A Model for Implementing Open Badges in a Resource-Constrained Environment

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Abstract

There is a growing need to highlight individuals' skills and allow skill-based learning. Open badges offer a unique opportunity to modularise the learning process and allow for the accreditation of skills via a variety of sources not traditionally classified as educational institutes. Given the current state of mismatch between employer expectations and educational institutions' skill offerings, a system such as Mozilla Open Badges could allow for targeted skill-based learning. Unfortunately, prior attempts in implementing such a system in a resource-constrained environment within South Africa have resulted in failure.

Current Mozilla systems have been developed for ideal environments, and do not account for the challenges presented by constrained environments. Addressing this problem, this research produces a model that allows for the successful implementation of open badges in resource-constrained environments.

This study employed a design science research process to enable the creation and evaluation of a complete and robust model that possesses a high level of detail and fidelity when addressing real world problems.

A rigorous review of the existing literature was conducted to identify the following: elements critical to the functionality of open badge systems; challenges in developing ICT4D systems for resource-constrained environments; and possible technologies and techniques that could be adapted to overcome resource-constrained challenges.

Employing the Mozilla open badges standards framework, adapted to the 4C framework, this research produced a conceptual model that was sent for expert review. Four experts were approached, all specialists in the field of ICT4D, and most possessing a high level of expertise in information communication technology (ICT)-based education or digital badging.

Employing an iterative process, as described by design science research, the feedback provided by experts, in conjunction with additional literature, was used in the

construction of a final model. This model is presented as a solution to the problem of implementing open badges in a resource-constrained environment.

Declaration

This thesis contains no material which has been accepted for the award of any other degree or diploma at any university or equivalent institution and that, to the best of my knowledge and belief, this thesis contains no material previously published or written by another person, except where due reference is made in the text of the thesis.

Publications During Enrolment

During the course of this research endeavour two research papers were published within peer reviewed journals. The papers were published with the assistance of co-authors and thus it needs to be clarified that the researching student was not the sole contributor of the research papers. The inclusion of co-authors reflects the fact that the work came from active collaboration between researchers and acknowledges input into team-based research. The core theme of the thesis is solution design for resource-constrained environments, focusing on implementing an open badge model to assist ICT4D initiates. The ideas, development and writing up of relevant contribution areas in the papers were the principal responsibility of myself, the candidate, working within the faculty of Computer and Information sciences, while pursuing a Master of Philosophy in Computer and Information Sciences degree under the supervision of Dr Stella Ouma and Dr Braam van der Vyver.

Thesis Chapter	Publication	Status	Nature and % of Student Contribution	Co-Author Names and % of Co-Author Contribution	Co-Authors Monash Student Y/N
2, 3, 4	Botha A, Salerno C, Niemand M and Ouma S. Disconnected Electronic Badges in Resource Constrained Environments. A use case from the rural Nciba district in the Eastern Cape. Second International Conference on Advances in Computing, Communication and Information Technology - CCIT 2014. University of Birmingham, UK 16-17 November, 2014.	Published	15% Assisted in the following areas of the paper: Digital Badging, Mozilla Open Badges and the application design screens for a badge receiving mobile application.	1.) Adele Botha, primary author and did initial paper excluding digital badge sections 60% 2.) Christopher Salerno, digital badge issuing sections 15% 3.) Stella Ouma, editing 10%	1.) No 2.) Yes 3.) No

2, 3, 4	Niemand M. D, Ouma S., and Botha A. Developing a Conceptual Model for Receiving and Authenticating Digital Badges in a Resource Constrained Environment. Paper presented at the IDIA, Nungwi, Zanzibar.	Published	85% Primary author and produced the content.	1.) Stella Ouma, editing 7.5% 2.) Adele Botha, editing 7.5%	1.) No 2.) No

Student signature: [redacted] **Date:** 12-04-2017

The undersigned hereby certify that the above declaration correctly reflects the nature and extent of the student and co-authors' contributions to this work.

Main Supervisor signature: **Date:**

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Chapter 1

Introduction

Mozilla Open Badges allows for the online distribution and collection of digital badges that certify individuals' skills in a manner similar to traditional forms of accreditation, such as diplomas (Mozilla-Wiki, 2014). Education is defined as 'a systematic instruction process' (Education, 2017), which implies a series of skill instructions that build upon each other to form a cohesive learning process. The Mozilla Open Badges initiative helps accentuate these skills gained from the learning process. A need for specific skill accreditation has been recognised in the current employment market to help employers identify exactly which skills a graduate possesses (Pearson, 2013). A 2012 report published by McKinley, stated that there are over 75 million youths unemployed worldwide, and more than half of the youth population in South Africa is unemployed (Mourshed, Farrell, & Barton, 2012). Carnevale, Hanson, and Gulish (2013) estimate that by 2020, approximately 65% of jobs will require some education or training beyond high school. Seventy two percent of education providers believe that they adequately prepare graduates to enter the job market, while only 42% of employers agree on this point (Mourshed et al., 2012). Added to the statistics above, the matter is only further complicated when considering that 40% of students reported that they were not familiar with all the skills or requirements needed for their chosen profession (Mourshed et al., 2012).

Digital badges emerged from the concept of physical badges being awarded to individuals and functions as symbols of rank, status and accomplishment (Gibson, Ostashewski, Flintoff, Grant, & Knight, 2013). Currently digital badges are commonly used as a reward within a gamified system due to their guiding and motivating nature (Blohm & Leimeister, 2013; Dale, 2014; Deterding, Sicart, Nacke, O'Hara, & Dixon, 2011; Gibson et al., 2013). Digital badges feature as rewards in prominent gamified websites and applications, such as FourSquare, StackOverflow and Duolingo, acting as proof that a user has earned an accomplishment or shown competency in a skill (Duolingo, 2015; FourSquare, 2015; StackOverflow, 2015). These digital badges are, however, context dependent, and do not contain additional value outside their respective systems (Madda, 2015).

Mozilla designed Open Badges to allow individuals to collect badges from a variety of issuers, and store and manage them in a single online repository (ALL4ED, 2013; Mozilla-OpenBadges, 2017). It is hoped that such an open system will encourage an attitude of 'lifelong learning', where people seek accredited skills from others and organisations outside of formal educational institutes (Ash, 2012; Madda, 2015). Such a process encourages education in a modular process, where it is still systematic, but where learning can be done in a variety of institutions or situations. The issue with such modularised components concerns their trustworthiness (Goligoski, 2012; Jovanovic & Devedzic, 2014). Open badges contain all the essential design characteristics of standard digital badges, such as a name, visual image and description, but have an additional layer of metadata that contains evidence of an individual's accomplishments, ensuring Open Badges' ability to act as credible certification (ALL4ED, 2013; Mozilla-Wiki, 2014; Pearson, 2013). Open badges are already endorsed by educational institutes such as Purdue University and Massive Open Online Courses (MOOCS) as a supplementary form of accreditation, illustrating how they can be used as meaningful rewards (Mehta, Hull, Young, & Stoller, 2013; Randall, Harrison, & West, 2013). Additionally, the use of open badges by the Clinton Project to help war veterans return to civilian life, with the skills they earned outside of a classroom environment, show the versatility of modularised learning by separating education from traditional educational institutions (Lewin, 2013).

Mozilla Open Badges offer many advantages and lend themselves to educational goals within developing nations, such as those seen within South Africa's National Development Plan for 2030. A problem arises, however, when attempting to implement such an online system within a resource-constrained environment (Botha, Salerno, Niemand, Ouma, & Makitla, 2014).

Resource-constrained environments are defined by a variety of factors that act as barriers to information communication technology for development (ICT4D) initiatives (R. E. Anderson, Anderson, Borriello, & Kolko, 2012; Kam, Ramachandran, Sahni, & Canny, 2005). In 2016, it was estimated that only 52% of South Africans had internet access (Internet-Live-Stats, 2017). The South African National Development Plan for

2030 aims to improve the country's skills pool, and simultaneously target schools in rural areas (National-Planning-Commission, 2011). One of the key attributes that the 2030 plan aims to achieve is: 'A wider system of innovation that links universities, science councils and other research and development role-players with priority areas of the economy' (National-Planning-Commission, 2011). This is similar to the goals of the Open Badges Initiative, which aims to help ensure that outcomes, skills and competencies are properly articulated to both employers and education providers, thus ensuring that learners have more market-focused skills when graduating (Pearson, 2013). Unfortunately, even if these initiatives share goals, there exists a technological barrier that inhibits the collaboration of ideas and solutions. The Mozilla Open Badges system has not been developed for environments where there is a perpetual lack of internet connectivity, or a low level of information communication technology (ICT) proficiency. Thus, the system cannot be fully utilised in certain parts of South Africa.

This research addresses this issue by adapting existing knowledge and technologies to produce a model for the successful implementation of open badges within resource-constrained environments.

This first chapter of the thesis contains the introduction. The following sections help establish the context of the thesis and outline how the study was conducted to produce a high-quality solution that addresses the identified problem. The introduction chapter is structured as follows:

- The first section describes the context of the thesis.
- Section 1.2 contains the research problem statement.
- The research questions of this study are outlined in section 1.3.
- Once the research questions have been examined, the research objectives are discussed in section 1.4.
- An overview of the methodology used in this thesis is presented in section 1.5.
- Delineations and assumptions are detailed in section 1.6.
- Finally, concluding this chapter, an overview of the thesis is presented in section 1.7.

1.1. Context

Heeks (2008) states that one of the primary purposes of ICT4D initiatives is to ensure that developing nations do not become excluded as the world moves to an increasingly digital landscape with regards to education, economics and politics. These ICT4D initiatives are often multidisciplinary endeavours that affect a multitude of stakeholders (Tongia & Subrahmanian, 2006). By producing a detailed model that outlines the elements of the open badge system adapted to overcome identified environmental challenges, this thesis hopes to ensure that ICT4D initiatives that attempt to utilise Mozilla Open Badges have a clear route to follow, and experience minimal risks.

Due to the magnitude of factors and areas of influence found in ICT4D initiatives, it was considered vital to delimitate the scope of the model and ensure that the thesis only addresses problems within a specific context and domain of knowledge. Thus, this thesis made use of the 4C framework proposed by Tongia (2005), which encompasses the different areas of ICT design, later adapted by Makitla, Herselman, Botha, and Van Greunen (2012), as shown in Figure 1.1 below:

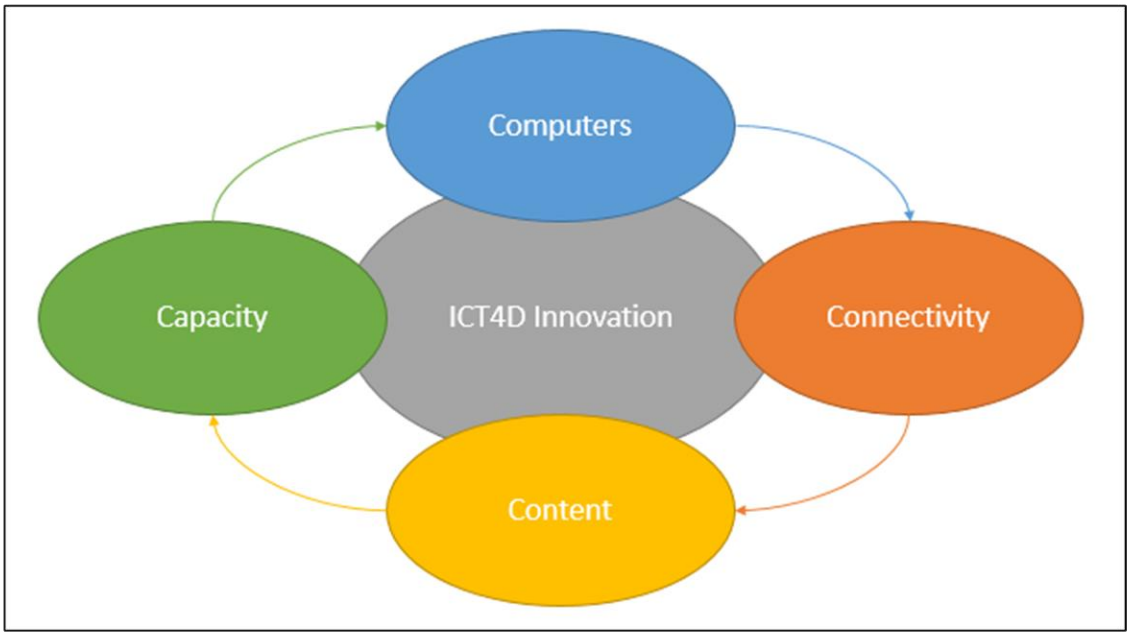


Figure 1.1 - 4C Framework Leading to Innovation within ICT4D (Adapted from Makitla et al. (2012), Originally Proposed by Tongia (2005))

The 4C framework proposed by Tongia (2005) apotheosises how innovation within ICT4D initiatives are composed within four main areas, which are briefly summarised below:

- **Connectivity** – This relates to the physical infrastructure in an area required to ensure a connected environment. This may include transport networks such as roads, but is primarily concerned with internet connectivity, and thus concerns mainly electrical supply and telecommunication networks.
- **Computers** – The personal or shared ICT devices used to access the content and services offered. These ICT devices can be mobile or desktop computing devices.
- **Capacity** – Refers to human capacity and an individual's ability to employ knowledge to operate their ICT device and access content and services.
- **Content** – The content and services offered by an ICT4D initiative. This implies any information or information systems that can be accessed and utilised.

Utilising the above framework, this research focused only on components that are required for the functionality of open badges. This study was primarily concerned with the content, capacity and connectivity components to try and ensure the production of a generalised model. It was necessary, however, to delve into the area of computers to help determine which ICT device would most likely be used by ICT4D initiatives. There is a large difference in designing for mobiles compared with designing for desktops, and it would be a fallacy of this thesis to claim to be able to develop a general model suitable for all ICT devices. While the elements of the model may be adapted to suit a variety of devices and situations, the model produced by this research was developed primarily for mobile ICT devices. Section 4.4 shows how mobile devices currently display the most potential within resource-constrained environments (PewResearchCenter, 2015).

Underscoring the lacunae that this research seeks to address by examining the current Mozilla Open Badges system within the realm of this framework, the following is noted:

- The current open badges system fits within the content and capacity areas of the framework. Examples of how the current Mozilla Open Badges system functions (Mozilla, 2014a, 2014b, 2014c) show that they are not intuitively intended for users who may require special consideration when utilising ICT. People located within resource-constrained environments often require additional training and specially designed applications to fully utilise ICT (Medhi et al., 2011). So, while the content is designed to be modifiable, the capacity of the users is not taken into account.

- To ensure these users have access to this content, the connectivity of the area must be analysed, and the human capacity of the users needs to be investigated. Due to the current design of the Mozilla Open Badges system, it cannot be thought of as a feasible service for deployment within ICT4D initiatives. The current Mozilla Open Badges system relies on an online connection to populate the user's badge 'Backpack' (Mozilla, 2017).

These issues exclude open badges from being used within a resource-constrained environment, and removes the possibility for the distribution of meaningful badge rewards. It is this gap that the research addresses with the production of a model to implement open badges within resource-constrained environments.

1.2. Problem Statement

There currently exists a need for a modularised skill-based assessment system (Ash, 2012; Devedžić & Jovanović, 2015; Madda, 2015; Mourshed et al., 2012; Pearson, 2013). This research produces a model that would enable the implementation of open badge systems within resource-constrained environments.

The Mozilla Open Badges system offers a unique opportunity for education to adopt a learning process that is modularised with well-articulated skills that could be earned from a variety of sources. Additionally, as previously mentioned, the Mozilla Open Badges system's goals are aligned with the educational goals of the South African National Development Plan for 2030.

Given the design of the current Mozilla Open Badges systems, however, they cannot be effectively used within resource-constrained environments due to various social and environmental challenges. There is currently no evidence of a mechanism to implement open badges within resource-constrained environments, meaning there is no way to issue or receive open badges within such environments. This consequently acts as a barrier for ICT4D initiatives to employ Mozilla Open Badges (Botha et al., 2014). This thesis addresses this problem by examining the elements required to construct a model that will allow the implementation of Open Badges within resource-constrained environments.

The research problems for this thesis can be summarised as follows:

- Current Mozilla Open Badges system is not designed to function optimally within resource-constrained environments.
- There is no current mechanism to aid ICT4D initiatives in implementing open badges within resource-constrained environments.

1.3. Research Questions

In the pursuit of solving the above identified problem, the following research question was formulated to assist with the production of a model to implement open badges in a resource-constrained environment:

Research Question (RQ)*:*

> *What are the elements of a model to implement open badges in a resource-constrained environment?*

This research question is, however, broad in context; therefore, it was found to be beneficial to introduce a series of sub-research questions that would ultimately aid in solving the primary research question. Three sub-research questions were formulated, each of which is the focus of a literature review chapter. The first sub-research question is concerned with establishing the 'why' of this research, and thus scrutinises the current Mozilla Open Badges system. This question is used to determine critical elements of badge systems in general, and more specifically open badge systems utilising the open badges framework. This research question focuses the thesis on examining the history of badges, the utility of badges within an educational context, and the structure of existing open badge initiatives to help determine elements. The first sub-research question is as follows:

Sub-Research Question 1 (SRQ1):

What are the elements of open badges that are critical to its functionality within the open badge standards framework?

Once the elements of open badges have been identified, this research focuses on enabling the functionality of these identified elements within resource-constrained environments. This requires an understanding of the challenges that resource-constrained environments impose on ICT4D initiatives. The purpose of the second sub-research question is to examine previous literature to identify challenges posed to ICT4D initiatives, and determine how they were overcome. The second sub-research question helps explain 'what' contributes to the problem that this research addresses. Employing Tongia (2005) 4C framework, as discussed in section 1.1, the literature review focuses on presenting challenges within the ICT4D areas of connectivity, content, capacity and computers.

Sub-Research Question 2 (SRQ2):

How do resource-constrained environments impact the functionality of ICT4D with regards to the context of connectivity, content, capacity and computers?

The final sub-research question was constructed to help identify the technical elements and design decisions needed to ensure the functionality of open badges within resource-constrained environments. This sub-research question explores 'how' this thesis addresses the challenges identified in the examination of the previous question. This question enables the research to examine literature that incorporated innovative design solutions that circumnavigated identified challenges posed by resource-constrained environments:

Sub-Research Question 3 (SRQ3):

What current knowledge can be adapted and utilised to ensure the functionality of open badges within resource-constrained environments?

For ease of reference, the research questions are shown in the table below:

Type	Question
RQ	What are the elements of a model to implement open badges in a resource-constrained environment?
SRQ1	What are the elements of open badges that are critical to its functionality within the open badge standards framework?
SRQ2	How do resource-constrained environments impact the functionality of ICT4D with regards to the context of connectivity, content, capacity and computers?
SRQ3	What current knowledge can be adapted and utilised to ensure the functionality of open badges within resource-constrained environments?

Table 1.1 – Research Questions

The next section explores the research objectives of this thesis.

1.4. Research Objectives

Given the identified problem, and having formulated the research questions of this thesis, the primary objective of this study is defined as follows: Producing a model to implement open badges within a resource-constrained environment. This research identified the following objectives that correlate with the primary objective:

- This research aims to identify the critical elements of an open badge system by analysing literature pertaining to the need and implementation of open badges outside resource-constrained environments.
- This study investigates resource-constrained environments with a focus on Tongia (2005) 4C framework for ICT4D, regarding content, connectivity, capacity and computers, to produce a list of challenges that would interfere with the functionality of an open badge system.
- The final objective of this research is to find solutions to these challenges within the existing literature, and employ these solutions in the design of the model.

1.5. Methodology Overview

This section provides a brief outline of the methodology used in this thesis. Chapter 5 fully details the research methodology and research design decisions. Utilising Saunders, Lewis, and Thornhill (2011) research 'onion' to guide the methodology, this research employed the following aspects:

- **Philosophy**: This research employs an interpretive philosophy.
- **Approach**: Data are analysed through an inductive approach.
- **Strategy**: The model is constructed with the use of a design science strategy.
- **Method**: Data gathered are qualitative, and thus this research employs qualitative methodologies.
- **Time Horizon**: This research is delineated within a cross-sectional time horizon.
- **Techniques and Procedures**: Data were gathered in the form of literature and expert reviews. A general inductive approach was used to analyse the literature and identify themes and concepts, which were then appraised and validated by experts in the field of ICT4D.

This research makes use of an interpretive research philosophy, as detailed by Klein and Myers (1999), utilising literature to gain an understanding of the context and requirements needed to construct a model. Thomas (2006) emphasises the use of an inductive approach when developing a model or addressing research questions, as opposed to hypotheses, as is the case in this research.

Gregor and Hevner (2013) argue that extending known solutions to new problems, as is the case with the Mozilla Open Badges system not functioning in resource-constrained environments, and utilising existing knowledge to design a model is a form of exaptation in design science research. A design science research strategy is employed, as detailed in section 5.4 of the methodology chapter, which employs K. Peffers et al. (2006) design science research process to design an IT artefact to address the research problem.

1.6. Delineation and Assumptions

This research addresses the functionality of content within ICT4D initiatives, as shown in Figure 1 in section 1.1 of this chapter. While the model questions aspects of connectivity and capacity within the 4C framework, it does not propose solutions that innovate within those components, rather, it circumnavigates the issues identified.

In the construction of a conceptual model for implementing open badges in a resource-constrained environment, this research gathers literature concerning a variety of topics, but does not contain fieldwork.

The primary focus for this research is the production of an expert-reviewed model that can be adapted to construct environment-specific applications. This research does not produce a proof-of-concept application because this was deemed to be outside the scope of this study.

