. A node is a participant that shows the way s/he interacts with every instance within the learning objects through comments or suggestions or image-tagging. Each node was monitored and information stored in the table through the tablet application.

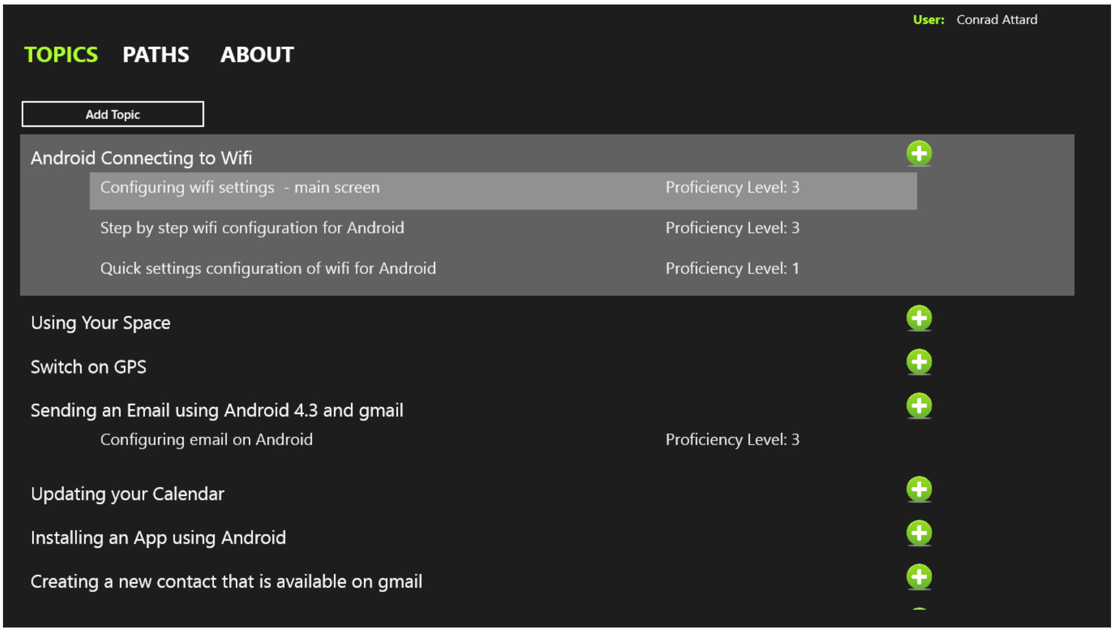


Figure 18: Main Screen - *YourSpace*

Once the user clicked on the app icon *YourSpace* from the tablet dashboard, the main screen in Figure 18 showed a summary of the topics being managed during the study. Three tabs—*Topics*, *Paths* and *About*—were available on the main screen. Participants could access *Topics* to find all case studies used for the study. *Paths* contained a combination of solutions that allowed the participants to solve problems without the need to move from one topic to another, and build learning across already existing ones by choosing one or more instances as required. *About* contained a summary of how the application could be used, including various links to specific online video manuals. The administrator and leader conducting the study created various subjects by clicking *Add Topic*, as shown in Figure 19. The topics contained the various cycles that were, in turn, made of various instances containing the learning objects created by users. Each cycle was assigned to a proficiency level, as seen in Figure 20.

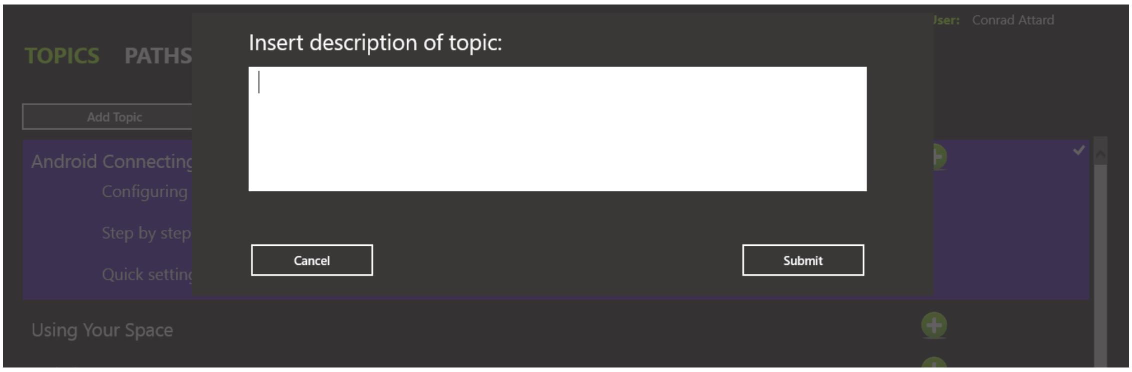


Figure 19: Adding a description to a new topic in the Main Screen

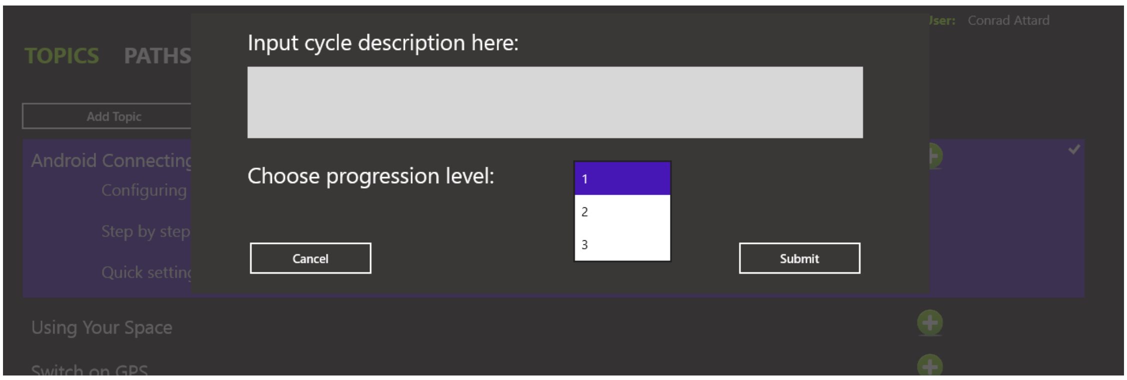


Figure 20: Add cycle and corresponding progression level

5.4.2 Module 2—Navigation and Creating Instance of Learning Object

Once a cycle was created, the participant had to choose the first image and accordingly assign the first icon that also would be the title or scope of that particular instance. In addition, the user could browse for an image when creating a new cycle and the first instance of the learning object. The image, which was created through a screenshot, was synchronised through the mobile device on the tablet, and accordingly made available to be displayed in the tablet application (see Figure 21). Section 4.1.3 and Section 4.1.4 describe how the image then is linked to Module 3, with the possibility of adding comments and suggestions, and choosing the type of ICON to tag on the image.

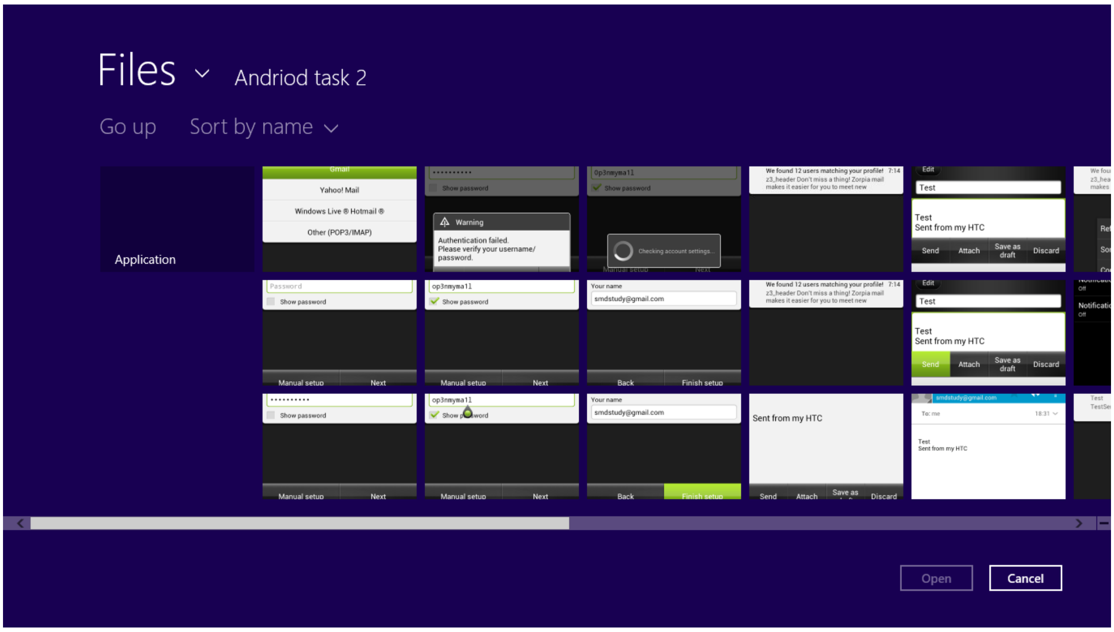


Figure 21: Create cycle – Selecting an image

5.4.3 Module 3—Personal Social Features

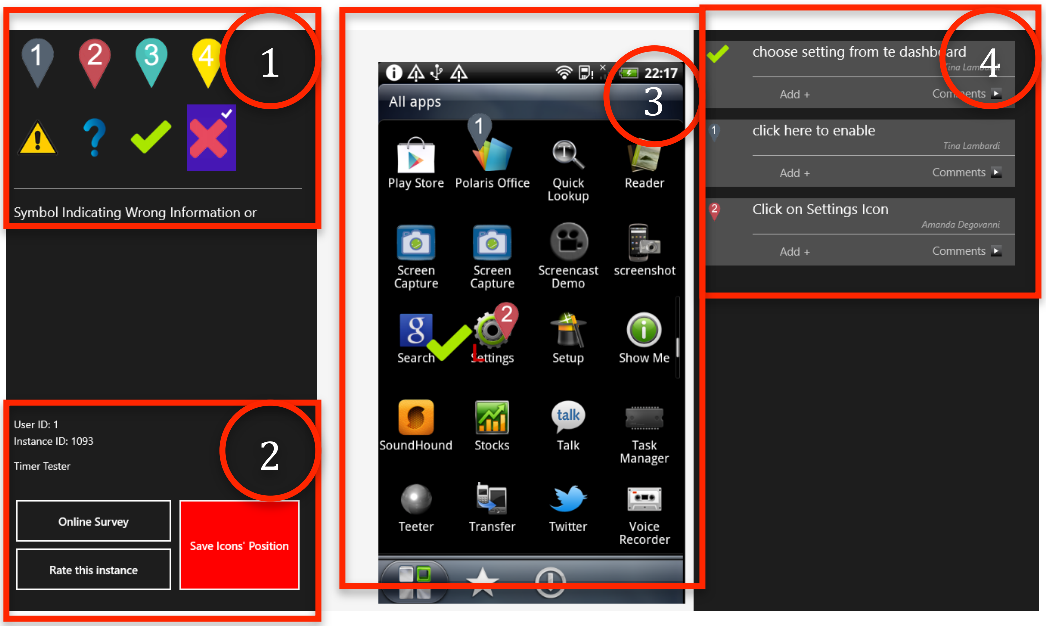


Figure 22: An instance of a learning object

The following is a sequence of how a participant could drag an icon or an image to create a remark or comment (see Figure 22):

1) An icon is selected according to the type of remark the participant/user wants to use.
2) Information about the learning object is shown with options to rate the instance, participate in an online survey and save the position of icons once completed.
3) An area is allocated for the image/s, and various icons are positioned to explain the concepts within the image.
4) To add social media functionality within the solution participants of a group create remarks. Each remark is allocated according to type indicated by an icon. Comments can be added to create a discussion about the instance and achieve knowledge sharing using text through Just in Time collaboration (see Figure 23).

Figure 23: Insert comment according to icon for a respective learning object

5.4.4 Extending Module 3—Drag and Drop Icons

Eight icons were identified from preparatory Study 2 during the workshop described in Chapter 3. Participants could drag and drop the icon on the image. These icons were selected to help users point at a particular area within a chosen image and accordingly add a remark related to that pointed area. The icons were grouped into two sets: the first was made up of four icons of numbered pointers, similar to those used in maps, and were used to describe a sequence of actions that a user may follow to complete a task (see Figure 24); the second set was made up of specific icons that also could be dragged within an area of the image. Through these icons, users could choose to ask a question related to an instance or otherwise alert other users about something important. They also could indicate how a successful action has helped them to complete a task or indicate something wrong when doing a particular action. The icons are defined in detail in Table 22. The following figure (see Figure 24 and Figure 25) is a screenshot of the icons used to interact with the learning object.

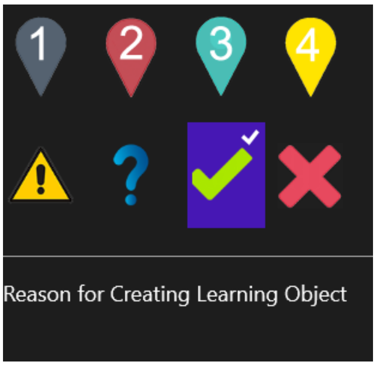
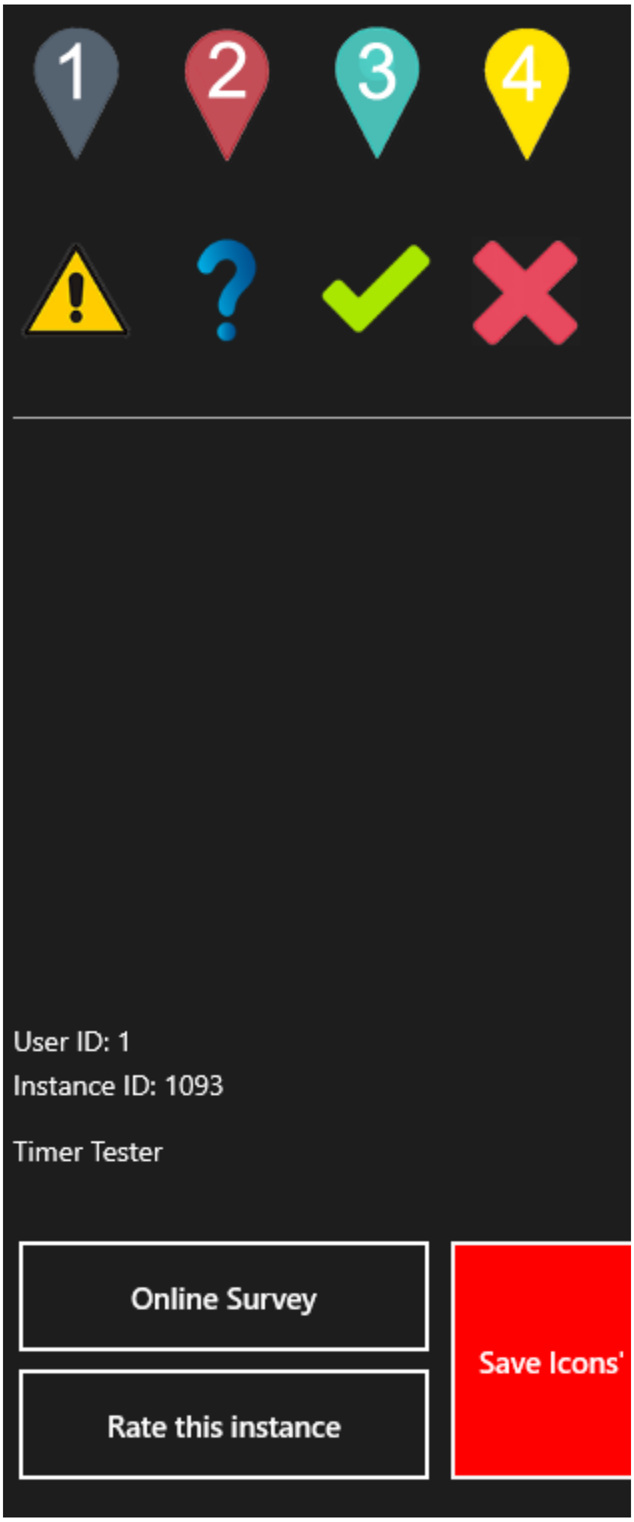


Figure 24: Icons grouped available for user to choose from

Icon	Description	Icon used on images	When to use Icon
	Reason for Creating Learning Object		Whenever a new instance is created.
	Alert to highlight an important aspect		When content creator needs to indicate that something needs attention.
	Question something that is not clear		When the participant needs to know something about the learning object.
	Wrong approach or choice to something		When the content creator needs to alert something.
	Pointer to an item that can be used within a sequence. Position 1		When the content creator or participant needs to indicate something about the learning object.
	Pointer to an item that can be used within a sequence. Position 2		When the content creator or participant needs to indicate something about the learning object.
	Pointer to an item that can be used within a sequence. Position 3		When the content creator or participant needs to indicate something about the learning object.
	Pointer to an item that can be used within a sequence. Position 4		When the content creator or participant needs to indicate something about the learning object.

Table 22: Icons used to interact with learning object



Select an icon to find out how to use it.

Double-click to choose icon to drag on image to create information within a learning object.

Information about the user interacting with learning object. Instance ID and amount of time spent on learning object.

The participant can save the instance after interacting with learning object by clicking on save icons.

After the user completes a given task the participant can rate the instance and participate in a short online survey.

Figure 25: Description of functions and drag and drop icons of an instance

5.4.5 Module 4—Collecting User Information for Each Instance and Cycle

The participants in the study could input the success or failure of an instance within a cycle by assigning a score from 0 to 4 (see figure 26), where 0 was the lowest value indicating that the instance within a learning object was not helpful or misleading, and 4 (highest value) indicated the instance was helpful, clearly explaining the action needed to carry out that particular instance.

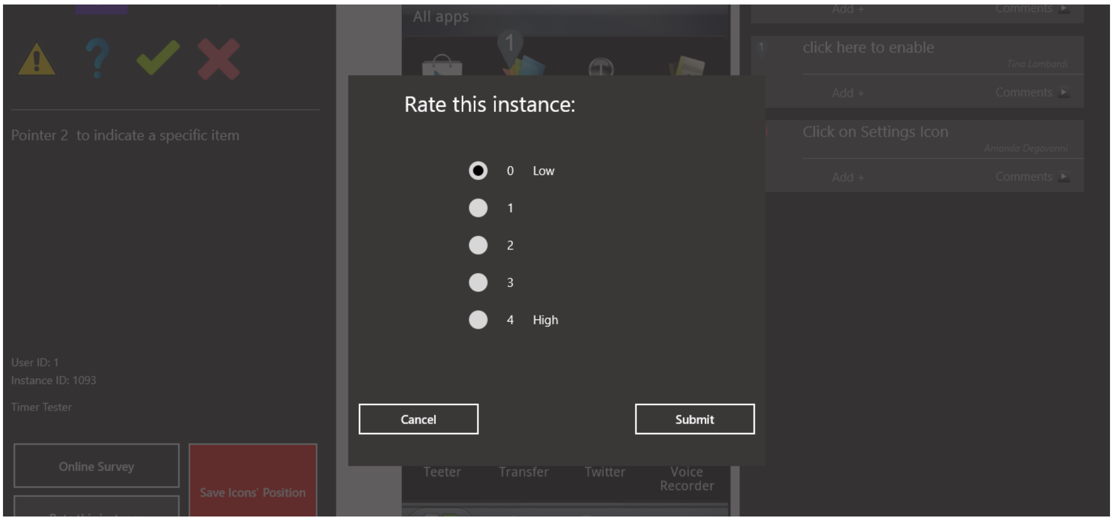


Figure 26: Rate an instance of the learning object according to how difficult the participant found it

5.5 The Components of the User Pervasive Context Progression Model Explained

Making reference to the hypothesis for this PhD (ref to section 1.2) a model is needed in order to gather user knowledge in a work setting ubiquitous context. The model is refered to User Pervasive Context Progression Model and its main elements are awareness, confidence and knowledge-sharing.

As considered in Section 2.5, various different frameworks associated with user engagement emphasise the value associated with outlining how design principles need to be adapted in line with the requirements of software (Oinas-kukkonen & Harjumaa, 2009). In this study, the solution suggested takes into account the model devised by Blaschke (2012), which explains the three progression layers from pedagogy to andragogy, and subsequently on to heutagogy (see Figure 1, Section 2.2), as investigated in Study 3 (see Section 4.1). Users are able to select whether they would like to create learning objects during the process of answering questions in relation to specific instances, and can also contribute through expanding on user knowledge or alternatively by only viewing the learning objects and accordingly completing steps on how the tasks assigned can be fulfilled. The modules explained in Section 5.2 detail a number of different interaction-related components that enable subjects to easily create the necessary learning objects.

This part of the study centres on the role of the user and context by outlining the User Pervasive Context Progression Model implemented for this work. When taking into account the context modelling and management for ubiquitous systems, it is necessary to consider the criteria established in prior works, as detailed in chapters 3 and 4, in addition to various context information features in pervasive systems (see section 3.2.3, 3.2.7 and 4.1.3). The concern of how this information can be represented and managed was carefully examined. Modelling context information through a ubiquitous computing system is satisfied through modelling context with the use of existing data modelling approaches from the domain of information systems, and accordingly storing and managing the information with the application of a database management system, as discussed in Section 5.3. The different stages necessary for interacting with the solution have been afforded attention in Section 5.2.

Object-modelling approaches can be utilised in order to create a model of context information, as in the cases of entity diagrams and UMLs, which are two different methods. These can be applied to support model mapping to the application of an object-centred programming language. This study utilised another approach with entity diagrams (see Figure 27). To begin with, the tracking data parameters were highlighted, with an algorithm detailed for explaining both the elements and context making up the model. Efforts were directed towards modelling the scenario detailed in Section 5.2 using the entity relationship model; the conclusion was drawn that social network analysis was the most suitable method for evaluating information flow between users within communities when modelling context information, as considered in Section 2.2.2. Accordingly, the decision was made by the researcher to implement this approach in order to help extract user information relating to the various components that made up the model. The figure below provides an overview of the study model - User Context Progression Model.

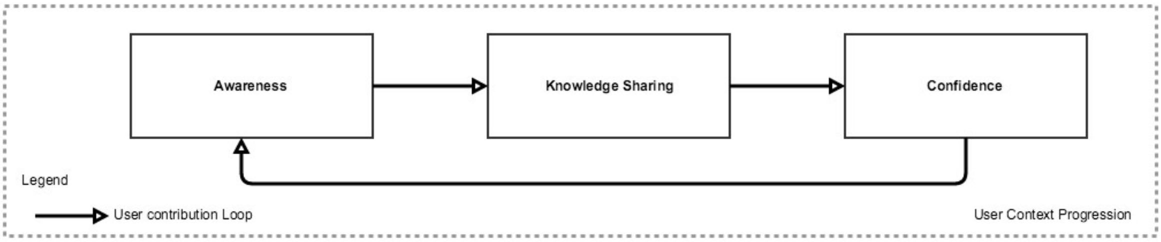


Figure 27: Diagram of Components considered within the User Context Progression Model

The suggested data management and solution functionality fit the User Context Progression Model devised for the current work, comprising three elements that are centred on how users interact with the solution. Such elements are awareness, confidence and knowledge-sharing, as displayed in Figure 27. Various approaches were applied in order to establish the different attributes making up each of the proposed model's components. Subsequently, the parameters used are further described through the entity diagram and algorithm. The relationship between components is highlighted in the entity diagram. Each of the components included in *YourSpace* was validated through the knowledge gathered in the crowdsourcing solution, which was assessed in Study 4 (see Chapter 6, Section 4).

Member information and the resources garnered as a result of data tracking are summarised in the following table, along with the respective parameters.

Table 23: Description of parameters with tracking data.

Parameters and corresponding database table	Description
Member Information participating by contributing to knowledge	
CLT_Name, CLT_Date,	Data about participant
CLT_JobRole, CLT_AmountOfEmployees,	Data about participant job
CLT_Tablet, CLT_Android	Data about devices used
Social media component of members who added a remark or commented or any instance.	
NOD_Contributor, NOD_IconPosition	Participant type of contribution such as creating instance, adding a remark and commenting or only viewing.
MON_StartTime, MON_EndTime, MON_ClientID, MON_Day, MON_InstanceId, MON_NoOfIterations	Data monitoring resources created by the member including; creating instance, uploading image, which drag and drop icon participant choose, commenting and only viewing.
Resources related the member that created a learning objects and interactions with their group members	
TPC_Description, TPC_DataCreated, TPC_DateModified	Researcher creates topics for tasks assigned for study.
CYL_Creator, CYL_Description, CYL_DateCreated, CYL_DateModified	Participant creates a cycle describing a solution on a related topic.
Description of resources used to generate learning object members that upload images and create instances	
INS_ImageId, INS_ParticipantID, INS_DateCreated, INS_DateModified, INS_Description, INS_Active	Members of group can upload images and create an instance.
ICO_IconId, ICO_X, ICO_Y, ICO_Remark, ICO_DateCreated, ICO_DateModified, ICO_ParticipantID	Members of group can drag and drop Icons that can be categorised to evaluate results.
COM_Text, COM_NodId, COM_IconPositionID, COM_DateCreated, Com_DateModified	Members of group can post comments for each instance related to any remark in the social media component.

The back end solution's design enables data collection, meaning the researcher is able to link and monitor user information across two different tables—nodes (NOD_) and monitor (MON_)—with the rest of the table making up the learning object. The corresponding parameters are listed in table 23.

The tables store data pertaining to interaction, for example, which subsequently is extracted, enabling the researcher to calculate, examine and draw meaning from information. Information needs to include the role of the participant, such as whether the participant is an active participant, a creator or a view, for example. A viewer is not recognised as being a contributor, but could have gathered knowledge that was pivotal in his or her learning through passing through the various stages created within *YourSpace*. The logs of dates and times were stored for all stages and interactions. The icon type detailed in sections 5.4.3 and 5.4.4 enables the author to assess and accordingly categorise what information was shared by which users. Various tables were created for the storing of data, including Topic, Cycle, Instance, Icon Position corresponding Remark, and Comment.

5.5.1 User Context Progression Model Components

A wealth of data is gathered through a crowdsource application, which subsequently is accessible to a collaborative computer solution. Accordingly, user understanding when founded on a number of attributes and implicit information is complicated. To begin with, information was extracted through the application of social network analysis, utilising sociograms and various approaches in order to establish valuable information that would be pivotal in facilitating the categorisation of how group members interact with one another. Further information relating to this is provided in Section 5.4.2. In an effort to develop understanding in awareness, the sharing of knowledge and confidence, data were tracked at different touch points, which then underwent subsequent analysis through the adoption of a statistical technique. In order to achieve this, an internal user representation was necessary.

For the purpose of this PhD tracking data for each component will be explained.

For this research **Awareness** is defined as the initial requirement a user consciously identifies when solving a problem and attempting to complete a required stage of a given task. It is satisfied in various ways. To begin with, users seek to carry out particular activities with the use of the mobile device provided. In the specific context of this work, the task was one of four assigned in Study 4 (see Chapter 6). Awareness is monitored through logging the actions carried out by the user, with *YourSpace* used for this purpose. Various touch points enable the researcher in tracking data that can be used to assess the hypotheses suggested in this work.

The opportunity to create a cycle and accordingly upload corresponding images in an effort to create instances relating to an action was provided to users. In an effort to develop further understanding on how awareness is achieved, PPT, as identified in Study 3, should be considered. For example, upon the identification of an obstacle, such as when an error message is displayed regarding there being no wireless connection, this information can be shared. This obstacle has different touch points that are clear in the solution:

1) An instance's image and title detailing the error message (the uploading of an image `INS_ImageId` creates a resource); 2) the ICON, choice, namely Alert ICON or Right ICON, for example, associated with a remark, provides the indication that users need to take certain actions (a resource is created by taking the icon and description, and dragging and dropping it; and 3) a comment that details how the problem can be solved in the correct way (posting a comment `COM_Text` creates the resource). In this instance, enough knowledge would be shared by the creator that could be tracked through querying the databases at the server side.

User awareness relating to actions needing to be taken is shown through each touch point. Group members can be involved by adding additional information to each action, such as through commenting on actions or posing questions. Depending on the ICON type selected or the comment shared by the user, action awareness is demonstrated. Awareness, in and of itself, does not necessarily mean that the user has gathered the necessary knowledge to carry out the activity; nonetheless, awareness is one of the earliest stages to knowledge-sharing.

Knowledge sharing by each participant is stored in the user profiles of the participants (see Table 24). Knowledge is recorded in line with the user role adopted in contributing to the construction of learning objects. The information gathered is assessed with the use of social network analysis, and further used to establish key players and accordingly identify knowledge communication flow within the group. This is achieved through the analysis of social interactions when making solution-relevant comments. Upon solving a task and sharing knowledge through the tablet application, a user shows they have garnered the knowledge needed in order to carry out a certain activity. The user profile parameters created for subsequent analysis, using statistical analysis, is shown below, in addition to the corresponding tables used to capture knowledge relating to an individual's role. There is the further acquisition and updating of user profile data in order to categorise the level of progression fitting users. Users' demographics were gathered in the pre-study questionnaire (See Appendix F).

