

### 3. Methodology

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#### 3.1 Introduction and Aims

This chapter describes the methodological perspective applied in this research. A general introduction to qualitative research methodology is first described before detailing methods applicable to user-centered research in Human Computer Interaction HCI and the specific methods used to address the research questions for each stage of the research.

#### 3.2 Research Approach

Kjeldskov and Graham (2003) reported that the use of mobile technology is difficult to emulate in a laboratory setting. However, field study offers the ideal opportunity to identify the user needs and translate that into new or existing design. It provides the ability for integrating detailed data from the research context in a short time. The qualitative rapid ethnography approach is using in this research, where it is “A collection of field methods intended to provide a reasonable understanding of users and their activities given significant time pressures and limited time in the field” (Millen, 2000, p.280) . That combines ethnography with the recording of sequences of interaction that are analyzed (videography). Videography is becoming the medium of choice for collecting data for educational and social science research projects. In the social sciences, videography is also understood as a specific research method of video analysis, which combines ethnography with the recording of interaction sequences, which are analyzed in detail with methods developed on the basis of conversation analysis (Heath et al ,2010). Video provides unprecedented opportunities for social science research, enabling fine-grained analysis of the social organization, culture, and communication. Video in Qualitative Research provides practical guidance for students and academics on how to solve problems and issues that arise when conducting video-based field studies and subject video recordings to detailed scrutiny and analysis (Knoblauch et al, 2014).

On the other side, as Jewitt (2012) addressed, also, as already the author has noted during research study, the ability of video to capture temporal sequential interaction is a valued quality of video. The time (gigabit) limits of video recording as opposed to participant observation for instance mean that video is often turned on and off within relatively short periods of time. This, combined with a tradition of micro-analysis, can serve to fracture representations and produce isolated moments when video is used for research. This can be a disadvantage when video data collection due to the limited history or context it provides. This can be dealt with by videoing over time as necessary and/or combining video data collection with other methods such as participant interviews, documentary analysis, or by adopting a participatory stance to the production of the video data.

However, are many reasons for choosing Videography: Video tape can preserve more aspects of interaction including talking, gesture, eye gaze, manipulatives, computer displays, moreover, video allows repeated observation of the same event, and supports microanalysis and multidisciplinary analysis.

There is a strong dependence on quantitative and experimental approaches in scientific research. However, the need for studying socially-based phenomena in Human Computer Interaction HCI research requires the use of different approaches. The qualitative approach provides methods to understand complex phenomena that cannot be easily quantified (Adams et al, 2008), such as understanding how people contribute to different phenomena in their life or describing the experience that people have in their world (Merriam, 2009). The qualitative research approach is defined as “research that involves analyzing and interpreting texts and interviews in order to discover meaningful patterns descriptive of a particular phenomenon” (Auerbach and Silverstein, 2003, p. 3). Denzin and Lincoln (2005) defined the qualitative approach in terms of the process and context of data collection: “Qualitative research is a situated activity that locates the observer in the

world. Qualitative research consists of a set of interpretive, material practices that make the world visible. These practices transform the world. They turn the world into a series of representations, including field notes, interviews, conversations, photographs, recordings, and memos to the self.

The strength of this approach lies in the ability to present the complexity of user experience, motivation, and expectation and so on, in regards to the research issues, in addition to the ability to describe the human side in the research, such as the user beliefs, attitudes, behaviors and relationships of individuals (Mack et al, 2005). Mack et al (2005) argue that qualitative methods are considered more flexible and effective than quantitative methods. Moreover, using open-ended questions in qualitative research makes this more effective for identifying user identities and social norms. Besides, as open-ended questions do not require the same type of responses from each participant, these methods are more flexible because the participants are free to answer in their own words (Fraser, 2004; Guest et al, 2012).

Consequently, the interaction between the researcher and the participants is more fluid and adaptable than in quantitative methods (Mack et al, 2005).

Moreover, Razavim and Iverson (2006) point out that, within HCI, designing and implementing an effective system requires more than focusing on the tasks; it needs an understanding of how usability issues are personally and communally experienced by users.

Therefore, there is an increasing need for HCI researchers to use a qualitative approach to study human interaction with technology to understand the users' behaviors, attitudes, perspectives, and emotions rather than measuring the users' performance (Adams et al, 2008).