1.7. Chapter Overview

This research is divided into nine chapters. At the start of each chapter there is a layout map (shown below in Figure 1.2), which highlights the current chapter and indicates the progression through this thesis. The layout of this thesis is based on K. Peffers et al. (2006) design science research process, and structured according to Gregor and Hevner (2013) publication schema.

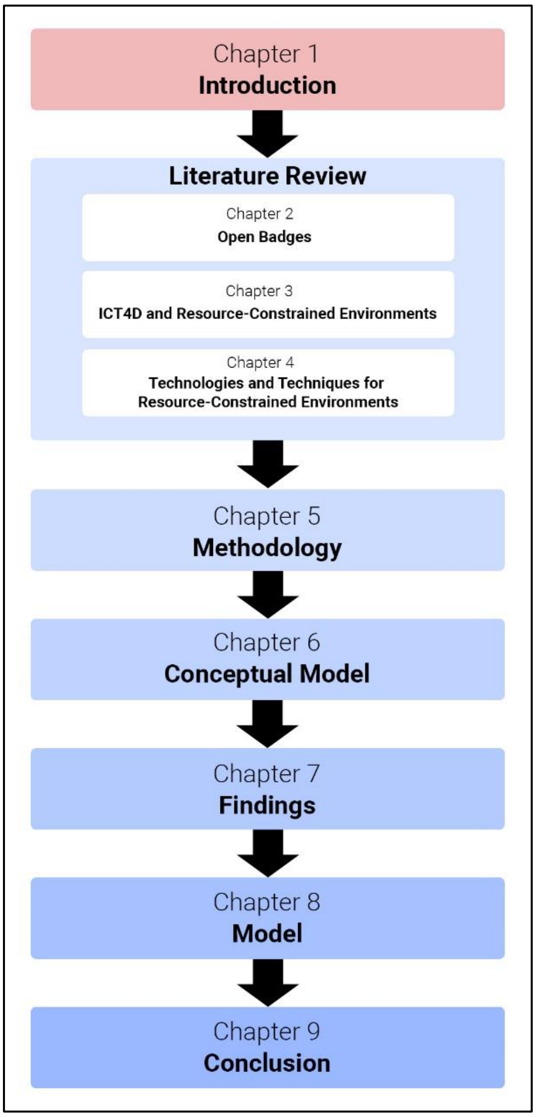


Figure 1.2 – Position Index Used Throughout this Thesis.

Gregor and Hevner (2013) propose the use of a design science research publication schema to accentuate the contribution of knowledge produced by research endeavour. The publication schema is composed of the following sections: introduction, literature review, method, artefact description, evaluation, discussion and conclusions. Alternatively, as opposed to following the exact publication schema suggested above, this research instead opted to split the artefact description between chapters 6 and 8, thus preventing any unnecessary repeat of argument. The bulk of the artefact description is presented in Chapter 8, where the model elements are discussed in detail.

Below is an overview of the layout of this thesis, discussed according to the content of each section:

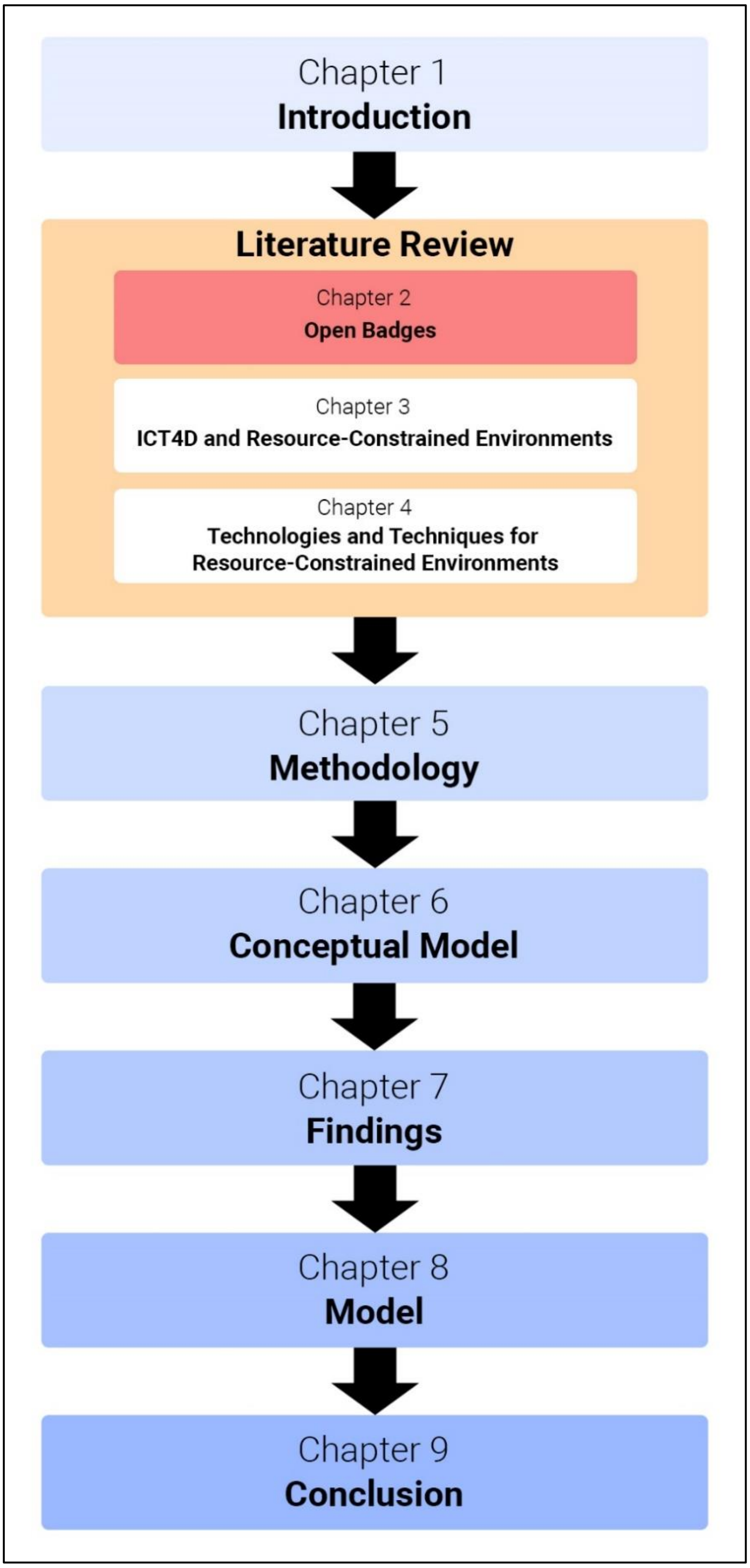
- **Chapter 1 – Introduction:** This chapter introduces the context of the study. Also, it highlights the problem statement, the objectives and research questions formed to address this problem.
- **Chapters 2,3,4 – Literature Review:** These chapters detail the background research, with the primary focus on gaining additional insights into the topics of open badges and resource-constrained environments. The content of these chapters is used to address the sub-research questions in a systematic approach: 1) stressing the needs and design of open badges; 2) the challenges of resource-constrained environments on such a system; and 3) the technologies and techniques to overcome these challenges.
- **Chapter 5 – Methodology:** This chapter details the methodology and research framework used to construct the model to solve the research questions.
- **Chapter 6 – Conceptual Model:** After implementing the key concepts derived from the literature, this chapter explains the construction of a preliminary model that attempts to address the primary research question. Only a summary is provided of the model elements; the full details can be found in Chapter 8. This model was not intended to be the final IT artefact produced by this research, and was used to extract feedback from expert reviewers. The expert reviewers were tasked with evaluating and critiquing the design in the hope of producing a final model that would be a suitable solution to the identified research problem.
- **Chapter 7 – Findings:** This chapter details the results extrapolated from experts in the field of ICT4D initiatives. As described above, this was achieved by having experts examine the conceptual model and deliver comments and criticisms.
- **Chapter 8 – Model:** This chapter details the final model proposed as the solution to the research questions. This model was constructed by implementing the conceptual model design, as detailed in Chapter 6, and incorporating the suggestions from the expert reviewers in Chapter 7. The changes are examined, and the reasons for implementation or exclusion are described. Each of the model components is analysed, and the elements are described according to

their characteristics and surrounding relationships. The model is intended to be the final IT artefact produced by this research.

- **Chapter 9 – Conclusion:** This chapter summarises and concludes the research. The research questions and objectives are revisited and discussed. The contributions that this study makes are highlighted, and further avenues of research are proposed.

Chapter 2

Open Badges



2.1. Introduction

Chapter 1 provided an overview of the topic of this thesis and served as a general introduction. It outlined the problem statement, the research questions and objectives, as well as the structure of this thesis. As previously stated, the literature review is divided across three chapters (chapters 2,3 and 4). Each chapter addresses a sub-research question. This chapter is the first of the literature review chapter, and addresses the first sub-research question:

Sub-Research Question 1 (SRQ1):

> *What are the elements of open badges that are critical to its functionality within the open badge standards framework?*

In the process of extrapolating the elements critical to the functionality of open badges, this chapter explores the interest in open badges as a form of skill assessment. Before any of the elements can be identified, it is important to first define what an open badge is within the context of this research. This is achieved by examining the history of badges in general, with a focus on digital badges.

This chapter contains the following sections that examine different aspects of open badges to ultimately help address the above sub-research question:

- Explore the background of badges in general to understand the conception of open badges.
- Examine the demand of open badges as a form of skill assessment.
- Investigate different Mozilla Open Badges projects to identify elements critical to the functionality of open badge systems.
- Examine and identify critical elements of the Mozilla Open Badge standards framework.

The first section of this chapter explores the background of badges.

2.2. Background of Badges

Badges have been around since the Middle Ages, signifying accomplishments, political allegiances or status (Goligoski, 2012). More recently, military and law enforcement badges have also been used as forms of identification and/or rank. Regarding signifying achievement, badges are generally awarded to people when they have accomplished a feat or milestone of worth. Organisations such as the American Boy Scouts use physical badges in an educational system to both motivate and guide young Scouts (Antin & Churchill, 2011).

The Scouts' physical badge system is, however, not easily transferable to a different context, nor does it allow much flexibility for individuals to select their own learning paths (Ostashewski & Reid, 2015). Examples of military and Scout badges are shown below, in Figure 2.1:

Figure 2.1 Variety of Traditional Military and Scout Badges (Metal-Detectors-SA, 2017; Scouts-SouthAfrica, 2017)

Based on the uses of traditional physical badges, and experiments in various digital games and online websites, digital badges have emerged as an online visual representation of skill and achievement (Gibson et al., 2013; Hamari & Eranti, 2011;

Ostashewski & Reid, 2015). Hamari and Eranti (2011) explain that, due to the goal- and achievement-based nature of games, digital badges were easily implemented to serve as motivational tools. Attesting to the success and popularity of badges as motivational tools, most of today's newly released games, across various platforms, feature digital badges (Hamari & Eranti, 2011), and popular web-services such as Duolingo, FourSquare and StackOverflow also use them.

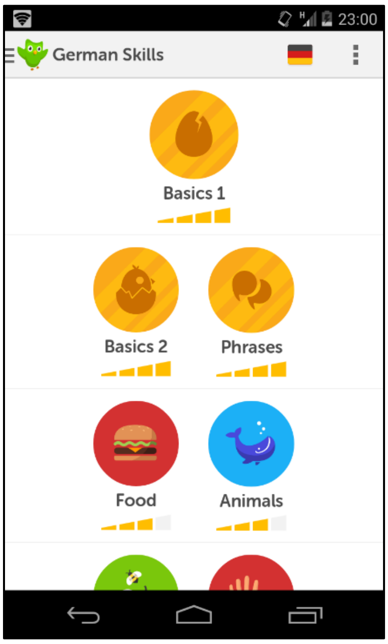


Figure 2.2. Duolingo's German Language Course Path implementing Digital Badges (Duolingo, 2017)

With digital badges, as well as traditional badges, there are necessary elements for a badging process to be established. The elements present in both these badging schemes are as follows: 1) an issuer; 2) a receiver; 3) a utiliser; and 4) the badge itself. Taking a user who attempts to learn a new language from the Duolingo service as an example, the language student is the receiver, Duolingo is the issuer, the badge is the award received for completing a language skill section, and the utiliser would be a social media site, such as Facebook, which could display the uncertifiable digital badge.

It can argued that Mozilla Open Badges is an online badge collecting system that provides a structured and standardised environment to utilise digital badges as a form of modularised accreditation over and above the standard use of badges (Ostashewski & Reid, 2015).

Mozilla Open Badges are based on existing digital badge designs, i.e. they contain a name, a visual image and a description. Regarding the use of metadata, however, Mozilla Open Badges allows evidence-based authentication, enabling them to serve as an alternative to standard qualification accreditation (Mozilla-FAQ, 2017; Ostashewski & Reid, 2015).

Open badges are considered a subset of digital badges, sharing many characteristics, with the addition of following the open badge infrastructure, originally designed by Mozilla (Devedžić & Jovanović, 2015; Otto & Hickey, 2014). The open badges infrastructure, following the goals and guidelines set forth by the Mozilla Open Badge standards framework, attempts to create digital badges that can be collected from various sources and different contexts to serve as an alternate form of assessment (Mozilla-FAQ, 2017; Ostashewski & Reid, 2015; Pearson, 2013; Sullivan, 2013).

Mozilla has thus modified the existing badge structure by changing the badge element to contain proof of accreditation, to enable it to be certifiable. The Mozilla Open Badges framework also adds a further element to the existing badge structure in the form of a centralised badge collection repository for each user (Moore, 2013; Mozilla-OpenBadges, 2017). The Mozilla Open Badges framework is examined in greater detail later in this chapter (section 2.5).

In this section, the background of badges has been briefly analysed (i.e. the conception of Mozilla Open Badges emerging from the structure of standard digital badges). There is an overlap in elements between these different badge processes. Mozilla Open Badges has utilised these original processes and expanded on them to enable the certification and collection of digital badges from a variety of sources. In the next section, the needs of Mozilla Open Badges and utilising Mozilla Open Badges as a form of modular assessment to aid in the learning process is discussed.

2.3. The Need for Alternative Assessment

The world is currently facing an unemployment crisis brought on by skills shortages (Mourshed et al., 2012). This will only increase in the coming years, and will affect developing countries the worst (Carnevale et al., 2013). Mourshed et al. (2012) state that one of the key contributing factors that keeps unemployment for graduates' high is the lack of clarity regarding skills earned from tertiary institutes and skills required by businesses. While traditional degrees might show success in a field, the individual skills learnt are often abstracted (Ostashewski & Reid, 2015). An example of this is students who graduate from the same degree, yet possess different skillsets and competencies. Baker, Bujak, and DeMillo (2012) propose that open badges might be the most suitable form of modularised accreditation in today's fast paced and ever-evolving world. Open badges could deliver skills in a targeted and timely manner, which would eliminate time spent on potentially irrelevant courses attached to obtaining traditional certification, such as degrees (Sullivan, 2013).

While this section might not establish or identify elements critical to the open badge process, it does contribute to the validity of the overall research by examining the potential uses of open badges. This section highlights the following areas in which open badges can alleviate the above described problems.

2.3.1. Micro-Credentials Clarify Skills

Open Badges serving as micro-credentials (accrediting a single skill) can bring clarity to employers seeking specific skills in applicants (Devedžić & Jovanović, 2015). Even if schools and employers are already in agreement about which overall skills are needed, Mourshed et al. (2012) point out that there exists a lack of clarity among graduates being able to correctly articulate their skills when applying for employment. Pearson (2013) examines how the implementation of micro-credentials can help articulate skills acquired during traditional courses. From an employer's perspective, searches for specific skill badges could allow employers to narrow down lists of applicants and speed up the vetting process. Learners, on the other hand, will have access to a single organised list that details all their accredited skills, enabling applicants to relate their skillset to employers more accurately. Finally, from a learning institute's perspective, because organisations can be more detailed in explaining their needs and sought after skills, educational programmes can be better designed to produce market-ready students, focusing on incorporating 'in-demand' skills (Devedžić & Jovanović, 2015; Mourshed et al., 2012; Pearson, 2013).

2.3.2. Support Information Communication Technology Use in Education

Hori et al. (2015) state that soon, conventional education systems, including standard brick-and-mortar classrooms, will be unable to cope with rapid population growth and the increased demands on universal education. Hori et al. (2015) propose that online educational systems using ICT will be a more feasible solution, not only for meeting the increased demand on education, but also in addressing educational challenges in resource-constrained environments.

2.3.3. Badges Exhibit Motivational Effects

Abramovich, Schunn, and Higashi (2013) consider how standardised assessment can have a negative effect on student motivation for learning, and instead force students to prepare only for exams rather than truly learn. Abramovich et al. (2013) further discuss how the use of badges as an alternative assessment method could overcome these negative effects on student motivation. Acting as a meaningful reward, and helping guide participants by providing an indication of what is needed to earn a badge, badges are gaining a reputation as motivational tools (Deterding et al., 2011; Gibson et al., 2013; Ostashewski & Reid, 2015). Santos et al. (2013) express the motivational importance of individuals being able to socially communicate with peers and interested parties about badges they have earned. With the implementation of Mozilla Open Badges, learners have the ability to easily broadcast their accomplishments and skills via social media (Mozilla-FAQ, 2017; Pearson, 2013) .

2.3.4. Innovation in Education by Implementing Badge Systems

One current example of a badge system that acts as an alternative form of accreditation is at Purdue University, where educators create badges based on unit criteria. Students earn these badges after completing specific unit criteria, with the badge representing proof of skill and competency in the unit, in conjunction with a traditional unit grade (Randall et al., 2013). Massive Open Online Courses employ a similar system, which guides a student to a badge provider, depending on the field of study the student has chosen. An accredited badge issuer then awards students who have achieved the required level of competency in a skill with a badge that is the equivalent of earning an Entrustable Professional Activities and Statement of Awarded Responsibilities (Mehta et al., 2013).

2.3.5. Open Badges and Digital Badges Have Overlapping Educational Goals

Ostashewski and Reid (2015) state that the predominant goals of digital badges within educational environments, such as in the examples above, are based around the following:

1.) Allowing learners to set their own learning paths or goals
2.) Motivating learners to engage in positive learning behaviours
3.) Representing learner accomplishment and achievement
4.) Providing evidence of accomplishments or achievements to enable communication within different contexts

Comparing Ostashewski and Reid (2015) goals for digital badges in education with the current goals of the Mozilla Open Badge standards framework, the Mozilla Open Badges overlap with all the goals, with the exception of explicitly stating the motivational aspect of badges:

- Free and open access to the technical software enabling institutions to modify the programme to suit their needs.
- The ability for badges to come from a variety of sources but be collected in a single repository for users, allowing learners the freedom to gather badges from

various sources and subjects, effectively granting the freedom to choose their own learning paths and goals.

- The ability to stack multiple similar badges, creating a more detailed guide of skills and achievements, in line with Ostashewski and Reid (2015) goal of representing learner accomplishment.
- The fact that badges record the evidence that links to the issuer, proving that the criteria for the badge have been achieved. This would enable trusted communication with various organisations from both within and outside the earned-badge environment.

While the motivational aspect of Mozilla Open Badges was not included in the framework goals above, earlier in this section it was shown how badges are inherently seen as motivational tools, and thus it can also be assumed that Mozilla Open Badges would have the same characteristic.

This section has identified the benefits of open badges as a form of alternate assessment within the following areas:

1. Micro-Credentials Clarify Skills
2. Support-ICT Use in Education
3. Badges Exhibit Motivational Effects
4. Innovation in Education by Implementing Badge Systems
5. Open Badges and Digital Badges Have Overlapping Educational Goals

To help identify elements critical to the functionality of Mozilla Open Badge systems, the next section explores various Mozilla Open Badges implementations using the 4C framework of ICT development as a focus (already briefly introduced in Chapter 1, and further detailed in the following chapter on resource-constrained environments).

2.4. Examining Mozilla Open Badge Initiatives

This section identifies some elements critical to the functionality of the open badges system. Utilising the 4C ICT development framework of Tongia (2005), as mentioned in the introduction chapter (section 1.1) and further detailed in the next chapter (section

3.4), this section investigates various initiatives that have made use, or attempted to make use, of Mozilla Open Badges.

This section analyses, within the contexts of connectivity, capacity, content and computers, three official Mozilla Open Badges initiatives, and a local South African initiative that attempted to implement open badges. Though the Information and Communication Technology for Rural Education Development's Teacher Professional Development (ICT4RED's TPD) programme failed to implement Mozilla Open Badges within a resource-constrained environment, it must be stated that the initiative did succeed in utilising badges in a physical manner. Critiquing the ICT4RED's TPD programme in this section is merely meant to bring attention to the challenges that inhibited the implementation of digital open badges, and not meant to be a criticism of the goal of the programme or how the programme utilised badges.

2.4.1. Case 1: Providence After School Alliance

The Providence After School Alliance is an American educational initiative providing middle- and high-school students with out-of-school-hours' education. This project operates within the city of Providence and encompasses a collection of schools (Mozilla, 2014a).

2.4.1.1. Connectivity

Because the project operates within the city of Providence, which is the capital of the state of Rhode Island, it cannot be expected that the same resource-constraints would be found as those in developing countries. Participants in this project have access to a connected environment.

2.4.1.2. Capacity

The project mentions that there are issues when attempting to involve outside stakeholders who are not badge issuers or receivers.

In this case, external stakeholders can be considered badge utilisers, and comprise educators, potential employers and policy-makes.

The badge receivers of this project are middle- and high-school students from various schools around Providence. These students participate in activities that help develop skills related to problem solving, resilience and teamwork within a non-traditional educational setting.

The issuers of badges in this project is the Providence After School Alliance, and various administrators and educators.