Table 24: Summary of the main User Profile Parameters.

Attributed storing data generated for statistical analysis	Description	Parameters being queried from respective databases
InstanceAmountOfTime	Amount of time participants allocated for any instance.	MON__StartTime, MON_EndTime
CycleAmountofIterations	No of iterations a participant has gone through a cycle.	MON_NoOfIterations
UserRole	Role participants have taken in successful learning objects that is creator, active participant or viewer when contributing to sharing knowledge	CYL_Creator, INS_ParticipantID, COM_ParticipantsID
TypeOfCategory	The type of knowledge being shared according to the drag and drop icon chosen.	ICO_IconID, ICO_ParticipantID

In the current work, **confidence** is when user takes a decision to share knowledge associated with a pain point or problem through suggesting a solution that effectively contributes to carrying out a certain activity. Confidence may be garnered by a user who is involved with creating learning objects and who further contributes by providing solutions to problems. Users with high levels of confidence, for this study, are those that usually begin to devise a solution by creating instances to address a particularly problematic situation. Extending the data tracked to share knowledge user patterns are created using user profile data. These include: 1) the number of instances created; 2) the number of successful answers to a particular question; and 3) the contributions by tracking data or each touch point shared for those instances rated as difficult.

As has been discussed in Section 5.2, feedback on instances recognised as obstacles was provided by users through assigning a rating of 0–4. In the present work, creators that have contributed to creating learning objects and sharing knowledge on different instances were recognised as confident participants. The learning objects then were rated at the cycle's conclusion (see Section 5.4.5) in order to highlight the overall effectiveness of objects throughout the experiment.

In regard to Study 4, as detailed in Section 6.5 of Chapter 6, manual text analysis was performed by establishing the key players and accordingly aligning their role when establishing or contributing to instances recognised as pain points. Upon extracting the data generated by members through social media, the ability to gain insight into knowledge flow, pertaining to the knowledge shared by participants in the group, became possible. A process map (see Section 6.5.2 in Chapter 6) provides details on all touch points and associated pain points shared across the groups and their members.

5.5.2 Pseudo Code of how the Model Components are calculated from the Interaction Data

Following the defining of all of the parameters detailed in Table 24 and accordingly providing a summary for which data track is required for different members and resources, there was the calculation of the model's components, as follows.

Following the completion of each study, there was the checking of the Android mobile device to determine whether the tasks were a success or failure for the users of the groups. Through querying the data of the various databases, the valid cycles attributed with high scores and high levels of participation were first considered. This was achieved through reviewing the data from the NOD_ and MONITOR_ tables for all groups and cycles generated. The obstacles (INS_ImageId) found to have a high score were established and recognised as successful learning objects by group participants. Key participants and players were established through SNA (see Section 5.4.2). A check was carried out in order to establish whether participants were considered cycle creators (CYL_Creator). Instances (INS_ParticipantID) and corresponding icon/s selected for specific (ICO_IconId) were retrieved for all of the cycles. Following the identification of participants' roles, the following was carried out:

1) We first check the type of contribution the participant made (Creator, Participant, and Viewer).
2) We check cycle score and amount of participation through posts to verify for success.

3) If the participant is a creator of a cycle we check first (CYL_Description) text is verified then instance (ICO_Remark) for awareness.
4) If the participant contributes by posting remarks (ICO_IconId) of comments (COM_Text), awareness is verified and a count of how many contributions is made. This is achieved by querying the database for each participant and type of ICON chosen.
5) The next check is done to verify knowledge-sharing. A count is kept of those who succeeded the tasks logged after the experiment for each group. A cross-check using a statistical tool is carried out in order to correlate the type of knowledge shared and whether they managed to complete the task.
6) If an instance has a high score, it is verified to be considered an obstacle.
7) A check is done to verify each instance by first filtering the type of contribution (ICO_IconId) then by analysis the text to show the respective participant knowledge sharing.
8) Confidence is calculated by the type of contribution a participant makes when creating the learning object amount of time allocated and the number of contributions.
    a. Type of contribution is checked by verifying whether the user just viewed the instances, posted a comment or created an instance by adding an image or remark. This data is tracked in the Nod_ and Monitor_ tables and mean value is assigned.
    b. A cross-check is carried out between the results obtained after the study to indicate success or failure and the results obtained from contributions.
    c. Mean time is extracted and cross-checked with the role the participants adopt for each instance (Creator, Participant, and Viewer).
9) All 8 steps are carried out for each task assigned, where each task is checked for level of difficulty and type of participation.

A lot of information is generated when using crowdsourcing collaborative computer solutions tools. Therefore, selected data is done to extract information. The following entity diagram (Figure 28) demonstrates the relationship of tables to extract data for each action for each group.

Figure 28: Knowledge and User Profile database schema

Information from successful cycles, social media interactions generated for each instance by participants and their corresponding ICON representing the type of knowledge shared can be extracted to be later filter using statistical analysis.

Selected data from the following tables (see Figure 28) can be extracted for every `Topic.TOP_Description`. The following steps can be done to extract the relevant information.

1) For success full cycles `Cycle.CYC_Description`, including the description of a cycle, the remark generated by the participant `IconPosition.ICO_Remark` and the comments shared by their peers `Comments.COM_Text` are extracted.

2) For our study, we need to know who is the creator of the cycle and the first instance `Cycle.CYC_Creator` as a creator of a Cycle, `Clients.CLT_Username` as a remark posted by a participant, `IconPosition.ICO_IconId` as a type of ICON dragged and dropped by the participant.

3) The roles, creators logged in Step 2, participants that actively participate by posting comments and viewer only are derived in `Clients.CLT_Role`.

4) The amount of time allocated by each participant for each interaction is extracted. This was done by selecting `IconPosition.ICO_DateCreated` as time created interaction,

iconposition.ICO_dateModified as time allocated for modification, Cycle.CYC_DateCreated as the total amount of time a participant allocated to create the entire cycle, Cycle.CYC_DateModified as the amount of time a participant allocated time to modify a cycle.

5) We needed to do this for each group, and valid cycles were considered, as explained in Section 5.5.1, where Clients. CLT_GroupName is equal to the group number being investigated.

Data then can be recoded for use for social network analysis to extract the source creating the post, corresponding target that replies, and ID of node and label, as will be described further on in the next section.

5.5.3 Social Network Analysis used for Capturing Knowledge-Sharing

One obstacle that needs to be managed in the design process of *YourSpace* was the designing of a back-end that would enable the extraction of social media data tracked through the solution, by the author, and accordingly assessed. Figure 25 provides a description for Module 4. This emphasises the various entities used to store data pertaining to *YourSpace*. The key requirement was concerned with extracting static patterns from all of the groups that utilised the application, and accordingly completed the activity assigned. Such patterns then underwent evaluation centred on the knowledge flow between the users. Graph-based patterns were used, including those adopted by Kleanthous Loizou & Dimitrova (2012), which enabled graph-based analysis to be performed so as to capture social network patterns amongst people in different domains, including education, whereby there is the sharing of knowledge between researchers and across more popular social media, including Twitter, for example (Treiber *et al.*, 2011).

An important feature that links social network analysis to knowledge sharing is tracking how information flows within a community. When tracking information, it allows the researcher to identify how knowledge sharing takes place within the community as well as identify who the key contributors are within the network and later identify their role.

There is the use of a social analysis tool to graphically demonstrate the links between individuals, in addition to establishing the ties across the entire network in an attempt to establish patterns. Gephi (Bastian M., Heymann S., 2009) is regarded as being a significant and value graph-based tool applied for social network modelling. Moreover, SNA is used in Study 4 in order to investigate which members were interacting, and to correlate the results obtained from the statistical tests carried out. A sociogram, which may be defined as a social network model graph, is established in an effort to provide a graphical depiction of the various elements of participants in the work setting, including the number of ties, degrees of centrality and betweenness centrality, and the density.

In order to create the network, there was the requirement of two inputs: the individuals who were positioned as actors in the group; and the various interactions between actors. There was the creation of various sociograms to visualise the interactions between actors (see Table 25).

The arrows' *density* —a common measure of connectivity—was applied in order to draw a contrast between the different groups. Such a measure is applied for undirected links, including in networks where there is the interaction and collaboration of people, acting as a calculation of the various actual ties to the potential ties. Network interconnectivity therefore may be extracted when considering the information exchange rate and the common knowledge extent.

Initially, centrality is valuable in establishing central members, especially those contributing to the community. It provides the initial stage to establishing unique knowledge possessed by key members, as well as how they relate to others. Establishing where unique knowledge can be found enables the research to draw meaning from the various members in regard to progression. Figure 29 provides an overview of the different network representations of centrality.

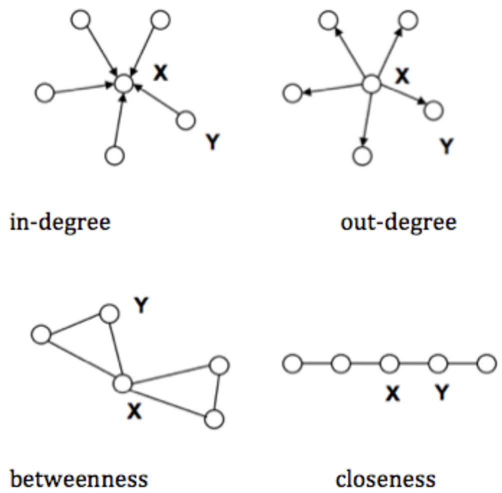


Figure 29: Various network representation of centrality

The concept of *closeness centrality* pertaining to a node is defined by Freeman (1979) as the sum of graph-theoretic distances from all other nodes, where the distance between nodes is recognised as the length (in links) of the shortest path from one to another. *Degree of centrality* recognises and identified a network's central actor, and the degree to which a network is arranged around the three actors. It is common for this to be done by establishing the various subjects with the most ties. When examining centrality, the tie's direction increases in importance in terms of interpreting the key participant's role. Actors with a significant *in-degree* are acknowledged as individually related to just one specific actor. In contrast, those with a high *out-degree* may be associated with various participants, in which case, it may be stated that the knowledge shared across participants is recognised as valuable and reliable by others.

Table 25: Sample of text generated to export to Gephi

```
Source;Target;Type;Id;Label;
Line1: 8;9;Direct;476;G48;
Line2: 8;9;Direct;477;G48;
Line3: 8;9;Direct;478;G48;
Line4: 8;44;Direct;479;G48;
Line5: 8;46;Direct;483;G48;
Line6: 8;46;Direct;480;G48;
Line7: 8;43;Direct;122;G48;
Line8: 43;9;Direct;487;G443;
Line9: 8;46;Direct;482;G48;
Line10: 46;46;Direct;484;G446;
Line11: 8;9;Direct;485;G48;
```

5.6 The Android SMD assigned to complete task

The solution presented for this research was available on an SMD. Therefore a high-level requirement of the solution was to cater for solutions that would address local problems in ubiquitous locations. To achieve this, a data logging service, which monitored up to five applications running according to the position in the stack, logged all errors in a similar way that a software program would do to debug a problem. The most recent applications the user was using on the Android mobile, logs were automatically matched for any errors. This means that errors related to the applications were mapped to services that were not functioning correctly, such as connectivity services including Wi-Fi.

5.6.1 Indoor location positioner

In the solution *YourSpace*, the identification of the location of the participants at the workplace was achieved through the use of an indoor-positioning tool. As mentioned earlier, the tool adopted was an extension of the RedPin Indoor Positioning system. The back-end service was used previously in another study on an Android SMD for indoor location to monitor patients suffering by dementia. Data collected and the way the study was designed gave the author enough information about the how location of participants movement being logged. During the project involving patients suffering with wandering and dementia the indoor location service had to be monitored continuously in order for results to be logged and verified (Cachia, Attard & Montebello, 2014).

For study 4 participants were not monitored in person while using the device so the quality of results played an important role in the exercise. Figure 23 shows the architecture of the open-source implementation through the Wi-Fi Access Point Fingerprinting method. As described by Bolliger (2008) the goals of this system are to provide at least room-level accuracy. The algorithm implemented in RedPin implements a Support Vector Machine (SVM) to match the Wi-Fi Received Signal Strengths (RSS) available in a particular location. The signals recorded during the training data phase are associated with the location closest to the signal. During this research, the user's current location was logged through the application by monitoring the movement. This was achieved by polling, i.e. sending requests from the user's location every five seconds for continuous positioning of a participant without requiring any interaction.

The tool ran as a background service and was configured using an SMD with maps of the location being used. The concept of RedPin is to let the users of the system generate fingerprints in a collaborative way. Thus, it does not require a designated training phase. At first, the system delivers poor accuracies because it would not have had any information about neither the building nor the Wi-Fi access points. However, over time all the fingerprints, which are stored in one common database, allow for easy sharing of different locations and enable a quick mapping of the system. The collaborative approach adopted by RedPin proved to be successful in websites such as Wikipedia or OpenStreetMaps, as people like to contribute and participate.

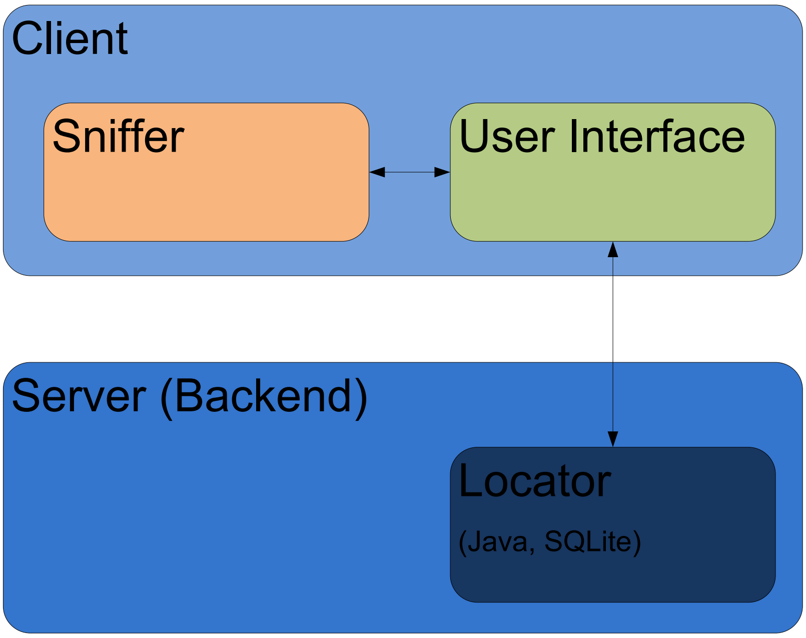


Figure 30: RedPin System Architecture

As seen in Figure 30, the RedPin system is made up of the traditional client-server system architecture. The client consists of two components: the sniffer and the user interface. The sniffer component gathers information on different wireless devices in range in order to create a fingerprint. The user interface of the RedPin client then allows the user to associate the fingerprint collected with a symbolic identifier, such as the room number or name. Also, since Wi-Fi signals may fluctuate, RedPin allows the assigning of multiple fingerprints to the same location.

The RedPin system server provides several services for mobile clients. The first service allows for the storage of fingerprints in a central database that is subsequently called whenever a user wants to store or redefine a location (ref to Figure 31).

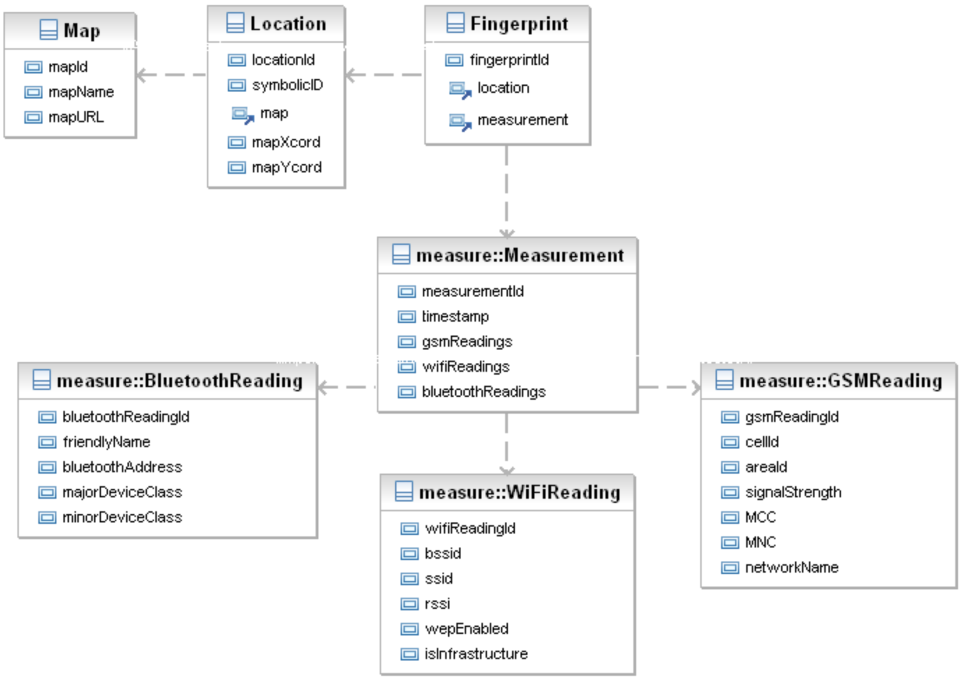


Figure 31: RedPin Data Model

The estimation of the location used in this system is a variation of the k-Nearest Neighbour algorithm. The k-Nearest Neighbour algorithm as defined by Lin, Zhang, Griss and Landa (2009), classifies objects based on the closest distances by a majority vote of the nearest neighbours. In the simplest case, if k=1, then the algorithm chooses the single closest match. The RedPin algorithm, in addition to the effect of signal strength, takes into consideration the number of common access points and also the number of not-common access points to identify the similarity between two fingerprints. It uses a weighted combination of the vector distance and the access points similarity and chooses k=1 to decide the best match.

In her research Bolliger (2008) states that RedPin located the device in the correct room in 9 out of 10 cases. Moreover, it was found that in most cases it is enough to have only one fingerprint per room. Therefore, to get a complete map of a building only a few users are required to contribute to the system. In fact, a survey using the tool showed that when 10 people contributed to the system, the map was completed after just one day. Although one fingerprint per room may be sufficient, RedPin allows multiple fingerprints for the same location, thus making it adaptable to changes in the environment.

An outcome of study 3 of this research was the need to log participant information and experience in a structured way. Diaries were considered useful to log technological obstacles that participants were faced with at the workplace Lazar, Jones, Hackley & Shneiderman (2006) Therefore his research made use of SMDs, which are ideal tools to be used as diaries to record experiences in a structured way and through which users could log technological problems they found challenging at the place of work.

5.6.2 Data Logger Service

This research required users to solve problems within the natural workplace environment. In order to capture knowledge within a ubiquitously environment, as defined in chapter 1, participants must be able to work on the various tasks in different locations at their workplace. This creates a challenge when observing users while interacting with the devices. Therefore during this research it was required to design and implement solutions that can log information that may be useful for the study. This information was considered if the participants did not succeed to solve the tasks assigned or failed to participate by sharing knowledge through the tablet application *YourSpace*.

Therefore a data logger background service was installed on all Android devices assigned to study 4 (ref to chapter 6). An xml file was generated to log the status of the mobile while the participant attempted to solve the assigned tasks. Logs were filtered and only the status of 5 top apps running was noted. The methods included `getRecentApps()` and `ApplicationInfo getApplicationInfo(PackageManager manager, Intent intent)`. The status of WIFI was logged. Additionally information about the mobile was also stored to refer to if needed. To achieve this two methods were implemented: `String getVersionNumber(Context context)` and `String getFormattedKernelVersion()`. Time, date and description of an event were logged in the XML in methods `matchTime(String txt)`, `matchDate(String txt)` and `matchText(String txt)`. An XML file was generated that could be parsed to filter the required information. The method `addToXmlQueue(String log)` was implemented to achieve this. Codes were assigned related to specific errors according to time date and description. The information generated in the XML was checked after each group returned the devices and the study was completed. A sample of parsed log file can be seen in Table 26.

Table 26: Extract generated from XML filter log.

```
20/2/2015 4:45:03 PM ; WIFI ; WIFI STATE DISABLED
20/2/2015 4:49:02 PM ; Internet ; no internet connection available
.
.
.
20/2/2015 4:54:04 PM ; ContactDetailActivity ; Failed to read data from android contacts
provider error code 10
```

5.7 Summary

Throughout the course of this chapter, the research has explained, in depth, the design of the crowdsourcing application and its application in this work. *YourSpace*, the tablet application, was designed in order to address the key aspects needed in order to address the findings garnered through the completion of Study 2 and Study 3. This chapter has further defined the user model applied for this PhD, which captured awareness, confidence, knowledge and sharing aspects. Through highlighting the tracking of data throughout all stages of the process, this was explained. There was the adoption of four modules in order to achieve the final solution through the use of technology that enabled people to share information in real time through the use of a provided mobile device. A social media component was applied in order to link various actions contributed by users when constructing a learning object. Lastly, knowledge patterns were extracted through SPSS and SNA, as discussed in the following chapter.

CHAPTER 6 – *YOURSPACE*: AN EVALUATION STUDY OF TABLET BASED JUST IN TIME CROWDSOURCE COLLABORATIVE SOLUTION

"Coming together is a beginning; keeping together is progress; working together is success."

(Henry Ford)

This chapter, through the completion of an experiment, attempts to demonstrate how participants share knowledge according to their levels of progression. A crowdsourcing computer solution that allows participants to share Just in Time knowledge within a virtual community, which promotes collaboration, is evaluated. The findings derived in the final study are described, which is the evaluation of the collaborative tablet solution, *YourSpace* investigating group dynamics and participants' individual role in the place of work. In particular, it examines how different participants contribute to knowledge-sharing at the workplace when given four different tasks to solve with increasing complexity. Participants were first given a familiar task before progressing to more complex and challenging ones, as they sought to resolve the case studies. This was done to help participants build their confidence in using the *YourSpace* application since the knowledge and skills acquired in the process of resolving an initial familiar task would help them to complete the tasks that followed.

In this final study, the initial hypothesis was necessary to evaluate *YourSpace*, described in the sections below within a natural workplace environment using devices that allowed them to ubiquitously construct knowledge available in real time to all members of their group. Participants were recruited from the Malta International Airport. Malta International Airport (MIA). MIA provided a natural workplace environment that could benefit from ubiquitous and just-in-time support.

6.1 STUDY 4 – Evaluation of *YourSpace* in a natural workplace environment

Study 4 sought to research how technology supported cooperative work within a natural workplace environment. Malta International Airport kindly accepted to allow its employees to take part in the study for the purpose of the evaluation of the research tool designed in this thesis. The aim was to observe in practice how collaborative asynchronous support tasks may be employed, and to analyse the social characteristics of *YourSpace*. This approach is known as "Ethnographic Research" and involves observing users in their natural environment. Designers of collaborative computing systems are increasingly applying ethnography to aid the development of social computing systems (Anon, 2003). The research described in this chapter was applied in typical workplace scenarios and the evaluation was carried out over five weeks, where each group used *YourSpace* for one week. *YourSpace* functionalities are described in detailed in Chapter 5. A review by Hagen, Robertson, Kan & Sadler (2005) has identified, defined and presented a primary framework for understanding methodological responses emerging in current Mobile HCI research. Traditionally, user-centred research has relied mostly on data collection methods based on observation and questionnaires. However mobile technologies are not bound to one particular location at the workplace so different approaches are required to address the research challenge posed by this study.

Study 4 Hypothesis:

H1: The ubiquitous collaborative solution *YourSpace* provides Just in Time support through crowdsourcing at the place of work. Users collaborate with others through *YourSpace* and capture the performed solution ready to be shared with others.

H0: *YourSpace* does not support collaboration at the workplace, nor knowledge capture through crowdsourcing at the workplace within a community that can access the Just in Time tool.

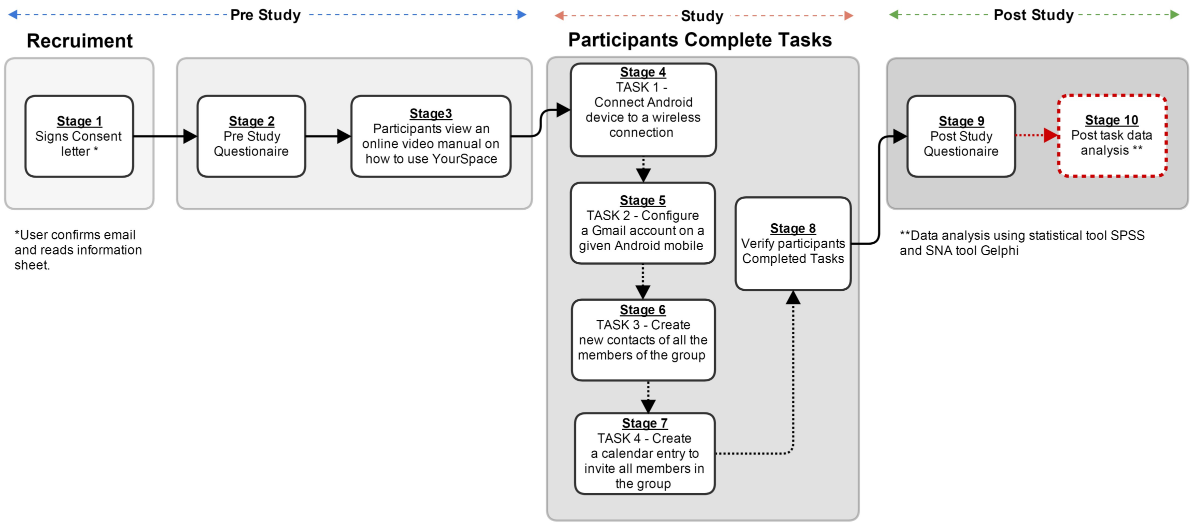


Figure 32: Workflow of study 4

Figure 32 shows the process involved in completing study 4. Data was collected through questionnaires carried out before and after the assigned task. During the use of *YourSpace* other data was also collected as described in chapter 5, such as the type of contribution given by participants, the time spent creating the learning objects, and other similar data, as will be described in detail in the sections below. Quantitative statistical analysis and qualitative data analysis of the results were carried out through social network analysis. Participants were then classified into different progression levels based on their performances when completing the task. This classification was utilised to categorise their contribution within *YourSpace* data tracked through the proposed individual user metric – awareness knowledge sharing confidence. This provided a comprehensive understanding of the success levels of a number of criteria that are listed in section 6.4

6.2 Methodology

As we have seen in chapter 3 Section 3.2, during study 3 held in March 2013, participants were given two familiar tasks to complete using an unfamiliar mobile device. The results and findings from study 3 were used to classify the same participants into the three levels of learner autonomy as described previously in Chapter 2: i) Pedagogy (engagement), ii) Andragogy (cultivation) and iii) Heutagogy (realisation) (Blaschke, 2010). Participants were recruited for study 4 participated in study 3 refer to section 3.2.1.

Each task in study 4 contained several learning objects. These are instances of information (knowledge) created by users via crowdsourcing. The *YourSpace* classified users' into three main roles: 1) Admin & Creator of the learning object, 2) Participant – someone who added to the initial contribution, and 3) Viewer, a person looking and learning from the learning object. Each role was assigned according to how the user contributed to a learning object within *YourSpace*. When encountering a problem participants were asked to create learning objects by sharing the solution/s they used. This solution was made accessible in real time to all other participants through the tablet application *YourSpace.*

As was described in section 2.2, the key concept of Heutagogy, the highest level of learner autonomy, take places when a learner develops independent learning capabilities (Hase & Kenyon, 2007). Therefore, this study was designed to promote a proactive approach, where learners helped each other by creating and using the learning objects to enhance their knowledge on how to solve problems. This process results in a personal experience where the learner himself is both a contributor and a beneficiary during the learning process (Fischer, 2002) thus, seeking to attain heutagogy. Thus through a social network tool learning occurs through an exchange of knowledge between people, who may be peers, who can take the role of a teacher or of a learner. In the first chapter of this thesis one of the objectives had been identified is investigating how members of a group, who have different knowledge and are at different progression levels, behave and the role they play in handling particular tasks, for example, when faced with obstacles.

a) Participants and group formation

Thirty participants were recruited for the study amongst Malta International Airport employees. They were divided in five groups of six participants. After data collection, only data from 28 participants were considered valid for the study. As a result, the fifth group was considered as made up of only 4 participants.

All participants who took part in study 3 and showed interest in being part of the new study were invited again to participate to this final evaluation. Participants were encouraged to attend to this study again through an email invitation, and all of them volunteered. No compensation was given to the participants for their time, but the human resources department approved the study. There were equal numbers of males and females in the study to maintain gender balance.