Based on the nature of this research, it was decided to apply the qualitative research approach in order to investigate and explore the research topics and provide a complete detailed description of them. Several qualitative methods e.g., observation, interview, questionnaire, and case studies, will be applied through different stages in the research.

### **3.2.1 The Research Design**

The use of qualitative methods provides a number of advantages for design of studies to be conducted in a social context. For example, Flick (2009) mentioned the benefit of collecting data from various social and cultural background which otherwise would be difficult. Guest et al (2012) suggested that the major advantage of a qualitative approach is the ability to investigate responses to gain further detailed explanations and descriptions. Anticipated answers of “how” and “why” questions provide rich and in-depth clarifications of human experiences, behaviors, and beliefs.

Several HCI research projects have used qualitative methodology design. For instance, Millen (2000) conducted a case study approach in the “Thinking Spaces” project which aimed to study how the use of the internet could change the way people work and conduct their business in the future. This study applied a qualitative rapid ethnography approach in order to discover the natural context of use and develop an understanding of the changes that may occur. The qualitative rapid ethnography approach is “A collection of field methods intended to provide a reasonable understanding of users and their activities given significant time pressures and limited time in the field” (Millen, 2000, p.280). The significant aspects of this approach include applying time-efficient techniques by using multiple observers, observation techniques, and collaborative qualitative data analysis in order to constrain the research scope. Millen (2000) suggested that the use of the qualitative rapid ethnography approach can provide a better understanding

of the users, the environments, and the interaction between both of them.

### **3.3 User Centered Design and Related Methods**

#### **3.3.1 User Centered Design Approach**

Products are designed for us every day, such as the mobile devices with applications we use, the devices we rely on for work or learning. Many theories exist for how to design these items effectively; however, we are often reminded that successful designs are those that allow users for example to perform tasks, share content, or capture information based on their preferences and needs. Still, designers often overlook the user, but user-centered design (UCD) puts the users' needs and wants at the center of the design process from start to finish (Still, 2017).

User-centered designers begin collecting feedback before anything is actually designed. They observe and interview users, and use this feedback to determine product requirements even before the initial design is prototyped. Each time, the design is revised until the product is molded to the users' needs, desires, and situations.

User Centered Design is a broad term which was firstly used in the 1980s by Norman and Draper (1986). It focuses on involving real users and their experiences throughout the technology design research process in order to develop more efficient, effective and suitable products (Abrams et al, 2004). Having direct contact with real users and understanding their experiences helps the researchers to manage the risks of technology development and increase the chance of system success (Nielsen, 2001).

The main aim of the user centered design approach is to enhance the usability aspects of the designed product instead of forcing the users to change the way that they interact with the product (Kahraman,

2010). Therefore, the benefits of the user centered research methodology in technology development research are: to reduce the potential for poorly designed or misused technology and to provide an insight into the complex relationships between people and technology, therefore, involving users in design one way or another has been shown to lead to developing more usable satisfying designs (Rogers et al, 2011; Sharp et al, 2019). The user-centered research methodology is also a powerful method of research development for the designers as it helps to gain a full understanding of the actual practice, habits and needs of the users, for whom they are designing, rather than having to rely on their own perceptions (Lofthous and Lilley, 2006).

Having knowledge of how to apply technology in learning effectively plays important role in teacher professional development and this kind of knowledge related to the three teaching-specific knowledge domain, that is the integration among content knowledge, pedagogical knowledge and technological knowledge, as it is called Technological Pedagogical and Content Knowledge (TPACK) (Kajonmanee et al, 2020). TPACK can be applied to promote the quality and effectiveness of teaching and learning activities, such as field trips (Mishra and Koehler, 2006; Shafie, 2012a).

According to ISO 2019, using a human-centered approach to design and development has substantial benefits for users, also, systems designed using this approach methods improve quality, for example, by:

- a) increasing the productivity of users
- b) being easier to understand and use
- c) increasing usability for users with a wider range of capabilities
- d) improving user experience
- e) reducing discomfort and stress
- f) contributing towards sustainability objectives

User-centered design (UCD) is a general term for a philosophy and methods which focus on designing for and involving users in the design of computerized systems. They do not necessarily focus on developing software that is considered usable (Blomkvist, 2005, Ferreira et al, 2007), i.e. usability defined as the extent to which a software can be used by specified users to achieve specified goals effectively, efficiently, and satisfactorily in a specified use context (ISO, 1998). At one end of the spectrum involvement may be relatively light; they may be consulted about their needs, observed and participate in usability testing. At the other end of the spectrum involvement can be intensive with users participating throughout the design process as partners in the design (Abrás et al, 2004). Therefore, UCD is a framework which is used to improve or guarantee high usability and user experience in any kind of application, including mobile applications (Quezada, Cueva, & Paz, 2021).