2.4.1.3. Content

There have been technical issues with the planning and development of the badge system, as well as with the digital badges themselves. The technical infrastructure has to be monitored to ensure that the project can expand in a sustainable manner.

2.4.1.4. Computers

Nothing is mentioned with regards to the ICT devices used in the project, meaning it could be either mobile or desktop ICT.

2.4.2. Case 2: Young Adult Library Services Association

As a division of the American Library Association, the Young Adult Library Services Association (YALSA) has the goal of strengthening and expanding library services for young adults aged between 12 and 18. Targeting older library staff, the YALSA hopes to train and provide library staff with the necessary skills to interact with a younger generation (Mozilla, 2014c).

2.4.2.1. Connectivity

There have been no connection issues because the entire system is web based. Furthermore, many of the badges require learning online competencies and skills. It would not be possible to engage in online discussions if there was no capacity for it.

2.4.2.2. Capacity

The badge receivers for this project consist of various types of library staff who require skills to better serve and assist teenagers with library services. There is also the possibility that the type of badge receivers could expand to include school staff who want training in library services.

The issuing organisation is the American Library Association; however, badges are awarded by online consensus. When an individual has adequately demonstrated progress of a skill in an online forum, they can be awarded the badge based on positive votes. In a sense, the issuer is an online body.

The beneficiaries and utilisers of these newly acquired skills are the teenagers who rely on library staff to assist them with library services.

2.4.2.3. Content

An issue was encountered with the design of the system, which led to the project seeking out different developers. A lack of communication between developers and end users resulted in a misalignment of goals and processes.

While the exact issues have not been disclosed, user input remains critical in human computer interaction (HCI) development, even without the additional challenges present within resource-constrained environments.

2.4.2.4. Computers

Which ICT devices are used has not been specified. The use of web applications could mean that it is either mobile ICT with internet capabilities, or fixed ICT, such as desktops or terminals.

2.4.3. Case 3: The Sustainable Agriculture and Food Systems Major

This project is a university-level course targeting undergraduate students at the University of California Davis. This badge system employed traditional and non-traditional education methods to help highlight and show students the skills and competencies they were developing and how they can be applied (Mozilla, 2014b).

2.4.3.1. Connectivity

No mention was made of connectivity issues. Heeding the fact that the project took place in California, which is a developed state within a developed country, it is assumed that there are no constraints relating to connectivity.

2.4.3.2. Capacity

The badge receivers of this project are the students enrolled in the sustainable agriculture and food systems major.

The main badge issuer is the University of California Davis; more specifically, the educational and administrational staff running the major.

The utilisers of these badges are defined as faculty, peers and potential employers.

2.4.3.3. Content

The importance of a well-designed user interface for all stakeholder elements (receivers, issuers and utilisers) is emphasised. A lack of focus on designing the user interface, nor having relevant user input, resulted in the need for a system redesign later in the project lifetime.

2.4.3.4. Computers

Information communication technology devices are not explicitly mentioned in the project case study; however, the description of error messages and debugging reports suggests either a system or web application that students can install on their chosen ICT device.

2.4.4. Case 4: The Information and Communication Technology for Rural Education Development's Teacher Professional Development Program

The ICT4RED is part of the larger TECH4RED initiative, which is a multi-organisational project supported by various government agencies as well as the Council for Scientific and Industrial Research in South Africa, focusing on how ICTs can be utilised to support teaching and learning in a modern education environment (Herselman & Botha, 2014).

The initiative takes place in the Cofimvaba school district in the Eastern Cape province of South Africa, which was classified as a resource-constrained environment when the initiative began. In the early phases of the initiative, teachers were issued tablets and expected to eventually implement their usage in everyday lessons. To aid in the adoption of mobile ICT in the classroom environment, teachers were expected to take part in a continuous Teacher Professional Development programme to help develop their ICT confidence. Making use of badges as proof of accreditation for completing specific modules, this programme originally attempted to implement Mozilla Open Badges, but due to the challenges encountered in the resource-constrained environment, it had to side-line the use of open badges and continue with using physical badges (Botha et al., 2014).

2.4.4.1. Connectivity

There was little to no connectivity available for participants in the area. Due to the lack of a steady internet connection, many online services and websites, such as the Mozilla online Backpack, could not be reached reliably (Botha et al., 2014).

2.4.4.2. Capacity

The badge receivers in this project are the teachers of the Cofimvaba school district. The teachers possessed a moderate level of English literacy (which is not to say they were not highly literate in their native language) but were not ICT confident. Because of this, teachers could not initially be expected to create online accounts and access online services, such as Mozilla Backpack (Botha et al., 2014; Niemand, Ouma, & Botha, 2015).

The main badge issuers of the ICT4RED initiative are composed of champions of the initiative and experts in the field of teacher professional development assessment. The badge issuers possess a moderate to high level of English literacy and ICT confidence (Herselman & Botha, 2014).

The badge utilisers are described as parties interested in hiring these teachers after the completion of the programme, or as the current educational institutes where the teachers are employed. Additionally, students benefit from their teachers' new found expertise and skill (Herselman & Botha, 2014).

2.4.4.3. Content

A custom interface for the Mozilla badge system was designed to be used in the ICT4RED TPD initiative but could not be adapted to work offline within the initiative's development timeframe due to a lack of previous research on the topic (Botha et al., 2014).

2.4.4.4. Computers

The ICT4RED project makes use of mobile ICT devices due to their popularity and scalable nature (Herselman & Botha, 2014).

Now that all the initiatives have been investigated, some conclusions can be drawn. For referencing purposes, a summary of this section is presented in Table 2.1, below.

Area	**Case 1** (Mozilla, 2014a)	**Case 2** (Mozilla, 2014c)	**Case 3** (Mozilla, 2014b)	**Case 4** (Herselman, & Botha, 2014; Botha, Salerno, Niemand, Ouma, & Makitla, 2014
Connectivity	Fully connected with no connectivity issues	Fully connected with no connectivity issues	Fully connected with no connectivity issues	Intermittent to no connectivity
Capacity	**Receivers** – Middle-school and high-school students **Issuers** – Providence After School Alliance educators and administrators **Utilisers** - Educators, potential employers and policy-makers	**Receivers** – Library staff **Issuers** – American Library Association and online communities **Utilisers** - Teenagers using library services	**Receivers** – Students in Sustainable Agriculture and Food Systems Major **Issuers** – Educators and administrators of SA&FS Major **Utilisers** - Faculty, peers and potential employers	**Receivers –** Teachers and educators in teacher development program **Issuers –** Initiative champions and experts in education **Utilisers –** Initiative schools and students
Content	Issues with planning the system design	Issues with user interface design related to mismatched system goals	Issues with user interface design	Could not implement and had to revert to physical badge system
Computers	Not specified	Web system, thus any ICT with web functionality	Not specified but hinted at an installable system	Initiative employed on Android tablet smart devices

Table 2.1 – Summary of Findings for Four Open Badges Initiatives

From the above summary, there were no connectivity issues for the first three cases because all the projects took place in ICT-accommodating environments. With the final case taking place in a resource-constrained environment, however, there was little to no internet connectivity.

There is a clear indication that most of these projects suffer from a lack of developer expertise when it comes to design and development considerations for interfaces, except the ICT4RED case, which was unable to be tested. This leads to the conclusion that developers and maintainers of an open badge system play a large role in the continued success of said system. There does not seem to be any pattern when it comes to classifying potential utilisers, however, apart from their use of badge receivers who have earned skills.

This section has identified that a connected environment is critical to the functionality of a Mozilla Open Badges system, and that a well-designed system interface is a high propriety for both issuers and receivers. The ICT4RED case study also identified potential issues when expecting non-ICT-proficient individuals to interact with a system such as the Mozilla online Backpack, which might be well designed for developed countries, but fails to accommodate users in resource-constrained environments.

Having reviewed three Mozilla Open Badges projects, and an initiative that could not implement Mozilla Open Badges due to the challenges of a resource-constrained environment, this section has shown that project developers/maintainers need to be regarded as elements within an open badge process. Since the term 'developers/maintainers' could be ambiguous outside of a development context, it would be more prudent to refer to these individuals as 'initiators', i.e. the initiators of badging initiatives, which covers a variety of project administrative roles.

The following section examines the Mozilla Open Badge standards framework to aid in understanding where the already identified elements fit in to the current framework.

2.5. Mozilla Open Badge Standards Framework

The Mozilla Open Standards aims to provide a framework for users to earn and track open badges, which act as a symbol of certification. These badges can be issued by organisations to validate a person's proficiency in a specific skill, and are stored in a user's central badge repository (Mozilla-OpenBadges, 2017). Figure 2.3, below, shows an example of the Mozilla Open Badges process.

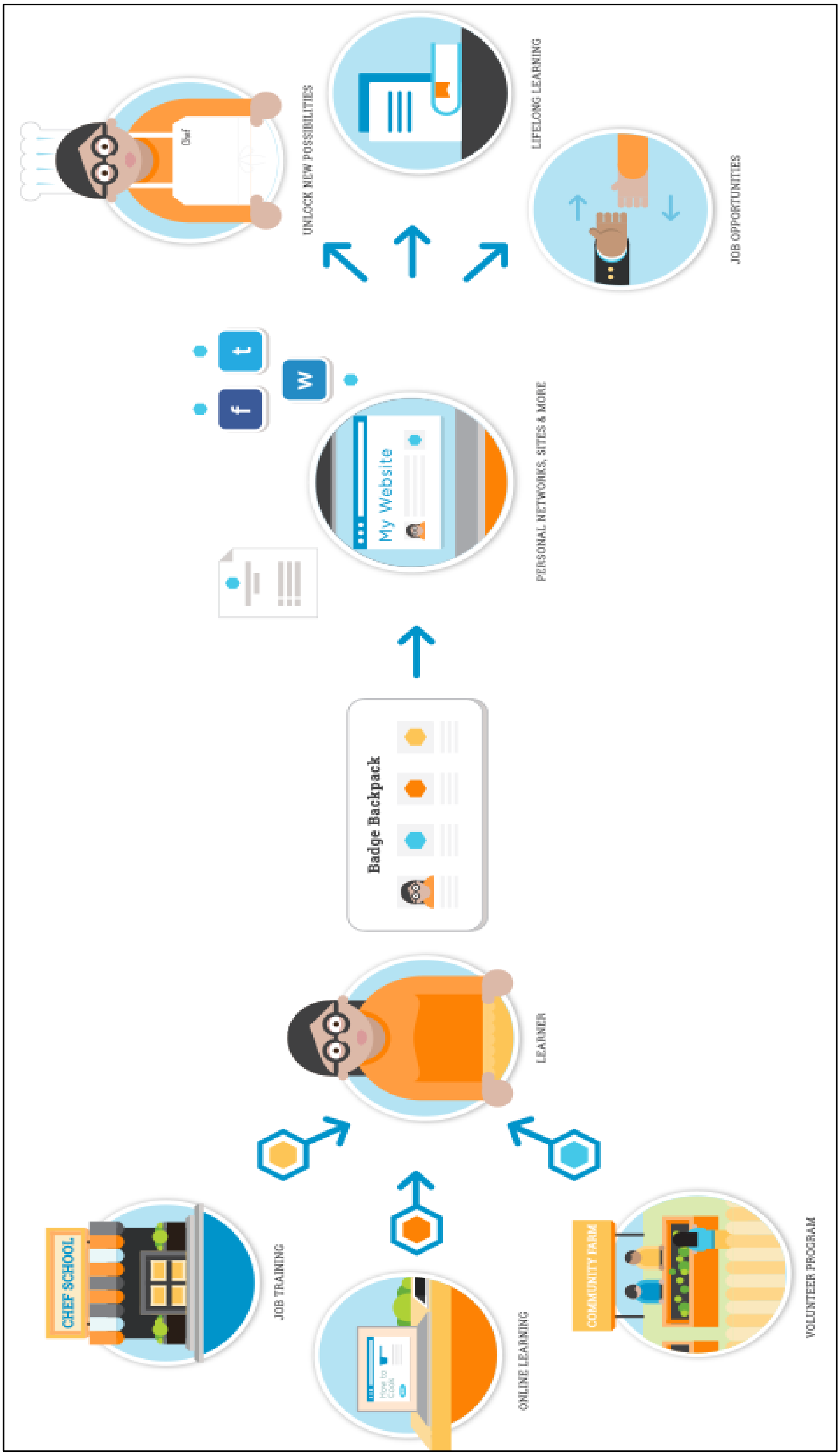


Figure 2.3 - Mozilla Open Badges Process (Mozilla-About-Wiki, 2017)

This section explores how open badges aims to gain acceptance as a form of accreditation through the use of metadata, and how issuing organisations are determined to be credible.

2.5.1. Must Implement Standard Metadata and Application Programming Interface (API)

Ostashewski and Reid (2015) argue that, for badges to be recognised as an alternative form of accreditation, the metadata has to enable the identification of 1) the issuer; 2) the standards achieved; and 3) the activities that prove competency of skill.

Mozilla ensures that there is a standard list of metadata contained within each badge, to ensure that anyone can create their own badges, which can then be issued and collected. Other organisations can view this metadata to ascertain the credibility of the issuing organisation, as well as the certification of skills awarded to an individual (Devedžić & Jovanović, 2015; Moore, 2013; Mozilla-OpenBadges, 2017; Niemand et al., 2015). Achievement can thus be proven by a link to relevant evidence, which states that the user has adequately completed the badge requirements. Jovanovic and Devedzic (2014) scrutinise how open badges, in its current development and testing stage, should not be considered a replacement for traditional certification, but rather as a form of augmentation, allowing employers the ability to quickly and effortlessly verify evidence of individual skills acquired during the progress of a traditional course.

As the metadata is specific to an individual, Mozilla maintains that open badges cannot be stolen, forged or duplicated (Mozilla-OpenBadges, 2017). The metadata standard employed by Mozilla-OpenBadges (2017) can be seen in Figure 2.4, below:

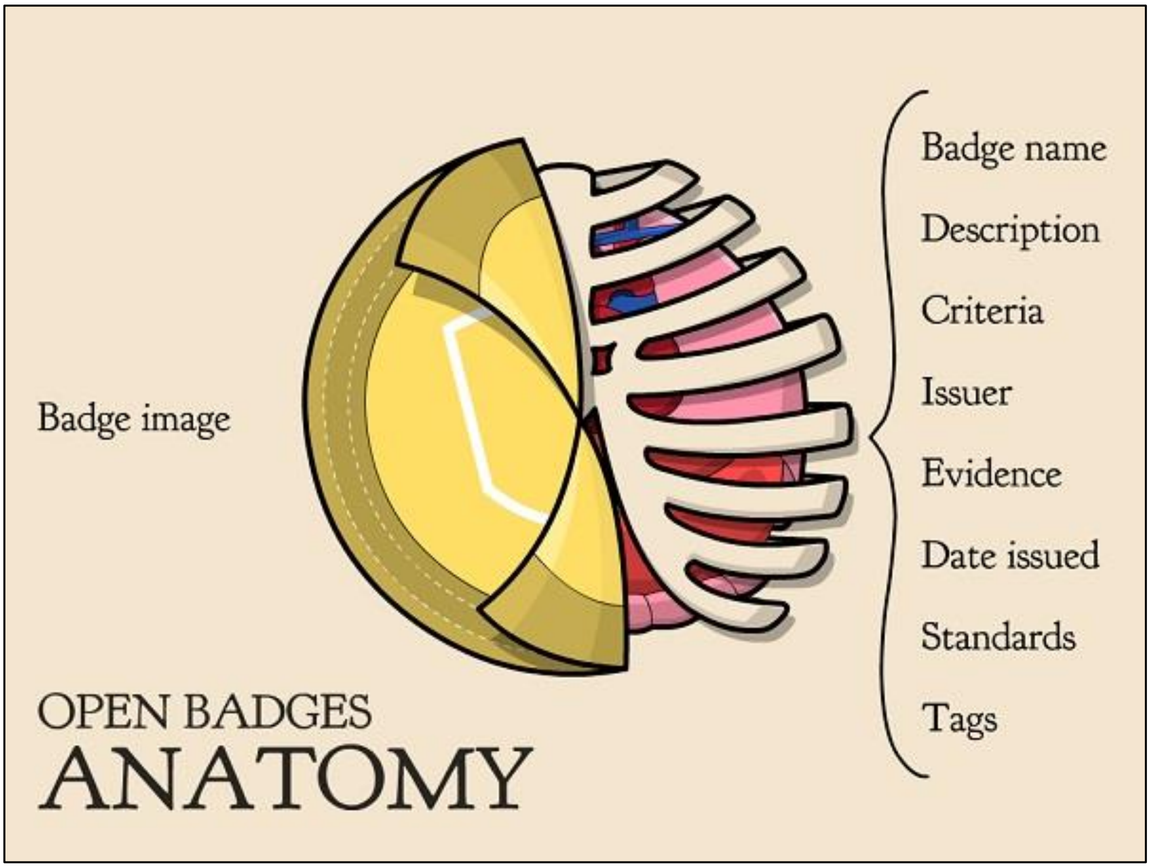


Figure 2.4 – Mozilla Open Badge Anatomy (Mozilla-Wiki, 2014)

- Badge Name – A unique name used to identify a badge.
- Description – A basic description of the skills the badge represents.
- Criteria – The required criteria that must be fulfilled to acquire the badge.
- Issuer – The identification of the issuer.
- Evidence – An image or document attached to the badge to show that the criteria have been achieved.
- Date issued – The date on which the badge was issued.
- Standards – Additional standards that the badge carries.
- Tags – Keywords used to identify and later search for the badge.

The model produced by this thesis, enabling open badges to be implemented in resource-constrained environments, requires the use of metadata in a homogeneous manner (not removing any information, but possibly adding more metadata fields if necessary). This would allow the preservation of the current standard of the Mozilla

Open Badges framework, while enabling the tracking of information required to circumnavigate challenges presented by a constrained environment. This would ensure that the badges produced by an application that implemented this research's artefact would maintain the credibility already associated to the current Mozilla Open Badges system.

In order for issuers to design and issue badges, they must implement an API script and make use of a Mozilla Baking Service, in which URL strings representing JSON (JavaScript Object Notation) are embedded into PNG files (Mozilla-OnboardingIssuer, 2017). The current Mozilla Open Badges Infrastructure is shown if Figure 2.5.

Implementing an API, and utilising the Mozilla Baking Service, requires application and software developers who possess the required skills to correctly program and integrate these modules into new or existing systems. In section 3.4.2, Heeks (2008), and Tongia and Subrahmanian (2006), stress the need to involve developers, service providers and funders as stakeholders, which influences the success of an ICT4D initiative. The figure below illustrates the need for initiators of ICT4D initiatives to have a certain level of technical expertise. The API and Mozilla Baking Service is freely supplied by Mozilla, allowing anyone to create their own badges, provided they can implement the system. The Mozilla Open Badge standards framework allows anyone to freely issue badges, which is discussed in the following section.

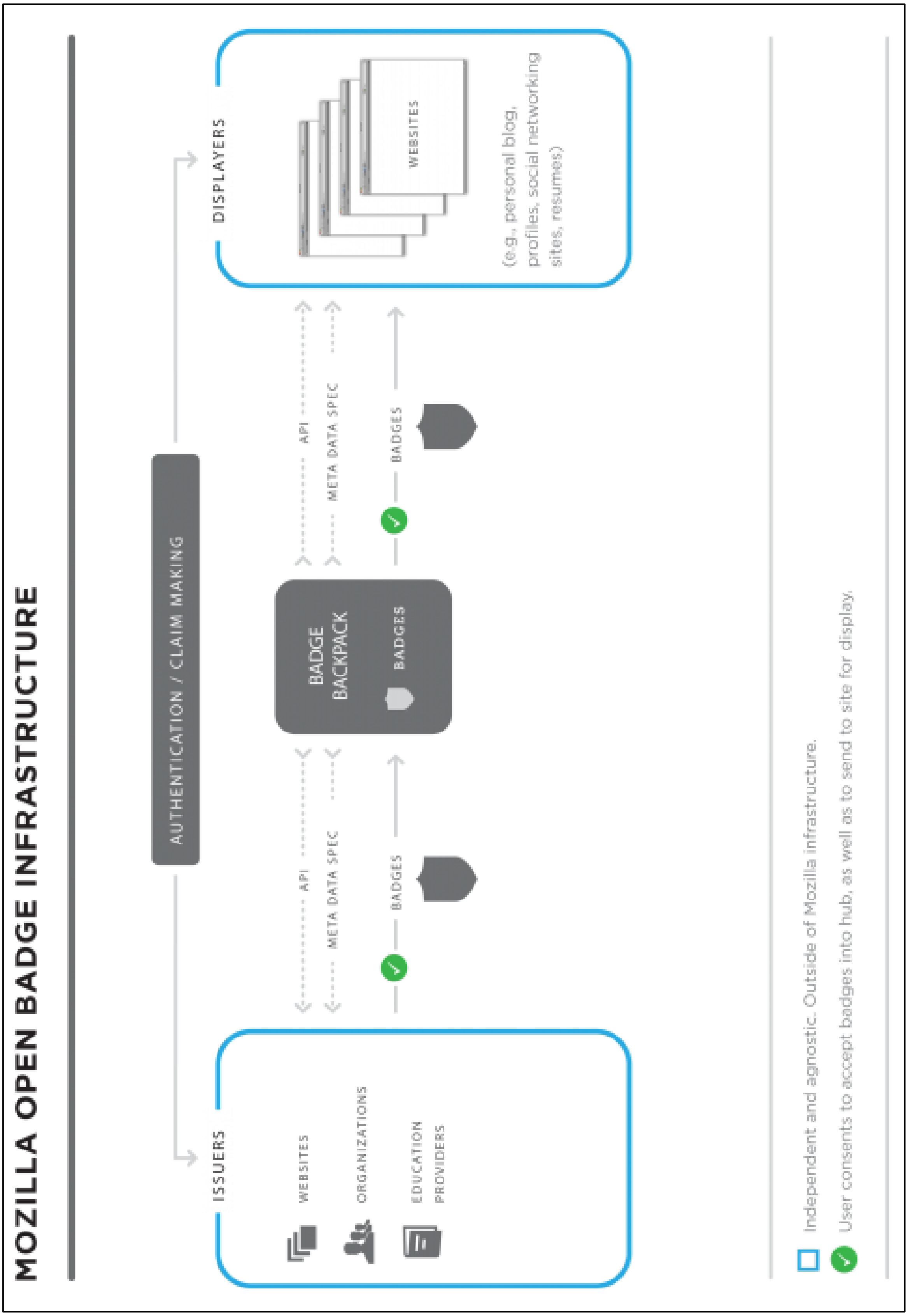


Figure 2.5 – Mozilla Open Badge Infrastructure (Mozilla-OnboardingIssuer, 2017)

2.5.2. Anyone Can Issue and Receive Badges

The idea of how an easily retrievable, universal form of accepted certification is not only an appealing prospect, but also has the potential to help employers and educational institutes painlessly identify and verify a prospective applicant's skillset (Devedžić & Jovanović, 2015; Mourshed et al., 2012; Pearson, 2013).