The participants in each group had different work experiences and job roles and were grouped into five categories according to the type of job they conduct in Malta Airport: *management, senior administrators, clerks, IT related Job and IT Support.* (The job type distribution can be seen in table 27 below). IT related jobs included 5 developers and 3 network technicians.

Table 27: Role and number of participants.

Manager of a team	2
Administrator	11
Clerk	5
IT related Job	8
IT Support	2
Total	28

The groups have been organized in such a way that participants will not be completing the study together if they worked in the same section. Each group had various members with different roles as seen in table 28. There offices where located away from each other to avoid face-to-face collaboration. Participants in groups had completed study 3. The groups had members that had different level of technical knowledge that were randomly chosen to be part of any five groups. Group 5 had IT and administrator roles only because two members where excluded from the study. These two members did not share any knowledge using *YourSpace* tablet applications and when given back the device it was noted that they did not attempt to complete the task. These two participants commented that the reason was they had unplanned work in the airfield. They could not allocate time during the period of the study and as result they did not have access to their devices required for the experiment.

Table 28: Job Role by group

Group	Job Role	N
1	Clerk	1
	Administrator	3
	IT	1
	Manager of Team	1
2	Clerk	1
	Administrator	2
	IT	1
	IT Support	2
3	Clerk	2
	Administrator	2
	IT	1
	IT Support	1
4	Clerk	1
	Administrator	3
	IT	1
	Manager of Team	1
5	Administrator	1
	IT	3

As listed in table 28 all groups had various members that had different job roles. Group 5 only had administrator and IT related jobs. All members came from different departments.

b) Instrumentation

Participants were asked to view an online video manual, which described how the application worked. The study was carried out with each of the five groups separately. Four tasks were given to each participant for this study[4] with the following instructions:

[4] www.conradattard.com/yourspace

a) Connect your Android device to a nearby wireless connection through 3G or WIFI at various points around your workplace that may include 3G and WIFI and visit an assigned web page (also in study 3)
b) Configure a Gmail account on a given Android mobile (same as in Study 3) and when complete send an email to all team members through the given mobile device.
c) Create new contacts of all the members of the group that are accessible on the Google account.
d) Create a calendar entry to invite all members in the group to meet at a defined venue to carry out the study.

The mobile devices used in this study were different from those used for study 3. For study 4 each participant was given the same set of SMDs i.e. an Android device that supports Jelly Bean platform, a tablet device 7inch screen supporting a Windows 8.1 operating system and MIFI, a wireless router that acts as a mobile Wi-Fi hotspot, to connect through Wi-Fi with the device and to 3G through Internet (see Figure 33).

Figure 33: Devices used for the study – Mobile, Tablet and Mi-fi

The interaction time of a participant with *YourSpace* was logged. As described in chapter 5 the interaction time is defined as the length of time that a particular learning object was viewed. Once a participant exited *YourSpace* the time was no longer logged. Additionally, in order to avoid the application from being kept idle, a screen saver was enabled on the tablet device, which was configured to activate 30 seconds after the device was in an idle position. This limited the possibility of the participants to become distracted from *YourSpace* or to focus on other things not related to the task.

c) Procedures

All case studies were carried out on the Android smart mobile device, a Google phone that was provided. Concurrently, each user was allowed to access the various tasks using a tablet device synchronised with the Android mobile device, supporting Windows 8.1, on which ran the application, *YourSpace*. Each task was available online and users were given four options: i) to create a solution, ii) to participate by sharing additional knowledge about an already published solution, iii) provide a constructive question or iv) to quit.

Figure 34 demonstrates the various stages that participants followed to create a learning object. Each device (see Figure 33) made use of a cloud solution to store images that could be retrieved from all devices and desktop computers (which were kept synchronised). The participant could capture a screen shot at any stage while completing any given task by clicking simultaneously on the power and lower volume button of the assigned Android device. Using this approach participants found the images needed to create learning objects within the respective cycles. These images were synchronised on their given tablet while completing the task and could be easily accessible through *YourSpace* (as described in Chapter 5). Only images created by the participants were available. Participants completed the tasks assigned to the study by accessing the documents or pictures available on their devices (see Figure 34).

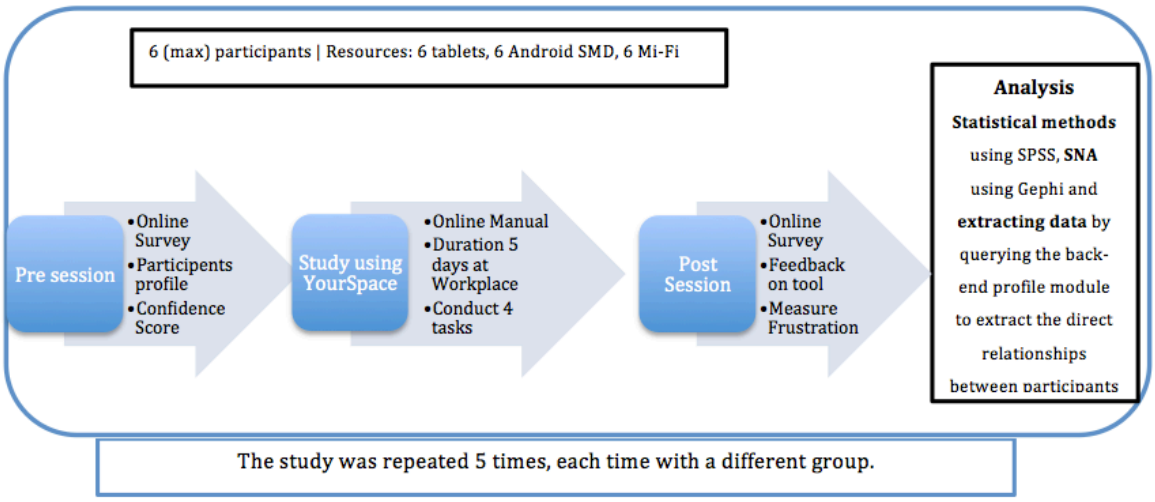


Figure 34: Overview of how study 4 was conducted.

Analysis was done using statistical methods as described in section 3.2.2. The study also made use of a social network analysis tool Gephi (Bastian M., Heymann S. 2009) to measure primarily density, centralization and centrality to describe the communication structure between peers for every group. By extracting data as nodes and edges from the monitoring module data logged including users profile and remarks, comments suggested for every instance, a graph was created for each group to understand the flow of knowledge from one participant to another see section 6.5.4. The final analysis was done by extracting data by querying the back-end module and checking the results mapping the remarks and comment participants suggested with the type of ICON created by the participants see section 5.4.4.

6.3 Results Study 4– Evaluation of *YourSpace* Interface and Functions.

The results of the study for which participants used *YourSpace* are presented. Initially the first sets of results focuses on the usability of the research tool proposed for the study, the tablet application *YourSpace*, while second set of results focuses on the use of the learning object and the experience of participants while capturing and sharing knowledge using the tool.

The use of crowdsourcing collaborative solution requires users to engage with computer solution design for this PhD. Therefor in the following sections the findings of the evaluation of *YourSpace* interface and functions are reported.

The majority of the participants (93%, n= 26) managed to complete the four tasks. Some participants (7%, n = 2) failed to complete task 3 and task 4. No log was recorded for two individuals in-group 5 and therefore the data from these participants could not be analysed (encoded as "None" in table 29 below).

Table 29: Success in completing the given tasks.

	NONE	Task 1	Task 2	Task 3	Task 4
All participants	2	28	28	26	26
Men	1	14	14	14	14
Women	1	14	14	12	12

After all tasks were completed by each group the devices were verified to ensure that participants managed to achieve the goals assigned and a log was taken as described in Chapter 5. Similar tests as discussed in chapter 3 section 3.2.2 were carried out using a statistical analysis of data by using SPSS. Additionally a qualitative analysis of the data collected from pre- and post- session questionnaires and from the data logged through *YourSpace,* was carried out.

6.3.1 *YourSpace* Icons

While carrying out the tasks, participants had the option to choose from eight icons with every instant created, as described in section 5.4.4. Participants dragged and dropped these icons on the images they created or when suggesting or querying an instance. The participants' choice allowed the researcher to investigate how users interacted with each stage.

In the final questionnaire participants were asked to indicate which of the various icons of *YourSpace* where most useful when solving a problem.

Table 28 shows the rating score of each ICON given by the participants, which gave insight to the researcher to understand which ICON was the most helpful for participants when explaining how a specific problem was solved. The mean rating score of 0-4 was used was 0 corresponds not useful and 4 correspond to extremely useful. Friedman test was used. The rational of using the Friedman test is that we want to compere the mean rating scores provided for a number of related statements all meanings on the Likert scale. Results show that the mean score provided for pointers (2.93) was the largest indicating most that it is the most useful drag and drop icon. This followed by very good sign (2.79), wrong sign (2.32) question mark (2.29) and alert sign (1.96) (see Table 30). The difference between these mean rating score is significant since the p value is approximately (0.00) is less than the 0.05 criterion.

Table 30: Scoring of *YourSpace* icons

From the following ICONS, which best helped you understand how to solve the problem?	Mean	Std. Deviation
Question Mark	2.29	1.243
Very Good Sign	2.79	1.287
Alert Sign	1.96	1.232
Wrong Sign	2.32	1.249
Pointers	2.93	1.412

$X^2(4)=21.792, p<0.001$

The participants scored the 'very good' icon and the pointer the most useful sign when trying to understand how to solve a problem. No ICON was rated not helpful.

6.3.2 Rating online manual used as a tutorial to learn about the device setup and how to participate using *YourSpace*.

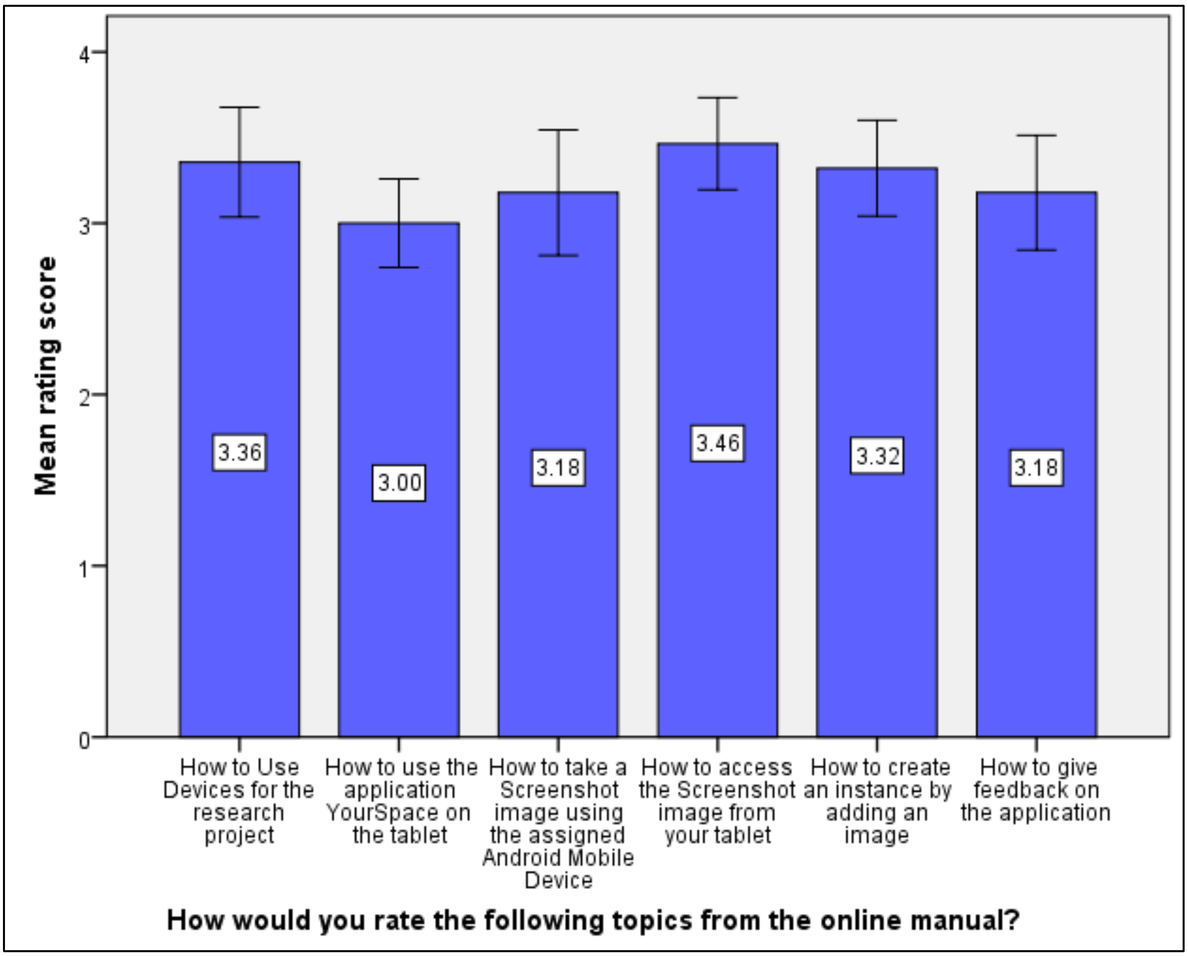
The online video, which was shown to the participants to help them familiarise with the application *YourSpace,* was evaluated. In particular the participants were asked: *How would you rate the following topics from the online manual based on their usefulness in understanding how to use YourSpace*. A list of topics was provided, as listed in table 31.

A Friedman test was used to compare the mean rating scores provided (see table 31). The mean rating score ranged from 0-4 where 0 corresponded to a low rating and 4 corresponded to a high rating.

Table 31: How would you rate the following topics from the online manual?

	Mean	Std. Deviation
How to Use Devices for the research project	3.36	0.826
How to use the application *YourSpace* on the tablet	3.00	0.667
How to take a Screenshot image using the assigned Android Mobile Device	3.18	0.945
How to access the Screenshot image from your tablet	3.46	0.693
How to create an instance by adding an image	3.32	0.723
How to give feedback on the application	3.18	0.863

$X^2(5) = 16.892, p = 0.005$



As can be seen in table 31 all mean rating scores provided by participants for the six topics where high (a mean of 3 or more), indicating that, on average, the participants considered the topics of the online manuals useful.

The mean rating score for manual 4, "*How to access the Screenshot image from your tablet*" scored the highest (3.46), indicating that participants found it the most helpful and informative. This is followed by the video manual 5, "*How to create an instance by creating an image*" (3.32), video manual 1 - *How to Use Devices for the research project* (3.36), video manual 3 - *How to take a Screenshot image using the assigned Android Mobile Device* and video manual 6 - *How to give feedback on the application* (3.18) and video manual 2 - *How to use the application YourSpace on the tablet* (3.00). A statistically test was carried out on the mean rating scores and the difference between them was found to statistically significant (p = 0.005). The results, which have a 95% confidence interval, provide a range of values for the actual mean rating scores for the online manuals. This means that if the whole population (people at the workplace using SMD) had to be studied the result provided would be similar to that obtained from this study. When two confidence intervals overlap considerably the respective mean rating scores is comparable. When two confidence intervals are disjointed or overlap slightly this indicates that the respective mean scores differ significantly.

6.3.3 How did users ultimately solve a problem using *YourSpace* and what problems did they find when using the devices throughout the experiment?

Participants were asked whether they experienced any difficulties during the study using the various components of the devices, namely: 1) the tablet 2) the Android mobile, 3) the Mi-fi and 4) Internet connectivity. For each of the four main components of the device, participants were asked to rate difficulties not related to the assigned tasks such as powering the device, accessing the application *YourSpace*, logging into the system and basic functionalities need to operate the devices. The mean rating score ranged from 0-4 where 0 corresponded to a low rating i.e. no problems and 4 corresponded to a high rating indicating they found difficulties.

Table 32: Problems encountered when using the tools assigned for study

	Mean Rank
Using the Tablet	1.96
Using the Android mobile	1.51
Using the MIFI	1.46
Using Connectivity	2.64

The mean rating score for the first three components (the tablet, the Android mobile and the Mi-Fi) did not exceeded 2, which indicates that participants found no problems when using the devices. However, when asked about Internet connectivity it was observed that although most people did not encounter difficulties, 33% of them did (Mean Score 2.64) (see Table 32).

Table 33 lists a number of reasons how participants ultimately solved the assigned task. "Valid Percent," is a percentage that does *not* include missing cases. When asked, most participants stated that they referred to *YourSpace* when they were stuck (n=12, 42.9%) asked questions through *YourSpace* tablet application when they stuck (n= 3, 10.7%), others figured out a way to fix the problem by themselves (n=1, 3.6%), while another group ignored the problem or found an alternative solution (n= 7, 25.0%) (See Table 33).

Table 33: How did you ultimately solve this problem?

	Frequency	Valid Percent
I used *YourSpace*, tablet application to know more what others did	12	42.9
I ignored the problem or found an alternative solution	7	25.0
I asked someone for help	4	14.3
I asked questions through *YourSpace* tablet application when I was stuck	3	10.7
I figured out a way to fix it myself without help	1	3.6
I was unable to solve it	1	3.6

6.4 Use of *YourSpace* at Malta International Airport.

In the following sections, the findings about the use of *YourSpace* by the Malta International Airport employees are described. In chapter 5 we described the various techniques of how data is being tracked and extracted through the tablet application *YourSpace*. The use of SNA and algorithm used to calculate the model proposed will be described. Statistical analysis was conducted to further collect the results. Findings are presented to investigate group dynamics and the type of contribution according to the participant's individual role at their workplace.

6.4.1 Clarity and Location of where tasks have been completed.

Most of the participants (93%, n=26) succeeded in completing the given tasks using the collaborative solution *YourSpace*, which were to connect the mobile to the Internet, configure to a Gmail account, create a new contact, and create a calendar entry. When these results are compared with those obtained in Study 3 (described in section 3.2), in which only 12 of participants (13%) succeeded in solving familiar problems with unfamiliar devices by themselves, it is clear that the collaborative solution *YourSpace* was a crucial tool for supporting the participants to complete the tasks. Table 34 and Table 35 show the participants' answers to the post-questionnaire. The mean rating score ranges 0-4 was 0 corresponds to "did not understand the task" while 4 corresponds to "understood task". As shown in Table 34, the majority of the participants stated that they understood what was required across all of the tasks.

Table 34: Did you understand clearly what was expected from you for every task?

(Mean rating score ranges 0-4)

	Number of participants	Mean	Std. Deviation
Task 1 - Connect your Android mobile device to a WIFI and browse Internet	28	3.82	0.476
Task 2 - Configure a Gmail account using an app and send an Email using your Android Mobile Device	28	3.43	0.742
Task 3 - Create new contacts that are available on your Gmail account	28	3.32	0.983
Task 4 - Creating an appointment using the calendar app on your Android Mobile Device and schedule/update an hour session for feedback focus group	28	3.43	0.920

Participant locations at the time of completing the tasks was detailed. Table 35 lists a number of places in which tasks were carried out at the workplace using the Android Mobile Device. Most of the subjects carried out the tasks at their office (Android Device n= 17, 63%),while others using their Android mobile "away from your office but within workplace" (n=10, 37%).

Table 36 lists a number of places in which participants shared knowledge in the work setting using the *YourSpace* tablet application. Most of the subjects carried out the tasks at their office (n=15, 62.5%) , whilst somewhere away from the office but in the workplace was the second most common location . The extracts taken from the device's log further emphasised that the participants spent most of their time in one specific location upon beginning the task.

The subjects did not always carry out the tasks in the same place, however, especially when completing tasks on the AMD.

Table 35: Places in which tasks were carried out in the workplace using the Android Mobile Device

(Max no of participants – 28)

Android Mobile Device	Number of participants	Percentage of Cases
Your Office	17	63.0%
Meeting Room	5	18.5%
Colleague Office	3	11.1%
Canteen	2	7.4%
Conference or Meeting Room	9	33.3%
Kitchen	2	7.4%
Away from your office but within workplace	10	37.0%

Table 36 lists places in which participants shared knowledge in the work setting using the *YourSpace* tablet application

(Max no of participants – 28)

Windows Tablet Solution	Number of participants	Percentage of Cases
Your Office	15	62.5%
Meeting Room	2	8.3%
Colleague Office	4	16.7%
Conference or Meeting Room	6	25.0%
Kitchen	1	4.2%
Away from your office but within workplace	7	29.2%

6.4.2 Process Maps—Summary of Learning Objects by Tasks

The following diagram (Figures 36 – 39) provides a summary of the results, categorised by task, comprising the different stages through which the subjects progressed throughout the course of the study.

The results were compiled into different process maps, as shown in figures 36–39, where each of the stages, referred to as 'touch points' in the pictures and referenced with a number, detailed an instance of the task, where all of the touch points came together to create the complete task (or learning object), as carried out through the assigned SMD. There was the creation of a process mark for all of the tasks, in addition to a table detailing all of the individual touch points (referenced by the subjects themselves), linked to that specific task (see tables 37–40). The use of colour-coding was implemented around all of the touch points to highlight whether a touch point was a pain point (red), was created by a particular group (using blue, green, magenta, orange and purple to indicate each group) or to show information a user was happy to share (yellow).

Four stages are involved in the process map, namely anticipate need, enter task, engage, and exit reflect. As discussed in Chapter 5, the data were extracted from *YourSpace*, with a number of key elements identified, which were detailed in the form of four layers in the process maps, namely *touch points*, representative of the various instances created by participants, *Internal Interactions*, *Description of Pain Points* and *Results by Group*. The first of these (touch points), notably one for each instance, may be defined as those actions carried out by participants to achieve a goal (see Figure 35). Various internal interactions are necessary that are not visible to the user when completing a task. A number of the tasks are recognised as pain points, and are scored by the participants as obstacles, ranging 0–4. The components making up the process maps are discussed in further detail below:

Stages (Columns in figures 36–39): Anticipating need is the first stage, during which touch points are recognised by the study when assigning the task. The way in which the tasks are carried out is chosen by the participants. The second stage highlights the method implemented. The subsequent stage comprises various touch points that the individuals have selected to share with information on how the instances may be completed. These may differ from one group to the next in line with the knowledge and skills held by the participants on the subject. Some of the groups might opt to focus on problems and create a number of more in-depth learning objects with few instances. The touch point concluding the process for the learning object created is exit or reflection.

The largest amount of touch points, or instances, devised by the individuals for a specific task of learning object are detailed and categorised in each of the process maps in line with the level of difficulty, which are represented by the red colour used under the Touch Points label (see figures 36–39). The *YourSpace* application logged the touch points, with a summary of the results provided in the process maps through categorising the various parts identifiable to the subjects, and how the individuals interacted with each of the touch points.

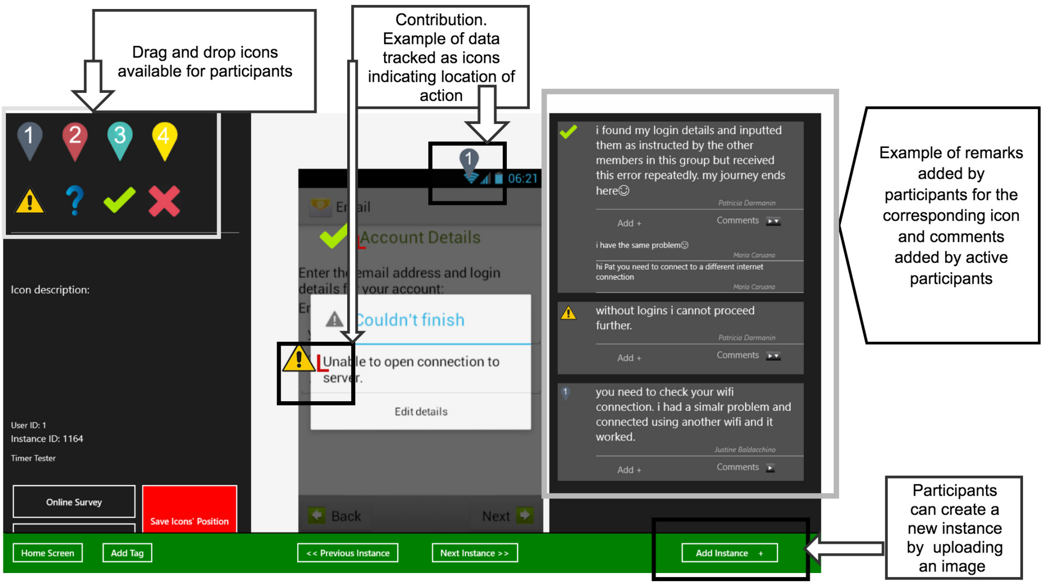


Figure 35: An example of an instance with different actions devised by the subjects

The **Internal Interactions** are defined as the events occurring in the background at specific instances (or touch points). **Pain Points (PPTs)** are defined in line with the score attributed by subjects and verified for the following criteria.

1) The logging of the interaction type and the amount of help required by the individuals;
2) The Type of learning objects created, including those the subjects specifically created for the PPT action;
3) Rated instances (0–4) to provide an indication of difficulty. 0 represents not difficult whilst 4 indicates highly difficult.

4) Type of icon used, including "Attention", "Question Mark" or "Wrong" ICON (see Table 22). Lastly, the completion of the task was verified and logged in line with whether the subjects were successful in satisfying the goal, which was done by checking each group's SMD following study completion.

The key results are summarised in line with the task is detailed in another category (Category 5). Each of the PPTs was summarised by detailing the amount and type of interactions occurring amongst the subjects in an effort to complete the touch point.

The process map's last row presents the results achieved by each group for that specific task.

Task 1	Anticipate	Enter	Engage	Exit/Reflect
TOUCH POINTS Group 1	1	2	3, 4, 5 A, 6 B, 7, 8, 9, 10 C, 11	12
Group 2	1	2	3 A, 4 B, 5, 6 C	7
Group 3	1	2	3, 4, 5 A, 6 B, 7 C	8
Group 4	1	2	3, 4, 5 A, 6 B, 7, 8, 9, 10 C	11
Group 5	1	2	3 A, 4 B, 5, 6 C	7
Lines of visibility **Internal Interactions**	Participants where given a task by accessing YourSpace website through the tablet application.	Know what Wi-Fi connections provide Internet at workplace	Wi-Fi connections have a symbol indicating that it is password protected or free to use. / Password needs to be provided. If participant does not have the information he or she may ask through YourSpace. Users supported their peers in their group for Groups 2,3 telling them how to obtain it. Others used free Wi- Fi. The location or where to configure the Wi-Fi had important role. The Wi-Fi must not only provide network connection status but also Internet.	Participants accessed through a browser of their choice the assigned website and saw a message Success! (Verification that task was completed)

Description of Pain Points (PPT)

PPT A
Challenge no correct credentials
Type of image indicated Error Failure
Mean Level of difficulty rated 3.48
Attention ICON was used.

PPT B
Challenge confusing which Wi-Fi to choose.
Showing different network names confusing participants
Mean Level of difficulty rated 3:00
Wrong and Questions ICON used.