User-centered design (UCD) ensures that the goals and needs of the system's end-users is the focus of the product's development (Brhel et al , 2015). Also, UCD approach is the most used technique and the right one to obtain optimal results with respect to metrics of this attribute, since it aims to design understandable software products, considering the needs and interests of end-users. (Salinas, Cueva, & Paz, 2020).

Therefore, to gain the benefits of applying a User-centered design approach in this research, it was decided to involve the users in the different research stages, such as defining the system requirements, system development, and evaluation. But due to the Corona crisis, the last step, which is evaluation has been skipped.

### **3.3.2 Research Framework**

The user centered approach involves four main interactive activities as shown in Figure. 3.1. These four basic activities present the simple interaction design life cycle model described by Preece et al (2011).

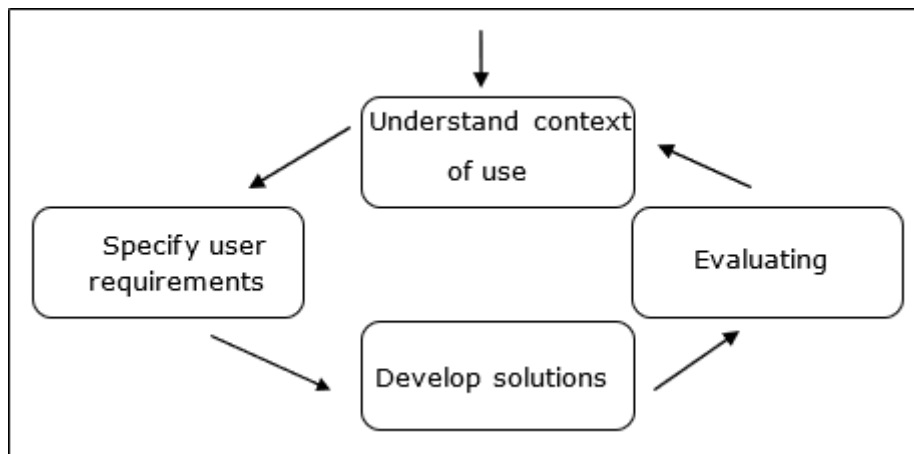


Figure 3.1: Simple Interaction Design Life Cycle Model

UCD approach these four basic activities are intended to identify information about users and goals and not about technology itself. The process starts with “Understand and specify the context of use”, which aims to provide a full understanding of the user’s (students) needs and their interaction with the environments (biology field trips).

The next activity in the UCD life cycle is the “Specifying the user requirements”, in most design projects, identifying user needs and specifying the functional and other requirements for the product or system is a major activity ISO 2010. For human-centered design, this activity extended to create an explicit statement of user requirements in relation to the intended context of use of the system, which is in this research the biology field trips objectives.

These two steps are described in chapter 4 in this thesis.

“Develop solutions” is the next activity in the UCD life cycle, which aims to design an initial or redesign an existing product using prototyping techniques. The goal of this step is to identify the interaction problems in the early stages of design. This step also is described in chapter 4.



Activities	Outputs from human-centred design
Understand and specify the context of use	Context of use description
Specify the user requirements	Context of use specification User needs description User requirements specification
Produce design solutions to meet these requirements	User interaction specification User interface specification Implemented user interface
Evaluate the designs against requirements	Evaluation results Conformance test results Long-term monitoring results
NOTE More detailed information on each output is to be found in ISO/IEC/TR 25060.	