Goligoski (2012) echoes the above point, adding that, with rising education costs, Mozilla Open Badges could be the most accessible way for individuals to promote themselves, if only it gains widespread recognition. A problem arises, however, with the verification of the credibility of the issuer of the badges, because any user with the ability to program their own website could potentially issue a badge (Goligoski, 2012; Jovanovic & Devedzic, 2014).

The onus falls on the community to police each other's badges to ensure that the system as a whole remains respectable. Sullivan (2013) proposes that issuers might be required to be certified before they are authorised to distribute badges. Checking the credibility of a badge issuer cannot be addressed within this study, however, due to the scale and multidisciplinary proficiencies required for such an endeavour. This research acknowledges that such an issue will continue to exist in the final model, but proposes that issuing powers are limited and controlled during an initiative's lifecycle until a better solution is found. Thus, there exists an opportunity for future research to perhaps implement an existing acceptance process, or to develop a new standardised test to ensure issuer accreditation and integrate it with the Mozilla Open Badge standards framework or this research's final IT artefact.

Once badges have been issued, regardless of organisation, they are received by an individual and collected in a single repository. This is explored in the following sub-section.

2.5.3. Badges are Collected in a Central Repository

As mentioned at the end of the section 2.3, one of the requirements of using the Mozilla Open Badge standards framework is that users must have the ability to collect badges from a variety of sources, adding them to a central badge repository referred to by Mozilla as a 'Backpack' (Moore, 2013; Mozilla-OpenBadges, 2017).

Badge receiving users are only required to sign up for a Mozilla Backpack using a personal email address, after which they will be able to receive, view and share their badges online (Mozilla-OpenBadges, 2017). With regards to fostering a mindset of lifelong learning, Cucchiara, Giglio, Persico, and Raffaghelli (2014) stress the importance for individuals to be able to regulate and determine their own learning paths. Põldoja and Laanpere (2014), in an exploratory study, note that students most appreciate the ability to share badges they have collected, and the ability to choose their path of learning from a variety of sources.

Addressing some critics who express concerns that badges offering micro-credentials might atomise and decontextualise learning, and create problems for students who attempt to link topics and create new knowledge (Sullivan, 2013), Jovanovic and Devedzic (2014) argue that the ability to design different levels of badges within the Mozilla Open Badge standards framework helps focus learners on pursuing a self-guided but coherent learning path.

Learners can opt to earn a selection of lower level badges to unlock a higher-level badge and, thanks to a central repository, it is possible to start learning a meta-skill at one institution and finish it at another. This would be achievable by completing a micro-skill accreditation at one institution, and then continuing at another institution with the next tier level of that skill, until a meta-badge is completed. To assist in this process, Mozilla has recently introduced a working prototype system, called Mozilla Discover, to help guide learners in discovering related skills based on previously earned badges or a pre-selected career path (Mozilla-Discover, 2017).

Regarding this research's objectives, the final model was created considering the use of multi-level badges in the badge collection repository. While this is not explicitly discussed in Chapter 6, which details the conceptual model, it is argued in Chapter 8, which presents the final model. To maintain the goals of the Mozilla Open Badge standards framework, it was important to ensure the final model allows the collection of a variety of low-level, micro-skill badges from a variety of issuers, but which still form a meta-skill badge.

In summary, the Mozilla Open Badge standards framework implements the following components:

1. The badges must contain a standard API and metadata structure, which is freely provided by Mozilla.
2. Anyone can issue and receive badges.
3. An individual's badges are collected in a central repository.

In section 2.1 of this chapter, it was mentioned that a central badge repository, and the addition of badge metadata to ensure certifiability, were the only additions to the standard elements of a normal physical/digital badge (an issuer, a receiver, a utiliser and the badge itself). In section 2.3, it was shown how there is a need to include initiators of badge programmes as elements that help maintain and develop a system, to ensure its functionality. This section has reinforced these findings. On a technical level, however, it has also shown how various deliberations must be made to implement these elements effectively. Deliberations such as the following:

1.) Securely authenticating badges with the standard API using JSON objects that Mozilla provides
2.) The ability for anyone to create badges, which could lead to a variety of coordination issues for both badge utilisers and initiators alike
3.) Badge sizing and 'stackability' to allow the formation of meta-skill badges

These deliberations were considered when researching the techniques and technologies (see Chapter 4) for addressing the challenges identified in the next chapter on resource-constrained environments. Additionally, during the examination of the conceptual model (Chapter 6), not all the technical deliberations were analysed, because it was felt that the elements could have changed, and then the discussion would be redundant. Instead, these technical considerations are discussed in Chapter 8, which explores the final model after the expert reviews have been considered.

This chapter now concludes with a brief chapter summary, which also outlines some reflections.

2.6. Summary

Addressing the first sub-research question, this chapter investigated the elements that open badges required to function under the Open Badge standards framework.

The first section, after the introduction to this chapter, explored the background of badges. This not only provided an overview on the history and design of badges, but also helped highlight the basic elements of a badge process, and how it has been modified by the introduction of Mozilla Open Badges.

Before continuing with the examination of open badges, this research presented a case for its use, and how it could be beneficial within an educational context to implement modularised accreditation in the form of skill certification. This helped emphasise the need for research in this field, and presented an argument for the pursuit of a model to implement open badges in a resource-constrained environment.

Once the need for such a model was presented, this chapter then focused on examining four case studies, offering general observations and highlighting how various badge elements were implemented within a 4C framework (content, capacity, connectivity and computers). This helped reinforce the validity of already identified elements, and assisted in identifying a missing element that could be considered critical for the continued functionality of a digital badging process.

Finally, this chapter concluded with an examination of the Mozilla Open Badge standards framework and a technical overview of what is needed to implement the identified elements. The elements of open badges identified in this chapter are shown in Table 2.2 below:

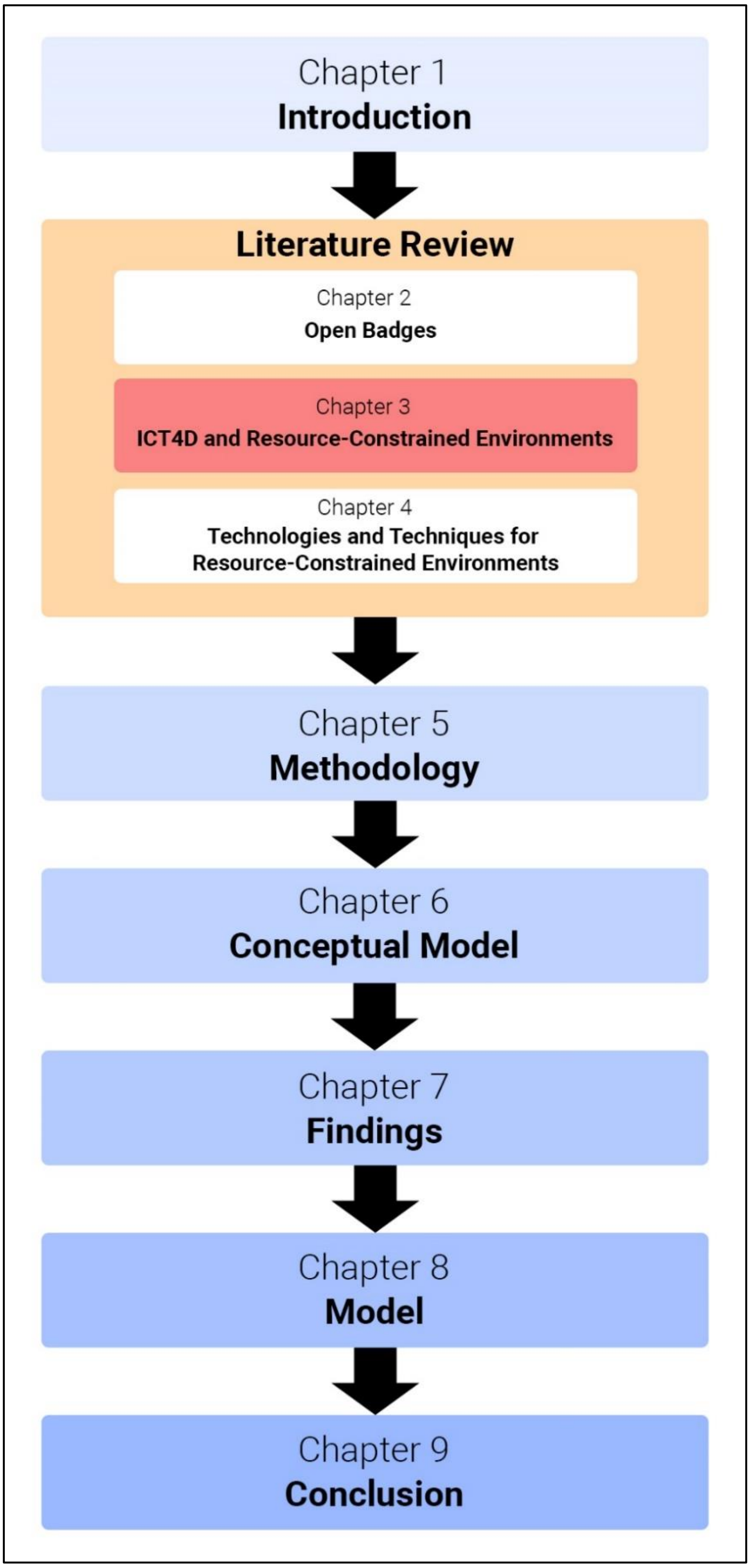
Element	Description	Author
Badge	A symbol of certification for achieving competency in a skill. A Mozilla Open Badges differs from a standard digital badge in that it contains evidence of the achievement within the metadata used to construct the open badge.	(Devedžić & Jovanović, 2015; Gibson et al., 2013; Moore, 2013; Mozilla-OpenBadges, 2017; Ostashewski & Reid, 2015)
Issuer	The individual/organisation who creates and issues the badges to receivers. Issuers are not regulated, and it is up to the utilisers to ensure the credibility and authority of the issuer.	(Botha et al., 2014; Mourshed et al., 2012; Mozilla-OpenBadges, 2017; Sullivan, 2013)
Receiver	The individual who receives the badge from the issuer. The receiver must show the necessary competency in a skill to receive the relevant badge. The receiver decides which badges to pursue and is subject to a variety of influences and motivations when working towards such badges. The badge receiver is generally the targeted participant for badging or educational initiatives.	(Botha et al., 2014; Deterding et al., 2011; Goligoski, 2012; Mourshed et al., 2012; Mozilla-OpenBadges, 2017)
Utiliser	Utilisers can be any and all external stakeholders not involved in the immediate badging process, but who rather make use of the badges earned by receivers. Utilisers could therefore be social media outlets/web sites who gain something by displaying badges, or organisations that seek to employ badge receivers.	(ALL4ED, 2013; Botha et al., 2014; Carnevale et al., 2013; Madda, 2015; Mehta et al., 2013; Mozilla-OpenBadges, 2017)
Initiator	Consisting of all administrational, developmental and maintaining individuals concerned with managing and running a badge processing initiative. Initiators can be initiative stakeholders who do not participate in a badge processing initiative, but rather develop the required systems, formulate the administrational rules, and maintain said system.	(Botha et al., 2014; Mozilla, 2014a, 2014b, 2014c)
Badge Backpack	A centralised repository that stores an individual's badges, which can be collected from a variety of different sources.	(Moore, 2013; Mozilla-OpenBadges, 2017; Mozilla, 2017)

Table 2.2 – Summary of Identified Elements of Open Badges Critical to their Functionality within the Mozilla Open Badge Standards Framework

Due to the online and technical requirements of the current Mozilla Open Badges system, limitations and issues arise when it is used in resource-constrained environments, as mentioned in section 2.4.4, when the ICT4RED's TPD project was analysed. The following chapter explores the challenges encountered by ICT4D initiatives, and discusses how these challenges inhibit the functionality of open badges within resource-constrained environments.

Chapter 3

ICT4D and Resource-Constrained Environments



3.1. Introduction

The previous chapter examined the elements concerned with the Mozilla Open Badge standards framework. Now that these elements have been identified, this chapter considers the challenges encountered in resource-constrained environments, which inhibit direct implementation of the mentioned framework. This is the second chapter of the literature review, and addresses the second sub-research question.

> **Sub-Research Question 2 (SRQ2):**
>
> *How do resource-constrained environments impact the functionality of ICT4D with regards to the context of connectivity, content, capacity and computers?*

To address this question, it is necessary to first define the meaning of the term 'resource-constrained environments'. This requires examining the need for ICT4D in general, to accentuate traits common across ICT4D initiatives. Once this is done, this chapter delineates the scope of ICT4D initiatives' areas of innovation, which might be affected by resource-constrained environments utilising the 4C framework (presented first in Chapter 1, section, 1.1). Only then can the impact of resource-constrained environments on ICT4D be investigated.

This chapter is concerned with the following topics:

- Defining the characteristics of resource-constrained environments for this study
- Examining the background of ICT for development, and possible areas of failure
- Examining ICT4D development frameworks, and explaining why the 4C framework was found to be the most suitable to help examine the general challenges that effect ICT4D initiatives
- Determining the general challenges of resource-constrained environments on ICT4D, with regards to the 4C framework

It is important to understand the difference between rural environments and resource-constrained environments. The next section of this chapter defines resource-constrained environments by examining the contrasts between them and rural environments.

3.2. Defining the Characteristics of Resource-Constrained Environments

Information communication technology has been hailed as an unprecedented device to help bring about equality and foster development in a variety of fields and contexts (Fong, 2009; Heeks, 2008; Ohemeng & Ofosu-Adarkwa, 2014).

Given the above statement, it would make sense that ICT is in high demand within developing countries that are trying to alleviate problems and lessen the effects of inequality. Unfortunately, ICTs are often developed for ideal situations, which produces issues when directly implementing ICT within developing countries (Ohemeng & Ofosu-Adarkwa, 2014).

Fong (2009) observes how developing countries attempting to adopt ICTs, to help alleviate poverty and increase economic competitiveness, trail behind developed countries due to pre-existing development challenges, such as lack of infrastructure and undeveloped human capabilities. Gillwald (2016) states that, within 11 Sub-Saharan African countries, excluding South Africa, only 16% of the population has ever used the internet. Similarly, an National-Planning-Commission (2011) report states that only 17% of South Africans had reliable access to the internet in 2012. Factoring in Firdhous, Ghazali, and Hassan (2013) statement that, in 2013, roughly 50% of the world's population lived in rural environments, and that in developing countries such as South Africa, 70% of the country's population was situated in a rural environment, it can be seen that internet connectivity is far from guaranteed for many people.

It is important to note, however, that this does not apply in all rural cases. While it may generally be the case in developing countries, 'rural environments' could also refer to developed communities situated in a non-densely populated area (Gardiner, 2008). It is important to define 'rural environments' to help resolve any ambiguity between references to rural environments and references to resource-constrained environments, especially in a South African context.

Jacobs and Hart (2012) define rural environments as areas containing their own culture and social practices, in addition to their non-urban environment. In the South African context, this definition is further broadened to include commercial farming areas and former homelands or traditional authority areas (Gardiner, 2008; Jacobs & Hart, 2012). Yunusa (1983) states that rural areas are sparsely populated areas that are not ‘economically integrated’, meaning there is much wasted and unproductive space between homesteads. South African history is filled with acts that have left large communities socially and economically divided due to the reallocation of land and resources to selected peoples. This creates difficulty when attempting to apply standard rural environment definitions to all South Africa’s various provinces, which often contain a multitude of different ethnic groups. As such, rural areas in South Africa cannot simply be defined by contrasting them with urban areas, and it is important to remember that some rural areas might have the capacity to support ICT (Gardiner, 2008).

The term ‘resource constrained’ generally implies a finite amount of resources, or that a required resource is limited. When examining resource-constrained environments in the context of ICT, such resources involve what is required for ICT to not only function, but to achieve its intended purpose without additional problems. R. E. Anderson et al. (2012) define resource-constrained environments as areas that have a lack of infrastructure development, technical limitations, and social constraints that provide unique development challenges for ICT projects. Similarly, Lewis et al. (2013) define resource-constrained environments as areas characterised by limited resources, a dynamic environment with high internet stress, and general poor connectivity. The agreed consensus for defining a resource-constrained environment is thus a lack of infrastructure, technical limitations and socioeconomic differences in communities, which all play a role in complicating the diffusion of ICT.

Resource-constrained environments can be regarded as a contributing factor to the digital divide experienced by developing countries. The Organisation for Economic Co-ordination and Development (OECD (2001) define the digital divide as the gap that individuals and communities from different socioeconomic levels and areas experience when attempting to access and use ICT. Due to lacking the technological- and social services offered by using ICT, and the increasing digitisation of our world, resource-constrained communities in developing countries are considered the most vulnerable population groups globally (Firdhous et al., 2013)

Utilising the above definition of R. E. Anderson et al. (2012) as a basis, and incorporating the points made by Firdhous et al. (2013), Gardiner (2008), and (Lewis et al., 2013), this research defines the characteristics of resource-constrained environments as follows:

> *Resource-constrained environments are areas that, regardless of urban or rural setting, inhibit the full functionality and usage of ICT devices or services due to environmental factors, such as low levels of infrastructure development or maintenance; technical limitations, such as the lack of a steady electricity supply or affordable and reliable internet connection; and socioeconomic factors relating to the low levels of welfare and education of the inhabitants of the area.*

In summary, this section has examined the characteristics of resource-constrained environments, contrasted them with those of rural environments, and formed the definition of resource-constrained environments used throughout this thesis. The next section discusses a brief history of ICT4D, and how it arose to address this digital divide. This helps identify possible problems that could lead to an ICT4D initiative's failure.

3.3. Background of Information Communication Technology for Development

Heeks (2008) states that the interest and study in the field of ICT4D arose from two events that occurred in the 1990s: the popularisation of the internet and the conception of the Millennium Development Goals.

First, regarding the popularisation of the internet, Norris (2001) examines how it heralded what many believe to be the 'information age'. This involved revolutions and innovations to peoples' personal lifestyles in the form of new methods for communicating and digesting public affairs. The information age has also seen a new divide form between developed- and developing nations. This digital divide formed as a result of the fact that developed nations generally have widespread access to the internet and ICTs, while developing nations do not (Heeks, 2008; Norris, 2001; Selwyn, 2004). Heeks (2008) states that this digital divide will grow larger if not addressed, because ICTs are gaining more traction and influence in social, economic and political affairs.

The Millennium Development Goals centred around reducing poverty, improving health and lessening gaps in gender inequality worldwide. Given that an avoidance of ICTs would lead to a digital divide forming, and that ICTs were seen as possible tools and delivery mechanisms to help achieve the Millennium Development Goals in a shorter time span, ICT4D was conceptualised (Heeks, 2008).

Relying on then emerging research, governments and private organisations turned to ICT devices and systems in the hope of transforming developing countries into knowledgeable and socially connected societies (Selwyn, 2004).

Selwyn (2004) discusses how the digital divide was often oversimplified during its emergence, and generally seen as a binary issue, in which individuals either did, or did not, have access to ICT devices. Those that had access would inevitably receive the perceived benefits associated with ICT, and those that did not were thought of as information deprived. Selwyn (2004) stresses that such thinking is flawed, because there is a difference between access to ICT and effective usage of ICT. Individuals have to be knowledgeable and confident in their ability to exert control over ICTs in order for them to use them effectively, with meaning and significance (Selwyn, 2004).

Engagement and willingness to adopt and learn ICTs are not limited to physical and psychological factors, but also influenced by social, economic and often pragmatic reasons (Selwyn, 2004). Taking into account the previous statement, Tongia (2005) states that the digital divide is most evident on four levels:

- **Awareness** - An individual's knowledge about the potential and limits of ICT usage. This influences an individual's attitude towards ICT. When an individual has knowledge about what can be accomplished using ICT, it could aid in the technological diffusion and willingness for uptake. Similarly, knowing the limits of ICTs could diminish possible frustration regarding failed expectations.
- **Availability** - The ability to acquire useful ICT within an individual's environment. Thus, ICT must be made available within reasonable proximity of the individual's

environment, and the ICT must contain appropriate hardware/software to accomplish the individual's goals.

- **Accessibility** - An individual's ability to use ICT. There are various factors that influence this, such as the interface design, and the individual's ICT confidence and literacy levels.
- **Affordability** - ICT usage costs must not be unreasonable or burdensome to an individual. This includes hardware and software costs, as well as the operational costs, such as electricity and connectivity.