PPT C
Challenge no internet error in browser.
Error message page cannot be displayed
Mean Level of diffculty rated 2.98
Questions ICON

Results by Group. (Cycles, Instances, Icons, Comments, Remarks of successful Learning Objects)

	C1
IN:	12
IC -P:	10
IC -A:	3
IC - Q:	5
IC - R:	12
IC -W:	1
CO:	18
RE:	26

	C1	C2	C3	C4	C5
IN:	3	3	2	1	7
IC -P:	-	-	-	-	4
IC -A:	-	-	-	-	-
IC - Q:	-	-	-	-	-
IC - R:	3	3	2	1	7
IC -W:	-	-	-	-	-
CO:	1	-	-	-	3
RE:	3	3	2	1	4

	C1	C2	C3
IN:	1	8	1
IC -P:	-	-	-
IC -A:	-	1	-
IC - Q:	-	2	-
IC - R:	1	8	1
IC -W:	-	-	-
CO:	-	4	-
RE:	1	9	1

	C1
IN:	11
IC -P:	12
IC -A:	1
IC - Q:	-
IC - R:	11
IC -W:	-
CO:	10
RE:	23

	C1	C2	C3
IN:	7	2	2
IC -P:	12	-	2
IC -A:	-	-	-
IC - Q:	-	-	-
IC - R:	7	2	2
IC -W:	-	-	-
CO:	13	-	1
RE:	6	2	4

Table 37 Task 1 – Topic: Connect Android SMD to Wi-Fi and browse Internet.	Touch Points per group				
Description of Touch Points	Group 1	Group 2	Group 3	Group 4	Group 5
Detailed account starting from the home screen	1	1	1	1	1
You get to this screen	2	2	2	2	2
Select Wi-Fi	3		3	3	
You get to a selection of Wi-Fi connections to choose from	4			4	
PPTA | Inserted password which I'm sure was correct but it gave the error: failed to authenticate	5	3	5	5	3
PPT B | Found another Wi-Fi connection with the name default	6	4	6	6	4
Browsing the internet via the default connection...whatever that may be	7	5		7	
After Wi-Fi connection open the browser	8			8	5
Click on URL tab at the top of the window	9			9	6
PPTC | Input link provided by task description on assigned website YourSpace	10	6	7	10	
Message that Wi-Fi connection is successful and case study complete:)	11				7
Browsing the net	12	7	8	11	

KEY	Description of keywords
Touch Points	Are instances created by participants to construct the require learning object Touch points included the maximum possibilities all groups have opted for when creating the learning objects. The colour code indicates the various groups or status.
Remark (RE)	Once a new instance is created a remark by default is required. Participant may comment and suggest
IN	Instance
CO	Comments
IC - P	Pointers
IC - A	Alert
IC - Q	Question
IC - R	Right
IC -W	Wrong
Red	Pain Point (PPT)
Yellow	Not Required Touch Point
Orange	GROUP 1
Blue	GROUP 2
Green	GROUP 3
Purple	GROUP 4
Magenta	GROUP 5

Task 2	Anticipate	Enter	Engage	Exit/Reflect
TOUCH POINTS Group 1	1	2	3, 4, 5 D, 6, 7, 8, 9, 10, 11, 12	13 E
Group 2	1	2	3 D, 4, 5, 6	7 E
Group 3	1	2	3 D, 4, 5, 6	7 E
Group 4	1	2	3, 4, 5 D, 6, 7, 8, 9, 10	11 E
Group 5	1	2	3, 4 D, 5	6 E

Lines of visibility

Internal Interactions	Participants where given a task by accessing YourSpace website through the tablet application.	Choose a Gmail APP or default Mail APP available on the SMD	Selecting from various Email Accounts when choosing the Default Mail APP. Internet is required.	Participants where assigned an email address and password that needs to be authenticated. Internet is required. Connection to a Wi-FI with Internet is the first requirement. Depending on the APP chosen the participant had to input requested information when asked. Confusion was created when different APPs where being explained at the same time.	Participants send emails to each other and through the assigned email. (Verification that task was completed)

Description of Pain Points (PPT)

PPT D

Challenge wrong password no authentication
Image showing Error authencation
Mean level of difficulty rated 3.20
Question and Attention ICON

PPT E

Challenge No internet, and error not understood
Image showing error message with configuraiton settings in background
Mean level of difficulty rated 3.90
Question and Attention ICON

Results by Group.

(Cycles, Instances, Icons, Comments, Remarks of successful Learning Objects)

	C1	C2
IN:	13	6
IC -P:	-	-
IC -A:	-	1
IC - Q:	-	2
IC - R:	1	6
IC -W:	2	-
CO:	-	4
RE:	1	9

	C1	C2
IN:	7	5
IC -P:	-	-
IC -A:	1	-
IC - Q:	2	-
IC - R:	7	5
IC -W:	2	-
CO:	-	-
RE:	7	5

	C1
IN:	7
IC -P:	2
IC -A:	1
IC - Q:	-
IC - R:	7
IC -W:	2
CO:	13
RE:	20

	C1
IN:	11
IC -P:	17
IC -A:	-
IC - Q:	2
IC - R:	13
IC -W:	-
CO:	17
RE:	27

	C1	C2	C3
IN:	5	2	6
IC -P:	-	-	1
IC -A:	1	-	4
IC - Q:	1	-	-
IC - R:	5	2	6
IC -W:	1	-	1
CO:	3	2	5
RE:	6	2	9

<table>
<tr><td>Table 38. Task 2 – Topic: Configure a Gmail account using an APP and send an email using your Android</td><td colspan="5">Touch Points per group</td></tr>
<tr><td>Description of Touch Points</td><td>Group 1</td><td>Group 2</td><td>Group 3</td><td>Group 4</td><td>Group 5</td></tr>
<tr><td>Click on the email app</td><td>1</td><td>1</td><td>1</td><td>1</td><td>1</td></tr>
<tr><td>A window to set up the account will open. Press next until you get to the next window shown in the next instance</td><td>2</td><td></td><td>2</td><td>2</td><td>2</td></tr>
<tr><td>Select Gmail and press next</td><td>3</td><td>2</td><td></td><td>3</td><td></td></tr>
<tr><td>Input username and password</td><td>4</td><td rowspan="2">3</td><td></td><td>4</td><td></td></tr>
<tr><td>PPT D | Error received because of incorrect password</td><td>5</td><td>3</td><td>5</td><td>3</td></tr>
<tr><td>Further email settings. I left them unchanged and just pressed next</td><td>6</td><td>4</td><td>4</td><td>6</td><td>4</td></tr>
<tr><td>Option to change name shown when emails are sent. I kept this unchanged too.</td><td>7</td><td></td><td></td><td>7</td><td></td></tr>
<tr><td>Inbox</td><td>8</td><td></td><td>5</td><td>8</td><td></td></tr>
<tr><td>New email window</td><td>9</td><td>5</td><td></td><td></td><td></td></tr>
<tr><td>Automatically takes you back to inbox</td><td>10</td><td></td><td></td><td></td><td></td></tr>
<tr><td>First step in creating email</td><td>11</td><td rowspan="2">6</td><td rowspan="2">6</td><td>9</td><td rowspan="2">5</td></tr>
<tr><td>Send Email</td><td>12</td><td>10</td></tr>
<tr><td>PPT E | Error when sending email. No internet error message</td><td>13</td><td>7</td><td>7</td><td>11</td><td>6</td></tr>
<tr><td>I found my login details and inputted them as instructed by the other members in this group but received this error repeatedly. My journey ends here</td><td>14</td><td></td><td></td><td></td><td></td></tr>
</table>

KEY	Description of keywords
Touch Points	Are instances created by participants to construct the require learning object Touch points included the maximum possibilities all groups have opted for when creating the learning objects. The colour code indicates the various groups or status.
Remark (RE)	Once a new instance is created a remark by default is required. Participant may comment and suggest
IN	Instance
CO	Comments
IC - P	Pointers
IC - A	Alert
IC - Q	Question
IC - R	Right
IC -W	Wrong
Red	Pain Point (PPT)
Yellow	Not Required Touch Point
Orange	GROUP 1
Blue	GROUP 2
Green	GROUP 3
Purple	GROUP 4
Magenta	GROUP 5

Task 3	Anticipate	Enter	Engage	Exit/Reflect
TOUCH POINTS Group 1	1	2	3, 4, 5, 6 F, 7, 8, 9, 10, 11, 12, 13 G	14 H
Group 2	1	2	3 F, 4, 5, 6 G	7 H
Group 3	1	2	3, 4, 5, 6 F, 7, 8, 9, 10, 11, 12, 13 G	14 H
Group 4	1	2	3, 4, 5, 6 F, 7, 8, 9, 10, 11, 12, 13, 14, 15 G, 16, 17	18 H
Group 5	1	2	3 F, 4 G, 5	6 H
Lines of visibility				
Internal Interactions	Participants were given a task by accessing YourSpace website.	Choice of two APPs available on Android to create a contact.	The Gmail APP automatically synchronizes the contact with email and is available email account. This requires you to enable synchronizations form setting. / 3 Groups created Gmail contacts and 1 group created contacts from the address book and required synchronization and 1 group created two learning objects explaining both of them. The required interactions in case 1 from Gmail is to create a contact and its automatically synchronized to the pre configure email account (Task 2). Case 2 requires the user to go to settings and enable synchronization.	Success is verified by viewing all contacts in Address book.

Description of Pain Points (PPT)

PPT F
- Challenge no Internet connection
- Image showing error cannot connect to Gmail.
- Mean Level of difficulty 3.40
- Attention and Wrong

PPT G
- Challenge participants could see contact list
- Image participants taht failed could not display
- Mean Level of difficulty rated 2.90
- Question Mark

PPT H
- Challenge those that did not enable sychronisation couldnt see the message
- Desmostrate Contacts
- Mean Level of difficulty rated 3.20
- Questions Marks

Results by Group.

(Cycles, Instances, Icons, Comments, Remarks of successful Learning Objects)

	C1	C2	C3	C4
IN:	5	1	14	2
IC -P:	1	-	9	2
IC -A:	-	-	-	-
IC - Q:	-	7	-	-
IC - R:	5	1	14	2
IC -W:	-	-	-	1
CO:	2	3	-	-
RE:	5	2	14	5

	C1
IN:	7
IC -P:	5
IC -A:	-
IC - Q:	-
IC - R:	8
IC -W:	-
CO:	-
RE:	5

	C1
IN:	6
IC -P:	3
IC -A:	-
IC - Q:	-
IC - R:	8
IC -W:	-
CO:	-
RE:	12

	C1	C2
IN:	15	20
IC -P:	21	15
IC -A:	4	2
IC - Q:	1	2
IC - R:	7	5
IC -W:	1	2
CO:	20	9
RE:	36	41

	C1
IN:	11
IC -P:	2
IC -A:	-
IC - Q:	6
IC - R:	11
IC -W:	-
CO:	18
RE:	7

<table>
<tr><td>Table 40 Task 3 – Topic: Create new contact that is available on your Gmail</td><td colspan="5">Touch Points per group</td></tr>
<tr><td>Description of Touch Points</td><td>Group 1</td><td>Group 2</td><td>Group 3</td><td>Group 4</td><td>Group 5</td></tr>
<tr><td>select contacts icon</td><td>1</td><td rowspan="2">1</td><td>1</td><td>1</td><td rowspan="2">1</td></tr>
<tr><td>select list of contacts</td><td>2</td><td>2</td><td>2</td></tr>
<tr><td>add account</td><td>3</td><td rowspan="2">2</td><td>3</td><td>3</td><td>2</td></tr>
<tr><td>choose between new and existing account</td><td>4</td><td>4</td><td>4</td><td></td></tr>
<tr><td>login details</td><td>5</td><td></td><td>5</td><td>5</td><td></td></tr>
<tr><td>PPT F | error message</td><td>6</td><td rowspan="2">3</td><td>6</td><td>6</td><td rowspan="2">3</td></tr>
<tr><td>select your network</td><td>7</td><td>7</td><td>7</td></tr>
<tr><td>success!</td><td>8</td><td></td><td></td><td>8</td><td></td></tr>
<tr><td>back to contacts</td><td rowspan="2">9</td><td></td><td>8</td><td>9</td><td></td></tr>
<tr><td>select add contact...</td><td rowspan="2">4</td><td>9</td><td>10</td><td rowspan="3">4</td></tr>
<tr><td>choose your account</td><td>11</td><td>10</td><td>11</td></tr>
<tr><td>insert name of your contact</td><td>12</td><td>5</td><td></td><td>12</td></tr>
<tr><td>you can add more fields if need be</td><td></td><td></td><td>11</td><td>13</td><td></td></tr>
<tr><td>select Google</td><td></td><td></td><td>12</td><td>14</td><td></td></tr>
<tr><td>PPT G | redirected back to contact list</td><td>13</td><td>6</td><td>13</td><td>15</td><td rowspan="2">5</td></tr>
<tr><td>go to phonebook</td><td></td><td rowspan="3">7</td><td></td><td>16</td></tr>
<tr><td>PPT H | check your contact list</td><td rowspan="2">14</td><td rowspan="2">14</td><td>17</td><td rowspan="2">6</td></tr>
<tr><td>photo of Gmail account accessed on tablet... showing synced contacts</td><td>18</td></tr>
</table>

KEY	Description of keywords
Touch Points	Are instances created by participants to construct the require learning object Touch points included the maximum possibilities all groups have opted for when creating the learning objects. The colour code indicates the various groups or status.
Remark (RE)	Once a new instance is created a remark by default is required. Participant may comment and suggest
IN	Instance
CO	Comments
IC - P	Pointers (ICON)
IC - A	Alert (ICON)
IC - Q	Question (ICON)
IC - R	Right (ICON)
IC -W	Wrong (ICON)
Red	Pain Point (PPT)
Yellow	Not Required Step of configuration Touch Point but contains additional information
Orange	GROUP 1
Blue	GROUP 2
Green	GROUP 3
Purple	GROUP 4
Magenta	GROUP 5

Task 4	Anticipate	Enter	Engage	Exit/Reflect
TOUCH POINTS Group 1	1	2	3, 4, 5, 6, 7, 8, 9 I, 10, 11, 12	13 J
Group 2	1	2	3, 4 I, 5	6 J
Group 3	1	2	3, 4, 5, 6 I, 7	8 J
Group 4	1	2	3, 4 I, 5	6 J
Group 5	1	2	3, 4, 5, 6, 7, 8, 9 I, 10, 11, 12	13 J

Lines of visibility

Internal Interactions				
Participants where given a task by accessing YourSpace website through the tablet application.	Enter Configured Calendar APP	An Assigned Gmail account must be configure on the SMD. The calendar APP chosen will be associated with the Gmail account and Contacts	Participants need to create and event while connected to Internet to be able sent and invitation to the peers. The contact, email account need to associated to the calendar APP.	Participants invited their peers when creating a calendar entry. (Verification that task was completed)

Description of Pain Points (PPT)

PPT I
Challenge: not accessing the proper gmail account to see contacts created
Image showing a calendar app with option to add contact
Mean level of diffuculty rated 3:40
Questions and Attention ICON

PPT J
Challenge: Error not sending invites
Image Showing Error request failed
Mean Level of difficulty rated 3:00
Questions ICON

Results by Group.
(Cycles, Instances, Icons, Comments, Remarks of successful Learning Objects)

	C1	C1	C1	C1	C1
IN:	13	6	8	6	13
IC -P:	1	-	-	6	3
IC -A:	1	-	1	2	1
IC - Q:	1	3	-	-	2
IC - R:	17	6	8	6	13
IC -W:	-	-	2	-	-
CO:	4	2	6	3	9
RE:	28	3	5	12	13

Table 40. Task 4 - Topic: Create an appointment using the calendar APP on your Android mobile device and invite others to join a meeting	Touch Points per group				
Description of Touch Points	Group 1	Group 2	Group 3	Group 4	Group 5
from main welcome screen choose which APP you used to create email.	1	1	1	1	1
first thing to do is choose the calendar app on your smartphone	2	2	2	2	2
calendar opens and you should see something like this	3				3
write down the name of the event and its location	4	3	3		4
choose also date in which event will take place and timings	5			3	5
and voilà...your calendar appointment has been created...bravo!!!!	6		4		6
scroll to select required date and time to emend	7				7
I chose the Gmail account available to add another member	8		5		8
PPT I | when changing to the Gmail account you will be able to also enter guests which is not available under the default calendar	9	4	6	4	9
Enter email and automatically a window will pop up with emails saved in the contacts	10	5	7	5	10
contact is selected... insert other contacts in the same line	11				11
Check if your contacts have been sent a request	12				12
PPT J| Error request failed	13	6	8	6	13

KEY	Description of keywords
Touch Points	Are instances created by participants to construct the require learning object Touch points included the maximum possibilities all groups have opted for when creating the learning objects.
Remark (RE)	Once a new instance is created a remark by default is required. Participant may comment and suggest
IN	Instance
CO	Comments
IC - P	Pointers (ICON)
IC - A	Alert (ICON)
IC - Q	Question (ICON)
IC - R	Right (ICON)
IC -W	Wrong (ICON)
Red	Pain Point (PPT)
Yellow	Not Required Step of configuration Touch Point but contains additional information
Orange	GROUP 1
Blue	GROUP 2
Green	GROUP 3
Purple	GROUP 4
Magenta	GROUP 5

6.4.3 Level of Difficulty Experienced by the Participant when Completing Tasks

Throughout the completion of the post-session questionnaire, the subjects were asked to provide a rating for all of the tasks in line with the perceived difficulty. The mean rating score ranged 0–4, with 0 representing no difficulty, whereas 4 represented high difficulty.

A measure of the level of difficulty experienced by the subjects in the completion of the tasks was achieved through a mean rating score. Table 41 provides results to show that Task 3 had the highest mean rating score, meaning the subjects experienced the most problems in carrying out this activity, whereas Task 1, on the other hand, was the least difficult. Overall, the subjects that rated the tasks as not difficult were those who succeeded in their completion and who went on to rate the tasks following completion (see Table 41).

Table 41: The difficulty of the tasks assigned as perceived by the participants

Legend of Tasks.
Task 1 - Connect your Android mobile device to a WIFI and browse Internet

Task 2 - Configure a Gmail account using an app and send an Email using your Android Mobile Device

Task 3 - Create new contacts that are available on your Gmail account

Task 4 - Creating an appointment using the calendar app on your Android Mobile Device and schedule/update an hour session for feedback focus group

		How difficult did you find the assigned task? TASK1	How difficult did you find the assigned task? TASK2	How difficult did you find the assigned task? TASK3	How difficult did you find the assigned task? TASK4
N		28	28	28	28
Normal Parameters	Mean	0.50	1.04	1.75	1.64
	Std. Deviation	0.882	1.170	1.578	1.283

Moreover, the participants were asked to provide a rating on the perceived difficulty of tasks compared with their ability to complete the task by themselves. Different progression levels were encompassed in other cases (creator, participants, viewer) (see Table 56).

The number of individuals that opted to contribute to Task 1 was much higher than for other tasks, as shown in the results, with the subjects rating the first task as not difficult. Overall, the tasks rated as less difficult were contributed to by a larger number of people.

a) Confidence and Frustration Score

In an effort to establish the confidence score, the rating scores of Q15 first underwent reverse coding (*Do you often get upset over things*?), with the rating scored at Question 10 then added to Q16 (*I have a very happy mood)*, which is similar to Study 3 (see Section 3.2). The scores ranged 0–28, with 0 representing an extremely low confidence level whilst 28 was seen to relate to an extremely high confidence level (see Figure 40).

The analysis score of Question 34 was added to that of Question 38 in order to derive a frustration score (see post-questionnaire in Appendix F.2), whereby the scores ranged 0–20, with 0 corresponding to low frustration whilst 20 signified high frustration.

Owing to the fact the Kolmogorov-Smirnov *p-value* exceeded the 0.05 level of significance, both score distributions were found to be normal.

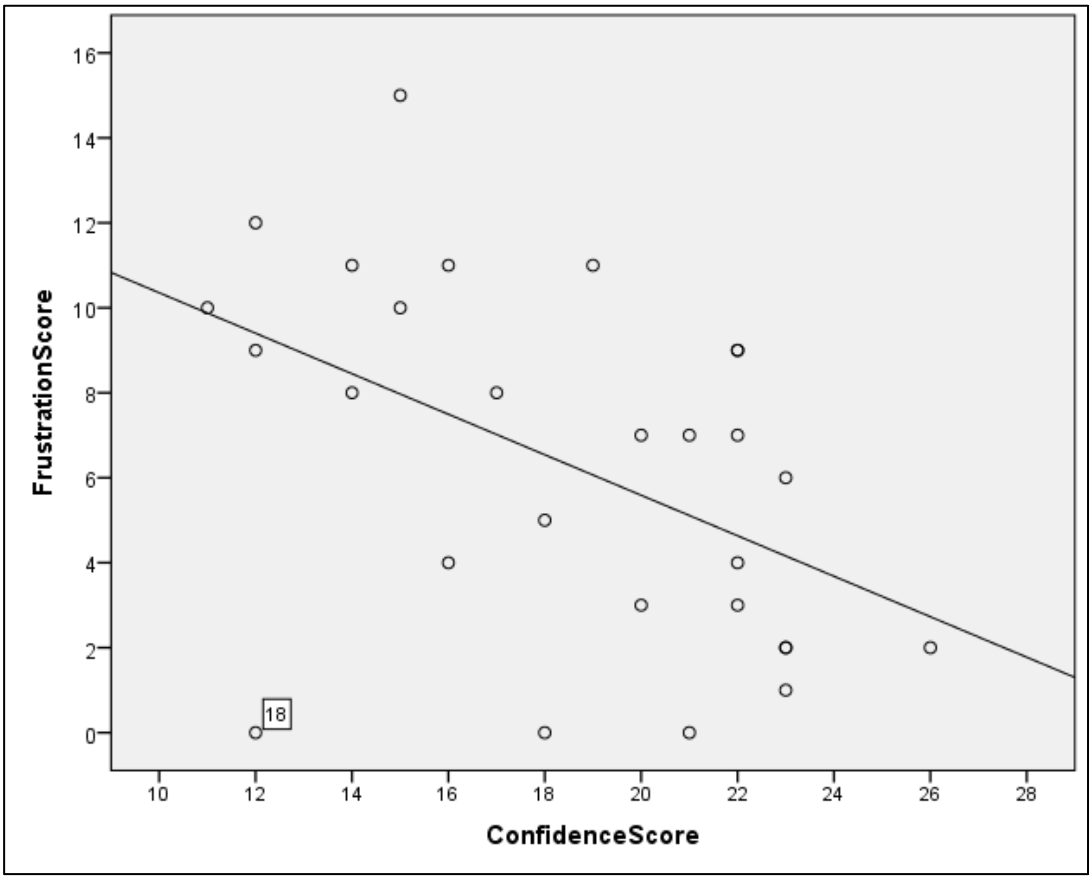


Figure 40: Study 4's Confidence and Frustration Score

There was the application of the Pearson correlation to measure the strength of the link between confidence and frustration scores. The Pearson correlation coefficient was −0.482, thus suggesting that those subjects that achieved a high score in confidence scored low in frustration, with the same conversely. The link is significant when considering that the *p-value* (0.009) is less than the (0.05) criteria. The Kolmogorov-Smirnov test results, along with the Pearson correlation, can be seen detailed in Table 42.

Table 42: Confidence and Frustration prior to and following task completion

Pearson Correlation

		Frustration Score
Confidence Score	Pearson Correlation	-0.482
	P-value (2-tailed)	0.009
	Sample Size	28

A One-Way Anova test (parametric test) was completed in order to establish the mean confidence/frustration score between independent groups. clustered by gender and job role. It is specified by the null hypothesis that the mean scores are comparable between the groups and therefore is accepted. More specifically, the 0.05 significance level is exceeded by the *p*-value.

The alternative hypothesis shows that the mean confidence/frustration scores did not differ significantly between the group, and the *p-value* is expected to be more than the 0.05 criterion (see Table 43).

Table 43: Confidence and Frustration prior to and following the completion of the tasks by gender

		N	Mean	Std. Deviation	Std. Error	P-value
Confidence Score	Male	14	18.57	4.603	1.230	0.965
	Female	14	18.50	3.956	1.057	
Frustration Score	Male	14	5.21	4.854	1.297	0.178
	Female	14	7.36	3.153	0.843	

b) Obstacles identified by participants from success learning objects

The subjects recognised various obstacles for cycles making up learning objects. These obstacles, along with their corresponding mean scores, are detailed in Table 44 and more detail can be found for each obstacle for every task in Appendix D. The participants rated the instances within a learning object they considered difficult to complete. The mean rating score spanned 0–4, where a low rating was assigned 0 whilst a high rating was assigned a 4. Section 6.2 details the four tasks, namely: 1) to Connect your Android device to a nearby wireless connection through 3G or WIFI at various points around your workplace; 2) Configure a Gmail account on a given Android mobile and when complete send an email to all team members; 3) Create new contacts of all the members of the group; and 4) Create a calendar entry to invite all members in the group to meet at a defined venue to carry out the study.

Table 44: Summarised Obstacles (PPT) identified by participants

	Task 1	Task 2	Task 3	Task 4
Obstacle Ref	PPT A	PPT D	PPT F	PPT I
Description	Failed to Authenticate	Problem when attempting to log	Error connecting to email account	Accessing the wrong Gmail account and corresponding calendar
Mean Score	3.48	3.20	3.40	3.40
Obstacle No	PPT B	PPT E	PPT G	PPT J
Description	Lost when choosing a Wi-Fi Connection	No internet error message	Participants could not access the contact list	Error not allowing participants to send invites
Mean Score	3.00	3.90	2.90	3.00
Obstacle No	PPTC		PPT H	
Description	Manage to connect a given website through a mobile browser		If synchronisation was not enabled contact list could no be viewed	
Mean Score	2.98		3.20	

6.4.4 Participant's Results of Knowledge-Sharing Network Exploration

Log data that has been monitored during the interactions of users with the collaborative tool can be useful in providing insight into knowledge-sharing patterns. Section 5.5. has provided insight into how social analysis tools can be described, graphically demonstrating the links between individuals in order to establish all the ties within the entire network so as to identify patterns. In order to achieve this, Gephi was utilised (Bastian M., Heymann S., 2009) in order to investigate who was interacting with whom throughout the course of the study, as well as in mind of providing a correlation between the findings derived from the statistical tests conducted. Extracting valuable information from social network analysis was recognised as valuable, which can be achieved by extracting data from graphs for monitoring knowledge flow in businesses.

As has been discussed in Section 5.5.3, two inputs are needed in order to generate a sociogram: 1) the subjects who were the actors in each group; and 2) the list of interactions between actors. The individuals actively involved in generating the learning objects were examined. Following data extraction and the identification of the knowledge-sharing patterns amongst participants, individuals within the group will be investigated further and accordingly classified as creators, participants or viewers (Chakrabarti & Faloutsos, 2008).

The sociogram detailed below comprises different nodes, representing the key contributors of the learning objects and their relation with peers. There has been the adoption of the NetViz Nirvana visual principles as close as possible. The creation of the sociogram was facilitated with the adoption of three Netviz Nirvana visual main principles, namely 1) every node is visible, 2) every node degree is countable, and 3) when possible, every edge can be followed from source to destination. Moreover, the identification of outliers and clusters was facilitated as much as possible.

ForceAtlas2 algorithm (Jacomy *et al*. 2014) for clustering the network structure was obtained as depicted in Figure 41. This is an enhanced version of force atlas, devised in mind of managing large networks, maintaining graph representation quality. Owing to the amount of nodes created for all of the graphs, the importance of members within the network was ensured. The group and individual participant IDs assigned for the research were indicated by labels.

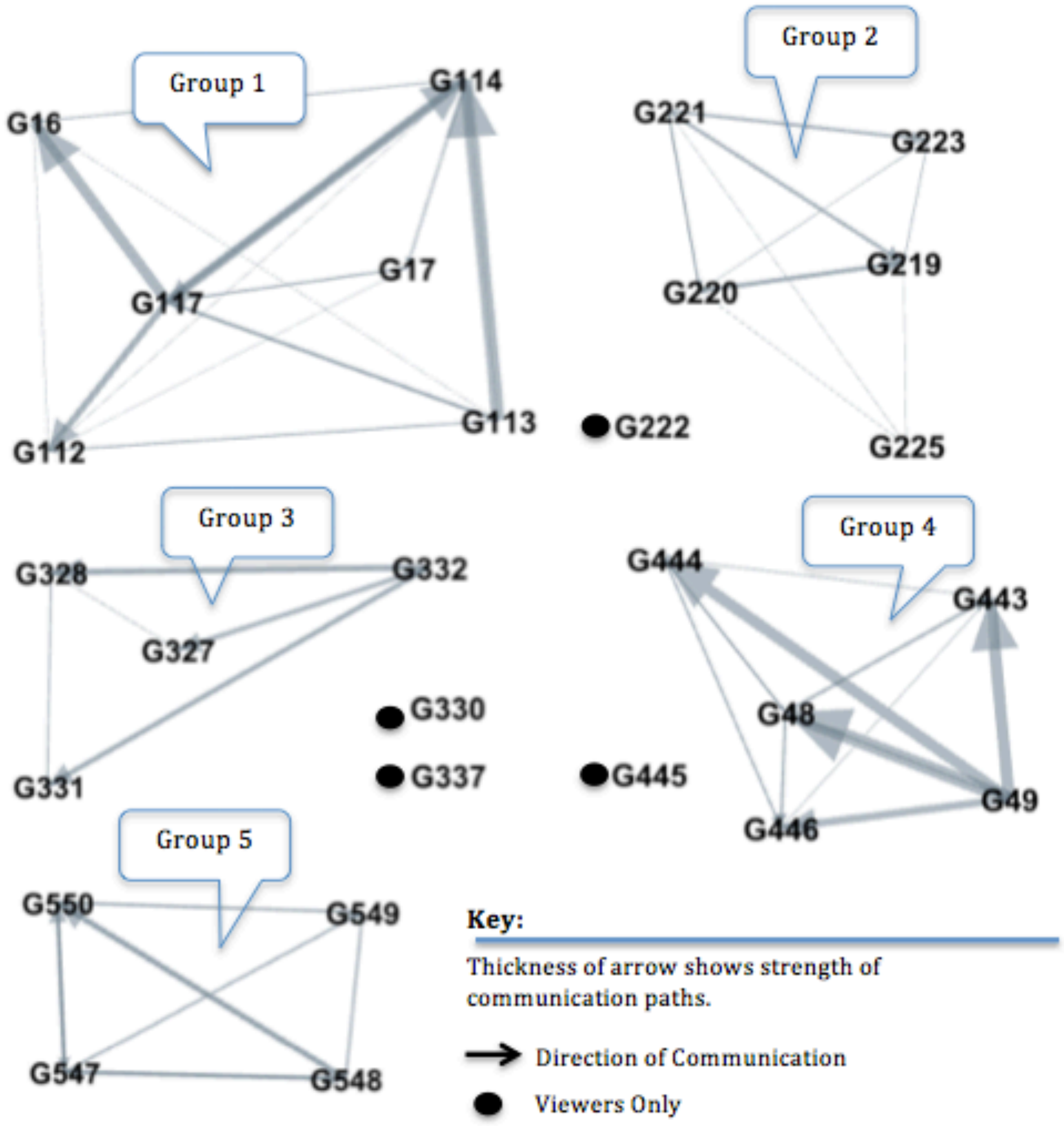


Figure 41: Sociogram by group, detailing those nodes recognised as more likely to be in communication with others. The direction of communication and flow of knowledge is depicted by the arrows, whilst a higher betweenness centrality of the points in the network is shown by a darker colour. Thus suggesting who would be affected and cut-off in the event of node breakage.