**Table 3.1: Examples of outputs from human-centered design activities (ISO, 2019)**

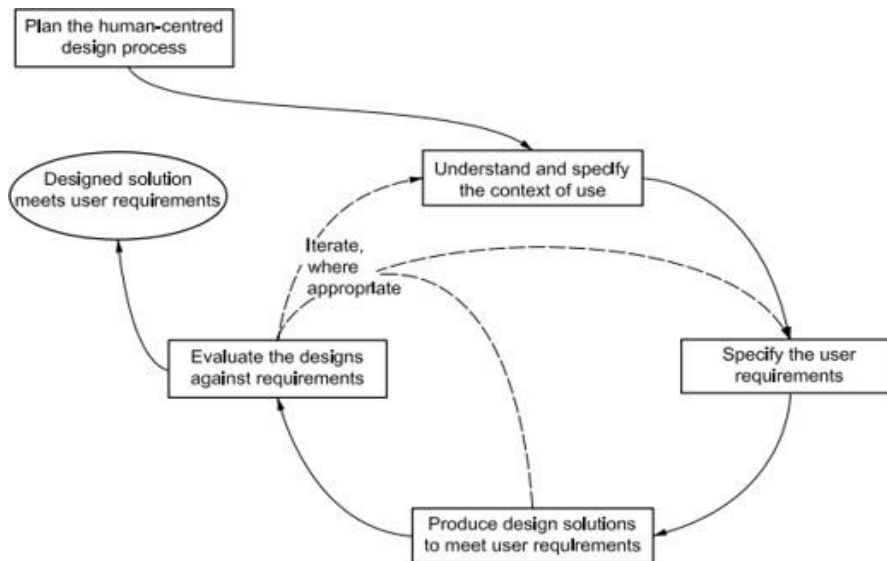


Figure 3.2: Interdependence of human-centered design activities  
(Volkman, 2018-, ISO, 2010)

### 3.3.3 Research Methods

The following methods were applied in this research in order to answer the research questions. These are observation, interview, and case study.

These methods have been applied in several studies relevant to the nature of this research. For example, Yeh et al. (2006), Priestnall et al. (2009) and Rogers et al. (2010) applied observation methods to understand the user interaction and behaviors with specific technologies in the context of use. In addition, interview methods were applied in the work of Rogers et al (2010), Ahsin et al (2019).

The following sections present an analysis of user centered research methods relating to this research.

#### Observation

In general, observation is a technique where researchers watch participants at a place of work. In this domain researchers are then able to

develop an understanding of the users' perceptions in relation to the research, which allows researchers to then explore in detail the user's physical view of the domain being addressed, against alternative evaluation product designs (Kothari, 2011). Observation can also provide specific information about aspects such as workload and interdependencies (Wilson and Sharples, 2015). There are a variety of observation types but, in general, direct observation is the most suitable method for this research. This method involves the collection of information on subject performance, which is directly observed by the researchers themselves, or from objective recording of subject behavior (Newman, 1998). Using this method yields a large amount of information that helps in understanding user opinion and behaviors in the context of use. In addition, this method allows gathering different types of data such as the user interaction, action and behavior; as well as the nature of the work environment (Wilson and Sharples 2015).

### **Interview**

The interview is a technique that aims to develop a conversation with users to explore in detail a given domain of interest or/and opinion about the proposed product development. Thus, it offers a flexible approach to data collection (Wilson and Sharples 2015).

In general, interviews may be structured or semi-structured. Maiden and Rugg (1996) and Stanton et al (2001) report that a semi-structured interview allows the interviewer to ask the interviewee about a topic with a prepared list of questions, but without a resolute order. This allows the interview to be an informal discussion and facilitates collection of a wide variety of data, such as the participant's knowledge, views, understanding, interpretation, experience and interaction (Wilson and Sharples, 2015). Therefore, this technique can be useful to help provide more in-depth explanation of data which has been collected from other methods.

## **Case Study**

The case study method is one of several methods that is applied in social science research and used to understand a situation, group, or organization of interest (Robson, 2011). It requires extensive involvement into the real life of people to manage potential technical distinctive situation (Yin, 2009). In case studies, it is common to study more than a single case. Yin (2018) considers that studying more than a single case study is akin to multiple studies. Multiple case examples are analyzed in order to generalize the findings to extended population (Hignett and McDermott, 2015).

### **3.4 Participants**

In this research, there were three different case studies from different backgrounds of biology field trips: a pilot study to establish the research methods was conducted with a convenience sample of undergraduate biology students from Technical University of Kaiserslautern for two days of Botany field trip. Then, the research focused on two different groups of undergraduate biology students from Technical University of Kaiserslautern and Saarland University in Germany, who attended Marine Molecular biology and Botany field study trips for one week duration. The main similarity between these case studies was that they all depend on practical learning in the field which related to biology for university students in Germany. However, the nature of field trips in each of these case studies was different. For example, the nature of biology field trip for students who attended Molecular Biology field trip took place in watery and muddy area of nature. Whereas, the botany field trip took place in a harsh rural area with a low access to electricity connections all the day and poor or no internet. It was therefore anticipated that studying different these two different biology field trip contexts would enrich the outcomes of this research.