These ICT adoption factors help confirm the definition of resource-constrained environments presented in the previous section. Apart from the physical challenges of resource-constrained environments, ICT4D initiatives must also account for the personal and social challenges of the individuals who inhabit these environments.

Heeks (2002) examined some successes and failures of early ICT4D initiatives, determining that failures were often the result of 'gaps' in design vs reality, brought about by country context, rational design vs political realities, or public sector vs private sector.

- A common design vs reality gap can form when a design is envisioned in a particular way, but could not be implemented due to realistic parameters or challenges. For example, a project requires a certain number of qualified staff and funding, but there was a shortage of either, and thus development could not be completed in a timely manner.
- Country context gaps occur when development practices from one country are applied to another, particularly between developed and developing countries. One example (Heeks, 2002) provides is of a failed project in which a system was designed to be maintained by skilled programmers, operated in an environment with a well-developed infrastructure, and constantly supplied with high-quality data. Instead, the system was deployed where none of these requirements could be met, and thus could not function.
- Rational design vs political realities can be observed when initiatives move from conceptual stages to implementation stages. A logical decision enforced a design choice, but the political reality differed, meaning the goal for the design was not

realised. An example of this is how an ICT initiative distributes ICT devices as an enabling mechanism, but instead, participants attach a social value to the ICT device, perceiving it as either a status symbol or a tool of oppression.

- Public vs private gaps occur when systems developed for private organisations are implemented by public organisations without the necessary changes. Heeks (2002) observed that the public sector played a larger role in developing countries, resulting in the need to transfer some technologies and systems developed for private organisations to government organisations. Unfortunately, there exist fundamentally different design philosophies and goals between the two, which often lead to an ill fit when transferring a system.

Taking into account the design gaps outlined above, along with the challenges of adopting ICT presented by Selwyn (2004) and Tongia (2005), it is clear there is considerably difficulty in designing and administrating a successful ICT4D initiative. Tongia and Subrahmanian (2006) further state that, for ICT4D to be successful in addressing the digital divide, this divide must be addressed across all dimensions of ICT development. To aid with this development process, Tongia (2005) proposed a 4C ICT framework, which is examined in the next section.

This section has examined the background of ICT4D, establishing its relationship with its attempts to address the digital divide. It has been shown that there are various challenges when developing ICT4D, and many possible areas for failure exist.

Before reviewing the 4C framework, the next section first examines the inception of ICT4D2.0 to help establish a need for a development framework. The 4C framework is then analysed and compared with similar frameworks to help understand why it was considered the best fit for creating a research context. Once this is achieved, the 4C framework is used to identify challenges of resource-constrained environments within their relevant area of development.

3.4. Designing for, and Addressing Challenges of, Resource-Constrained Environments

As alluded to in the previous section, when examining the failures of ICT4D initiatives, there is a clear indicator that the defining characteristics of resource-constrained environments are at odds with ICT design employed in developed countries. Before examining the 4C framework presented by Tongia (2005), this section first examines ICT4D2.0 and the need for development frameworks.

Examining past failures, Heeks (2008) points out that new watchwords and areas of interest to ICT4D initiatives developed in the following areas:

- **Sustainability** – Many ICT4D initiatives failed due to being short lived and unmaintainable. This led to the examination of sustainable techniques and processes that could be implemented in the design of future ICT4D initiatives.
- **Scalability** – As traditional technologies were not mobile, and had a fixed ranged, issues arose concerning the expansion of ICT4D initiatives. More scalable solutions were needed that could grow as a community grows.
- **Evaluation** – Critical evaluation is always crucial in the development of new technologies and systems. Identifying key aspects that led to success or failure helps initiatives prepare for, and overcome, common challenges.

As these areas gained research and support, ICT4D initiatives changed their priorities, processes and purposes (Heeks, 2008). While admitting that there is no strict dividing line between past and current definitions of ICT4D, Heeks (2008) attributes the above mentioned insights as the starting point for ICT4D2.0.

ICT4D2.0 initiatives are more mobile in nature, and aimed at not only addressing the digital divide by educating and inspiring non-ICT-confident users, but to produce ICT4D champions who can lead others from within their communities. ICT4D2.0 is centred around designs incorporating the targets area’s resource capabilities and demands (Heeks, 2008). Tongia (2005) states that the only way to address all levels of the digital divide (awareness, availability, accessibility and affordability) is by designing for it within each of the dimensions of ICT development.

The 4C Framework for ICT development, as briefly detailed in section 1.1 of the introduction chapter of this thesis, was proposed by Tongia (2005), and comprises connectivity, capacity, content and computers.

- **Connectivity** – In addition to pertaining to the physical infrastructure in an area required to ensure a connected environment, the connectivity area is also concerned with cost and availability of internet connectivity. This includes analysing network infrastructures and the technical limitations of an area. This area can heavily influence the affordability, accessibility and availability of ICT services.
- **Capacity** - Characteristics of users in relation to ICT operation. This area examines the human capacity of individuals regarding utilising ICT devices. The characteristics of individuals who might influence ICT usage are generally related to unique cultural understandings, literacy of languages and ICT confidence levels.
- **Content** - For individuals to properly make use of ICT, they must feel that they are accessing meaningful content. Apart from the content and information contained within an application, the usefulness of content is dependent on how well an individual can access and understand it.
- **Computers** - The computing dimension analyses the suitability of ICT devices. There are various factors that could influence an ICT4D initiative to employ a type of ICT device, but they are generally related to the sustainability and scalability aspects of an initiative.

Tarasewich (2003) proposes a similar but simpler framework for developing ICT4D applications, where the only major difference from Tongia (2005) 4C framework is that the ICT device itself is not brought into deliberation because it is strictly aimed at mobile ICT development. While examining Tarasewich (2003) framework (see below), this research compares it with the 4C framework of Tongia (2005), found above. Tarasewich (2003) proposes the following areas of thought for ICT4D development:

- **Environment** - This includes the physical location, properties of the location and the ICT resources available in the area. This element is similar to that of Tongia (2005) connectivity element. Both present a case for the physical environment's effect on ICT devices, which relates to infrastructure development, internet connectivity and electricity availability.

- **Participants** – The capacity of communities in resource-constrained environments focuses on the personal characteristics of participants, such as age, gender, level of education, physical and mental health and overall expectations. Tarasewich (2003) participant element shares similarities with Tongia (2005) capacity element; both elements are related to the inhabitants of the area and their socioeconomic circumstances.
- **Activities** - The tasks and goals of the participants regarding ICT usage. Activities can also include events of the environment or community that influence ICT usage. Tarasewich (2003) activities element is not as detailed as Tongia (2005) content element. While both are concerned with the activities individuals will use ICT for, Tongia (2005) examines the user experience of individuals while attempting these activities also. This research believes Tongia (2005) is correct in the assessment that a good user experience is essential for ensuring sustainable usage of ICT. Therefore, Tarasewich (2003) activities element is not detailed enough for the purposes of this study when considering the points Heeks (2008) made about ICT4D 2.0 earlier in this section.

Another framework to consider is that proposed by Fanta, Pretorius, and Erasmus (2015), which, while more focused on the area of e-Health development, covers similar elements to Tarasewich (2003) and Tongia (2005). When analysing the sustainability of e-Health systems in resource-constrained environments, Fanta et al. (2015) make use of the following four development and deployment factors that influence ICT4D success:

- **Environmental Factors** - These factors are concerned with the environment's readiness to support an ICT system's functionality. This includes technical aspects, such as infrastructure and connectivity, but also legal and political aspects, hence the support of government and organisations. This could be done by providing access to training, and availability of content. Though similar to Tongia (2005) connectivity element, and Tarasewich (2003) environment element, Fanta et al. (2015)'s environmental factors include elements that might not be germane to the development of an ICT4D solution, but rather organisational and governmental issues that must be addressed. This research's objective of producing a model to implement open badges in resource-constrained environments focuses on an ICT4D initiative level, and it is beyond the scope of this research to address factors that influence economic practices related to ICT. This could lead to a future avenue of research, potentially focusing on implementing open badges in an economically sustainable manner.

- **Social Factors** - These include an individual's ethical, social and cultural aspects. These are focused on understanding and properly addressing the needs of the stakeholders of the initiative. This element shares similarities to Tarasewich (2003) participants element, and Tongia (2005) capacity element, because they are all concerned with the socioeconomic circumstances of individuals using ICT.
- **Economic Factors** - Factors concerned with the operation costs of ICT, such as initial hardware and software costs, connectivity tariffs and return on investment. While unique to Fanta et al. (2015) framework, it could be argued that Tongia (2005) computers element does allude to the affordability, sustainability and scalability of ICT devices. Fanta et al. (2015) framework is, however, more focused on the long-term economic impact of ICT in a health setting, i.e. hospitals and clinics where individuals do not personally own ICT devices.
- **Technological Factors** - These are related to the satisfaction of an individual's needs when using the system. These factors are concerned with user experience, and the reliability of hardware and software. The technological factor of Fanta et al. (2015) framework is only similar to Tongia (2005) 4C model regarding the inclusion of user experience as an important aspect of development. Otherwise, this element incorporates more than one of Tongia (2005) elements, and is therefore too broad in scope.

Having examined and compared Tongia (2005) 4C development framework with that of Fanta et al. (2015) and Tarasewich (2003), it is clear that Tongia (2005) has the most suitable framework. The exclusion of computers in Tarasewich (2003) framework limits any model produced by this research to being exclusively implemented on mobile ICT without arguing the potential disadvantages of such a decision. Additionally, Tarasewich

(2003) framework dismisses aspects of sustainability and scalability in the analysis of content, which were underlined by Heeks (2008) as important areas for successful ICT4D development. While Fanta et al. (2015) framework bears a close resemblance to the 4C framework, there is a high emphasis on developing ICT in a health setting. Therefore, the framework is too focused to be utilised within the broader context required.

Now that the 4C framework has been shown to be the most suitable for this research, the remainder of this section examines general challenges encountered in resource-constrained environments regarding connectivity, capacity, content and computers.

3.4.1 Connectivity

Lewis et al. (2013) detail the following general issues, found in resource-constrained environments, regarding the transmission of data and connection to the internet: 1) occasional to frequent loss of signal; 2) limited or no presence/access to traditional wired connectivity infrastructure; 3) the environment is unpredictable and unsuitable for stable network expansion; 4) resource challenges such as a non-stable electricity supply and limited access to ICT devices; 5) periods of high stress and load can tax the transmission medium.

Straumann (2015) investigated data released by the World Bank and detailed it in Figure 3.1, below.

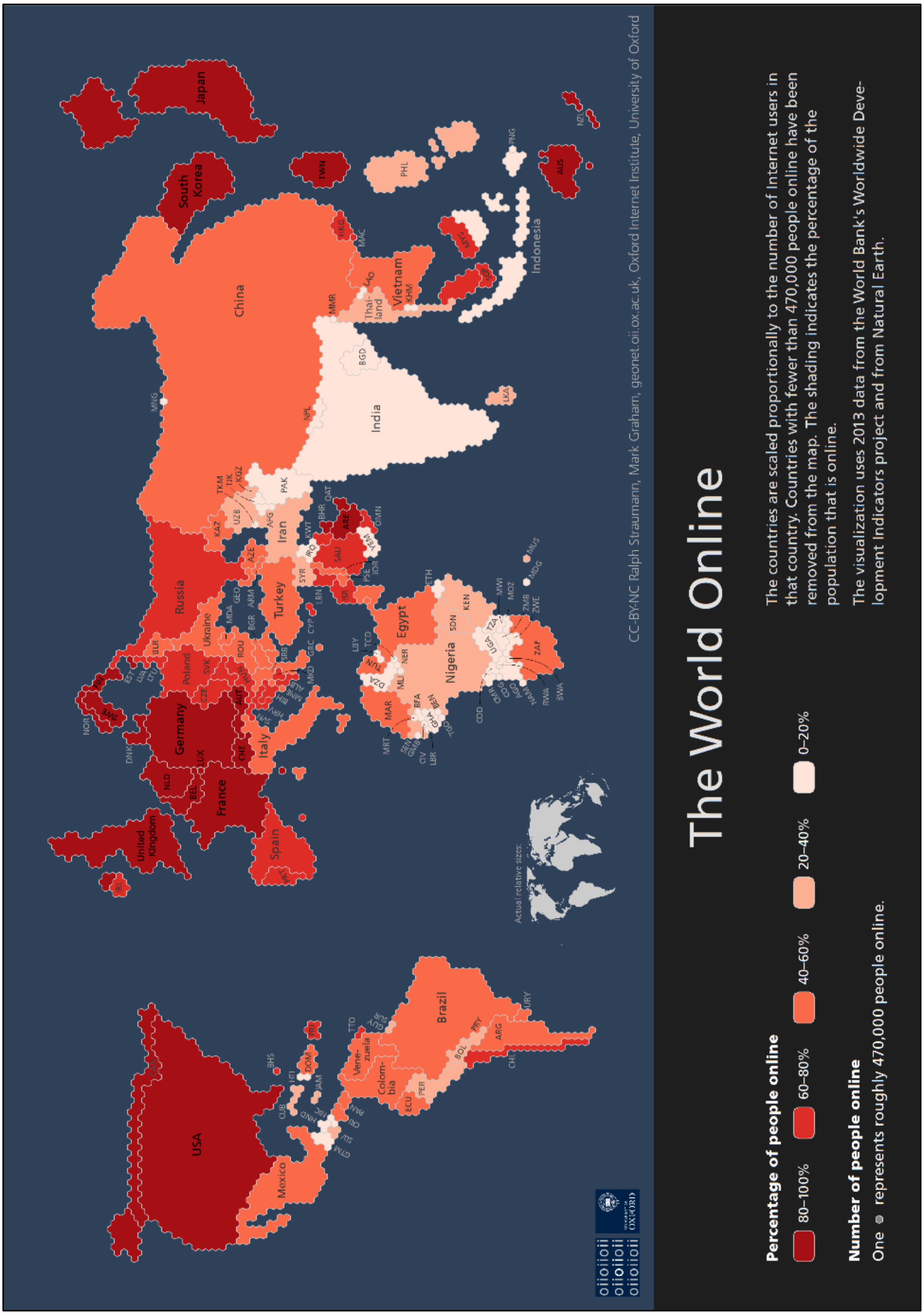


Figure 3.1 - The World Online (Straumann, 2015)

Straumann (2015) notes that although there is evidence that suggests there is a rise in the total number of internet users throughout the world, especially in rapidly developing countries within Asia, there is still a large gap between internet users in developed countries compared with those in developing countries.

Some countries with resource-constrained environments within Sub-Saharan Africa showed nearly no growth between 2011 and 2015, and remain at less than 10% of the population having access to the internet (Straumann, 2015).

In 2009, South Africa had one of the highest international bandwidth prices in the world, which was only lowered due to international development, concerning the installation of undersea cables (Gillwald, Moyo, & Stork, 2012). While South Africa did show a growth larger than most Sub-Saharan African countries, Gillwald et al. (2012) point out that there remains a shortfall in the supply of bandwidth, especially in rural areas of South Africa, as seen in Figure 3.2, below.

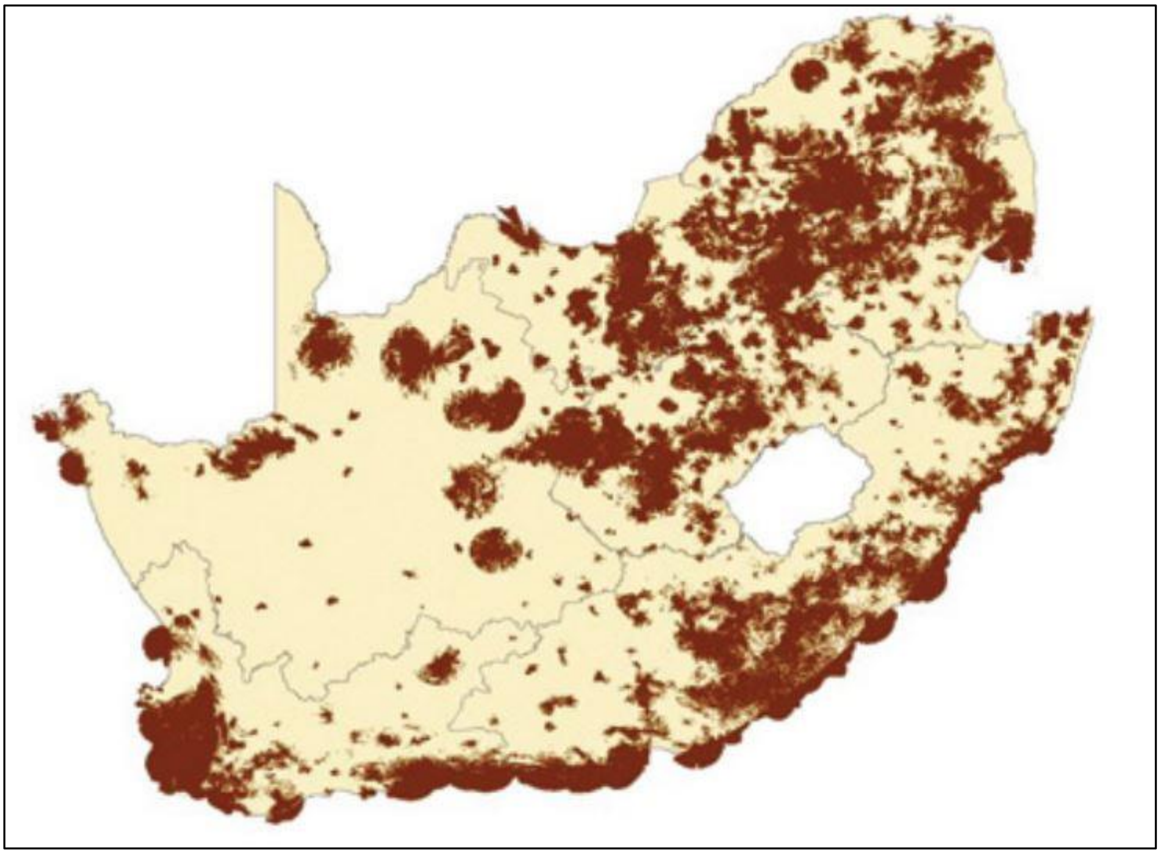


Figure 3.2 – Broadband Coverage in South Africa in 2012 (Gillwald et al., 2012)

Resource-constrained environments with issues such as poor infrastructure development, and little to no internet connection, require new and innovative content delivery solutions (Botha et al., 2014).

3.4.2. Capacity

One of the primary aims of ICT4D initiatives is to build ICT confidence in non-ICT-proficient users (Heeks, 2008; Tongia & Subrahmanian, 2006). Hori et al. (2015) express concern over a widening of the digital divide as developing countries develop higher levels of ICT literacy, while the conditions found in communities located in resource-constrained environments do not seem to improve.

Cullen (2001), and Kanagawa and Nakata (2008), state that resource-constrained environments can contain users with a low level of English literacy. Firdhous et al. (2013) echo these views, explaining that a general lack of social services, such as educational- and healthcare institutes, contributes to high levels of poverty, unemployment, illiteracy and poor health. To ensure an efficient solution when designing the model, it should be assumed that the participants could be non-ICT-proficient users with a low level of literacy.

Tongia and Subrahmanian (2006) mention that the beneficiaries of an ICT4D initiative are not only the stakeholders, but that the development/service providers, the ICT developers and the funding entities should also be included. It stands to reason that the initial developers of the system, as well as the funders and services providers, would not face the same challenges as the beneficiaries. Heeks (2008) states that one of the goals of ICT4D2.0 is to enable the beneficiaries of ICT4D initiatives to eventually become content providers themselves, but that initially there needs to be developers with a technically sufficient aptitude to begin the project.

3.4.3. Content

As discussed by Heeks (2008) and Selwyn (2004) in the previous section, the task and goals of ICT4D initiatives generally centre around building ICT confidence to help address the digital divide. Tongia (2005) also stresses the importance of addressing awareness and accessibility of ICT before diffusion can take place in a community.

In section 3.3, Heeks (2002) stressed how gaps that arose between rational design, political realities and the ICT context of the deployed country could result in a failure of ICT4D initiatives. HCI heuristics and design guidelines can help ensure that participants not only find the produced system accessible, but also develop ICT confidence in their continued interactions.

3.4.4. Computers

'Computers', within the 4C framework, refer to any ICT device. As already mentioned in section 3.3, Heeks (2008) stresses the importance of scalability to ICT4D initiatives. Traditionally, fixed ICT devices, such as desktop computers and terminals, suffer from a lack of mobility, and struggle to adjust to dynamic and changing areas, as often found within resource-constrained environments (Lewis et al., 2013).

Furthermore, as R. E. Anderson et al. (2012), and Kam et al. (2005), point out, generally, within resource-constrained environments, there is not always a guaranteed or steady supply of electricity. This could cause complications with fixed ICT devices due to the need for additional backup generators in the event of a power failure. While mobile ICT devices could be influenced in the long term if there is no electricity supply, the immediate repercussions following a power outage would generally be less harmful.

Reinforcing the above point, mobile ICTs have shown the ability to allow for easy scalability. As Gillwald et al. (2012) state, the nature of mobile ICTs circumnavigates the need for developing countries to have extensive, fixed landline networks. Only 6% of South Africans own fixed landlines, while the majority of developing African countries show only around 2% landline penetration (PewResearchCenter, 2015).