As discussed in Section 5.1.3, subjects can select from 5 different remark types, including Pointers and Alerts, for example, which can be shared within an instance. Members having read and responded to remarks is depicted with the use of arrows. The arrows' direction emphasises the source of the information, whilst the target is shown by the arrow point. The thickness of the arrow shows who contributed the most and who responded to those contributions. The dots in black show those viewers who did not contribute by commenting on or suggesting learning object instances that were valid.

Upon database querying for all of the groups, it was found that, overall, there are 1,290 different contributions through *YourSpace*, which enabled the building of different learning objects by the groups. Importantly, the study considered only valid cycles. Such contributions included creating instances making up learning objects, as detailed in Section 6.5.3, with the creation of remarks achieved by selecting an icon that helps in the categorisation of the type of contribution shared across all team members and the comments left by the different group members. All of the items will be examined in greater depth primarily through the use of network analysis, and subsequently with the application of statistical techniques. Lastly, a number of different examples will be provided on how groups or individuals create learning objects.

a) Calculating Connectivity—Density

Data first were extracted in mind of calculating the number of links between subjects. Through such data, an individual's communication and contact load could be identified. Although there were only six members in each group, a high volume of communication was identified, meaning it was possible to draw a comparison between the network results (see Table 45).

Arrow density was used to contrast the connectivity of a group. Group 1 and Group 5 are seen to demonstrate the highest amount of network interconnectivity. It is considered that these networks had the highest rate of information exchange and knowledge sharing compared to Group 2, Group 3 and Group 4.

Table 45: Graph Density—Sociogram results by groups

	Participants Nodes (Actors)	No of edges	Graph Density	Average Path Length
Group 1	6	23	0.767	1.333
Group 2	6	13	0.434	1.65
Group 3	6	8	0.267	1.11
Group 4	6	17	0.567	1.25
Group 5	4	11	0.917	1.08

The density of Group 1 and Group 5 indicates that more members with the group chose to contribute actively to sharing knowledge. In group 1, G117 was recognised as a key player (see Figure 36). The member is an administrator. All other members were found to have contributed by sharing knowledge through making suggestions and adding comments (G114, G112 G113). In a comparable vein, Group 5 members G547, G548 and G550 created the largest number of instances and accordingly communicated with members of their groups. Group 2 and Group 3 were found to have the lowest density, suggesting that members G220, G221, G332and G328 were communicating with team members through the creation of instances and the making of remarks; however, few of the members responded with the addition of comments. These members were 3 IT support and 1 administrator, respectively.

b) Calculating Centrality

For all of the groups, there was the generation of a sociogram, with Table 51 detailing the results. There was the calculation of the average path length. The degree of *betweenness centrality* was generated and detailed in the graph, which established which nodes (Actors) in the network were likely to break and how they would affect the network as a whole (Brandes, 2001). Through the metrics, the influential nodes—notably those demonstrating the highest values—are indicated. Large nodes graphically represent the amount of contribution made by participants to specific learning objects. The knowledge direction is depicted by the arrow, with the size of the arrow representing the *betweenness centrality* metric, showing the amount of influence the different individuals had on one another.

Through the results, it can be seen who adopted the role of the central actor within a network, as well as the degree to which the network was organised around such key actors. G117 (26.09%), G221 (39.46%), G220 (23.08%), G328 (37.5%), G332 (37.5%), G49 (29.41%), G548, G547 and G550 (27.27%) are subjects in their respective groups that have been recognised as having the most ties. Upon completing an analysis based on centrality, the direction of the tie becomes important in interpreting the role of the key participant (actor). Those actors seen to have a high in-degree are recognised as related to only one particular actor. In contrast, a significant out-degree suggests a specific individual is linked to various other participants. In the latter case, it may be stated that the knowledge shared by the individuals is recognised as valuable by the other participants. These members had a high out-degree G117, G221, G220, G332, G49, G548, G547 and G550; therefore, these have contributed to helping other peers complete the given tasks. Such individuals are recognised as being notably influential in the community, whereas those recognised as having a low degree of centrality may have been keeping a low profile. However, low centrality does not necessarily suggest such individuals are lacking in the knowledge necessary, such as in the cases of G114 or G13, but rather that they may have decided not to contribute in using the *YourSpace* app (see Table 46).

Table 46: The percentage indicates Degree Centrality and Role in Community: Creator, Active Participants and Viewers

	Total no of Participants Nodes (Actors)	Creators	Active Participants	Viewers
Group 1 (G1)	6	G117 (26.09%)	G114 (21.74%) & G113 (17.39%) & G12 (13.04)	G17 & G16 (8.7%)
Group 2 (G2)	6	G221 (39.46%) G220 (23.08%)	G223 (15.38%) & G225 (15.38%)	G219 (7.69%) & G222
Group 3 (G3)	6	G328 (37.5%) G332 (37.5%)	G331 (25%)	G327& G330 & G337
Group 4 (G4)	6	G49 (29.41%)	G48 (23.53%) & G444 (23.53%) & G446 (17.65%)	G445 & G443 (5.86%)
Group 5 (G5)	4	G548 G547 G550 (27.27%)	G549 (18.18%)	NULL

Figure 32 details how the participants interacted with one another when making remarks, as well as when others made suggestions or posted comments in response to the remarks. Centrality degree pertaining to the subjects does not refer to a particular job role; rather, those subjects with a high degree of centrality had a number of different positions in the organization, including IT support assistants, managers and administrators, but not clerks. It is recognised that a high degree of centrality infers that the key players in the activities took part in sharing information and were of influence to their peers. Moreover, as considered in Section 6.5.4a, Group 2 and Group 3 had the lowest graph density. The findings emphasise that these groups had the highest amount of viewers who did not participate in any of the cycles, as they did not direct any efforts towards creating, commenting on or suggesting of the instances created (G219, G222, G327, G330 & G337). When examining the fact that the key players in the groups were mostly those with roles in IT support seems to have had some degree of influence on the other subjects, all of whom had a different role to play in the organisation. G221, G220 and G332 are full-time employees that have worked in IT for a long period of time. G328, whose role is an administrator, also created various instances and shared knowledge by answering questions. Group 1 and Group 5 made the largest number of remarks and comments.

c) Participants Contributions by Type Creator, Active Participant or Viewer

User-created interaction frequency is monitored across all instances, with the mean time (minutes) logged and extracted as detailed in Section 5.5 (see Table 47). As can be seen when reviewing the results, there was the calculation of the three key components to measure the type and contribution made by individuals in terms of knowledge-sharing, awareness and confidence across each group in relation to the contributions made in the creating of different learning objects. A One-Way Anova test was carried out since the variables were normally distributed. The mean amount of time allocated to create instrances for every task varied except for viewers. Creator and active participant spent more time in task 3 (mean over 4.44) and task 4 (mean over 3.94). Both tasks had the highest amount of pain points and required more support. The p values did not exceed the level of significance implying that mean time according to type of contribution varied for each group.

Table 47: One-Way Anova mean time allocated by participants for each task according to type of contribution

		Mean time in minutes	Std. Deviation	95% Conf. Int. for Mean		P-value
				Lower Bound	Upper Bound	
Time to create instance or posts (Task1)	Creator	5.00	2.330	3.05	6.95	0.000
	Participant	2.55	0.688	2.08	3.01	
	Viewer	0.00	0.000	0.00	0.00	
Time to create instance or posts (Task 2)	Creator	5.19	2.267	3.29	7.08	0.000
	Participant	3.32	1.347	2.41	4.22	
	Viewer	0.03	0.100	0.00	0.11	
Time to create instance or posts (Task 3)	Creator	7.63	1.506	6.37	8.88	0.000
	Participant	4.27	0.564	3.89	4.65	
	Viewer	0.17	0.332	0.00	0.42	
Time to create instance or posts (Task 4)	Creator	6.63	1.506	5.37	7.88	0.000
	Participant	2.27	1.104	1.53	3.01	
	Viewer	0.03	0.100	0.00	0.11	

A One-Way Anova test was carried out since the variables were normally distributed. The various iterations and associated actions have been correlated with the aim of establishing the mean number of interactions and instances for each task. The p values of Task 2 ($p = 0.030$) and task 3 ($p = 0.008$) did not exceed the 0.05 level of significance, implying that mean no of iterations varied for each group i.e. creator, active participants and viewers. While p values of task 1 ($p = 0.334$) and task 4 ($p = 0.141$) did not vary much between groups. Viewers experiencing issues normally would visit an instance a higher number of times as a viewer. Task 3 and task 4 had high number of iterations for viewers, were mean was over 7.06 and 5.52 respectively. Those members who choose to involve themselves by posting questions and through general participation would visit any instance to retrieve solutions less frequently. Table 48 shows that the subjects viewed Task 3 and Task 4 more times, meaning these tasks are recognised as more difficult (see Table 48). The time allocated for those instances and scored as pain points have experienced a high viewing time and more interaction. Task 3 had the highest amount of views (Mean no of iterations 11.00).

Table 48: One-Way Anova mean number of iterations for each task according to type of contribution.

		Mean no of iterations	Std. Deviation	95% Conf. Int. for Mean		P-value
				Lower Bound	Upper Bound	
Number of iterations per task (Task 1)	Creator	2.50	0.756	1.87	3.13	0.334
	Participant	3.36	1.690	2.23	4.50	
	Viewer	3.44	1.509	2.28	4.60	
Number of iterations per task (Task 2)	Creator	3.50	1.195	2.50	4.50	0.030
	Participant	5.00	1.612	3.92	6.08	
	Viewer	5.67	1.871	4.23	7.10	
Number of iterations per task (Task 3)	Creator	6.25	2.964	3.77	8.73	0.008
	Participant	6.73	2.649	4.95	8.51	
	Viewer	11.00	4.062	7.88	14.12	
Number of iterations per task (Task 4)	Creator	4.63	2.774	2.31	6.94	0.141
	Participant	5.09	2.071	3.70	6.48	
	Viewer	7.56	4.531	4.07	11.04	

6.4.5 The progression layer participants identified themselves after participating in the study

Participants' relationships across each group were analysed, as well as amongst the community at work, and the pre- and post- studies, which enables patterns of knowledge-sharing to be identified across the three progression levels, namely pedagogy, andragogy and heutagogy. Those individuals recognised as having the greatest degree of centrality can be considered those in the heutagogy level, which infers that such subjects are those positioned to create successful learning objects and accordingly provide support in a number of instances, as described in Section 5.4.5. Upon examining the learning objects detailed in Section 5.4.2, the participants adopted a logical sequence, allowing themselves to answer anticipated issues that other members might have come across, including "Do not forget to enable Wi–fi", "Choose Gmail APP not the default APP on the welcome screen" and "Bluetooth is not used for Internet", for example. In section 6.4.7 we evaluate in detail how active participants and viewers have contributed to creating learning objects. These have been detected by the type of contribution they gave. To better understand how members have been identified as creators, active participants and viewers we have also discussed 5 objectives describing a knowledge sharing pattern. Some of these include: members that uploaded images and created instances; members referred to as active participants that uploaded only an image that is a one off instance with a problem they came across.; members who posted questions or identified solutions without the need to create several instances that made up learning objects. (These are also referred to as active participants); active members that shared knowledge by adding remarks or commenting on various instances. These could be active participants or creators who shared knowledge in existing instances. Finally viewers who did not interact with any instance or create instances.

6.4.6 Construction of Learning Objects with the tablet application *YourSpace*.

Through the way participants interacted with the tablet application *YourSpace,* it was possible to learn how they created the learning objects in practice. In Table 49 to 53 below, we first show the amount of learning objects that are compared with the valid ones created, and those that failed. Groups 1,2 and 3 had a number of failed attempts that is 4, 9 and 9 respectively when creating learning objects. Most of the learning objects had only a few instances about 1, 2 or 3 with no proper description and problem or action being addressed (ref to section 6.4.2). The images of the failed learning objects were related to the topic within the correct sequence that the participants were referring to, but found difficulties when trying to explain the solution or problem. Similarly the amount of pain points were identified for each group 8 or 9 with the highest related to Task 3 except for group 3 with Task 4 having the highest amount of pain points. Groups 2, 3 and 5 in Task 1 had highest amount of successful learning objects. Participants seem to contribute to more than one learning object with the same topic. Each of them scored high as described in section 6.4.2.

Table 49: Summary of construction of Learning Object – Group 1

		Construction of Learning Objects			
Group 1 (No=6)		No of Attempts to create Learning Objects	No of Successful Learning Objects	No of failed Learning Objects	No of Pain Points
Task 1	Count	2	1	1	2
Task 2	Count	2	2	0	2
Task 3	Count	4	2	2	3
Task 4	Count	2	1	1	2
	TOTAL	10	6	4	9

Table 50: Summary of construction of Learning Object – Group 2

		Construction of Learning Objects			
Group 2 (No=6)		No of Attempts to create Learning Objects	No of Successful Learning Objects	No of failed Learning Objects	No of Pain Points
Task 1	Count	6	5	1	2
Task 2	Count	6	1	5	2
Task 3	Count	2	1	1	3
Task 4	Count	1	1	0	2
	TOTAL	15	6	9	9

Table 51: Summary of construction of Learning Object – Group 3

		Construction of Learning Objects			
Group 3 (No=6)		No of Attempts to create Learning Objects	No of Successful Learning Objects	No of failed Learning Objects	No of Pain Points
Task 1	Count	4	3	1	1
Task 2	Count	3	1	2	2
Task 3	Count	2	1	1	2
Task 4	Count	2	1	1	3
	TOTAL	15	6	9	8

Table 52: Summary of construction of Learning Object – Group 4

		Construction of Learning Objects			
Group 4 (No=6)		No of Attempts to create Learning Objects	No of Successful Learning Objects	No of failed Learning Objects	No of Pain Points
Task 1	Count	1	1	0	1
Task 2	Count	1	1	0	2
Task 3	Count	2	2	0	3
Task 4	Count	1	1	0	2
	TOTAL	5	5	0	8

Table 53: Summary of construction of Learning Object – Group 5

		Construction of Learning Objects			
Group 5 (No=4)		No of Attempts to create Learning Objects	No of Successful Learning Objects	No of failed Learning Objects	No of Pain Points
Task 1	Count	3	3	0	1
Task 2	Count	3	3	0	2
Task 3	Count	1	1	0	3
Task 4	Count	1	1	0	2
	TOTAL	8	8	0	8

The next stage is to investgate the amount of time invested by participants in completing the study as a whole was calculated with consideration to the logs kept within the application *YourSpace*. A One-Way Anova test was carreid out since the variables were normally distributed. Time in minutes was measured on a per-cycle basis, with the mean time by task examined in mind of relating to the type of contribution made by the individuals when constructing the learning object (see Table 54). The p values did not exceed the 0.05 level of significance (p=0.00) implying that mean time according to type of contribution varied for each group. Upon completing the analysis, each of the subjects was assigned a label for the most prominent role s/he may have had for each task. Creators have spend more of the time creating learning objects where mean value was over 18.11 (mean was 31.10). Active participants spend time posting where mean value was over 11.35 (mean was 19.72).

Table 54: One-Way Anova mean time allocated to create learning objects and participate by commenting and suggesting knowledge.

	Mean time in minutes	Std. Deviation	95% Conf. Int. for Mean		P-Value
			Lower Bound	Upper Bound	
Creator	31.10	6.129	25.97	36.22	0.000
Active Participants	19.72	4.427	16.75	22.69	
Viewer	2.47	3.778	0.00	5.38	

Table 55 details the number of participants for each role in the construction of a learning object. Through the results, it can be seen that, according to the type of contribution creator, active participants and viewers found the tasks difficult. The *p-value* of the Kolmogorov-Smirnov Test carried out garnered scores of less than 0.05 for both Task 1 and Task 4, meaning there is a notable difference between progression layers. Task 2 and Task 3 did not exceed the 0.05 level of significance, which implies that, when constructing the learning object, participants were adopting different roles. In Task 1, more creators contributed to the task (n=11), whereas in Task 4, there were fewer participants in the role of creators (n=6). Results in table 56 emphasise that, in Task 3 and 4, the task was not completed by two of the subjects.

Table 55: What type of contribution did participants feel they gave after completing the four tasks?

Task 1	N	Mean	St. Dev	P. Value
Creator	11	0.00	0.000	
Participant	6	0.50	0.548	0.016
Viewer	11	1.00	1.183	
Task 2	**N**	**Mean**	**St. Dev**	**P. Value**
Creator	6	0.50	1.225	
Active Participants	9	1.11	0.601	0.273
Viewer	13	1.23	1.423	
Task 3	**N**	**Mean**	**St. Dev**	**P. Value**
Creator	5	1.00	1.414	
Active Participants	9	1.33	1.414	0.205
Viewer	12	2.29	1.637	
Task 4	**N**	**Mean**	**St. Dev**	**P. Value**
Creator	6	0.33	0.516	
Active Participants	8	1.38	0.916	0.004
Viewer	14	2.36	1.216	

6.4.7 Objectives identified of how participants contributed to knowledge sharing.

The data in Section 6.5, pertaining to individual roles and those of groups, may be combined with the framework discussed in order to calculate awareness, knowledge-sharing and confidence. The degree of progressions across individual's heutagogy, andragogy and pedagogy and the link with the type of contribution will be considered. The three levels are taken into account by drawing a link between the individual's role as creators, active participants and viewers, respectively, with the progression level. In this section, the individual roles have been established. The following stage will involve the findings being extended, as identified thus far, in mind of examining what factors are responsible for influence participants in different settings. The aim was to give examples of how this was done. A summary of the user metric was given, as detailed in Section 5.5.

The main hypothesis of this study is further verified in more depth by addressing the following objectives:

Obj1: Members that uploaded images and created instances. Participants are considered creators and have some form of self-determined learning and are highly autonomous.

Obj2: Members that uploaded an image (one off instances) with a problem they came across. We referred to them as active participants.

Obj 3: Members posed questions or identified solutions without the need to create several instances that made up learning objects. These are referred to as active participants.

Obj 4: Active Members that shared knowledge by adding remarks or commenting on various instances. These could be active participants or creators who shared knowledge in existing instances.

Obj 5: Viewers who did not interact with any instance or created instances.

The aim is to verify whether ubiquitous collaborative solution *YourSpace* provides Just in Time support through crowdsourcing at the place of work. Users collaborate with others through *YourSpace* and capture the performed solution ready to be shared with others. Evaluation of hypothesis was further achieved by identifying five objectives of how various members contributed to *YourSpace*. Each objective was structured to identify, 1) Type of action chosen and why it is important, 2) data being tracked, 3) results and 4) examples of how a particular group constructed the learning objects through the log actions. Finally objective 6 focused on how members in specific cases contributed and the influence they had within the community.

An example of the results is taken from successful cycles for those that have been positively rated by participants and had a high amount of collaboration from different members of groups.

> **Obj1:** Members that uploaded images and created instances. Participants are considered creators and have some form of self-determined learning and are highly autonomous.

Type of Action chosen and why it is important: Members contribute by creating the learning object and describing the instance/s to provide a step-by-step solution. We refer to these participants as creators. They are important because they are key players and they have the best valuable knowledge within the group. They also share their knowledge and influence other member's interests when solving the assigned tasks.

Data being tracked: Participants that have been identified as creators of one or more cycles and their respective instances are verified as described in section 5.5.2. We investigate Heutagogy by checking each instance within the learning object that meet the criteria establish for calculating awareness, knowledge sharing and confidence in section 5.5.

Results: Creators showed to be aware of various actions in several instances. They managed to complete a task independently. They proved they knew how to solve solution at any particular instance by verifying the initial remark created for each cycle (ref to figure 42).

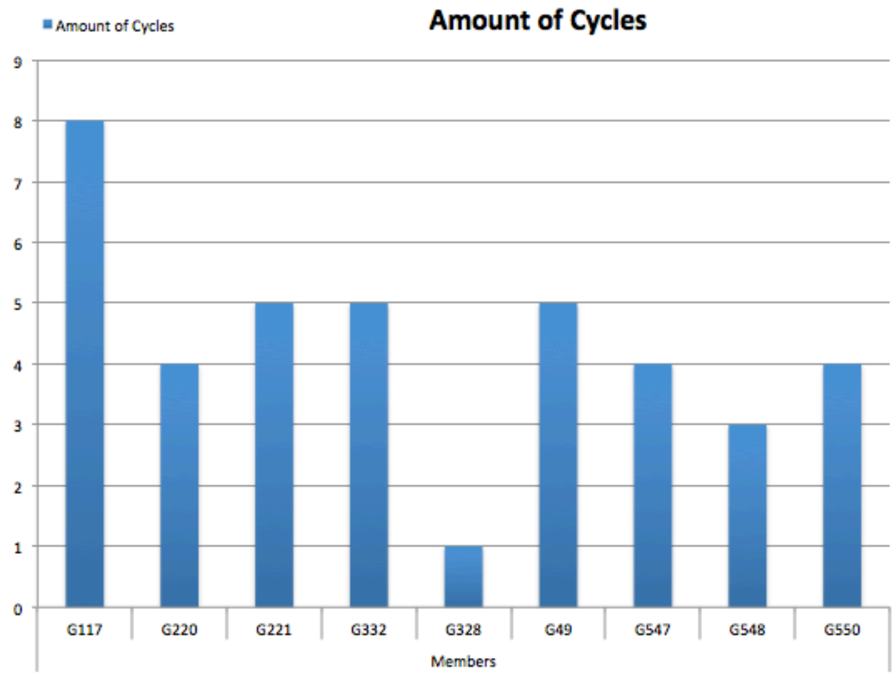


Figure 42: Amount of successful cycles members created. (Role Creators)

Creators G117 (Administrator), G220 (IT Support), G221 (IT Support), G332 (IT Support), G49 (Manager of Team), G547 (IT), G548 (IT) and G550 (Administrator) were found to have the greatest number of valid instances, with all of their created cycles scored highly, thus suggesting that the subjects of their respective groups considered them valuable (see Graph 2). The ability to acquire knowledge and skills, and accordingly share them with others, has been proven. This level of progression is referred to as heutagogy. These individuals also are recognised as being good at communicating knowledge to others.

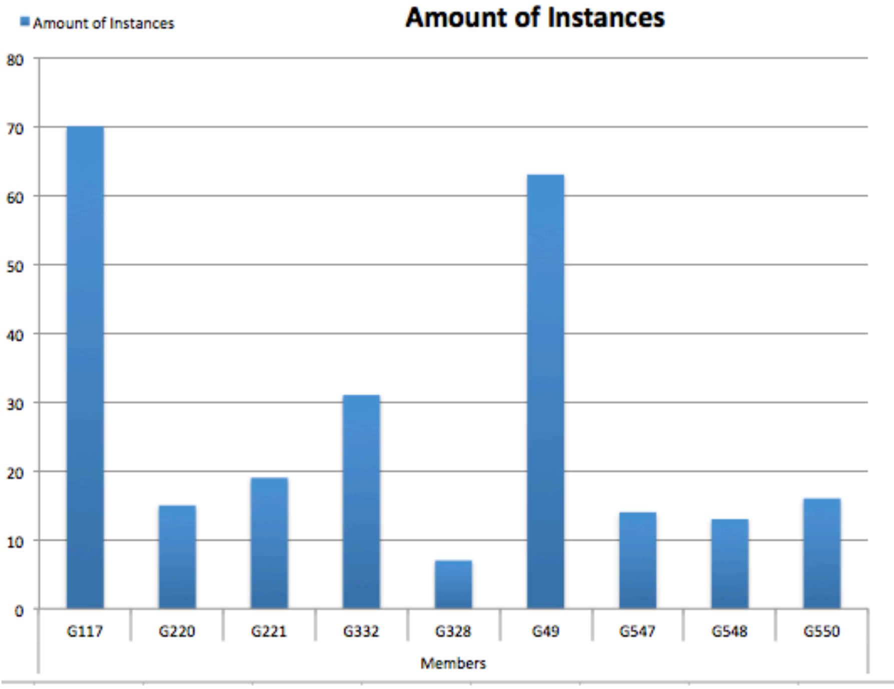


Figure 43: Amount of instances creators created.

Participants recognised as creators kept a constant role across all of the tasks. They created a step-by-step procedure of all required instances till they completed the tasks. In one of the cycles created by group 3 for task 3 G328 (Administrator) and G332 (IT Support) have contributed together to construct a cycle where G328 (Administrator) created 7 instances and G332 (IT Support) created 8 instances.

When it comes to tackling issues, creators demonstrate confidence, as has been confirmed through the manual visiting of each. It is clear that the most time is directed towards creating learning objects, whilst a lower amount of iterations were found when viewing the various learning objects (see tables 54–55).

Examples: Members that have uploaded images with a solution, including G117 (Administrator), for example, further included a remark "Error received because of incorrect password", which was noteworthy in devising a solution to a problem prior to participants seeking assistance. Comparably, G332 (IT Support) uploaded an image emphasising a common issue potentially facing users in "enabling WiFi" as single instance in a cycle before completing any tasks. This learning object was created in Task 1.

G117 (Administrator), G220 (IT Support), G221 (IT Support), G332 (IT Support), G49 (Manager of Team), G547 (IT), G548 (IT) and G550 (Administrator) were found to have at least one full successful cycle for all tasks. Further, they communicated with their group members in the sharing of information in regard to how the task can be completed. A minimum of 78 icon pointers enabled the sharing of knowledge relating to an action within the learning objects created. One comment added with a pointer included "Click on this icon to add emails". Upon creating a new calendar event using pointer ICONS, the comments "Click on the top right button" followed by "Click on new event" were found to be pivotal in assisting subjects to solve one of the pain points identified. This instance provides a valuable example of one of the instances added by the creator to the learning object when a participant needed support.

Obj2: Members that uploaded an image (one off instances) with a problem they came across. We referred to them as active participants.

Type of action chosen and why it is important: Images were uploaded to an existing learning object by users, with a problem described by adding an instance to request support. This is important when considering that members can communicate effectively when facing a problem through providing all members with accurate information in that instance.

Data being tracked: Participants identified as active participants in one or more cycles, along with their respective participation in various instances, has been verified, as described in Section 5.5.2. Typically, they added an instance following the creator having completed the learning object. An error was shown in the instance, with a remark made on the problem.

Detect awareness: Awareness is identified through choosing instances that have been mostly created by a subject adopting the role is a creator, whilst another participant adds instances. The question icon is applied when seeking further information. A problem is identified, with actions taken by participating in the collaborative computer solution. These are recognised as andragogy (Blaschke, 2012). They know how to explain the problem.

Example: G114 (Administrator), G113 (Administrator), G225 (Administrator), G331 (Administrator), G446 (Administrator) and G444 (Administrator) are active participants, who are recognised as having created at least 1 instance showing an error and requesting support.

Obj 3: Members posed questions or identified solutions without the need to create several instances that made up learning objects. These are referred to as active participants.

Type of action chosen and why it is important: The subjects could pose questions through utilising the question icon (see figure 44) or otherwise by adding comments to identify solutions. The same participants might have added one instance to request support, as detailed in obj2. This is value when considering participants who are able to solve specific problems within an instance can be identified.

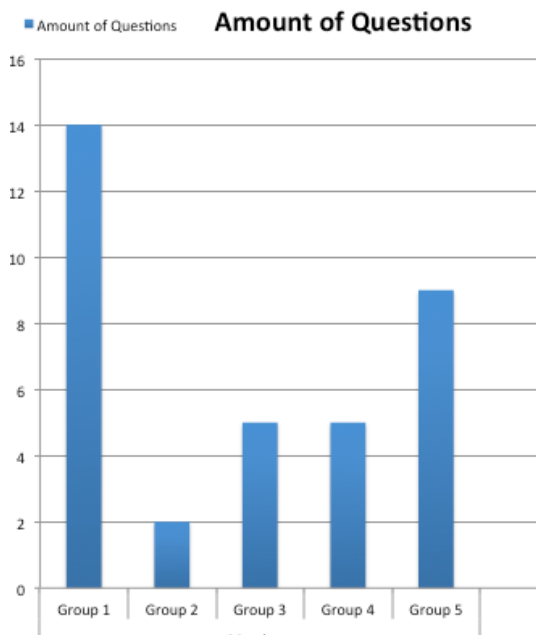


Figure 44: The number of questions generated by each group

Data being tracked: Those instances that have used the icon question mark have been selected and respective participants identified. They were verified as being or not being creators. Comments have been extracted for those questions and verified as being acknowledgments.