### 3.5 Analysis Approach

In social sciences, various methodologies are used to analysis the collective data from qualitative approach and these methods have been used in HCI research (Suchman, 1987; Fafchamps, 1991). For example, a thematic based content analysis method (TBCA) can be applied to analyze the qualitative data which has been collected through different methods. Theme Based Content Analysis is a qualitative method which focuses on identifying and describing both implicit and explicit ideas within themes (Guest and MacQueen, 2012). In this method, the data would first be divided into meaningful codes (Neale and Nichols, 2001). Then through analyzing the data, the codes are used to identify themes and link them to the research questions. There are different methods for presenting the identified themes. In this research the identification of codes was by used the qualitative data analysis software MAXQDA2 to code the papers. As a universal tool for qualitative data analysis, MAXQDA is usually employed to analyze textual data, such as interview transcripts, and supports a variety of qualitative research methods (Brhel et al, 2015).

Neale and Nichols (2001) argue that the thematic based content analysis method is compatible with different data forms which are collected through different data collection methods such as: observation, and interview.

Adams et al (2008) found that this approach frequently supports analysis of many HCI interaction projects because it can be related to patterns of experience. Guest and MacQueen (2012) pointed out that this approach is still the most useful approach to capture the complexity of meaning in qualitative research. For example, a study by Stanton et al (2001) aimed to design a tangible interface to the KidPad collaborative drawing tool in order to support interactive storytelling activity within

classroom environments. In this study, theme-based content analysis was applied to analyze the researcher's journal entries.

The benefits of applying this approach are providing a flexible procedure to integrate useful and detailed information about students' opinions and behaviors. In addition, the process of data analysis is less-time consuming than other approaches such as grounded theory method which is started by break the data down, then put it back in a new conceptualized way (Strauss and Corbin, 1990), and the analyzed results can be presented in a simple format which allows clear feedback of user explanations (Neale and Nichols, 2001). Therefore, this analysis approach is applied to analysis the qualitative finding from observation and interview methods at particular stages from this research.

The scenario method is a storytelling method which aims to illustrate the students' context in a descriptive way in order to understand the user situations and therefore aid in usability decisions (Gudjonsdottir and Lindquist, 2008). Carroll (2003) describes the scenario method as a sequence of actions which include characteristics such as an actor (user), a goal (task), and a setting (context of use) without including any details about the design decisions. The effectiveness of this tool makes it popular in interactive system design research because it provides a method to facilitate rapid communication between the usage possibilities and the user concerns, i.e., by using storyboard researchers can clearly illustrate the essential interaction design elements (Rosson and Carroll, 2009).

### **3.6 User-Centered Research Methods applied in this Research**

#### **3.6.1 Multiplicity of User-Centered Research Methods**

As has been suggested, the qualitative approach includes a variety of methods that provide different ways of examining and interpreting the same phenomena. Whilst each method can be used alone, there is no

one single purpose method because each has different strengths and weaknesses (some of these are discussed in the following section). It is therefore recommended that researchers should not focus on a single technique, but use several different methods in combination to help to balance and complement each other, and to avoid biases which are inherent in any one approach (Rogers et al, 2011).

Each stage of the research activities conducted in this PhD research employed a multiplicity of user centered methods as described in the sections below.

However, it is worth mentioning that there are a number of methods that could be chosen to be applied in different stages in this research, but some have limitations that could negatively affect the study; for instance, the participant observation method is difficult for documenting data because the researcher has to actively participate in the event as well as closely observe the participants, especially when sometimes the participants were separated into groups during the field trip, each group was around two or three hundred meters far away from each other, but the researcher tried to overcome this barrier by observing each group ten minutes then back again. However, in this research case, it was difficult to obtain well organized and lively group interaction after the field trip and it was considered that there may be a risk of introducing personal biases into the study.

Each of these methods has advantages and disadvantages. In the end, the methods selected were those considered to provide the information to address the research questions of interest. These are described below according to the stage of research in which they were implemented.