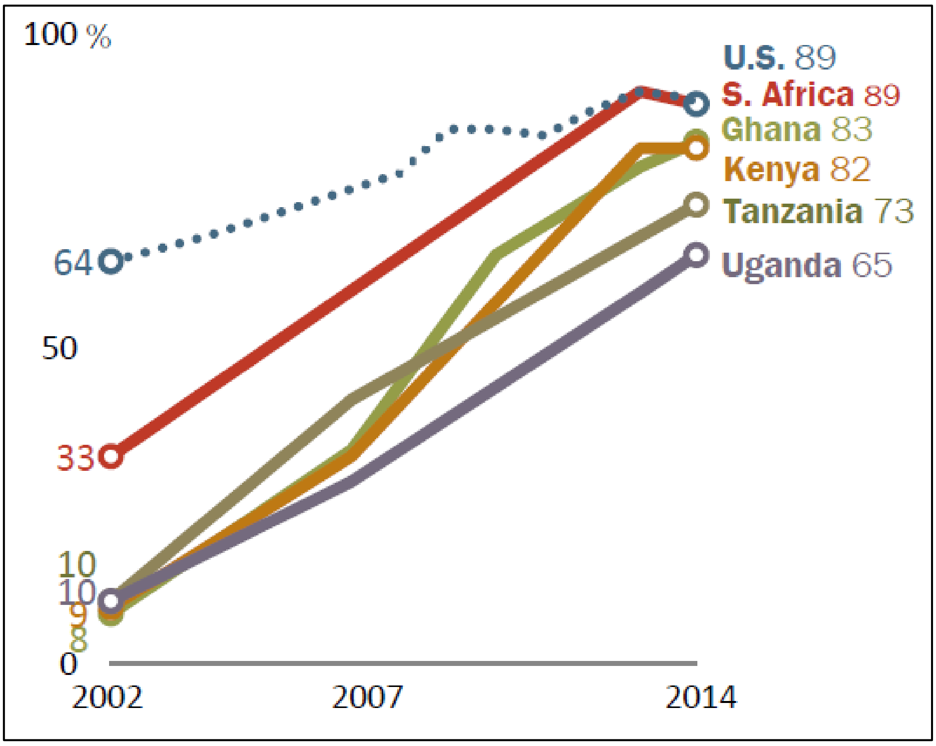


Figure 3.3. Cell Phone Ownership in Africa (PewResearchCenter, 2015)

Medhi, Gautama, and Toyama (2009) remark on how, already in 2007, of the 3.3 billion mobile users, 60% of them were in developing countries. While Figure 3.4, above, shows high cell phone ownership statistics throughout the fastest developing African countries, PewResearchCenter (2015) notes that, in countries such as South Africa, only 34% have access to smart devices (i.e. devices that can run complex internet pages and mobile applications).

While there is still a low uptake of smart mobile ICT devices, a lack of fixed line connections forces individuals to look for mobile alternatives if they want access to the internet. Therefore, this research focuses on developing a model for mobile ICT devices due to their innate scalability property and their already high level of popularity in developing countries.

Considering the four sub-sections above, there are various challenges facing ICT4D initiatives. Solutions to these challenges are addressed in the next chapter, in which techniques and procedures for ICT4D development are examined and discussed. The following section concludes this chapter with a brief chapter summary and some reflections.

3.5. Summary

The purpose of this chapter was to examine how resource-constrained environments impact the functionality of ICT4D regarding the contexts of connectivity, content and capacity in relation to the second sub-research question.

This chapter began by contrasting the characteristics of resource-constrained environments with those of rural environments, to present a definition of resource-constrained environments in section 3.2.

The following section, 3.3, outlined the background of ICT4D, the need for addressing the digital divide, Tongia (2005) four considerations for addressing the digital divide, and Heeks (2002) possible areas of failure for ICT4D initiatives.

Once the background of ICT4D was examined, section 3.4 examined and evaluated three different ICT4D development frameworks, determining that Tongia (2005) 4C framework as the most suitable to help examine the general challenges that affect ICT4D initiatives.

This chapter then concluded by identifying the challenges of resource-constrained environments on ICT4D, which are summarised in Table 3.1., below.

Area of Development	Challenge	Author
3.4.1. Connectivity	Poor wireless signal. Little to no wired connectivity infrastructure. Dynamic environment, making expansion difficult. Non-stable electricity supply. Limited access to ICT devices. High stress when internet available. Low internet usage overall.	R. E. Anderson et al. (2012), Lewis et al. (2013), Straumann (2015), Gillwald et al. (2012).
3.4.2. Capacity	Potentially low level of English literacy. Low access to education. Potentially low level of ICT-confident individuals. High levels of poverty and unemployment.	Cullen (2001), Firdhous et al. (2013), Heeks (2008),

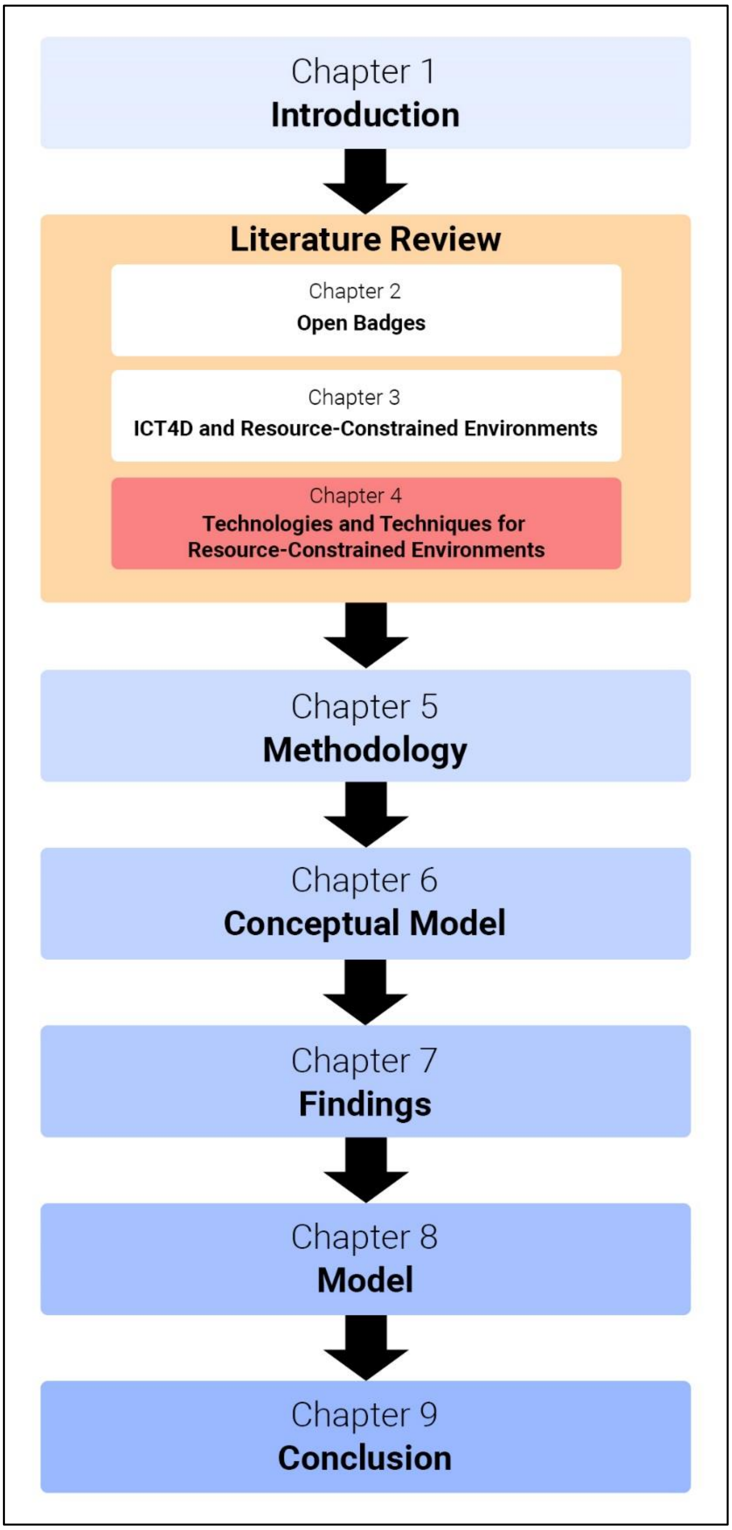
		Hori et al. (2015), Kanagawa and Nakata (2008), Tongia and Subrahmanian (2006).
3.4.3. Content	Localised understanding differs from general acceptance. Interface design linked to literacy and ICT confidence. Hardware and software must be able to accomplish individual's goals.	Heeks (2002), Heeks (2008), Selwyn (2004), Tongia (2005).
3.4.4. Computers	Fixed ICT struggle with dynamic and changing environment. Fixed ICT are reliant on stable electricity supply. ICT4D solutions require scalable technologies. ICT4D solutions must incorporate ICT that are popular locally.	R. E. Anderson et al. (2012), Gillwald et al. (2012), Heeks (2008), Kam et al. (2005), Lewis et al. (2013), Medhi et al. (2009), PewResearchCenter (2015).

Table 3.1 – Summary of Challenges Posed by Resource-Constrained Environment on ICT4D Initiatives, Examined Using Tongia's (2005) 4C Framework.

The following chapter presents the case for various technologies and techniques that were researched to help overcome the challenges identified in this chapter. It is hoped that these technologies can be adapted to enable the functionality of the elements for Mozilla Open Badges detailed in Chapter 2.

Chapter 4

Technologies and Techniques for Resource-Constrained Environments



4.1. Introduction

This chapter is the final literature review chapter. It addresses the final sub-research question. The previous literature review chapters focused on determining the elements of an open badge system (Chapter 2), and the challenges ICT4D initiatives face in resource-constrained environments (Chapter3). This chapter focuses on researching and identifying existing technologies and techniques that could aid in addressing the identified challenges to enable the functionality of open badge systems within resource-constrained environments.

Sub-Research Question 3 (SRQ3):

> *What current knowledge can be adapted and utilised to ensure the functionality of open badges within resource-constrained environments?*

Various challenges of constrained environments have been identified in separate areas of development utilising the 4C framework, as discussed in the previous chapter. Observing the challenges in the context of the 4C framework, it was noted that there are overlapping issues regarding the areas of computers and connectivity, and content and capacity.

Using a similar approach to that of the chapter examining resource-constrained environments, this chapter addresses identified challenges within areas of development. This chapter is not divided into four sections mirroring the 4C framework, however, but rather only two, to avoid needlessly addressing overlapping challenges.

This chapter begins by examining technologies and techniques that could be used to address issues between the areas of computers and connectivity, which are inhibited by the physical environmental characteristics of resource-constrained environments.

The second section addresses challenges related to the social conditions of individuals located in these environments. This section focuses on human computer interaction for development (HCI4D) and HCI-related solutions. It covers development considerations within the areas of content and capacity – the other two facets of the 4C development framework.

The final section of this chapter investigates content delivery, focusing on mobile ICT devices. This section explains why this research narrowed the scope of delivering content primarily to mobile ICT devices, as opposed to fixed devices, and the design choices that must be debated as a consequence of this decision.

The following section examines how mesh networking and localised device databases could be used to emulate an internet connected environment, thus addressing challenges related to computers and connectivity.

4.2. Connectivity and Computers

In Chapter 3, sections 3.4.1 and 3.4.4, it was noted that the connectivity and computers developmental factors of the 4C framework struggle with similar challenges, generally related to infrastructure development, within resource-constrained environments. The following challenges to ICT4D initiatives regarding computers and connectivity were identified in Chapter 3:

- Poor wireless signal
- Little to no wired connectivity infrastructure
- Dynamic environment, making expansion difficult
- Non-stable electricity supply
- Limited access to ICT devices
- High stress when internet available
- Low internet usage overall
- ICT4D solutions require scalable technologies
- ICT4D solutions must incorporate ICT that is popular locally

To address these challenges, it was found that mesh networks showed the most promise when concerning issues related to connectivity and data transmission. Mobile mesh networks are a collection of mobile nodes connected to one another via a wireless medium (Bruno, Conti, & Gregori, 2005). Subramanian et al. (2006) scrutinise how fixed line networks might not be viable for developing countries to deploy in resource-constrained environments due to cost. An alternative would be a wireless network that requires less setup, enabling quick deployment.

Brewer et al. (2005) propose a range of wireless technologies utilising intermittent networking as the most cost-effective solution. Hori et al. (2015) examined how the Kenyan government, in conjunction with MOOCs, employed a mobile ad-hoc network, connecting mobile devices with one another in a mesh network to share data and simulate a connected environment when internet connections are not possible.

Bruno et al. (2005) highlight the following benefits of utilising mesh networks:

- **Reduction in installation costs**: A cabled connection backbone is slow to deploy, costly and unscalable. Conversely, mesh networks are easy to deploy, a fraction of the installation cost and easily scalable. Mesh networks will expand automatically as the network grows.
- **Large scale deployment:** Once a fixed line network has been installed, it is limited to a specific coverage area, requiring additional access points to expand. Multihop communication networks, such as mobile mesh networks, offer long distance communication by 'hopping' through intermediate nodes.
- **Reliability:** Fixed line networks are limited in providing services if an error or fault is encountered where a bottleneck occurs. To ensure this does not happen, it is necessary for a fixed line network to have many redundant paths/links, which could be costly to install if the network is new. Due to the multitude of possible hopping nodes, mobile mesh networks do not experience this issue if there are enough mobile devices.
- **Self-management**: Mobile mesh network setup is automatic and transparent to users. This results in the network containing the properties of self-configuration and self-healing; nodes are automatically added and removed as mobile devices enter and leave the network.

Due to the popularity of mobile devices (discussed in section 3.4.4), and the scalability of mobile mesh networks, this research suggests the usage of mobile ICT in the design of ICT4D initiatives. Using mobile ICT devices would overcome the challenges posed by fixed line networks and systems.

Utilising mesh networks, it might be possible to simulate an online environment. Brewer et al. (2005) discuss how maintaining a synchronous communication can be costly in resource-constrained environments. Therefore, an alternative solution would be an asynchronous solution. Asynchronous systems store information and then post or send that information when a network becomes available. This can easily be achieved by maintaining a device database that stores and retrieves the information, enabling full application functionality and updating when possible. This would help alleviate high stress on networks because there is no immediate connection required.

The next section examines how HCI4D development practices and frameworks can be used to overcome the capacity and content challenges of individuals situated in resource-constrained environments.

4.3 Capacity and Content

The capacity of individuals could be said to influence the content design of a system. Tongia (2005) states that an individual's accessibility to ICTs is influenced by being able to understand and operate the provided content. In Chapter 3, section 3.4.2, the following challenges were identified that could affect ICT usage in resource-constrained environments regarding the capacity of individuals:

- Potentially low level of English literacy
- Low access to education
- Potentially low level of ICT-confident individuals
- High levels of poverty and unemployment

While these problems cannot be solved in the short term by simply distributing ICT to the individuals concerned, ICT4D development must acknowledge these challenges and attempt to develop around them to ensure ICTs are deployed in a sustainable manner. Devezas et al. (2014) state that HCI4D frameworks are designed around providing a positive user experience to individuals from a resource-constrained environment to increase the rate of technology acceptance.

Before examining various HCI and HCI4D guidelines, this research first defines the need for its implementation. Nielsen and Norman (1998) define the perfect user experience as an interface that allows users to fulfil their exact needs in a simplistic and elegant manner. Further elaborating on this principle, HCI is said to be experienced with all computer interaction that involves people. Thus, designing any machine interface or software should make use of HCI principles to ensure a positive user experience (Kim, 2000). HCI4D is research focusing on HCI principles, but applied in a resource-constrained environment (Ho, Smyth, Kam, & Dearden, 2009).

Kim (2000) notes that not implementing HCI principles in the design of user interfaces could lead to poor user experiences, in which users are prone to make mistakes and misinterpret feedback. Additionally, Medhi et al. (2009) remark on how, when users do not possess certain skills, such as fluent literacy and ICT confidence, they refrain from using systems and applications that require those skills. This confirms the earlier statement of Tongia (2005) concerning the accessibility of ICT to individuals. Following basic HCI guidelines in the development and design of a system could potentially help the heuristic process, which would result in a faster diffusion of the system (Chetty & Grinter, 2007; Dray, Siegel, & Kotzé, 2003).

HCI design guidelines generally assist the development process of interfaces when access to end users is limited or impossible (Devezas et al., 2014). Devezas et al. (2014) state that, in resource-constrained environments, this development process is further complicated due to the unique challenges such an environment provides. As observed in sections 3.4.1 and 3.4.2, and confirmed by Medhi et al. (2011), individuals in resource-constrained environments often possess low levels of English literacy and, are non-ICT confident.

Medhi et al. (2011) analysed the different user interfaces employed within ICT4D initiatives' applications and came to the conclusion that it seemed that standard textual interfaces were 'unusable' by low literate and non-ICT-confident individuals. Medhi et al. (2011) thus proposed the following list of design recommendations to ensure some sustainability and accessibility of systems in resource-constrained environments:

- Providing graphical and visual cues

- Providing voice-annotated support, or text to speech functionality
- Provide local language support both in text and audio
- Minimise hierarchical structures
- Avoid user input in the form of words or phrases (any non-numeric input)
- Avoid scrolling or the need for scrolling navigation or menu systems
- Minimise soft-key mappings
- Assist with training and provide human mediators

Reinforcing the validity of Medhi et al. (2011) user interface design recommendations, this research now examines two sets of guidelines, by Devezas et al. (2014) and Carvalho (2011), to indicate overlapping ideologies. These guidelines are critiqued in sub-sections later in this section.

Devezas et al. (2014) propose a set of guidelines centred around the areas of interface design, device manipulation, navigation and information architecture and content, these are set out below:

- **Familiar language:** Users who are not fully literate rely on identifying familiar words and symbols that they might encounter in their daily lives. Using local languages helps aid in a natural interaction experience. When users are literate in non-local languages, it is still important to take into consideration that their interpretations of specific words might differ.
- **Avoid complex interaction styles:** Implementing an abundance of different interaction methods and styles within a single interface can lead to confusion and cause problems for non-ICT-confident individuals.
- **Linear navigation**: Linear navigation is initially easier to understand compared with hierarchical navigation structures.
- **Encourage interface exploration**: Enabling the prevention of, and easy recovery from, errors, as discussed in the heuristics in the previous sub-section, encourages individuals to experiment and explore an interface. Individuals are thus less concerned about breaking the system.

- **Keep screens simple and limit tasks:** Due to the lack of screen space, it is thought to be beneficial to employ a minimalistic design, with simple interfaces that are not used to accomplish a multitude of tasks on the same screen.
- **Avoid scrollbars**: Scrollbars are linked to the point made in the device manipulation area. They might be considered a complex and foreign interaction.
- **Use real-life metaphors to explain concepts:** Implementing the use of common, local metaphors that individuals can understand could aid in explaining concepts when text instructions fail.
- **Text**: There should be minimal reliance on text due to possible literacy issues; however, text should never be entirely removed, but instead complemented by other media. This could benefit reading skills.
- **Graphics:** Make use of culturally relevant icons accompanied by captions. This fosters quicker comprehension. Icons should not be overly abstract because they might not be relatable. Additionally, using motions to accompany actions, instead of static images, also aids understanding.

Carvalho (2011) proposes a similar set of guidelines when designing for low literacy and non-ICT-proficient users. These guidelines are centred around the four main areas of application design, language and metaphors, graphical interfaces, and application interaction. These guidelines are summarised as follows:

- **Build confidence:** Basic functions must be easy and simple to use, and advanced functions are initially hidden to reduce frustration and inspire confidence in novice users.
- **Simplistic design:** The interface must be simple and easy to comprehend, allowing users to perform only one, or a minimal number of functions at a given time. It is hoped that small sets of instructions to accomplish tasks can help improve ease of use and learnability.
- **Language**: Consider the dialect spoken by the intended users and, by making use of cultural and social meanings, the application interface hopes to invoke a feeling of familiarity to aid in user acceptance.
- **Metaphors**: Similar to the metaphor point above, avoid unfamiliar metaphors that users who have not used technology regularly before might not have

encountered. Base metaphors on familiar concepts that the intended users might have encountered.

- **Colours and shapes:** Reflecting on the effect colours have in drawing users' attention to specific parts of the interface, navigational areas can be highlighted. Colours and shapes can improve navigational design on interfaces that present a large amount of content.
- **Graphical style:** An abundance of abstraction might confuse users. Abstraction might lead to multiple interpretations of elements. Some elements might have different meanings due to a user's cultural and social norms.
- **Geographic navigation:** Use well-known local landmarks in addition to regular directions. This point is not entirely relevant to this research, but for sake of completeness, it is added to this list. Perhaps when designing an application based on the model produced by this research, it may be required for users to select their location before they can access data.
- **Dynamic text highlighting**: When producing voice-feedback, highlighting the screen element concerned could help with user understanding.
- **Numbers**: Numbers can be used to aid in navigation, within the scope of user numeracy skills. Numbers tend to be universally understandable, and help avoid the ambiguity that language and metaphors might possess.
- **Multimodal interfaces**: Additional output modalities, such as photos, animation, videos and sound, ensure that users understand what is happening. While a variety of input modalities, such as keyboards, touch and voice recognition, ensure natural interaction.
- **Physical interaction**: Unfamiliar technologies, such as the keyboard and mouse, can be obstacles for non-ICT-proficient users, while touch and haptic interaction can help them learn interaction naturally.
- **Speech interfaces**: Users from cultures with strong oral traditions could more easily interact with applications that offer speech recognition. Implementing such a feature might be very costly, however.
- **Sharable information:** Users might not have exclusive access to the mobile device, and might need features to help them share or store information in a

separate location. A mesh network and a synchronised local device database, as proposed earlier in this chapter, might enable this share ability.

When comparing the above sets of guidelines by Medhi et al. (2011), Devezas et al. (2014) and Carvalho (2011), there are overlapping design features indicating a degree of consensus. Employing Carvalho's (2011) main areas of focus to summarise the above guidelines, sub-sections 4.3.1 to 4.3.4 critique the above sets of guidelines by comparing them with each other and indicating their relevance to this research.