Detect awareness: In the majority of cases, the subjects were unaware of a solution until a member of their group shared information. For this object, knowledge-sharing is not taken into account.

Example: G114 (Administrator), G112 (IT), G113 (Administrator), G225 (Administrator), G223 (Administrator), G331 (Administrator), G48 (Administrator), G446 (Administrator), G444, (Administrator) and G549 (IT) are members that have used the question icon or acknowledge a solution. An example of typical questions is the following "How have you add a new event?"G112 (IT) or "Which log in credentials shall we use here?"G223 (Administrator) or "Which WIFI connection works? I am getting several errors"G331 (Administrator).

Examples of participants that were seen to recognise a solution are G48 (IT) "I have managed to connect ☺" and G446 (Administrator) "Invite Sent, problem solved"

> **Obj 4:** Active Members that shared knowledge by adding remarks or commenting on various instances. These could be active participants or creators who shared knowledge in existing instances.

Type of action chosen and why it is important: Subjects made comments or added remarks to different instances that included wrong, alerts or pointers icons. This was valuable in establishing how the various participants collaborated through providing comments according to the type.

Data being tracked: Icons, such as wrong, alerts and pointers, were chosen, with the respective subjects identified. The subjects were identified as creators or active participants, as discussed previously.

Detect awareness and knowledge-sharing: Subjects shared knowledge through the use of the alert or wrong icons in an effort to highlight an important action needing to be carried out. Wrong icons were adopted in order to establish understanding, whereas alert signs have helped participants identify problems or misleading options that could confuse them during the process of completing the assigned tasks.

Examples: The subjects that used the alert sign, such as in Task 1 Group 4 G444 (administrator), made reference to which Wi-Fi was connected but did not provide Internet. Task 2 Group 5 G547 (IT) alerted the group members to the most suitable app for configuring an email account.

Obj 5: Viewers who did not interact with any instance or created instances.

Type of action chosen and why it is important: Some of the subjects did not take any action, with some of the participants having opted to carry out a few actions but cannot be considered active participants (see Figure 36). This objective is essential in establishing whether they managed to overcome the issues following reviewing the learning objects completed, and whether they failed to complete any of the tasks in order to try to understand why. These are referred to as the lowest progression level, recognised as pedagogy, where the instances were viewed several times and accordingly assigned the highest amount of time.

Data being tracked: There was the extraction of the data pertaining to the number of iterations and viewing time. Viewers have spent zero time creating, as shown in Table 54, and had the highest amount of iterations viewing the learning objects once created. Those not interacting at any point by submitting a remark or comment were all female and clerks.

Examples: G222 (Clerk), G330 (Clerk), G337 (Clerk) and G445 (Clerk) have not actively participated by adding a remark or comment or created and instance for any of the tasks. G17 (Manager of a team), G16 (Clerk), G219 (IT), G327 (IT), G443 (IT), had a low participation by only commenting a few times or once and are considered as viewers (ref to table 42).

Obj 6: Individual cases participants and how they contributed.

Type of action chosen and why it is important: Some of the actions of the subjects are unique and worth documenting in relation to how they affected the team or how they failed or moved roles throughout participation in this study.

CASE 1: G17 (Manager of a team), in Group 1 Task 3, was able to present one instance to an issue not highlighted by any of the groups and their members. This was the only item logged by the user. In this study, the individual is recognised as a viewer only due to the fact he did not communicate with any team members. A cycle was created by the individual, comprising one instance, which explained how to enable synchronisation for the Gmail account that allowed participants in the group who chose to configure the default app to access the contacts available on the calendar. This provided the participants with the ability to send a calendar event to all team members.

Case 2: G16 (Clerk) and G330 (Clerk) failed to complete tasks 3 and 4. Upon the collection of the device, it was checked to determine whether all of the tasks had been successfully completed. Upon the data extraction from *YourSpace*, the amount of iterations per cycle in tasks 3 and 4, as identified as pain points, were noted. The results show that the cycles were viewed a number of times, with the highest amount of time spent on viewing pain points. These tasks may have been failed by these participants owing to their lack of involvement and choice not to communicate their problems with their team. The support needed therefore was not given.

Case 3: G444 (administrator) and G331 (administrator) participants were viewers in tasks 1 and 2, but became active participants in tasks 3 and 4. This shift from the position of viewer to active participant could be owing to the need to solve problems in tasks 3 and 4, especially for those instances identified as pain points.

Case 4: One active participant became a creator in Task 3, namely G328 (administrator), through collaborating in creating a learning object with G332 (IT support) in Task 3 and Task 4. A learning object was created, which was found to be successful in collaboration with G332 (IT support) (see Graph 2).

Table 56 provides an overview centred on group and corresponding actions described above from objective 1 to 6, corresponding to individual user metrics, highlighting the objective which affects awareness, knowledge-sharing and confidence. The overview summarises the results discussed above, mapping the role members had to the type of contribution, creator, active participant and viewer. Each objective investigated explains further how the type of contribution was achieved. In this summary, listed by group, each member and his role are the Job role corresponding to their progression level.

Table 56: Categorising Creator, Active Participant and Viewer with respective action being investigated and corresponding job role.

	Group	Member	Job Role	Effect on model components	Type of Action Investigated	Level of Progression Characteristics
Creator	1	G117	Admin	High (Aw, KS, C)	Obj 1 & Obj 4	Heutagogy
	2	G220 & G221	IT Support	High (Aw, KS, C)		
	3	G328 & G332	Admin & IT Support	High (Aw, KS, C)		
	4	G49	Manager of a Team	High (Aw, KS, C)		
	5	G547, G548 & G550	IT, IT & Admin	High (Aw, KS, C)		
Active Participant	1	G114, G112, G113	Admin, IT & Admin	AW,KS,,C	Obj 2, Obj 3 & Obj 4	Andragogy
	2	G225 & G223	Admin	AW,KS,C		
	3	G331	Admin	AW,KS,C		
	4	G441, G446 & G444	Admin	AW,KS,C		
	5	G549	IT	AW,KS,C		
Viewer	1	G17 & G16	Manager of a Team & Clerk	Low Participation	Obj 5	Pedagogy
	2	G219 & G222	IT & Clerk	Low Participation		
	3	G327, G330 & G337	IT, Clerk & Clerk	Low Participation		
	4	G443 & G445	IT & Clerk	Low Participation		

Legend: Aw (Awareness) KS (Knowledge Sharing) C (Confidence)

6.4.8 The Motivation of Participants when Contributing to Constructing the Learning Object using *YourSpace*

Throughout Study 4, the activities assigned needed to be solved in the workplace within a 5-day period. As discussed in the previous chapter, the subjects were required to learn to utilise the application without assistance, such as by reviewing manuals, for example, and then were required to create learning objects and share knowledge with others. Prior to creating the learning objects, the subjects were able to test their knowledge by creating instances using their choice of images and instances. The subjects responded to the tool in a positive way due to the social use, commenting on photos and taking pictures of their colleagues, all of which was pivotal in creating a positive environment and facilitating interaction.

Upon the completion of the task, data were gathered pertaining to the quality time spent by the participants on the study and the amount of interactions. The results, as detailed in sections 6.5.3–6.5.5, highlight how the participants interacted with the tablet application and subsequently overcome the problem, providing an overall success rate when establishing how participants interacted with *YourSpace* and their overall ability to complete the task, which was verified following each session.

Upon examining the comments left by the participants, there was the identification of positive comments across the groups. Some examples include those of G113 (Administrator) *“managed to get to point*” and “*well done ☺”*, which were commonly identified in twenty-six instances. Sixteen succeeded millstones were reciprocated at least once by a positive comment, such as G114 (Administrator), who stated *“almost there”* or G328 (Administrator), who commented *“Hurray”* or *“well done”.* Eighteen comments steered the participants towards seeking advice when they had completed a certain instance. Out of the thirty-four questions posed, thirty-two were answered, which highlights the amount of participation.

Collaborative solutions, such as that suggested for this study, enables knowledge sharing in the work setting through providing employees who are continuously aimed at solving problems related to the use of different applications for their work with the necessary support.

6.5 Discussion

This research centres on two key research questions: examining whether users in the work environment are able to secure adequate support through the implementation of collaborative knowledge-sharing computer solutions, making use of ubiquitous technology on a Just in Time basis; and examining the potential of using social media and how both individuals and groups alike are supported so as to empower them throughout the progression levels to autonomy.

The main objectives relevant to evaluate the data used to construct learning objects have been discussed in section 6.4.7. The hypothesis for this study was whether ubiquitous collaborative solution *YourSpace* provides Just in Time support through crowdsourcing at the place of work. Users collaborate with others through *YourSpace* and share knowledge by constructing learning objects. Section 6.4 describes how learning objectives have been created and the type of contribution various members gave. The hypothesis has been proved within the current study's where findings show that the subjects were successful in knowledge-sharing when carrying out the tasks. The majority of the subjects were able to garner the right skills for using the research tool *YourSpace* alone, with the majority of them sharing knowledge with their colleagues and partaking in collaboration regardless of their role.

Subjects' attitudes and behaviours in knowledge-sharing with their colleagues through the use of *YourSpace*—especially with regard to confidence and frustration when using a new instrument—was critical, with the findings collected through the completion of the pre- and post-study questionnaires. The success rates of those who completed the task by themselves in Study 3, as well as in the following tasks in Study 4 using *YourSpace*, were seen to feel confident, which could be owing to a number of factors. Primarily, the participants chose to work on the tasks in a location of his/her choice at the workplace, which possibly made them more at ease than in the experimental setting. This was possible when considering that all of the subjects utilised a tablet application that was configured with a permanent Mi-Fi, meaning a 3G Internet connection would enable devices to access the Internet in and around the workplace.

One further fundamental consideration was the potential to share knowledge and ask questions when experiencing problems. The knowledge of the subjects was shared through the app upon its creation, thus meaning other subjects could utilise it. Accordingly, even those individuals who had not commented or interacted could be successful in completing the tasks by following the steps outlined by their team members.

The learning objects' quality, which included step-by-step solutions or touch points, was useful in enabling users to gain trust not only in the system but also in the suggestions made by their peers. A large portion of the team members completed the tasks assigned and engaged with the app in order to share knowledge. Obj 1 detailed in Section 6.5.5 provides insight into the actions and findings associated with those participants who were creators in the construction of learning objects. Those creating successful learning objects were recognised as administrators, IT Support and Manager of team and IT-related roles.

When learning objects were lacking in useful information or were not well structured, they were ignored, with the subjects making the decision to create new objects instead, which was commonly the case amongst self-determined individuals (see Section 6.5.5).

It is shown through the results that knowledge-sharing learning with other people and with the use of a visual tool can facilitate subjects in communicating through the use of images. The failure and success of the task completion was logged following the finalisation of the study. Should participants not have been able to construct the learning objects and had there been adequate information available on the app, it would have been difficult to monitor data and accordingly assess the tool in mind of collaboration purposes.

The various findings identified in objectives 1–6 in Section 6.4.5 make it clear that, throughout the process, participants were actively involved in creating the learning objects. The tool was valuable in facilitating the process of communication amongst group members by minimising the misunderstanding of any part being described by the participants. Once adequate, the individuals participate in constructing the learning object with members that have different skills able to complete the tasks. Accordingly, the necessary cognitive process needed to construct the learning object and highlight key factors, enabling participants to interact in order to complete the tasks assigned (see Section 6.5.5, Obj 4). Achieving learning object quality is a key factor that can be constructed and evaluated by participants. This is achieved by adopting a crowdsourcing technique comparable to that suggested in this research.

It is shown through the results that the role of self-determined individuals is paramount in the creation of learning objects. Upon examining the results, it was recognised that, in some key instances, there was a need amongst users to create particular learning objects in an effort to decrease the explanation required. When drawing a contrast between logs, it was recognised that, upon the identification of a pain point, when other members had not successfully devised a solution, the learning object creator made the decision to discuss how the problem could be addressed easily. This was recognised in the various cycles devised for tasks 1 and 2.

During the completion of the study, time was continuously logged, which subsequently were examined to highlight the amount of time assigned to the process of learning object creation. One key factor affecting participation was the time required by subjects to interact with the collaborative solution, and their relation with the role selected when contributing through the use of *YourSpace*.

Quality and participation are critical in crowdsourcing, with the findings emphasising that SMD interaction occurred within a short period (See Table 56), thus providing validation that there is a positive effect on workplace productivity. It was further shown through examining the logs of those users who were successful in task completion had taken less than 10 minutes, on average, to finish the task; therefore, the conclusion was drawn that solution quality was good enough to achieve the objectives outlined. Owing to the fact that the learning objects could be built by a number of different participants, the solutions are more robust and complete when defined.

The examination of links between the subjects in the network emphasises that the learning objects that resulted in success detail the fact that the result was achieved in various different ways, such as when, for example, a contact was created in Task 4, a success screen was displayed in Task 1, or an email was sent in Task 2. This created a positive effect as participants build trust in the application.

Those individuals who were able to create a learning object and also were successful in completing the task became a point of reference. This was clearly noted when comparing which learning objects succeeded vis-à-vis those that failed (see Table 49–36).

It was possible that the link between participants could be computed through drawing a contrast between participants, considering the highest connection represented by the highest value of betweenness of centrality and noting the direction represented by the arrow through the graph, which was created using a SNA tool. By extracting information relating to the network, the relationship between participants could be captured, emphasising how different groups communicated.

Knowledge flow between the subjects was recognised by examining the extent of the connection between subjects. This result emphasised the trust invested in the system by the participants, and the rationale for selecting one learning object rather than another. Some of the questions posed in order to develop more insight into the links between individuals were: "*How often did a user interact?" "How often did a user get feedback*", "*how often did you use YourSpace?", "Who is sharing knowledge with whom?" and "Who is engaging with whom?"*

Creators, as independent learners, had a leading role in creating knowledge for others, and could be identified in each group. This was because, it was only through their own initiative that participants could learn how to user *YourSpace*. As a result, they were able to complete the tasks assigned and share their knowledge through the collaborative solution. Viewers that where mostly clerks did not interact with the solution but form the post questionnaire and evaluating the logs it was observed that they manage to acquire knowledge to complete the tasks. Two females failed in task 3 and 4 and described in case 2 objective 6 they used *YourSpace* but did not ask questions.

The research was centred on gaining insight into how users in a group gain knowledge through Just in Time collaboration by implementing a ubiquitous method that can be achieved through the use of a computer solution. By applying a crowdsourcing approach, there was the capture of knowledge, which was shared with colleagues in the work setting who were involved in the study. Moreover, system knowledge was considered fundamental in order to solve the issues in the creation of various learning objects. The process of creating the various learning objects assigned for the study was logged, meaning the data could be examined between each study and following task completion. Two technical solutions were applied in order to aid results evaluation: 1) the use of the principles of graph theory applied to social network analysis, and 2) statistical analysis collected from the feedback participants gave throughout the experiment.

Overall, the suggested solution for knowledge-sharing and self-learning—that of *YourSpace*, as discussed and assessed in this chapter—has provided results that emphasise that, through knowledge-sharing, individuals are aided in solving problems through utilising others' knowledge and the skillsets of others in the same work setting. This provides other team members with the opportunity to progress and complete tasks.

CHAPTER 7—SUMMARY OF WORK DONE, OVERALL RESULTS, DISCUSSION AND CONCLUSIONS

This chapter presents a summarised overview of the work compiled; the results discussed in the earlier chapters, and consider the key findings. This thesis proposes that it is possible that users can readily make use of technology in a simple way so that they are not required to invest a wealth of effort in order to garner and share knowledge, and interact with technology with the goal of efficient completion of work tasks.

Importantly, through the application of a crowdsourcing computer solution, implemented within a real workplace setting, knowledge is captured and shared.

However, there is also the need to address key technical challenges in order to cater for a ubiquitous environment in which people can share knowledge Just in Time and accordingly gain access to learning objects devised and made available by their community through their SMDs.

More research is needed in this area to further develop the various advantages secured through the work conducted in this thesis as highlighted in the concluding part and as described later in this chapter.

7.1 Challenges and Summary of Work

Various challenges had to be overcome in order to secure valuable results, such as those discussed in this study. The study required the active involvement and support of different organisations, with agreements reached with Malta International Airport, Sheffield University and the University of Malta to allow their staff to participate in all the different studies required for this research, despite the fact that involvement was time-consuming.

Only those individuals who worked full-time or for more than 30 hours a week, and who also had a fixed workplace location, were selected to participate a the study in its different phases. These criteria would affect. Upon receiving approval for the research study to go ahead, as provided by the Sheffield University Ethics Committee, the resources necessary for completing the research needed to be acquired. The author provided a presentation of the study to key people at the Microsoft Innovation Centre and Vodafone Malta, securing agreement to support part of the initiative by offering devices for the completion of the study.

One further challenge faced was the fact that the study combined different aspects of educational psychology with computer science, meaning there was a need to take into account various key models and their foundations and concepts from both domains when devising the study plan. A wealth of work was deemed necessary when addressing technology enhance learning (TEL) in the workplace. Through the involvement of more participants in studies and the detailing of their experiences with the *YourSpace* app, solutions could be improved to include mapping software design requirements developments so as to enable users to construct learning objects and collaborate with one another in solving problems in real time in a more efficient manner.

Various technical challenges also needed to be overcome in order to ensure that a collaborative computer solution could be identified. Subjects needed to be provided with access to learning objects in real time, along with the necessary knowledge to construct such objects, (for example Just in Time,) when seeking solutions to problems. Suitable logs were required to enable the researcher to monitor data and garner findings. SNA adoption was only possible if the subjects were actively involved in contributing to and utilising the tool assigned for Study 4. Accordingly, one fundamental consideration was the usability of the crowdsourcing tools.

The results identified by users and businesses emphasise that the tool was designed to meet the established requirements of the workplace, with the online user manual designed for the thesis rated highly and considered valuable by participants. The subjects also said that they learnt how to use the tool independently, alongside accessing the manual

The work carried out can be summarised in the following points, which illustrate the key results garnered.

All of the four studies carried out—comprising Study 1 and Study 2, which were preparatory studies and Study 3 and Study 4, which were the two main studies—were discussed in chapters 3, 4 and 6.

Study 3 was conducted to examine levels of confidence and frustration amongst the users when they were working towards independently solving the problems, which the users needed to overcome for completion of familiar tasks on SMDs.

Study 4 adopted an experimental approach, which involved examining the various ways in which users in a work setting achieve support through the adoption of collaborative knowledge-sharing computer solutions.

The overall study outcomes suggest an innovative approach to knowledge-sharing, such as through the application of a crowdsourcing method that may be adopted in the work setting as a support tool. A user framework was suggested and assessed, the results of which linked the individuals' roles and the skills in the sharing of knowledge. These included awareness, confidence and knowledge-sharing, as detailed in Section 5.5, during which the relationship between the roles and skills and the respective progression levels were examined.

In order to achieve the goals of each task, it was necessary to acquire a sample of participants that could carry out the tasks assigned within a workplace setting. The suggested solutions as discussed in previous chapters, were tested on key stakeholders, all of whom were individuals with varying levels of technical skills and experience, with some recognised as self-determined learners, represented by those employees in an organisation who have the ability to build learning objects and can share or create learning objects.

Gaining insight into the users' different behaviours and attitudes and abilities when solving problems when utilising devices enabled the researcher to establish the different requirements of users, and thus to provide the necessary methods for transition from one level to the next Accordingly, the suggested framework provided the users with support in a short period of time, with support being tailored to meet requirements.

Through the adoption of a crowdsourcing solution via TEL and a collaborative support solution, four case studies were observed, with the subjects being asked to create the various learning objects as requested through the use of suitable instruments using the *YourSpace* tablet app. The design of the case studies was centred on solving IT-related problems frequently experienced by users in the work environment. After using the tool for a specific time, the learner was observed to become empowered and more independent, acquiring or using the IT skills necessary to allow the completion of the task.

The researcher was able to analyse potential exploitations of shared user modelling through the designed tool, which was based on a concept that was tested in a number of different user studies. The results obtained were useful in more effectively reaching the overall scope and precision of crowdsourcing models on touchscreen SMDs. Prior studies conducted by other scholars, such as those centred on adaptive user interfaces, for example, relied on domain-specific and local user models, which lacked user involvement throughout the course of workplace experimentation (Kay & Kummerfeld 2010; Rogers et al. 2009). The findings in this thesis emphasise that shared user models were pivotal in improving the overall depth and accuracy of the data, which resulted in the ability to fine-tune the interfaces, which subsequently enabled users to interact with one another when gathering and sharing knowledge through the Just in Time support solutions made available.

7.2 Hypothesis and Decisions Made when Designing the Studies

Throughout the course of this chapter, the hypotheses and assumptions detailed in the first chapter are again discussed.

Hypothesis

The adoption of crowdsourcing knowledge through the application of Just in Time collaborative solutions will help users overcome obstacles and challenges more proficiently in the work environment. We argue that people sharing knowledge in the workplace are sharing all the knowledge they are aware of in the most effective way because it is shared in the situation where they naturally experience problems: at the workplace. In the same vein, it is considered that users would garner new skills spanning beyond physical and departmental restrictions, thus aiding the organisational community in knowledge-sharing, where such knowledge can be accessed, expanded upon and developed by users, at any time, in line with the needs of users. It is recognised that this could help to overcome problems in a relatively short period of time.

Study 4 findings show that subjects in the workplace constructed learning objects Just in Time that can facilitate their engagement with the *YourSpace* collaborative computer solution enabling completion of the assigned tasks. The suggested approach was useful in aiding the assessment of various elements as individual users and their varying roles in the workplace, taking into consideration their level of progression. In this group, there were different users with roles that were seen to influence their degree of involvement and contribution, i.e. active participants, creators, their abilities and attitudes. This provided the researcher with the opportunity of a number of unique cases that have been analysed.

Various decisions were taken throughout the course of the research study to address the research questions in a more comprehensive manner to reach the overall objectives of the study.

7.2.1 Research questions and decisions taken in choosing the methodology.

In the first chapter, the goal was centred on clearly identifying the research questions, to be answered, which were devised as follows:

1. What is the relationship between the levels of confidence and frustration amongst workplace users when focused on independently solving problems in the completion of familiar tasks on a non-familiar SMD?

Study 3 - Problem-Solving, confidence and frustration when carrying out familiar tasks on non-familiar mobile devices was an experiment carried out in three different work settings, namely Malta International Airport, University of Malta and Sheffield University. The experiment studies were carried out with the view of measuring the level of confidence prior to and frustration following the study when aiming to complete assigned tasks. A video analysis of the participants was performed in mind of garnering insight into the different actions taken in the completion of the tasks. The findings were valuable in providing greater understanding of users' behaviours and attitudes when completing tasks according to their experiences when using smart mobile devices. The link with IT support was analysed and findings revealed that a number of participants (87%) failed the task as detailed in Section 3.2.2. The high risk-failure rate in this study seems to indicate that despite a familiarity with the tasks, users are not necessarily acquiring transferable skills when using SMDs.

2. How can users in the work setting identify and utilise support through the application of collaborative knowledge-sharing computer solutions through the adoption of methods using ubiquitous technology on a Just in Time basis?

As considered in chapters 5 and 6, the collaborative computer solution used in Study 4 was available to participants at Malta International Airport through a tablet application known as *YourSpace*. A total of four tasks were assigned to the subjects after viewing an online manual describing how the tools for the study could be used. A decision was made to create a collaborative computer tablet solution with the capacity to fulfil the criteria derived throughout the course of studies 1–2, as detailed in chapters 3 and 4. Subjects were able to upload instances and accordingly collaborate through adding comments and remarks by selecting an icon that was useful in establishing the image being described. This was also useful in helping the user to understand the type of remark suggested by the creator. All of this knowledge and data could enable users to gain access to and accordingly update all learning objects in real time. MI-FI use provided connectivity for the device, which allowed the users to synchronise images when carrying out the various tasks.

As considered in Chapter 6, the various ways in which knowledge was shared by group members was discussed in terms of how they support their peers. All of this was achieved in the work environment, facilitating the use of a Just in Time method with a ubiquitous environment. Subjects were identified as coming from four different progression levels, and actively participated in using, or otherwise created, the collaborative tablet application so as to create learning objects, with viewers able to check the solutions and make reference to them in mind of task completion.

3. Through the computer supported cooperative works by adopting the business of social media, innovative study methods and applications have been pivotal in creating a number of opportunities. How can these approaches, when using a mobile social network, be used and applied whilst also ensuring users' approaches in knowledge construction are supported so as to enable them through the progressive autonomy levels?

Designing and implementing a business social module, based on community-tracking data, centrality was extracted. This enabled the identification of the flow of knowledge between members by extracting the interactions between users. There has been the identification of five user actions that have been formulated into objectives in Section 6.5.5. The researcher has taken the decision to relate icons with a specific meaning to help categorise the interactions amongst users. A large number of different interactions are devised when applying a crowdsourcing solution. As an SNA tool, Gephi was adopted in order to help visualise the type of interactions in which users are involved when collaborating to construct learning objects. Such decisions helped in achieving better understanding of the key players, as well as their roles, whether as creators, active participants or viewers, in the completion of tasks. There was also the possibility of deriving the different levels of progression when further examining the results obtained by adopting statistical analysis. The learning objects were manually checked in order to identify the statements and overall quality pertaining to the construction of learning objects. A number of examples were selected from the learning objects created by the subjects, and were further explained. Such examples then were discussed through linking them to their respective objectives, in line with the actions carried out by individual subjects.

7.3 Overall Results

The research outcomes were pivotal in directing more focused attention to the obstacles experienced by users when carrying out familiar actions. Various aspects that could be recognised as obstacles—referred to as pain points—were identified and logged in the first three sub studies, and accordingly were used to establish the various requirements for the proper scientific experiment required to complete the research plan through the adoption of different approaches with the objective of achieving workplace crowdsourcing, which is one of the main study objectives.

Throughout the earlier studies—namely Study 1 and Study 2, as well as the subsequent study—various challenges were identified:

1) The limitation of the use of SMDs as a means to communicate in the traditional way: phone calls, SMS etc.

2) The lack of experience when using applications on SMDs, such as browsing the web, which differs from that on traditional desktop computers.

3) The differences between the setup and environment of desktop computers or laptops from SMDs, including the different input and output ways of the former that users are now accustomed to.

Findings in Study 3 suggest that, irrespective of the position and role held by an individual, difficulties are encountered when utilising unfamiliar SMDs. Despite the fact that SMD use is increasing in the workplace, with the adoption of such technologies by organisations, various obstacles are identified as limiting the comprehensive use of SMDs. Designers of such devices are continuously seeking to improve mobile operating systems and applications; nonetheless, the issues faced by users when completing normal, everyday tasks facilitated by technology, including those assigned in this work, demonstrate that users face a number of challenges that could take time and resources to be solved, thereby detracting from the benefits of usage. Moreover, messages intended to alert users to their mistakes given on SMDs are not always properly understood by users, meaning they lack value in providing the support deemed necessary to solve a solution.

Various aspects to make the research possible have been highlighted in this thesis such as gaining insight into and understanding how and why Smart mobile device users are affected when failing or succeeding in overcoming a technical issue.

One fundamental aspect that was seen to occur continuously is the fact that participants need to be *engaged* with a particular app by actively contributing to the construction of learning objects and knowledge-sharing so as to derive better results and thus make full use of the SMD.

Studying users' behaviour and attitudes, especially with regards to levels of frustration in the use of new tools, are pivotal in finding solutions for successful IT systems. . The present study has been useful in identifying how subjects overcame the challenges experienced when seeking to solve problems on an SMD. In Study 3, when comparing success rates and confidence levels, it was found that users with more confidence usually experience a lower level of frustration; however, a higher success rate is not always seen. Behaviour and attitude are recognised as gender-biased, with males more likely to show confidence but not necessarily more likely to establish higher problem-solving rates (Attard *et al*., 2016 in press).

The extent and usefulness of IT support roles combined with how users independently overcome problems seems to have an impact on users' confidence and how they might opt to solve some of the issues they came across d. This thesis shows that individuals think they might know how technology can be used, but when they actually come to face challenges, they continue to fail without the necessary support.

Furthermore, it appears that confidence and actions are linked to the role users adopt in performing a task, which is seen to have an influence on their views of technology, self-directed learning, and overall knowledge

Familiar tasks completion and the failure rate suggest that users do not usually acquire the skills necessary to maximise the opportunities available in the use of SMDs. Despite the fact that SMDs are becoming more widely available and used, more research is necessary in order to understand how smart mobile users can best engage with new devices and their supportive features. Users' knowledge can be improved, with problem-solving accelerated, through the collection of more data relating to mobile usage with the goal of better supporting the needs of users.