### 3.6.2 Methods Applied in the research study

The first and second stage activity of this research aimed to provide an understanding of the user, and user requirements, with their current experiences and activities in the context of use.

The first and second research questions:

• **RQ 1: How do students capture and share their learning experiences during Biology field trips? What is the meaning of learning and field experience during biology field trip?**

• What is the meaning of learning and field experience during the field trip?

• What kinds of tools are suitable to capture and share the learning experience in the field?

**RQ2: What are the user requirements of mobile technology to support capturing and sharing learning experiences during the field trip?**

This part of the research was to investigate the possibility of applying mobile technology for capturing and sharing learning experience in the field, direct and indirect observation methods were applied during initial field trip visits for the researcher to gain an initial understanding of the user's (students) behaviors during the field trip. These methods were used to allow for an understanding of the user's activities in capturing and sharing experience in the field, in addition to identifying the meaning of experiences in the different topics of biology field context.

A semi-structured interviews was conducted to understand how the students captures the experience in the field. This provided the researcher with more detailed information to gain a deeper understanding of the students' needs and information about the students' activities, their portfolios, notes and tools that they use to capture their knowledge and experiences in the field.



The use of both of these methods allowed the researcher to gain a detailed understanding of students needs and requirements for information capture and sharing which could then be used to identify system requirements of mobile technology to be used in field trips especially biology field trips in two different contexts.

The third research question and sub-questions:

**RQ 3: How does the Mobile Technology Impact Upon the capturing of learning experience during the Field Trip?**

**What kind of learning experience do the students capture in the field by using mobile devices?**

- **What are the usage implications of mobile technology to enhance field experience in the field?**
- **What are the key contextual factors that affect the use of mobile technology during the field trip to capture and share learning experience?**

Based on the need to understand action in the situation, two studies have been used which combined the methods of observation and interview, there were undertaken during the biology field trips with biology students from two different universities, each group attended biology field trip but in a different context and topic. Using mobile devices helped to identify the kind of learning experiences the students could capture and share during the field trip.

Moreover, the use of semi-structured interviews which were carried out with participants after they had finished the field trip, helped to validate the direct observations.

**Note:** Supposed that there is also a one more research activity that deals with the fourth research question: What is the potential for mobile technology to contribute to the aspects of capturing the learning experience

during the biology field trip? But this stage is canceled due to Corona crisis restrictions.

### **3.7 Reliability and Validation**

The substantial philosophy of the research described in this thesis is user-centered research, which entails a variety of standard methods, including observation, interview. Whilst conducting this research, the author tried to maximize the reliability and validity of the information gained. Reliability of a particular research method refers to its ability to give the same results if applied repeatedly to the same study conditions and this can be affected by different sources from participants and the observer, such as observer error, observer bias, participant bias and participant error (Babbie, 1998; Robson, 2016).

In contrast, validity refers to whether or not a particular indicator measures what it is intended to measure, rather than some other phenomenon (Robson, 2016; Carmines and Zeller, 1979). There are various aspects that could affect the validity of research such as: not considering explanations, or a lack of understanding of the study phenomena, generating inaccurate or incomplete data and incorrect interpretation. In fact, validating the information is what makes it appropriate, useful and meaningful (Gregory, 2004).

As Jick (1979) argues, triangulation is a powerful technique, in that it uses a combination of sources or methods to study the same phenomena in order to enhance its validity. The triangulation technique has been used during the course of this research to study the impact of mobile technology on capturing and sharing the experience during field trips. For instance, using the methods of observation and interview in studies that took place at different times, in different places with different participants. Triangulation enhances the reliability of the information gathered once the results are consistent, because it shows that the same data collection methods produce the same results even from

different information resources. Triangulation has also been applied to improve the validity of these research findings. Using, collecting and measuring different data types, which have been produced from different methods, enhances the validity of the information. In addition, the researcher can better understand the problem domain by allowing interpretation to emerge without preconceptions about cause and effect. The focus is on the research within the real usage context and thereby improves the validity of the research undertaken.

### **3.8 Conclusion**

This chapter has outlined a range of user centered research methods which have been applied in this research, with a focus on qualitative methods. Multiple methods were applied in a triangulation technique, in a flexible way by combining and balancing each method. This technique provides rich information to address the answering the research questions, as well as improving the reliability and validity of this research.