4.3.1. Application Design

Carvalho (2011) states that applications designed to target non-ICT-proficient users must build confidence and be simplistic in design. This guideline is related to the HCI heuristic of simplistic and minimalistic design proposed by Inostroza, Rusu, Roncagliolo, and Rusu (2013), which is discussed later in section 4.4, and the design guidelines of Devezas et al. (2014) for navigation and information architecture.

Doerflinger and Gross (2010) state that involving the target audience at the earliest possible stage during the design process could help build trust and acceptance towards the application. Abras, Maloney-Krichmar, and Preece (2004) agree, but add that there needs to be a balance in user involvement, as either too much or too little involvement can disrupt the design process. Alternatively, Doerflinger and Gross (2010) propose to instead incorporate context simulation when developing and testing applications aimed at resource-constrained environments.

In Chapter 8, when presenting the final model, this research proposes content simulation as a feasible method for designing for resource-constrained environments. The most reliable design methods, however, still rely on gathering user requirements from the target audience personally, as suggested Doerflinger and Gross (2010).

4.3.2. Language and Metaphors

Carvalho (2011) discusses the use of language and metaphors that users would encounter in their daily environment. This is reinforced by Devezas et al. (2014), who throughout their various design guidelines propound the importance of implementing localised speech and text for accessibility. Similarly, Medhi et al. (2011) also mention the importance of implementing local language in both text and audio.

Carvalho (2011) provides the example that, due to the unique nature of resource-constrained environments and the lack of ICT knowledge, some users might misinterpret commonly used metaphors, such as the floppy icon indicating a save button. Tarasewich (2003) argues that it might be simpler to use language in place of certain metaphors, because using metaphors requires understanding the dynamic environment in terms of the participants' cultural and social outlooks in which the application is to be deployed. Winthrop and Smith (2012), and Devezas et al. (2014), emphasise the need to develop applications that are easy to use, which could be aided by employing commonly used terms and visuals encountered by the users.

Medhi, Sagar, and Toyama (2006) state that textual information is more difficult to interpret and utilise for low literate individuals, and thus should be avoided entirely. Devezas et al. (2014) argue against removing all text, and mention that it might be beneficial in the long term to include minimal text, so that individuals can slowly learn to associate words with actions, thus aiding their literary education.

4.3.3. Graphical Interface

The graphical interface area covers a wide variety of style options used in mobile application development, from colours and shapes, and the use of graphical style in writing terms, to the use of numbers in navigating (Carvalho, 2011).

The graphical interface can similarly be seen to relate to a number of HCI heuristics, such as consistency and standards, efficiency of use and performance, customisation and shortcuts, and aesthetic and minimalist design. Hori et al. (2015) emphasise the need for an 'excellent' user interface to help negate issues with mobile devices, such as small screens, restrictive input controls, and limited battery life. Winthrop and Smith (2012) similarly argue that the easier an interface is to understand, the less attention a user has to devote, and the less arduous a task becomes.

Medhi et al. (2011), and Devezas et al. (2014), both mention the avoidance of hierarchical menus and scrollbars to help increase readability on screen. If individuals are non-ICT confident, complex interaction styles and soft-key mappings that would strain individual memory load might make the application/system appear daunting (Devezas et al., 2014; Medhi et al., 2011).

Regarding assisting the user in interpreting the system status or receiving interaction feedback, Carvalho (2011), Devezas et al. (2014) and Medhi et al. (2011) all mention the use of graphical and vocal cues, highlighting text, and making use of animated graphics as helpful methods.

4.3.4 Application Interaction

Carvalho (2011) states that the area of application interaction focuses on multimodal interfaces and physical interaction. Devezas et al. (2014) discuss how speech interfaces might make use of strong oral traditions and act as a natural interaction style for non-ICT-confident individuals. Similarly, touch interaction can help users learn to interact naturally, and would not have the same stumbling issues found in the use of the mouse and keyboard (Carvalho, 2011). Medhi et al. (2011) show how different forms of user interaction, such as fully graphical or speech interfaces, helped low literate and non-ICT-confident users better interact with applications in early stages.

Carvalho (2011), and Devezas et al. (2014), caution that the use of a multitude of different interaction styles might confuse non-ICT-confident users, and it should clearly be indicated which type of interaction is required. Additionally, Winthrop and Smith (2012) state that, before developing, the features and limitations of the mobile devices, on which the application will be deployed, have to be fully understood.

This section discussed HCI development frameworks that address the capacity and content challenges of individuals situated in resource-constrained environments (Chapter 3, section 3.4.2). Now that this section has discussed guidelines that would aid the acceptance and adoption of ICT by users located in resource-constrained environments, the next section focuses on explaining why this research chose to develop solutions catering to mobile ICT devices, as opposed to fixed ICT. Once these reasons are analysed, the required mobile HCI heuristics that influence content presentation and navigation are discussed.

4.4. Content Delivery Aimed at Mobile ICT Devices

Earlier in this chapter (section 4.2), how ICT4D initiatives could benefit, with regards to the scalability and popularity of mobile ICTs in resource-constrained environments, was discussed. This section expands upon this reasoning, and then presents a set of HCI heuristic considerations aimed at general mobile development.

In the previous literature chapter, section 3.4.4 discussed the popularity of mobile ICT devices in various developing African countries. This fact is reinforced by the majority of the world's mobile users being located in developing nations (Medhi et al., 2009).

Comparing the advantages of mobile ICT devices with those of fixed ICT devices, this research hopes to illustrate how mobile ICTs make a strong case for being the preferred ICT device for ICT4D initiatives.

Investigating the characteristics of fixed ICT devices, such as desktop computers, Vota (2012) notes the following four advantages over mobile ICT:

- **Ruggedness**: Due to the relatively weak structure of mobile devices compared with fixed devices, there exists the potential for the entire fixed device to become non-operational if an accident occurs. For example, if a touch-based tablet device is dropped, and the screen breaks, the device would lose most of its functionality. A broken screen would not only inhibit the user from seeing what they are doing, but also mean that the primary method of input is disabled. In contrast, if a computer screen is dropped, it can be swapped, in a relatively simple manner, if extra screens are present.
- **Theft**: Due to the size of fixed ICT devices, they are harder to steal than small mobile devices.
- **Sharable**: Similar to Carvalho (2011) guideline on sharable information presented in the previous section, fixed ICT devices can be designed to allow multiple users to interact with the device simultaneously.

- **Versatility in capabilities**: Fixed ICT devices can be upgraded to fulfil a variety of functions. For example, if there is a need to expand a system's memory capacity, additional hard drives can be installed. Mobile ICTs do not often have the ability to upgrade due to their solid design. This could, however, lead to a large variation between devices in an initiative.

While these advantages should be considered when an initiative selects their ICT device platform, Yadav et al. (2010) argue that environmental factors are often of a higher priority due to device operationality. Tackling some of the constrained challenges of the previous chapter, the following list of mobile advantages is presented:

- **Mobile features in central device:** Donner (2010) argues that with the rapid development of mobile devices, a host of new features has been implemented, which makes them more attractive than fixed ICTs for initiatives. The ability to take photographs might not be germane to all ICT4D initiatives, but when collecting badge evidence, a simple method would be for the issuer to record a video or take photos of the relevant work. These files can then be attached to created badges as evidence. If this approach were to be attempted using fixed devices, the individual must make use of a camera, and then transfer the files to the fixed device before they can be used.
- **Minimal electricity supply reliance**: Wicander (2010) notes, in a case study on mobile phone usage in Tanzania, that in 2006, only 2% of the rural population, and 39% of the urban population, had access to electricity. In the same study, it was also observed how, in a survey of mobile phone usage, 97% of participants had access to mobile phone services. This suggests that despite a steady supply of electricity not being present, individuals in this area were not hindered in their mobile phone usage. This is not the case for fixed ICTs, which rely on alternative power supplies if an electrical grid were to go down.
- **Mobility and scalability**: As already addressed earlier in this chapter, the usage of mesh networks enables mobile devices to form a scalable and mobile network (Bruno et al., 2005). While the same can be done with fixed ICTs utilising Wi-Fi connections, they are not mobile, and thus they would have to be placed strategically, because the network would not move.

After comparing the advantages of mobile ICT devices with fixed ICT devices, the utility provided by mobile ICTs is believed to be better suited for an open badge system.

Now that the research has made a case for mobile ICT4D, it can examine specific mobile HCI guidelines. Norman and Nielsen (2010) point out that most HCI principles are easily ignored when developing applications for smart mobile devices, which could potentially lead to a poor user experience. In Chapter 2 (section 2.4.), it was shown how bad interface design could lead to issues in adopting a system, even in an ideal environment. The issues identified in section 3.4.3 of Chapter 3 relating to the content factor of the 4C framework, share similarities with that of the capacity factor of the 4C framework. As such, this research again examines HCI practices and guidelines to aid in overcoming the identified challenges; however, with a greater focus on hardware and software development.

To help avoid poor HCI design that might lead to bad user experiences, Shneiderman and Plaisant (2010) originally published eight golden rules of interface design in 1985. Later, Nielsen (1995) expanded these to ten general principles for interaction design, also referred to as Nielsen's ten heuristics. Po, Howard, Vetere, and Skov (2004), however, argue that the heuristics are not environment immune, and they do not assess the type of device in use, nor consider the conditions of the physical environment in which the user must use the system.

Inostroza et al. (2013) propose that, in addition to the original heuristics, flexibility and efficiency of use be split into two separate heuristics, namely, customisation and shortcuts, allowing users to have access to customisation or shortcut options to more easily navigate where they feel confident in a system; and efficiency of use and performance, which pertains to the performance of applications on a device, and the ability to complete tasks with the minimal number of required steps. The additional heuristic that Inostroza et al. (2013) propose, physical interaction and ergonomics, involves the physical layout of the device; if it is touch screen, it should offer ergonomically placed buttons for main device functionalities.

Bearing in mind the identified elements of resource-constrained environments that present a challenge for ICT4D initiatives, this research briefly examines Inostroza et al. (2013) updated list of heuristics aimed at mobile development.

- **Visibility of system status** - The interface will always require the ability to inform the user of the current system status through appropriate feedback within a reasonable time. When users who are not ICT confident attempt to interact with a system, and they do not receive feedback, it could lead to issues that inhibit their enjoyment of the experience.
- **Match between system and real world** – Utilising a user's language and concepts helps their understanding and processing of information in a natural order. In resource-constrained environments, it is important to understand that individuals might have unique interpretations of standard and conventional metaphors, and thus developers cannot make assumptions and rely on standard meanings.
- **User control and freedom** - Users should be allowed to explore the system without fear they might damage its functionality or compromise their future interactions. Interfaces must be designed that allow for easy backtracking or escape.
- **Consistency and standards** – These generally refer to using words or actions in a conventional manner. Thus, when users navigate between systems and interfaces, they do not experience unexpected outcomes due to reinterpretations on behalf of the developers. While it is important to develop interfaces following platform conventions, as stated in the previous point, resource-constrained environments often have unique social and cultural interpretations that might not follow standard conventions. In such a case, it would most likely lead to a decision between increasing immediate accessibility to users versus preparing users for interacting with future ICT systems.
- **Error prevention** - By employing the use of drop downs, buttons and minimising the breadth of possible user-entered input, mobile applications can be designed to prevent errors before they occur. The interface should warn users before they

commit to an action that might lead to an error, and, if an error has been encountered, the interface should help in recovering from it.

- **Minimise the user's memory load** – Interface design of mobile applications is often limited in the amount of information it can display at any given time due to smaller screens. It is paramount that the user's memory load is not strained, however; ensuring that instructions are visible or easily retrievable helps in minimising the user's memory load.
- **Customisation and shortcuts** – Mobile ICT devices do not always have access to traditional inputs, such as a keyboard and mouse. This does not mean that navigation has to be impaired, however. Instead, utilising a variety of different inputs readily available to mobile ICT devices could improve navigation and overall user interaction. Utilising shortcuts or allowing for user customisation when it comes to button creation and placement, voice commands, or figure gestures, could make user interaction feel more natural.
- **Efficiency of use and performance** – Interfaces requiring large amounts of instructions or user interactions to perform functions might be daunting for non-ICT-proficient individuals. Additionally, this could deter experienced users as well, due to a perception of inefficiency.
- **Aesthetic and minimalist design** - A minimalistic approach in design is paramount in developing mobile interfaces that only have limited screen size. Unnecessary information would not detract from relevant information, but would most likely clutter the mobile screen.
- **Help users recognise, diagnose and recover from errors** - When an error occurs, the user should be notified by an on-screen indication. This could be a visual or audible prompt recognisable to the user. Errors should not inhibit the functionality of the system, and users should be able to easily recover from them.
- **Help and documentation** – Help and documentation can come in the form of application assistance and external tutorials. When documentation is provided, it is important that is easily understood and difficult to misinterpret. This becomes more challenging when considering that individuals in resource-constrained environments might have literacy- or language-barrier issues.

- **Physical interaction and ergonomics** – Mobile ICT devices come in a variety of different hardware combinations that influence the device weight, screen size and button layout. The screen size and button layout should play a crucial role in deciding where on-screen elements are placed when designing an interface. Equally important, however, is following standard interface conventions and layouts to help minimise user confusion when transitioning between different systems/applications.

Utilising the above heuristic guidelines, standard and well defined HCI practices can be applied to mobile interface development.

4.5. Summary

This final chapter of the literature review discussed some current technologies and techniques that can be used to ensure the functionality of open badges in resource-constrained environments.

The first section of this chapter discussed mobile mesh networks and how, with the aid of local device databases and utilising asynchronous transfer techniques, it is possible to emulate an internet connected environment for applications. This would serve as a possible connectivity and computers solution. This section alluded also to mobile ICT devices being the most suitable option regarding scalability and popularity, which was then discussed in section 4.4.

Section 4.3 of this chapter examined possible HCI4D solutions to help alleviate capacity and content challenges experienced by individuals situated in resource-constrained environments. The important points gained from examining three prevalent HCI4D frameworks are summarised in Table 4.1, below:

Areas of Focus	Elements for Development	Authors
Application Design	Design with user involvement and user context simulation. Application/system must be simplistic and minimalistic in design.	Abras et al. (2004) Carvalho (2011) Devezas et al. (2014) Doerflinger and Gross (2010)

Language and Metaphors	Localise language and metaphors. Minimise text but do not remove entirely. Use local metaphors and comparisons or ensure that used metaphors do not allow different local interpretations.	Carvalho (2011) Devezas et al. (2014) Medhi et al. (2011) Medhi et al. (2006) Tarasewich (2003) Winthrop and Smith (2012)
Graphical Interface	Minimalist and simplistic interface. Consistent design Avoid hierarchical structures and scrollbars. Avoid complex interaction styles and soft-key mappings Make use of graphical and vocal cues. Make use of text highlighting and animated graphics.	Carvalho (2011) Devezas et al. (2014) Hori et al. (2015) Medhi et al. (2011) Winthrop and Smith (2012)
Application Interaction	Touch and voice interaction might seem more natural to non-ICT-confident individuals. Minimise amount of interaction styles for initial users. Clearly indicate the type of interaction required. Understand device limitations when designing interaction interfaces.	Carvalho (2011) Devezas et al. (2014) Medhi et al. (2011) Winthrop and Smith (2012)

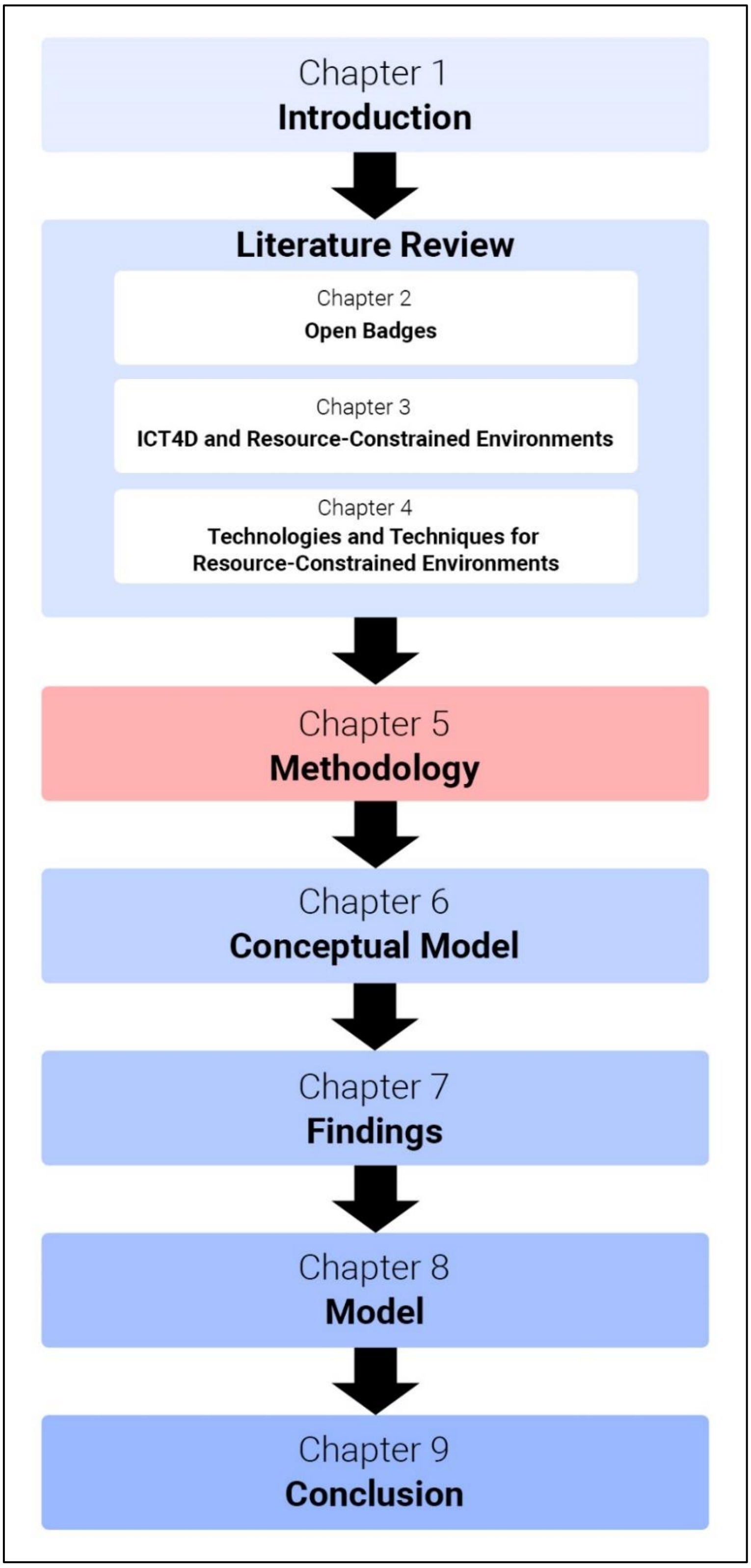
Table 4.1 – Summary of Elements for HCI Development Addressing Challenges Identified Regarding Individual Capacity

Finally, this chapter concluded with section 4.4, which explained this research’s focus on providing content delivery for mobile ICT devices. Once it was established why it would be more beneficial to develop a solution for mobile ICTs, this section then examined HCI heuristics and user interface considerations for mobile ICT devices to ensure that content is easily accessible and understandable. This research identified Inostroza et al. (2013) updated version of Nielsen (1995) ten heuristics as the most suitable for mobile interface development.

The next chapter delineates and defends the research methodology choices employed by this research.

Chapter 5

Methodology



5.1 Introduction

O'Leary (2004) has defined a methodology as a set of standardised, well explained, and credible methods that are employed in addressing a research's questions and objectives. A well-designed research methodology not only helps to convey information to readers, but also highlights the contributions of the study (Kothari, 2004; O'Leary, 2004). Without a well-planned methodology, it is difficult to explain research choices or how literature was analysed and interpreted by the researcher (Mackenzie & Knipe, 2006).

The primary objective of this research is to address its research questions by producing a model through which open badges can be implemented within a resource-constrained environment. Therefore, the design of this thesis' methodology will be defined by the development of this model. In designing its methodology, this study employed the onion research model proposed by Saunders et al. (2011), as shown below in Figure 5.1.