The high level of collaborative participation observed during this research when users were solving the tasks as well as when they were constructing the learning objects, indicates that experience shared among peers can be successful. Participants appeared to trust their peers and they worked together to ensure that the information being created and stored was correct. Furthermore, this was verified after every study as the devices and their configuration were checked. Breaking down solutions into steps, allowing participants to revisit each step in order to contribute or to learn helped them to focus on a specific task. Each instance recorded on the device represented an action a participant performed to achieve the final solution. When more participants visited the learning object and shared their knowledge, a higher quality assurance was achieved.

Results showed that users could create a learning object in minimal amount of time. It is observed that the proposed tablet application, *YourSpace* stipulated that ubiquitous computer solutions need to be designed met the established criteria when designing the application. The process of contributing to knowledge by creating each instance within the learning object needed to be seamless and efficient, and needed to occur within the shortest possible timeframe so that users did not feel that they were required to invest significant efforts. This was evidenced by the fact that the low average mean time participants took to complete the task in Study 4 when supported by the solution, combined with the fact that a greater number of participants, from different levels of progression, were successful in completing the tasks in study 4 when compared with the results of participants of study 3.

Through the *YourSpace* app, social network communication appeared to be pivotal in ensuring users are involved and motivated to complete tasks whilst also ensuring the construction of learning objects. Throughout the course of the overall study, there was the sharing of knowledge with different subjects through different comments and suggestions, which were pivotal in building a knowledge base similar to that identified in social networks. Icons that can be dragged and dropped onto the images devised and uploaded by users provide greater clarity on the discussion. It was observed that the subjects also learnt through reviewing examples of how knowledge can be shared through *YourSpace*.

Individuals with various skills and levels of knowledge need to be involved with the solution in order for crowdsourcing knowledge to be possible. One aspect identified throughout the completion of these studies was the need for a larger number of software solutions that fulfil the requirements established by different disciplines, including education and psychology.

More work needs to be done in this field so as to ensure all components of any learning object can add value to workplace task completion. SMD use could also be further examined in the experimental context, different solutions can be developed to propose a design, which users engage in , that minimise the problems in the collaborative process.

The experiment studies carried out thus far and documented in this thesis indicate, that those using SMDs require a greater degree of support in order to overcome the obstacles being faced. This study drew a comparison between the efforts made in task completion without technology use and the amount of effort invested when utilising technology. The research study concludes that “Not much effort” is inversely proportional to “cognitive load”, whereby a high cognitive load would produce stress. Accordingly, this study aimed at decreasing the effort users need to invest in completing a task. This included the effort of learning how technology should be used.

Through this research study, it has been established that participants with different roles are able to work collaboratively in order to support one another. , However, monitoring patterns of behaviour and observation, have subsequently shown that subjects may be categorised at reaching different progression levels depending on the task complexity; in other words, the more complex the task, the more difficult it is for subjects to complete tasks. Creators are recognised as self-determined users, i.e. at a higher level of progression Heutagogy mostly are administrators, management or a part of IT support; therefore may not be aware of the challenges that other workers can face. Conversely, the findings show that viewers generally were in the position of clerk.

7.3.1 Contributions

Throughout the course of this study, the goal of devising a new employee-focused method through crowdsourcing knowledge in line with SMD use has been pursued by applying a collaborative computer solution framework in the work environment. More specifically, this study sought to extend past works in the social media field through capturing Just in Time knowledge via the adoption of an innovative method, implementing a ubiquitous solution within the natural workplace (Bijedic *et al.,* 2012; Manske *et al.*, 2007). Social network analysis was conducted to evaluate individuals’ roles and the ways in which they collaborate and communicate with their colleagues so as to achieve knowledge construction.

This thesis has provided a number of key contributions, as explained in the following paragraphs.

Through crowdsourcing, users were invited and readily accepted the opportunity to construct solutions through learning objects when dealing with issues in SMD use. The completion of an experiment carried out in the work setting, a ubiquitous support creation through crowdsourcing Just in Time knowledge was examined, with the presentation of the various key findings. Workplace community members shared knowledge concerning how problems could be solved in different ways on the tablet application. These were available for capture through Just in Time with colleagues across the work setting. Through the proposed methodology, that is by adopting problem solving techniques users work efficiency would be improved.

By applying the various underpinnings of persuasive technology, namely social media, and accordingly encouraging users, through the completion of the experiments, findings contributed to gaining more insight into team motivation (workplace communities) and the ways by which users can construct learning objects simultaneously.

The present study has provided insight into the processes carried out by users in the creation of learning objects, in addition to the various methods applied during collaboration and interaction across the community in mind of sharing knowledge, learning, and devising solutions. Through community pattern capturing and reviews, the opportunity to observe users' behaviours presented it self, meaning members could be grouped into different progressive levels in order to garner knowledge information that contributes to establishing the learning objects.

7.4 Discussion

This thesis work has centred on examining different knowledge-sharing methods for application in the work setting. It has devised a solution centred on maximising the potential to apply collaborative solutions on tablet apps that enable staff to construct and share knowledge that is accessible to colleagues in the work environment in real time. Focusing on problem-solving and addressing support on technical topics is only the first stage.

Across this study, data has been collected through the application of a number of methods, including interviews, workshops, online surveys and video analyses, as described in chapters 3, 4 and 6, with the resultant findings being pivotal in gaining insight into the field under examination. When analysing the environment and its context, one key considered is the level of intrusiveness, as taken into account in the work of Shen Xiaobin P.Eades, (2007). Experiments conducted in locations such as the workplace should consider intrusive and non-intrusive approaches to assessing such information systems.

In this work, the choice of when and how the solution is used was a critical concern in the planning of the fourth and final study. Subjects were provided with a suitable amount of time to attempt to solve the tasks assigned and to participate in the collaborative solution *YourSpace* designed for Study 4 with the aim of observing the behaviours and attitudes of the users during the experiment's duration.

One further aspect needing to be taken into account when seeking to garner insight into the various challenges experienced when exploring the usability of SMDs is the learning process adopted when a user faces issues during engagement with pervasive technologies on an SMD. Moreover, how users used their devices outside of the work environment was taken into account when defining the technology proficiency of participants.

Businesses face situations comparable to that mocked up through studies 1–3 with regard to inadequate IT support in the application of in-house customised IT solutions. Thus far, there has been the completion of limited research on IT knowledge management across firms. In this vein, Dignum (2004) and McGarrity (2001) consider the issue of knowledge management when users apply different scattered tools in mind of documenting knowledge related to IT systems. Such studies have not conducted in depth investigation of the role adopted by individuals when using their solution, but rather centre on standardising information documentation for using knowledge-based tools. Furthermore, other studies completed centre on the provision of support solutions in line with specific systems or learning tools (McLoughlin C. & Lee, 2010; Kim *et al,* 2009). Through the data collected from the sources in studies 1, 2 and 3, it was recognised that, despite the availability of a "*Help tab"* for most popular applications on desktops (although these are less widely available on mobile APPs), very often, subjects sought out other engaging ways of learning how problems could be solved in the work setting, such as through the use of the instrument devised in this research—that of *YourSpace*.

YourSpace and other comparable solutions provide a higher degree of involvement, and may be easily available through online or offline solutions and sources and through shared information, such as through peers. Every stage enables users to centre on one issue before another, meaning they can progress through dealing with issues and take the necessary actions or seek out further assistance. When creating solutions, participants in the work environment can discuss all stages of the process whilst also noting their approaches and technical observations and those of others, which enriches the learning objects and further improves the overall relevance of the information being shared.

7.5 Further Work

The data gathered in studies 3–4 could undergo further analysis: for example, the textual analysis of comments and remarks in the creation of learning objects in Study 4 may be completed. This would provide a greater degree of knowledge on the interaction of users during the construction of different learning objects.

This area would benefit from further work, such as involving greater numbers of participants, extending the range of tasks they are asked to complete and by introducing additional options that enable users to utilise rich media, including animations, diagrams and videos for creating learning objects. Such tools should be user-friendly and need to be focused on the study's key requirements—namely decreasing the need to invest significant efforts into the construction of learning objects.

One of the key concerns affecting the outcome of Just in Time learning solutions is the type of communities involved. Upon drawing a comparison across the different groups, this study centres on those individuals that participate (or who do not) in the completion of a task, and how they influence the success factor of the community, which can be seen in the quality of the learning object. Accordingly, more work needs to be completed on the type of workplace communities and their structure, the learning objects that are best suited to their needs creating more personalised solutions. Further studies may be carried out with the view of facilitating interaction between users and the tool over a longer period of time, and analysing how communities and individuals change with the passing of time.

A number of benefits can be achieved through crowdsourcing, such as the fact that it enables knowledge to be captured by users. It can be applied in a broader context when, for example, adopted during the initial stages of setting up enterprise resources planning (ERP) solutions within organisations. More in depth studies need to be carried out in order to ensure that the knowledge created is of higher quality, such as through for example measuring a learning object's success factor.. This could be achieved by involving a larger number of users in the studies from various entities. Applying different methods such as contrasting workplace settings also could enable the analysis of texts generated by users and the process of categorising content to be automated. This could, in turn, result in solutions being devised and recommended that could invite participants to contribute to certain topics, and learning objects according to user profiles that change and update with time.

7.6 Conclusion

In the modern-day world, more and more employees are adopting tools such as SMDs within the workplace (Giannakouris & Smihily, 2012). Importantly, however, this work emphasises that, during the adoption of these tools, users are faced with various issues; and these can have a negative effect on their ability to perform their role. Accordingly, those adopting IT roles need to acknowledge the challenges of such issues.

The study's findings further demonstrate that, in order to secure better results from a solution, there is the need for users to be actively involved and to make contributions. Engagement amongst users is fundamental throughout research in the proposed area of study as this helps to ensure findings are valuable and can provide understanding as to how and why smart mobile users are affected when succeeding or failing in dealing with a technical issue.

This work emphasises that people tend to believe they understand technology, but that, all too often, when facing a task, they might be unsuccessful in solving a problem. The findings further emphasise that age and experience are not necessarily factors that discriminate the individual's ability to solve problems. On the other hand, a person's job role improves levels of confidence when dealing with problems. Accordingly, the actions taken and the confidence in using such technology seem to influence perceptions of technology, their ability to self-direct learning, and their overall knowledge.

When taking into account the effect of personalisation across these studies, it becomes apparent that more in-depth work is necessary in order to establish how systems similar to that proposed in this thesis can contribute to improving the involvement of users by improving the suggested tool, which not only would enhance the various learning objects created by people but also how solutions can be better linked to the skills and learning approaches required by users.

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Appendix A - Ethics Approved Documents

Participant Consent Form

Title of Research Project:

Crowdsourcing Just in time Knowledge at Workplace aligned with the constant evolvement of smart mobile devices

Name of Researcher: Mr Conrad Attard

Participant Identification Number for this project: **Please initial box**

1. I confirm that I have read and understand the information dated *[__/__/____]* explaining the above research project and I have had the opportunity to ask questions about the project. ☐

2. I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason and without there being any negative consequences. In addition, should I not wish to answer any particular question or questions, I am free to decline. *Email: acp10ca@sheffield.ac.uk* ☐

3. I understand that my responses will be kept strictly confidential. I give permission for members of the research team to have access to my anonymised responses. I understand that my name will not be linked with the research materials, and I will not be identified or identifiable in the report or reports that result from the research. ☐

4. I agree to be recorded during the sessions and my identity will remain confidential. A profile will be created that will be used for the proposed study and for further analysis. ☐

5. I agree for the data collected from me to be used in future research. ☐

6. I agree to take part in the above research project. ☐

____________________	______________	_________________
Name of Participant (*or legal representative*)	Date	Signature
______________________	______________	_________________
Name of person taking consent (*if different from lead researcher*) *To be signed and dated in presence of the participant*	Date	Signature
______________________	______________	_________________

Lead Researcher Date Signature

To be signed and dated in presence of the participant

Copies:

Once this has been signed by all parties the participant should receive a copy of the signed and dated participant consent form, the letter/pre-written script/information sheet and any other written information provided to the participants. A copy of the signed and dated consent form should be placed in the project's main record (e.g. a site file), which must be kept in a secure location.

Participant Information Sheet. Ref Version 1 Date 18/01/2012

Title: **Crowdsourcing Just in time Knowledge at Workplace - aligned with the constant evolvement of smart mobile devices**

You are being invited to take part in a research project. Before you decide it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Ask us if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part. Thank you for reading this.

Aim of this project:

To explore the barriers and facilitate adoption of a new generation of smart devices. To provide users an application, solution, and/or product to rapidly acquire the competences necessary to be part of the digital world. Competence should be achieved seamlessly through smart mobile devices. The users will be observed to determine whether this transition has an impact on improving their quality of life and increase productivity.

You have shown interest in taking part in this project. After participating in an online survey you will be given a task and participate in one to one interview or workshops prepared in relation to research on smart mobile applications.

It is up to you to decide whether or not to take part. If you do decide to take part you will be given this information sheet to keep (and be asked to sign a consent form) and you can still withdraw at any time without if affecting any time without it affecting you in any way. You do not have to give a reason.

A session will be organised during which you will be given clear objectives/tasks and enough time to share your experiences within a comfortable environment. All information will remain confidential and if any information will be published it will be done in such a way that the participant will not be identified. A number of tasks shall be assigned some of which you will be expected to use a smart mobile device.

Whilst there are no immediate benefits for those people participating in the project it is hoped that this work will contribute in suggesting new ways of how to adopt social networks within smart mobile applications as a means to help users make better use of new emerging technologies and smart mobile solutions.

At the end of each session participants will be allowed to give feedback on how they felt during the workshop.

All the information that we collect about you during the course of the research will be kept strictly confidential. You will not be able to be identified in any reports or publications.

The audio and/or video recordings of your activities made during this research will be used only for analysis and for illustration in conference presentations and lectures. No other use will be made of them without your written permission, and no one outside the project will be allowed access to the original recording.

Thank you for participating in this research project.

General Info:

This project has been ethically approved via University of Sheffield Computer Science Department Ethics Review Procedure.

If you would like further information about the project you can contact us:

Leader Researcher	Supervisor
Mr Conrad Attard Room 201 Computer Building University of Malta Malta	Dr Daniela Romano Room G10 Regent Court, 211 Portobello University of Sheffield Sheffield, S1 4DP UK
conrad.attard@um.edu.mt	daniela.romano@sheffield.ac.uk

Co Supervisor
Professor Gail Mountain Professor of Health Services Research (assisted living research) School of Health and Related Research 30 Regent Court University of Sheffield Sheffield S1 4DA

Appendix B – Study2 | Material used during the preparatory workshop during the second study.

Workshops one and two - Study 2 Held on 4th and 5TH June 2012.

Research Smart Mobile Applications at Workplace.

Profile: User No: ______ Mobile No:____

Mobile being used for study____

Personal mobile you currently own? ____

Did you ever own the mobile used for this study Yes ☐ No ☐

Match Icons With Description: (Some may refer to more then one ICON)

1	2	3	4	5	6		7	8	9	10	11

	No	Description of ACTION	Not Known
WIFI			
3G			
BLUETOOTH			
Synchronisation			
SIM CARD			
GPS			
ERROR			
USB			

I don't know what these symbols mean. ☐

Research Smart Mobile Applications at Workplace. (JUNE 2012)

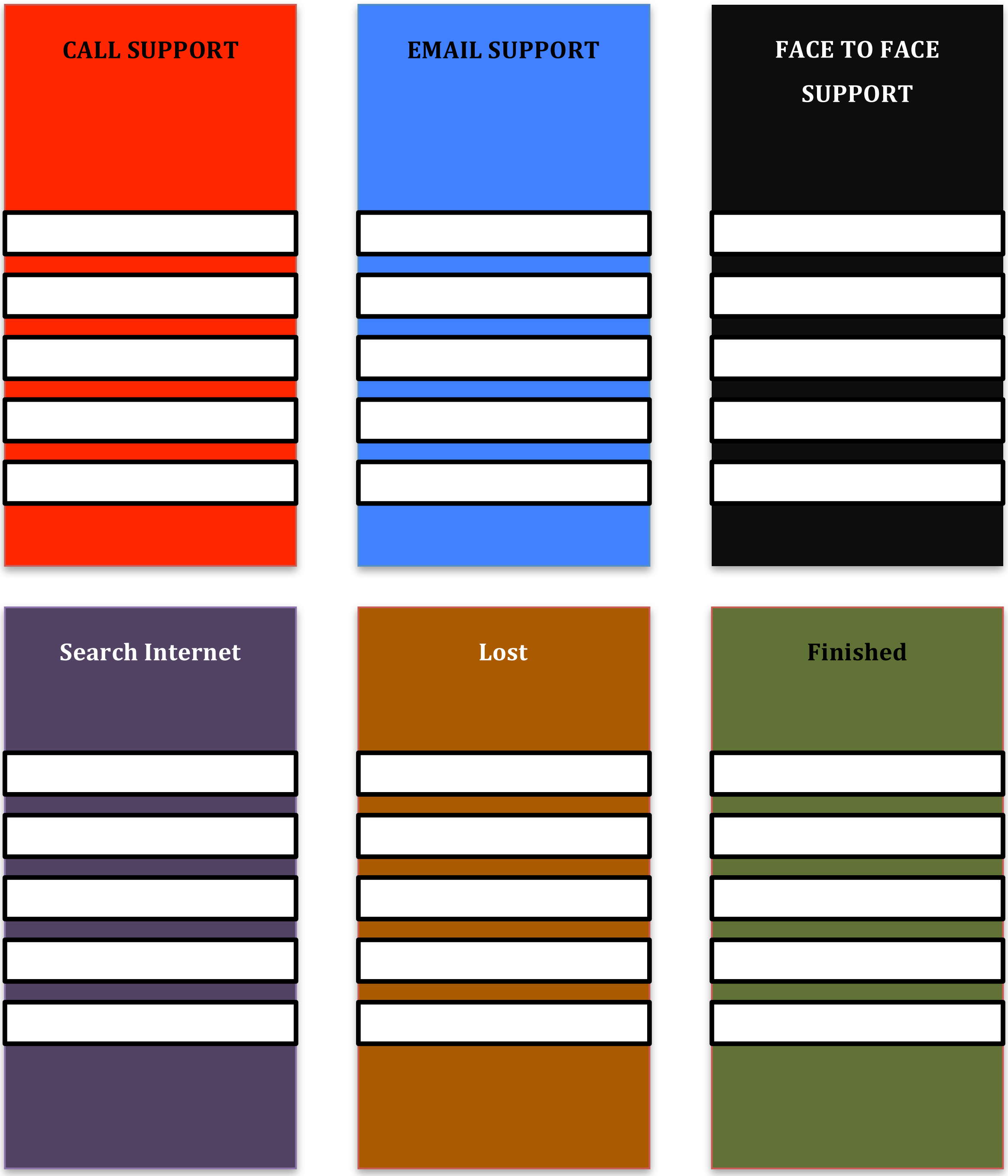
Profile: User No: ______

Input Sequence of how you tackled problem. *(Difficulty of step: 1 lowest and 5 highest)

[key :**CS** CALL SUPPORT | **ES** EMAIL SUPPORT | **FS** FACE TO FACE | **INT** INTERNET]

Sequence	Short Description	CS	ES	FF	INT
	* 1 2 3 4 5				
	* 1 2 3 4 5				
	* 1 2 3 4 5				
	* 1 2 3 4 5				

Card 1 Ref Task1 and 2 Preparatory Study 2



User log type of support and status of task - Ref Task1 and 2 Preparatory Study 2

Awareness, Acquiring technical Knowledge & Confidence [Participant Number. ___]

Awareness

	Question		1	2	3	4	5
1	How responsive was he/she to problem?						
2	Did he/she identify the source of problem?						
3	Ability to take action						
4	Access to different ways to acquire solutions.						
5	Attitude to unfamiliar technology						
6	Ability to notice and interpret messages and icons during tasks.						

Acquiring technical Knowledge

	Question		1	2	3	4	5
1	Amount of Time to solve problem						
2	Memory span to solve problem						
3	Access to solution						
4	Understanding of various stages.						
5	Interaction with learning object						
6	Any external factors creating difficulties when interacting with the device.						

Confidence

	Question		1	2	3	4	5
1	How much do they recall what they have done?						
2	Can they share their knowledge to others?						
3	Do they recommend ideas of how to improve learning object?						
4	Do they know more about the subject after the task has been solved?						
5	How much of the solution has been done by them independently.						
6	Acceptance of Technology						

Evaluation Sheet – Observation of how participants performed during task in preparatory study 2

Appendix C - Study 3 (Instructions to do tasks and Video Analysis Logs)

Study held February & March 2013

at Sheffield University, University of Malta and Malta International Airport.

Access the following wireless connection:

SSID: 802.11 G- SSID

Open a mobile browser and access the following page:

http://192.168.1.10:8888/conrad

Verify that you can see a message that you have successfully access the page.

When task 1 is completed please complete task 2. (Task 2 is not related to Task 1)

Task 2

1. Configure an email account.
2. Send an email to the following email address

Configuration Settings:

Email smdstudy@gmail.com

Password:

(where 0 is number zero - l is letter L small caps - no spaces)

IMPORTANT: Consider all options.

Verify that email was sent. Send an email to smdstudy@gmail.com to confirm you have configured correctly Task 2.

You can't exceed 15mins. If you give up you may say so and stop the study any time.

Table 57: Sample of Data logged for Video Analyses

	Codes/Total Time/Iterations	Time one	End Time	Time Two	End Time
Approach in solving tasks	1				
Reason Completed/or Not Tasks 1	1				
Reason Completed/or Not Tasks 2	7				
Start-up Device	0	00:00:00	0		
Initial Time	25	00:00:25	25		
End time	908	00:15:08	908		
Identified that Internet is not available yes/no	No	no	no		
Identifying Menu and Icons/ Yes/NO	Yes	yes	yes		
TASK 1					
Initial Time Task 1	25	00:00:25	25		
Task 1 Iteration 1a					
Task 1 Iteration 1a Time Total					
Task 1 Iteration 1b Initial	1	00:01:26	00:02:01		
Task 1 Iteration 1b Time 1 Completed	35	35			
Task 1 Iteration 1c Initial					
Task 1 Iteration 1c Time 1 Completed					
Task 1 Iteration 2a	1	00:02:06	00:03:07		
Task 1 Iteration 2a time 1	61	61			
Task 1 Iteration 2b					
Task 1 Iteration 2b time 1					
Task 1 Iteration 2c					
Task 1 Iteration 2c time 1					
Task 1 Iteration 3 Exploring without direction					
TASK 2					
Initial Time Task 2	196	00:03:16	196		
Task 2 Iteration 1a	4	00:03:16	00:04:48		
Task 2 Iteration 1a Time total	337	92			
Task 2 Iteration 1b					
Task 2 Iteration 1b Time total					
Task 2 Iteration 1c					
Task 2 Iteration 1c Time total					
Task 2 Iteration 2a	7	00:04:48	00:06:14		
Task 2 Iteration 2a Time total	271	86			
Task 2 Iteration 2b					
Task 2 Iteration 2b Time total	n/a				
Task 2 Iteration 2c					
Task 2 Iteration 2c Time total	n/a				

Task 2 Iteration 3a	n/a				
Task 2 Iteration 3a Time total					
Task 2 Iteration 3b	n/a				
Task 2 Iteration 3b Time 1					
Task 2 Iteration 4a	n/a				
Task 2 Iteration 4a Time 1					
Task 2 Iteration 4b	n/a				
Task 2 Iteration 4b Time 1					
Task 2 Iteration 5a Lost	1	00:13:55	00:14:47		
	52	52			
TASK 1					
PP1 Configuring Wi-Fi	5	00:01:26	00:02:01		
	35	35			
PP2 Accessing Site	5	00:02:06	00:03:07		
	61	61			
PP3 Figuring out how device works					
TASK 2					
PP1 Configuring Email	4	00:03:16	00:04:48		
	337	92			
PP 2 Sending Email	4	00:04:48	00:06:14		
	271	86			
PP3 Checking Connectivity	n/a				
PP4 Choosing another Wi-Fi	n/a				
PP5 Time taken to Connect	n/a				
PP6 Figuring out how device works	n/a				

Appendix D – YourSpace Study 4, Obstacles (PPT) per task.

Obstacles (PPT) mean time identified by participants categorised by role for task 1

		Mean Time in minutes	Std. Deviation	95% Conf. Int. for Mean		P-value
				Lower Bound	Upper Bound	
Duration (Task 1 PPT A)	Creator	1.70	1.326	.59	2.81	0.145
	Participant	2.34	1.607	1.26	3.42	
	Viewer	3.32	1.952	1.82	4.82	
Duration (Task 1 PPT B)	Creator	2.97	1.789	1.48	4.47	0.765
	Participant	3.33	1.435	2.36	4.29	
	Viewer	3.65	2.365	1.83	5.46	
Duration (Task 1 PPT C)	Creator	2.19	1.291	1.11	3.27	0.119
	Participant	3.36	1.358	2.45	4.27	
	Viewer	3.46	1.401	2.38	4.53	

Obstacles (PPT) mean time identified by participants categorised by role for task 2

		Mean Time in Minutes	Std. Deviation	95% Conf. Int. for Mean		P-value
				Lower Bound	Upper Bound	
Duration (Task 2 PPT D)	Creator	1.97	1.513	.71	3.24	0.247
	Participant	3.00	1.020	2.31	3.69	
	Viewer	2.49	1.372	1.43	3.54	
Duration (Task 2 PPT E)	Creator	2.40	1.244	1.36	3.44	0.310
	Participant	1.65	1.446	.67	2.62	
	Viewer	2.58	1.525	1.41	3.75	

Obstacles (PPT) mean time identified by participants categorised by role for task 3

		Mean Time in Minuites	Std. Deviation	95% Conf. Int. for Mean		P-value
				Lower Bound	Upper Bound	
Duration (Task 3 PPT F)	Creator	3.28	2.313	1.34	5.21	0.145
	Participant	4.20	1.470	3.21	5.19	
	Viewer	5.04	2.190	3.36	6.73	
Duration (Task 3 PPT G)	Creator	3.28	2.351	1.31	5.24	0.765
	Participant	4.26	2.027	2.90	5.62	
	Viewer	5.23	2.130	3.60	6.87	
Duration (Task 3 PPT H)	Creator	3.60	1.349	2.47	4.73	0.119
	Participant	3.99	0.769	3.47	4.51	
	Viewer	3.80	1.869	2.36	5.24	

Obstacles (PPT) mean time identified by participants categorised by role for task 4

		Mean	Std. Deviation	95% Conf. Int. for Mean		P-value
				Lower Bound	Upper Bound	
Duration (Task 4 PPT I)	Creator	3.34	1.569	2.03	4.65	0.062
	Participant	4.05	1.088	3.31	4.78	
	Viewer	5.30	2.217	3.60	7.00	
Duration (Task 4 PPT J)	Creator	2.16	1.222	1.14	3.18	0.183
	Participant	3.38	1.578	2.32	4.44	
	Viewer	4.09	3.048	1.75	6.43	

Appendix E - Online Survey Questionnaires for Study 3.

The following are three questionnaires that have been used 1) for the initial preparatory study (E.1) described in Chapter 3. Chapter 4 study 3 (Problem Solving while Carrying out familiar tasks on non-familiar mobile devices) 4 2) pre session E.2 and 3) post session questionnaire E.3.

E.1 Study 1 Understanding Mobile Usage

1. General Information

* 1. Information about you.

ID assigned for this study: ____________

Company: ____________

Male: ____________

Female: ____________

* 2. What age group are you in?

[▾]

* 3. Which of the following best describes your employment or student status?

- ◯ Working full time paid employment (35 or more hours per week)
- ◯ Working part time paid employment (less than 35 hours per week)
- ◯ Self employed (35 or more hours per week)
- ◯ Self employed (less than 35 hours per week)
- ◯ Casual employment
- ◯ Other form of paid employment
- ◯ Not currently in paid employment
- ◯ Studying full time
- ◯ Studying part time
- ◯ Other (please specify)

____

* 4. Describe your current Job or Course:

____

E.1 Study 1 Understanding Mobile Usage

2. Type of Mobile

Information related to mobile device.

* 1. What type of phone do you have?

- ◯ SmartPhone (Example: Android, Iphone, Windows phone 7)
- ◯ Normal Phone

E.1 Study 1 Understanding Mobile Usage

3. more info

* 1. What type of Mobile do you own?

- ○ Smartphone Iphone
- ○ Smartphone Nokia
- ○ Blackberry
- ○ Android
- ○ Windows Mobile

Other (please specify)

[ ]

E.1 Study 1 Understanding Mobile Usage

4. last page

* 1. How many hours a week do you spend doing the following activities?

	0	1	1 to 3	4 to 6	7 to 10	11 to 15	16 to 20	20+
Using email through your Smartphone Mobile device.	○	○	○	○	○	○	○	○
Using email through your desktop computer.	○	○	○	○	○	○	○	○
How many hours a week do you spend socializing with friends using your Smartphone Mobile device excluding text and calls.	○	○	○	○	○	○	○	○
How many hours a week do you spend socializing with friends using your desktop computer.	○	○	○	○	○	○	○	○
How many hours a week do you spend purchasing using your mobile device?	○	○	○	○	○	○	○	○
How many hours a week do you spend purchasing using your desktop computer?	○	○	○	○	○	○	○	○
How many hours a week do you spend reading ebooks using your mobile device?	○	○	○	○	○	○	○	○

What other activity do you do using your mobile device (please specify)

* 2. What are preferences when using your mobile device?

	Email using Mobile device	Social Network Using Mobile Device	SMS	Phone Call	Skype Through your mobile device	Nothing of the above
If you need to talk to someone about something personal, do you prefer to 1st most likely thing to do? (1ST preference)	☐	☐	☐	☐	☐	☐
If you need to talk to someone about something personal, do you prefer to 2nd most likely thing to do? (2nd preference)	☐	☐	☐	☐	☐	☐
If you need to talk to someone about something personal, do you prefer to 3rd most likely thing to do? (3rd preference)	☐	☐	☐	☐	☐	☐

E.1 Study 1 Understanding Mobile Usage

5.

* 1. How do use your mobile device?
Select option according to preference 1 being the highest and 5 least.

	1	2	3	4	5
SMS	◯	◯	◯	◯	◯
Phone Calls	◯	◯	◯	◯	◯
Download Ring tones	◯	◯	◯	◯	◯
Social Networking	◯	◯	◯	◯	◯
Mobile Banking	◯	◯	◯	◯	◯
Mobile Wallet	◯	◯	◯	◯	◯
Location Base Services such as Google maps	◯	◯	◯	◯	◯
Stream TV/Video	◯	◯	◯	◯	◯
Mobile Browsing	◯	◯	◯	◯	◯
Download APPS	◯	◯	◯	◯	◯
Searching through web browser (example google)	◯	◯	◯	◯	◯
Download Games	◯	◯	◯	◯	◯
Play Games	◯	◯	◯	◯	◯
Listen to Music	◯	◯	◯	◯	◯
Download Music (example itunes on mobile)	◯	◯	◯	◯	◯
Email	◯	◯	◯	◯	◯

Other (please specify)

* 2. Can you think of person between age 35 and 65 that would accept to be part of group and learn more about smartphones and how to use them? If yes can you submit some info and how to contact this person.

E.2 Pre Study - Mobile Usage and Support Solutions at Workplace

1. Consent Form

* 1. I understand that my responses will be kept strictly confidential. I give permission for members of the research team to have access to my anonymised responses. I understand that my name will not be linked with the research materials, and I will not be identified or identifiable in the report or reports that result from the research.

I give permission to the researcher to make use of the data collected from me for future research.

I agree to take part in the above research project.

For more information please access www.[removedfromthisversion]/yourspace

- ○ Agree
- ○ Disagree

E.2 Pre Study - Mobile Usage and Support Solutions at Workplace

2. General Information

* 1. Please input the ID assigned for this survey.

ID ______________________

* 2. Education:

- ○ Primary
- ○ Secondary
- ○ Post-Secondary
- ○ Under Graduate
- ○ Graduate Master
- ○ Doctoral Level

* 3. What is your first language?

- Turkish
- Bulgarian
- Hungarian
- Greek
- English
- Maltese
- Italian
- French
- German
- Arabic
- Chinese
- Swiss
- Korean
- Thai
- Persian
- Vietnamese
- Urdu

Other (please specify)

* 4. Gender

- Male
- Female
- Prefer not to say

* 5. What age group are you in?

* 6. Which of the following best describes your employment or student status?

- Working full time paid employment (35 or more hours per week)
- Working part time paid employment (less than 35 hours per week)
- Self employed (35 or more hours per week)
- Self employed (less than 35 hours per week)
- Casual employment
- Other form of paid employment
- Not currently in paid employment
- Studying full time
- Studying part time
- Working full time paid employment and studying part time
- Other (please specify)

* 7. Describe your current Job or Course:

* 8. How experienced do you think you are when it comes to using a smart mobile device?

- 1 (Very Inexperienced)
- 2
- 3
- 4
- 5 (Very Experienced)

* 9. In a typical week, about how many hours do you spend using a desktop computer?

- 0
- 1 to 3
- 4 to 6
- 7 to 10
- 11 to 15
- 16 to 20
- 20+

E.2 Pre Study - Mobile Usage and Support Solutions at Workplace

3. Type of Mobile

Information related to mobile device.

* 1. What type of Mobile Device do you have? (Tick all that apply)

- [ ] SmartPhone (Example: Android, Iphone, Windows phone 7)
- [ ] Tablet (Example: iPad, Samsung Galaxy Tab)
- [ ] Netbook (Mini Laptop)
- [ ] Normal Phone without SmartPhone Features

* 2. What brand or platform is your Mobile? (Tick all that apply)

- ○ Smartphone Iphone
- ○ Smartphone Nokia
- ○ Blackberry
- ○ Android
- ○ Windows Phone
- ○ Other (please specify)

[ ]

4. Mobile Usage

Information on how you use your mobile device. For this study the device can be a normal device without smart features, smart mobile phone or tablet.

* 1. How many hours a week do you spend doing the following activities?

	0	1	1 to 3	4 to 6	7 to 10	11 to 15	16 to 20	20+
Using email through your Smartphone Mobile device.	○	○	○	○	○	○	○	○
Using email through your desktop computer.	○	○	○	○	○	○	○	○
How many hours a week do you spend socializing with friends using your Smartphone Mobile device excluding text and calls.	○	○	○	○	○	○	○	○
How many hours a week do you spend socializing with friends using your desktop computer.	○	○	○	○	○	○	○	○
How many hours a week do you spend purchasing using your mobile device?	○	○	○	○	○	○	○	○
How many hours a week do you spend purchasing using your desktop computer?	○	○	○	○	○	○	○	○
How many hours a week do you spend reading eBooks or journal papers using your mobile device?	○	○	○	○	○	○	○	○

What other activity do you do using your mobile device (please specify)

* 2. If you want to discuss with someone about a personal matter and you cannot discuss face to face, what are you most likely to use?

	1 - not likely	2	3 - mid	4	5 - very likely
Phone Call via home phone	○	○	○	○	○
Phone call via own mobile device	○	○	○	○	○
Text (SMS) via mobile phone	○	○	○	○	○
Email using desktop computer	○	○	○	○	○
Email using a mobile device (iPhone, androids, blackberry, iPad, mini laptop, and similar))	○	○	○	○	○
Social Network (e.g. Facebook/yahoo chat/skype/ other online chat tool) on desktop computer	○	○	○	○	○
Social Network (e.g. Facebook/yahoo chat/skype/ other online chat tool) on mobile device	○	○	○	○	○
Skype	○	○	○	○	○
WhatsApp	○	○	○	○	○

Other (please specify)

E.2 Pre Study - Mobile Usage and Support Solutions at Workplace

5. Mobile Usage Continued

* 1. What do you do with your mobile device ?

	N/A	1 - less likely	2	3 - mid	4	5 - most likely
Text/SMS	○	○	○	○	○	○
Phone Calls	○	○	○	○	○	○
Email	○	○	○	○	○	○
Calendar	○	○	○	○	○	○
Multiplayer games (playing at the same time via internet)	○	○	○	○	○	○
Individual player games	○	○	○	○	○	○
Entertainment (e.g. TV guide, iBeer, Phone tracking)	○	○	○	○	○	○
Utilities (e.g. translators, sleeptalk recorder, Alarm, torch, battery check)	○	○	○	○	○	○
Social Networking (e.g. Facebook, whatsapp, Twitter, skype)	○	○	○	○	○	○
Music (e.g. Radio, download music, Shazam, Magic Piano)	○	○	○	○	○	○
Productivity (e.g. Dropbox, iTranslate, shopping list, to do list)	○	○	○	○	○	○
Lifestyle (e.g. eBay, Amazon, online shopping /supermarket)	○	○	○	○	○	○
References (e.g. google search, bird search, wikipedia, dictionary)	○	○	○	○	○	○
Travel (e.g. train time, route planner, google Earth)	○	○	○	○	○	○
Sport (e.g. sport news)	○	○	○	○	○	○
Navigation (e.g. TomTom, parking, plane finder, Navfree)	○	○	○	○	○	○

	N/A	1 - less likely	2	3 - mid	4	5 - most likely
Health and Fitness (e.g. calories counter, ab workout, BMI calculator)						
News (e.g. BBC news, e-newspaper)						
Photography (e.g. Adobe Phtoshop, Photo editors)						
Finance (e.g. account tracker, e-banking)						
Business (e.g. Office, bar code reader, job finding app)						
Educational apps						
Books						
Medical (e.g. medical encyclopedia, drugs and medications, Vision test, period calendar, weight loss)						
Download Music (example itunes on mobile)						

* 2. Which one of the following applications you use the most for your work (on mobile device or desktop/laptop)?

	None of the listed	1 - not likely	2	3 - mid	4	5 - most likely
Skype						
Facebook						
WhatsApp						
Viber						
Twitter						
Bump						
LinkedIn						
Windows Live Messenger						
Google Circle						
Google Talk						

Other (please specify)

* 3. Which one of the following applications you use the most for personal communications (on mobile device or desktop/laptop)?

	None of the listed	1 - not likely	2	3 - mid	4	5 - most likely
Skype	◯	◯	◯	◯	◯	◯
Facebook	◯	◯	◯	◯	◯	◯
WhatsApp	◯	◯	◯	◯	◯	◯
Viber	◯	◯	◯	◯	◯	◯
Twitter	◯	◯	◯	◯	◯	◯
Bump	◯	◯	◯	◯	◯	◯
LinkedIn	◯	◯	◯	◯	◯	◯
Windows Live Messenger	◯	◯	◯	◯	◯	◯
Google Talk	◯	◯	◯	◯	◯	◯
Email	◯	◯	◯	◯	◯	◯

Other (please specify)

E.2 Pre Study - Mobile Usage and Support Solutions at Workplace

6. IT Support

Think of an experience that you encountered while using smart mobile device and you needed to contact support. If you have no experience when using your smart mobile device try to recall an experience when using computer/laptop. This should include both major problems such as smartphone related problems or application crashes, and minor issues such as a program not responding the way that you need it to.

* 1. When you require IT support what is the first thing you do? (You may choose more then one answer according to preference)

	1 (Lowest)	2	3	4	5 (Highest)
You call support using a telephone or mobile.	○	○	○	○	○
You send an email requesting support.	○	○	○	○	○
You walk into the support section and ask for help.	○	○	○	○	○
You fill in an online form with all information related to your problem.	○	○	○	○	○
You ask a friend or work colleague to help you out. He/she may not be part of the IT support team.	○	○	○	○	○
Search the internet using your favorite search engine.	○	○	○	○	○

Other (please specify)

[ ]

* 2. How long do you have to wait before an IT support representative is available?

- ◯ Less than 1 minute
- ◯ 1 to less than 3 minutes
- ◯ 3 to less than 5 minutes
- ◯ 5 to less than 10 minutes
- ◯ 10 minutes
- ◯ 30 minutes
- ◯ 1 hour
- ◯ 4 hours
- ◯ 1 day
- ◯ 2 days
- ◯ 3 days and more

* 3. How satisfied are you with IT customer support techniques adopted by your company or university?

- ◯ Very satisfied
- ◯ Somewhat satisfied
- ◯ Neutral
- ◯ Somewhat dissatisfied
- ◯ Very dissatisfied

* 4. If your problem was not resolved, do technical support representatives offer to follow-up after the call?

- ◯ Yes
- ◯ No

* 5. Rate the IT technical service representative on the following attributes.

	1 (Lowest)	2	3	4	5 (Highest)
Responsiveness	◯	◯	◯	◯	◯
Professionalism	◯	◯	◯	◯	◯
Politeness	◯	◯	◯	◯	◯
Knowledge of the problem	◯	◯	◯	◯	◯
Efficiency in solving the problem	◯	◯	◯	◯	◯
Manner of handling follow-up questions	◯	◯	◯	◯	◯

E.2 Pre Study - Mobile Usage and Support Solutions at Workplace

7. About the Problem

Think of an experience that you encountered while using your smart mobile device. If you do not recall an experience when using a smart mobile device you may refer to a problem related to your computer/laptop. This should include both major problems such as smart mobile device or application crashes, and minor issues such as a program not responding the way that you need it to. Think of anything that frustrated you

* 1. What software or app did the problem occur in? If the problem was on your smart mobile device, please state the program that you were using when it occurred.

* 2. On a scale of 1 (not very important) to 5 (very important), how important was this task to you?

	1 (Lowest)	2	3	4	5 (Highest)
Task	○	○	○	○	○

* 3. How did you ultimately solve this problem? (please check only one)

- ○ I knew how to solve it because it has happened before
- ○ I ignored the problem or found an alternative solution
- ○ I figured out a way to fix it myself without help
- ○ I was unable to solve it
- ○ I asked someone for help.
- ○ I tried again
- ○ I consulted online help or the system/application tutorial
- ○ I restarted the program
- ○ I consulted a manual or book
- ○ I rebooted
- ○ I went to a mobile phone support outlet (eg. Apple Store)

* 4. Please provide a short step by step description of all the different things you tried in order to resolve this incident.

* 5. How often does this problem happen? (please check only one)

- ◯ more than once a day
- ◯ one time a day
- ◯ several times a week
- ◯ once a week
- ◯ several times a month
- ◯ once a month
- ◯ several times a year
- ◯ first time it happened

* 6. How did you feel?

- ◯ angry at the device
- ◯ angry at yourself
- ◯ helpless/resigned
- ◯ determined to fix it
- ◯ neutral

Other (please specify)

____

* 7. How many minutes did it take you to fix this specific problem?

- ◯ 5 mins
- ◯ 10 mins
- ◯ 30 mins
- ◯ 1 hour
- ◯ 2 hour
- ◯ 3 hours
- ◯ 1 day or more

* 8. Other than the amount of time it took you to fix the problem, how many minutes did you lose because of this problem? (if this has happened before, please account only for the latest time lost; e.g. time spent waiting or replacing lost work).

____

* 9. Until this problem was solved, were you able to work on something else?

- ◯ YES
- ◯ NO

E.2 Pre Study - Mobile Usage and Support Solutions at Workplace

8. About your feelings at the moment.

For the following questions please choose the number that best corresponds to your feelings.

* 1. Smart mobile devices make me feel:

- 1 (Very Uncomfortable)
- 2
- 3
- 4
- 5 (Very Comfortable)

* 2. When you run into a problem on the smart mobile device or an application you are using, do you feel:

- 1 (Anxious)
- 2
- 3
- 4
- 5 (Relaxed/Indifferent)

* 3. When you encounter a problem on the smart mobile device you are using, how do you feel about your ability to fix it?

- 1 (Helpless)
- 2
- 3
- 4
- 5 (Confident I can fix it)

* 4. When there is a problem with your smart mobile device that I can't immediately solve, I would stick with it until I have the answer.

- 1 (Strongly Disagree)
- 2
- 3
- 4
- 5 (Strongly Agree)

* 5. If a problem is left unresolved on your smart mobile device, I would continue to think about it afterward.

- 1 (Strongly Disagree)
- 2
- 3
- 4
- 5 (Strongly Agree)

* 6. Right now, how satisfied with your life are you?

- 1 (Very Unsatisfied)
- 2
- 3
- 4
- 5 (Very Satisfied)

* 7. How often do you get upset over things?

- 1 (Not Very Often)
- 2
- 3
- 4
- 5 (Very Often)

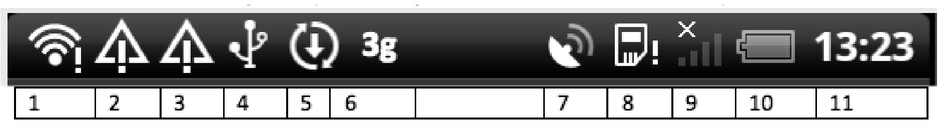
* 8. Right now, my mood is:

- 1 (Very Unhappy)
- 2
- 3
- 4
- 5 (Very Happy)

E.2 Pre Study - Mobile Usage and Support Solutions at Workplace

9. Smart Mobile Status Bar Visual Icon Test

For the following questions refer to the image below. Go through the mobile status bar normally found at the top part of the screen of your smart mobile device (Image Title: Screen Shot of typical mobile status bar)



1. Match Icons With Description: (Some may refer to more then one ICON)

	1	2	3	4	5	6	7	8	9	10	11
WIFI	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
3G	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Bluetooth	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Synchronisation	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
SIM Card	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
GPS	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Error	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
USB	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Time	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Battery	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

* 2. Describe the action you are expected to take with respective Icons.

WIFI ______

SIM CARD ______

GPS ______

ERROR ______

E.3 Post Study - Mobile Usage and Support Solutions at Workplace

Post Session - Smart Mobile Research at Workplace

For the following questions, please select the number that best corresponds to your feelings.

* 1. What is your ID assign for this task?

* 2. Which smart mobile platform have you used for this study?

- Windows 7 (HTC)
- Android (HTC)
- IOS (iPhone)

* 3. Which tasks have you managed to complete?

- Task 1
- Task 2
- Task 1 and Task 2
- None of the above.

* 4. If you had a problem and managed to solve it would you share your knowledge through a support on line community at your workplace?

- YES
- NO

* 5. Are the incidents that occurred while you were completing the task typical of your everyday mobile experience?

- YES
- NO

* 6. Right now, my mood is:

- 1 (Lowest)
- 2
- 3
- 4
- 5 (Highest)

7. Overall, how frustrated are you after these experiences?

- ◯ 1 (Not at all Frustrated)
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 5 (Very Frustrated)

* 8. How will the frustrations that you experienced affect the rest of your day?

- ◯ 1 (Not at All)
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 5 (Very Much)

* 9. In general, do you experience more or less frustrating incidents while using a smart mobile device on an average day?

- ◯ 1 (Less)
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 5 (More)

* 10. Did these frustrating experiences impact your ability to get your work done?

- ◯ 1 (No impact)
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 5 (Severe impact)

11. Did these frustrating experiences impact your interaction with your peers?

- ◯ 1 (No Impact)
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 5 (Severe Impact)

Appendix F – Pre and Post Questionnaires used for *YourSpace* study 4.

The following is a questionnaire that has been used for pre session F.1 and post session F.1 questionnaire when participants where using *YourSpace*.

Smart Mobile Study using YourSpace

F.1 Pre Questionnaire before using YourSpace and tasks assigned

Consent Form

1. I understand that my responses will be kept strictly confidential. I give permission for members of the research team to have access to my anonymised responses. I understand that my name will not be linked with the research materials, and I will not be identified or identifiable in the report or reports that result from the research.

I give permission to the researcher to make use of the data collected from me for future research.

I agree to take part in the above research project.

For more information please access www.[removedfromthisversion].com/yourspace

- ◯ Agree
- ◯ Disagree

Smart Mobile Study using YourSpace

Pre Session - Smart Mobile Resesarch

Basic Information on Participant

* 2. Enter Assigned ID

* 3. Gender

- Male
- Female
- Prefer not to say

* 4. What age group are you in?

- 16 - 25
- 26 - 35
- 36 - 45
- 46 - 55
- 56 - 65
- 65+

* 5. Which of the following best describe your job type?

- Working full time paid employment (35 or more hours per week)
- Working part time paid employment (less than 35 hours per week)
- Self employed (35 or more hours per week)
- Self employed (less than 35 hours per week)
- Casual employment
- Other form of paid employment
- Not currently in paid employment
- Studying full time
- Studying part time
- Working full time paid employment and studying part time
- Other (please specify)

* 6. Describe your current Job or Course:

* 7. In a typical week, about how many hours do you spend using a desktop computer?

- ○ 0
- ○ 1 to 3
- ○ 4 to 6
- ○ 7 to 10
- ○ 11 to 15
- ○ 16 to 20
- ○ 20+

* 8. What brand or platform is your Mobile? (Tick all that apply)

- ☐ Smartphone Iphone
- ☐ Smartphone Nokia
- ☐ Blackberry
- ☐ Android
- ☐ Windows Phone
- ☐ Other (please specify)

* 9. How experienced do you think you are when it comes to using a smart mobile device?

- ○ 0 (Low)
- ○ 1
- ○ 2
- ○ 3
- ○ 4 (High)

Smart Mobile Study using YourSpace

About your feelings when using a Smart Mobile device

For the following questions please choose the number that best corresponds to your feelings.

10. When you run into a problem on the smart mobile device or an application you are using, do you feel relaxed?

- 0 (Strongly Disagree)
- 1
- 2
- 3
- 4 (Strongly Agree)

* 11. When you encounter a problem on the smart mobile device you are using, do you feel confident about your ability to fix it?

- 0 (Strongly disagree)
- 1
- 2
- 3
- 4 (Strongly agree)

* 12. When there is a problem with your smart mobile device that you can't immediately solve, you would stick with it until you have the answer.

- 0 (Strongly disagree)
- 1
- 2
- 3
- 4 (Strongly agree)

* 13. If a problem is left unresolved on your smart mobile device, you would continue to think about it afterward.

- 0 (Strongly Disagree)
- 1
- 2
- 3
- 4 (Strongly Agree)

* 14. Right now, are you satisfied with your life?

- 0 (Strongly disagree)
- 1
- 2
- 3
- 4 (Strongly agree)

* 15. Do you often get upset over things?

- 0 (Strongly disagree)
- 1
- 2
- 3
- 4 (Strongly agree)

* 16. I have a very happy mood.

- 0 (Strongly disagree)
- 1
- 2
- 3
- 4 (Strongly agree)

Smart Mobile Study using YourSpace

F.2 Post Session Smart Mobile Study using YourSpace

For the following questions, please select the number that best corresponds to your experience using the application.

17. Did you understand clearly what was expected from you for every task?

	0 (Low)	1	2	3	4 (High)
Task 1 - Connect your Android mobile device to a WIFI and browse Internet	○	○	○	○	○
Task 2 - Configure a gmail account using an app and send an Email using your Android Mobile Device	○	○	○	○	○
Task 3 - Create new contacts that are available on your gmail account	○	○	○	○	○
Task 4 - Creating an appointment using the calendar app on your Android Mobile Device and schedule/update an hour session for feedback focus group	○	○	○	○	○

* 18. How would you rate the following topics from the online manual?

	0 (Low)	1	2	3	4 (High)
How to Use Devices for the research project	○	○	○	○	○
How to use the application YourSpace on the tablet	○	○	○	○	○
How to take a Screenshot image using the assigned Android Mobile Device	○	○	○	○	○
How to access the Screenshot image from your tablet	○	○	○	○	○
How to create an instance by adding an image	○	○	○	○	○
How to give feedback on the application	○	○	○	○	○

19. Where did you use devices assigned for the given tasks?

	Your Office	Meeting room	Colleague Office	Canteen	Conference or Meeting Room	Kitchen	Away from your workplace building
Android Mobile Device.	☐	☐	☐	☐	☐	☐	☐
WIndows Tablet Solution.	☐	☐	☐	☐	☐	☐	☐

* 20. Which tasks have you managed to complete by yourself without referring to YourSpace through the assigned Tablet?

- ☐ Task 1 - Connect your Android mobile device to a WIFI and browse Internet
- ☐ Task 2 - Configure a gmail account using an app and send an Email using your Android Mobile Device
- ☐ Task 3 - Create new contacts that are available on your gmail account
- ☐ Task 4 - Creating an appointment using the calendar app on your Android Mobile Device and schedule/update an hour session for feedback focus group
- ☐ None of the above.

* 21. Which tasks have you solved after referring to YourSpace?

- ☐ Task 1 - Connect your Android mobile device to a WIFI and browse Internet
- ☐ Task 2 - Configure a gmail account using an app and send an Email using your Android Mobile Device
- ☐ Task 3 - Create new contacts that are available on your gmail account
- ☐ Task 4 - Creating an appointment using the calendar app on your Android Mobile Device and schedule/update an hour feedback focus group
- ☐ None of the above.

* 22. Which tasks have you contributed to effectively?

	Creator of Solution	Participant Contributing by asking or suggesting solutions by adding comments.	Viewer Only
Task 1 - Connect your Android mobile device to a WIFI and browse Internet	○	○	○
Task 2 - Configure a gmail account using an app and send an Email using your Android Mobile Device	○	○	○
Task 3 - Create new contacts that are available on your gmail account	○	○	○
Task 4 - Creating an appointment using the calendar app on your Android Mobile Device and schedule/update an hour feedback focus group	○	○	○

* 23. How difficult did you find the assigned task?

	0 (Not Difficult)	1	2	3	4 (Very Difficult)
Task 1 - Connect your Android mobile device to a WIFI and browse Internet	○	○	○	○	○
Task 2 - Configure a gmail account using an app and send an Email using your Android Mobile Device	○	○	○	○	○
Task 3 - Create new contacts that are available on your gmail account	○	○	○	○	○
Task 4 - Creating an appointment using the calendar app on your Android Mobile Device and schedule/update an hour feedback focus group	○	○	○	○	○

* 24. How did you ultimately solve this problem? (please check only one)

- ◯ I used YourSpace to know what others did.
- ◯ I asked questions through YourSpace when I was stuck
- ◯ I knew how to solve it because it has happened before
- ◯ I ignored the problem or found an alternative solution
- ◯ I figured out a way to fix it myself without help
- ◯ I was unable to solve it
- ◯ I asked someone for help.
- ◯ I tried again
- ◯ I consulted online help or the system/application tutorial
- ◯ I restarted the program
- ◯ I consulted a manual or book
- ◯ I rebooted
- ◯ I went to a mobile phone support outlet (eg. Apple Store)

* 25. Please provide a short step by step description of all the different things you tried in order to resolve this incident. (Refer to Task example task 1, task 2, task 3 and task 4)

* 26. How much time did you allocate for each Task? (in minutes)

	5	10	15	20	25	30	40	50	60	75	90	90+
Task 1 - Connect your Android mobile device to a WIFI and browse Internet	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Task 2 - Configure a gmail account using an app and send an Email using your Android Mobile Device	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Task 3 - Create new contacts that are available on your gmail account	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Task 4 - Creating an appointment using the calendar app on your Android Mobile Device and schedule/update an hour feedback focus group	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

* 27. If you had a problem and managed to solve it would you share your knowledge through a support on line community at your workplace?

- YES
- NO

* 28. Are the incidents that occurred while you were completing the task typical of your everyday mobile experience?

- YES
- NO

29. If yes please explain why.

30. Did you encounter other problems when using the tools assigned for this study? (Exclude problems related to the tasks. Example of problems are switching on/powering up the device, accessing the applications, understanding how to use the device)

	0 (Low)	1	2	3	4 (High)
Using the tablet	○	○	○	○	○
Using the Android mobile	○	○	○	○	○
Using the MIFI	○	○	○	○	○
Internet Connectivity	○	○	○	○	○

* 31. From the following ICONS which best helped you understand how to solve the problem?

	0 (Low)	1	2	3	4 (High)
Questions Mark	○	○	○	○	○
Very good Sign	○	○	○	○	○
Alert Sign	○	○	○	○	○
Wrong Sign	○	○	○	○	○
Pointers	○	○	○	○	○

* 32. Do you recall one or more instances within a sequence of steps you particular found helpful? Give a explanation why.

Smart Mobile Study using YourSpace

Attitude and Behaviour: The tasks assigned.

For the following questions, please select the number that best corresponds to your feelings.

* 33. How was your mood before every task:

	0(Lowest)	1	2	3	4 (Highest)
Task 1 - Connect your Android mobile device to a WIFI and browse Internet	○	○	○	○	○
Task 2 - Configure a gmail account using an app and send an Email using your Android Mobile Device	○	○	○	○	○
Task 3 - Create new contacts that are available on your gmail account	○	○	○	○	○
Task 4 - Creating an appointment using the calendar app on your Android Mobile Device and schedule/update an hour feedback focus group	○	○	○	○	○

* 34. Overall, how frustrated are you after these experiences?

- ○ 0 (Not at all Frustrated)
- ○ 1
- ○ 2
- ○ 3
- ○ 4 (Very Frustrated)

* 35. How will the frustrations that you experienced affect the rest of your day?

- ○ 0 (Not at All)
- ○ 1
- ○ 2
- ○ 3
- ○ 4 (Very Much)

* 36. In general, do you experience more or less frustrating incidents while using a smart mobile device on an average day?

- 0(Less)
- 1
- 2
- 3
- 4 (More)

* 37. Did these frustrating experiences impact your ability to get your work done?

- 0 (No impact)
- 1
- 2
- 3
- 4 (Severe impact)

* 38. Did these frustrating experiences impact your interaction with your peers?

- 0 (No Impact)
- 1
- 2
- 3
- 4 (Severe Impact)