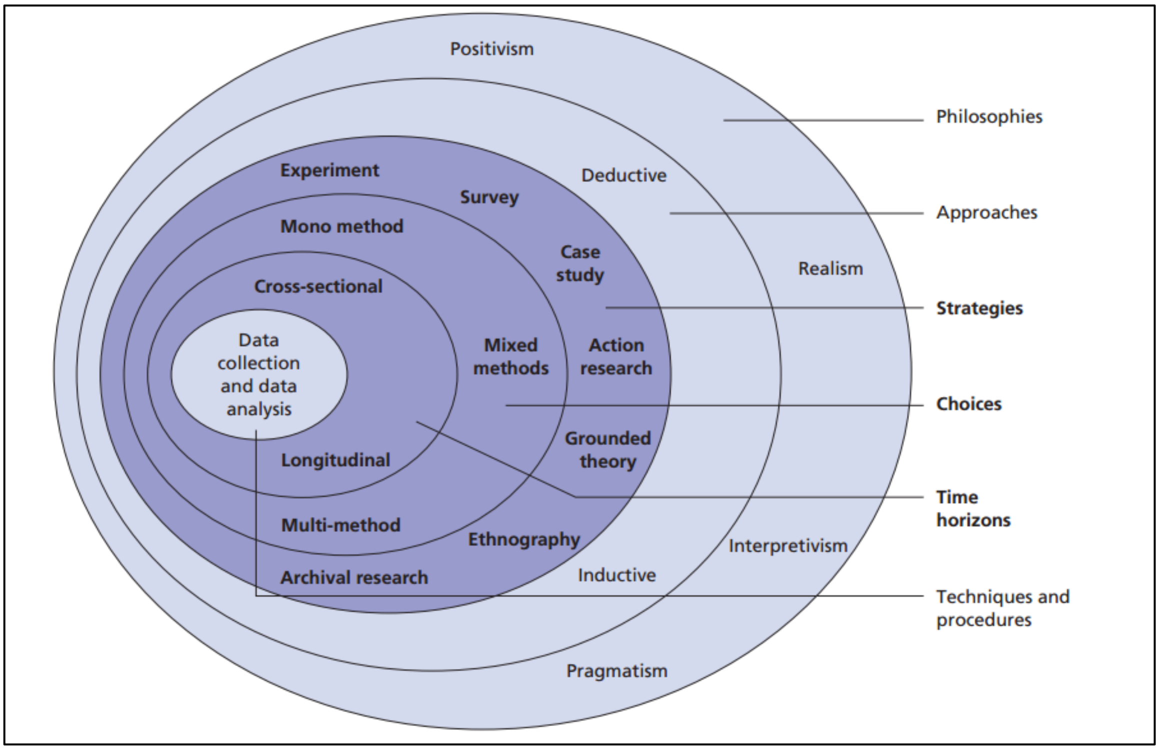


Figure 5.1 - Onion Research Model, Proposed by Saunders et al. (2011)

An adapted model showcasing only the methods selected and employed in this study can be seen below in Figure 5.2.

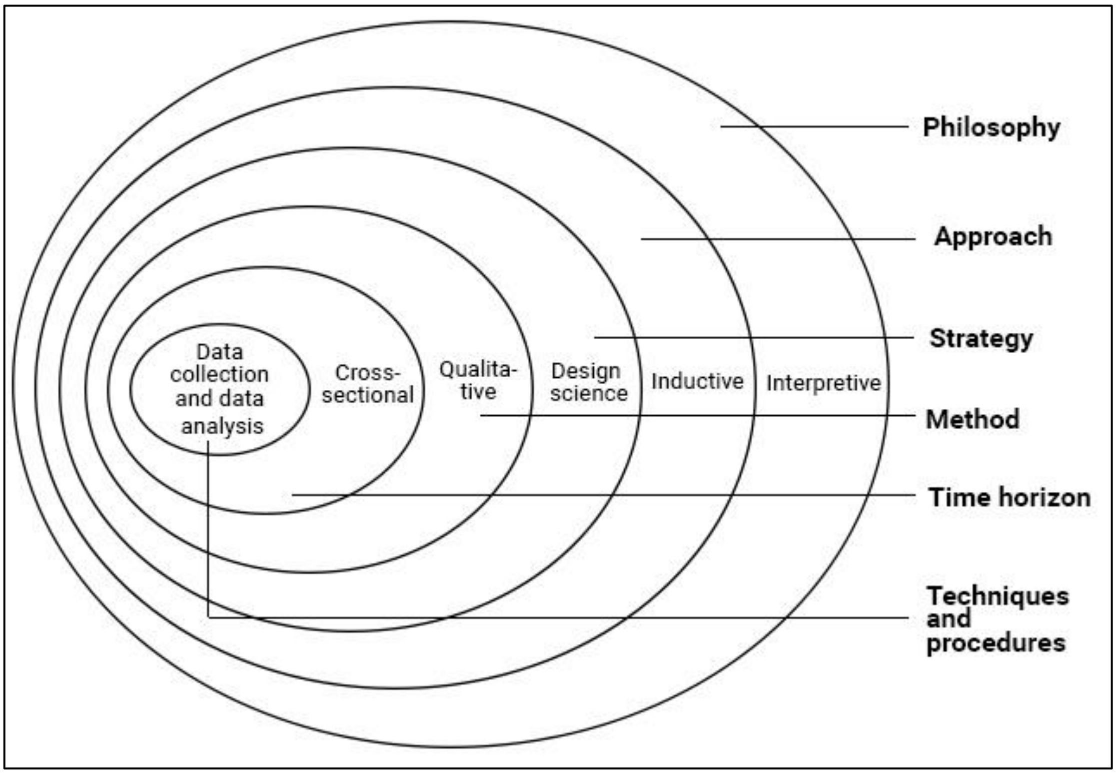


Figure 5.2 – Adapted Onion Research Model, Originally Proposed by Saunders et al. (2011)

The methodology design of this research is discussed by sequentially examining each layer of the onion research model: philosophy, research approach, strategy, methods, time horizon, and techniques and procedures.

The next section begins these examinations with the model's outermost layer, critiquing the various research philosophies. It concludes with an explanation of why interpretivism was selected to be the philosophy of this thesis.

5.2. Research Philosophy

Research philosophies are theoretical frameworks used to focus research, including guidelines on how knowledge is collected, analysed and interpreted (Mackenzie & Knipe, 2006; Saunders et al., 2011). They are commonly accepted sets of assumptions and perceptual orientations. Choosing one philosophy is helpful in conveying what research decisions a study has made (Donmoyer, 2008).

A multitude of different research philosophies can be observed in the onion research model (Figure 5.1), all of which could have been implemented as a framework to guide this research. Guba and Lincoln (1994) and Trochim (2006) have stated that a choice between these philosophies should largely be based on epistemological and methodological differences. Saunders et al. (2011), however, have argued that research philosophies also differ with regard to ontology and axiology. By comparing the positivist, pragmatist, realist, and interpretivist research philosophies, this section argues that the interpretivist research philosophy is the most suitable for this research.

5.2.1. Positivism

Saunders et al. (2011) have described positivism as a philosophical stance that produces generalisations based on observations of phenomena that engender credible data. Ontologically, the researcher separates themselves from the research and remains independent of the data, thus not contributing any biases. Epistemologically, the researcher observes a single reality that is not influenced by social actors but by truths that are always applicable (O'Leary, 2004; Saunders et al., 2011). O'Leary (2004) has stated that positivist philosophies are usually hypothesis-driven and require re-creatable experimentation to prove their results. This usually leads to quantitative findings and results. Saunders et al. (2011) agrees that, while they are not always quantitative in nature, positivist methods lend themselves to highly structured and often large sample measurements of data.

5.2.2. Interpretivism

Interpretivism is often contrasted with positivism due to its ontological stipulation that researchers do not exclude themselves or their views when analysing and interpreting phenomena (K. T. Anderson, 2008; Creswell, 2009; Saunders et al., 2011). Creswell (2009) and Klein and Myers (1999) have stated that, from an epistemological perspective, researchers following an interpretivist philosophy examine the following when interpreting phenomena: social circumstances, environmental contexts and historical experiences of social actors. The interpretivist researcher must also ontologically recognise that their view is subjective and their own interpretations influence the study (Klein & Myers, 1999; Saunders et al., 2011). Interpretivists rely on gathering large amounts of information and data about specific aspects of topics, before expanding the complexity of the perspectives on phenomena until a broader discussion can be created (K. T. Anderson, 2008; Creswell, 2009). While Klein and Myers (1999) have argued that an interpretivist philosophy is not a synonym for qualitative research, Creswell (2009), O'Leary (2004), and Saunders et al. (2011) have stated that interpretivist research most commonly employs qualitative methods.

5.2.3. Pragmatism

Pragmatist philosophies focus above all else on answering a study's research questions. As a result, they allow for a flexible approach to ontology and epistemology, enabling the researcher to adopt the most appropriate view needed in their situation (Creswell, 2009; Saunders et al., 2011). However, this flexible view is criticised for allowing researchers to determine their own truths and reality by adopting their own set of objective and subjective beliefs, thus not conforming with conditions found in the real world (McCaslin, 2008). Nevertheless, Goldkuhl (2012) is in favour of this flexibility, as it allows researchers to adopt ontological and epistemological views that could allow for greater freedom of action in research to bring about change. The ability to adopt views from both the interpretivist and positivist philosophies allows pragmatists to approach issues with a mix of qualitative and quantitative methods (Creswell, 2009; Saunders et al., 2011).

5.2.4. Realism

Realism is often split into two categories, depending on the epistemological view that is adopted. These are direct realism and critical realism (Saunders et al., 2011). Critical realism examines phenomena in the world and how the researcher interprets them. Conversely, direct realism is only concerned with the phenomena. Olsen (2009) has examined the ontological view of realist researchers. They state that realists believe that not all results or applicable phenomena are observable, and they therefore do not separate current socio-political events from their research. Olsen (2009) has also argued that such an approach leads to research that cannot always follow a pre-specified sequence and that must involve elements of exploration in its data gathering. Realism may use qualitative, quantitative, or mixed methods, depending on the situation (Olsen, 2009; Saunders et al., 2011).

5.2.5. Selected Research Philosophy: Interpretivism

In this study, an interpretivist philosophy is followed in answering the primary research question and fulfilling the primary research objective. This research is focused on the production of a model to enable the implementation of open badge systems within resource-constrained environments. As a result, the research questions are designed to identify the critical elements of open badges that ensure that a produced system complies with the current Mozilla Open Badge standards framework. The questions also allow for an examination of ICT4D initiatives located in resource-constrained environments, with a focus on the Tongia (2005) 4C framework, for areas of ICT development.

Ontologically, making use of grounded methods, this research requires subjective input from researchers in order to draw clear conclusions from themes and patterns in collected data. Epistemologically, this research is concerned with analysing specific contexts, their social communities and actors, and their environmental conditions. While followers of both pragmatist and interpretivist philosophies are able to employ these ontological and epistemological views, there is no advantage in pragmatism when utilising a mono method, such as that found in this study. As detailed in Section 2.5, this research employs qualitative methods. According to Saunders et al. (2011) and O'Leary (2004), this clearly implies that interpretivism is the most suitable philosophy for this study.

5.3. Research Approach

A research approach determines the relationship between theory and research within a study (Blackstone, 2012). The clarity of the research's theory at the start of the study is a determining factor of which research approach should be employed (Saunders et al., 2011). Saunders et al. (2011) have stated that two opposing research approaches exist: deduction and induction.

5.3.1. Deduction

The deductive approach is often referred to as a top-down research approach, where researchers works from a generalised context to a specific context (Trochim, 2006). Utilising the deductive approach, researchers would first identify a theory that they would like to test (Blackstone, 2012). Saunders et al. (2011) have explained that, since the theory must be known at the start of a study, the deductive approach is generally more concerned with testing hypotheses than research questions. Moreover, while Saunders et al. (2011) does argue that not all deductive research uses only quantitative data, they concede that there is a trend in hypothesis testing to prefer quantitative data to qualitative data. Trochim (2006) has explained that this predisposition is due to the nature of hypothesis testing; deductive approaches are generally narrow and non-exploratory, focusing instead on identifying relationships between specific variables. Blackstone (2012) has summarised the deductive approach as starting with the identification of a theory, progressing to the analysis of data, and concluding with the eventual support or denial of the chosen theory. This process is illustrated in Figure 5.3

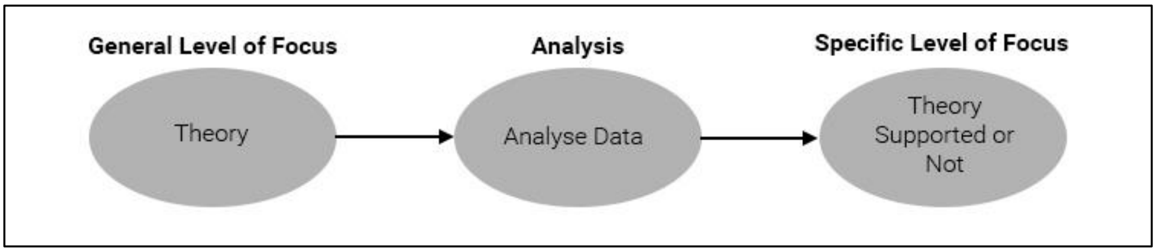


Figure 5.3 - Deductive Research Process, adapted from Blackstone (2012)

5.3.2. Induction

Conversely, the inductive approach is often referred to as the bottom-up approach. Data is initially gathered with a focus on specific research questions, before eventually being expanded and adapted to general theories or conclusions (Trochim, 2006). As shown in Blackstone (2012) summary of the inductive process (depicted in Figure 5.4), its timing in theory identification is the inverse of that of the deductive approach.

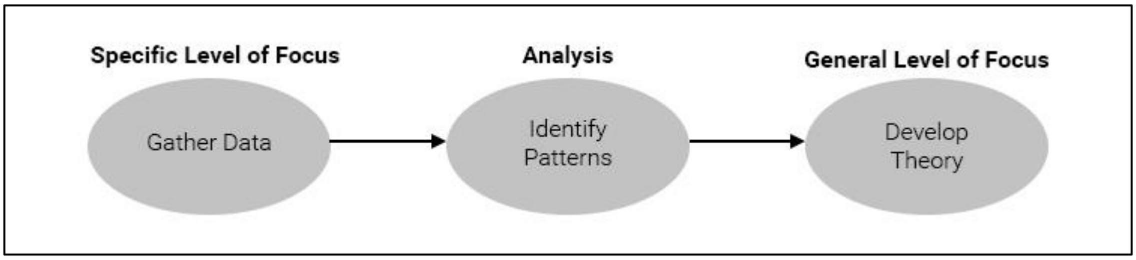


Figure 5.4 – Inductive Research Process, Adapted from Blackstone (2012)

Saunders et al. (2011) and Trochim (2006) have confirmed that the final step of the inductive research approach is developing a theory, and that it therefore utilises research questions in its initial stage. Research following this approach focuses on investigating small samples of subjects and phenomena, as well as developing solutions that can be applied to more general contexts (Saunders et al., 2011). The data gathered in the first step is usually of a qualitative nature, as it can be open-ended and allow for more exploration into additional themes and concepts (Saunders et al., 2011; Trochim, 2006). Once the data has been gathered, patterns can be identified using a suitable research strategy and method before a theory is finally developed (Blackstone, 2012).

5.3.3. Chosen Research Approach: Induction

As detailed in Section 1.2, this research has identified a problem with the implementation of open badges within resource-constrained environments. Addressing this problem has led to the formation of research questions (Section 1.3) and a research objective (Section 1.4). As stated in the previous section, the addressing of research questions falls within the domain of the inductive approach. A research problem should be specific in context, and there is a need to gather information, identify themes and patterns, and thus make the solution more abstract and applicable in wider variety of contexts. The use of questionnaires and a small sample size of two experts (as detailed in Sections 2.7.1.1 and 2.7.2) conforms to the statements of Saunders et al. (2011) and Trochim (2006) about inductive data gathering.

Figure 5.5 below shows how this research implemented the inductive research process, starting with the gathering of data through a literature review that can be found in Chapters 3, 4, and 5.

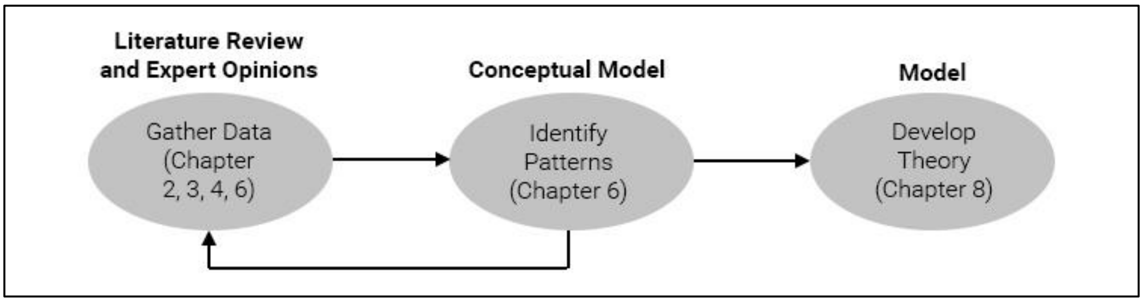


Figure 5.5 – Applied Inductive Research Process Adapted from Blackstone (2012)

Employing the use of grounded methods and coding (Section 5.7.2), patterns identified through the literature review were used in the construction of a conceptual model found in Chapter 6. Before developing a finalised model, additional data was gathered from experts reviewing the conceptual model. This additional data is analysed at the beginning of Chapter 8, which then concludes with the construction of the finalised model.

The next section discusses the research strategy employed in this study, which is suited to pattern identification and theory construction.

5.4. Research Strategy

Saunders et al. (2011) have included a multitude of research strategies in their onion research model. However, not all of these are applicable to qualitative studies, and even fewer are of use in qualitative studies in the domain of information sciences. Action research and design sciences have emerged as prevalent strategies when designing IT artefacts as solutions (Goldkuhl, 2004; Hevner, March, Park, & Ram, 2004; Iivari & Venable, 2009; Järvinen, 2007; K. Peffers et al., 2006). Iivari and Venable (2009) have stated that the major difference between design science and action research is the context in which they are used and the scope of the solution that they provide. Action research is used to address an organisational problem and thus generally produces an organisation-specific solution. Design science likewise addresses a specific problem, but it is detached from organisations and thus produces a generalised solution.

Carlsson, Henningsson, Hrastinski, and Keller (2011) have argued that design science research can be used to develop and test design theory and knowledge by reviewing extant knowledge. Knowledge and theory contributions take the form of IT artefacts when employing design science (Gregor & Hevner, 2013). This fact is in line with the research objective and research questions of this study, as can be seen in Figure 5.6.

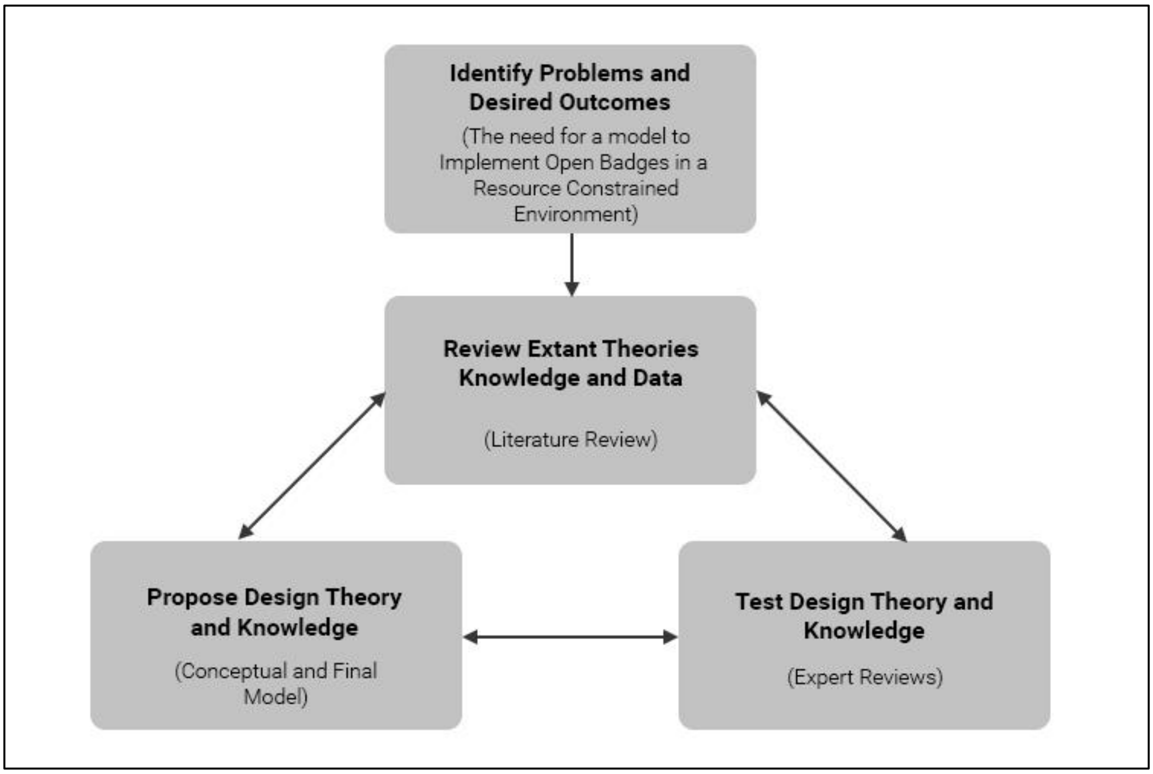


Figure 5.6 – Socio-Technical IS Design Theory Development Model, Adapted from Carlsson et al. (2011).

This study has identified the need for a model to implement open badges in resource-constrained environments. K. Peffers et al. (2006) have stated that one of the most important goals of design science is the production of an artefact to address a problem. Gregor and Hevner (2013) have stressed that models produced from design science strategies are considered to be nascent design theory contributions. Nascent design theories are generally balanced in their focus on specific and abstract knowledge. By implementing grounded theory methods as a form of data analysis (as described in Section 5.7.2), primary and secondary data can contribute to the production and evaluation of such a model. This process conforms to Carlsson et al. (2011) socio-technical IS design theory development model.

Hevner et al. (2004) have stated that design science is closely associated with pragmatic philosophies. However, K.; Peffers, Tuunanen, Rothenberger, and Chatterjee (2007) have argued that combining it with interpretative philosophies is theoretically possible, although not always implementable in practice. As a way of demonstrating the applicability of design science research in this study, Hevner et al. (2004)'s design science research cycle is examined in the next section.

5.4.1. Design Science Research Cycle

Gregor and Hevner (2013) have stated how the use of known solutions and previous theory in the production of a model that address a new problem is a form of exaptational knowledge contribution. Section 5.4.3 examines the design science research contribution framework proposed by Gregor and Hevner (2013), and how it was used to determine the validity of this studies contribution.

Before this, the present section discusses Hevner et al. (2004) design science research cycle as it is applied in this study. Figure 5.7 details the applied design science research cycle, of which the relevance cycle, design cycle, and rigor cycle are systematically examined below.

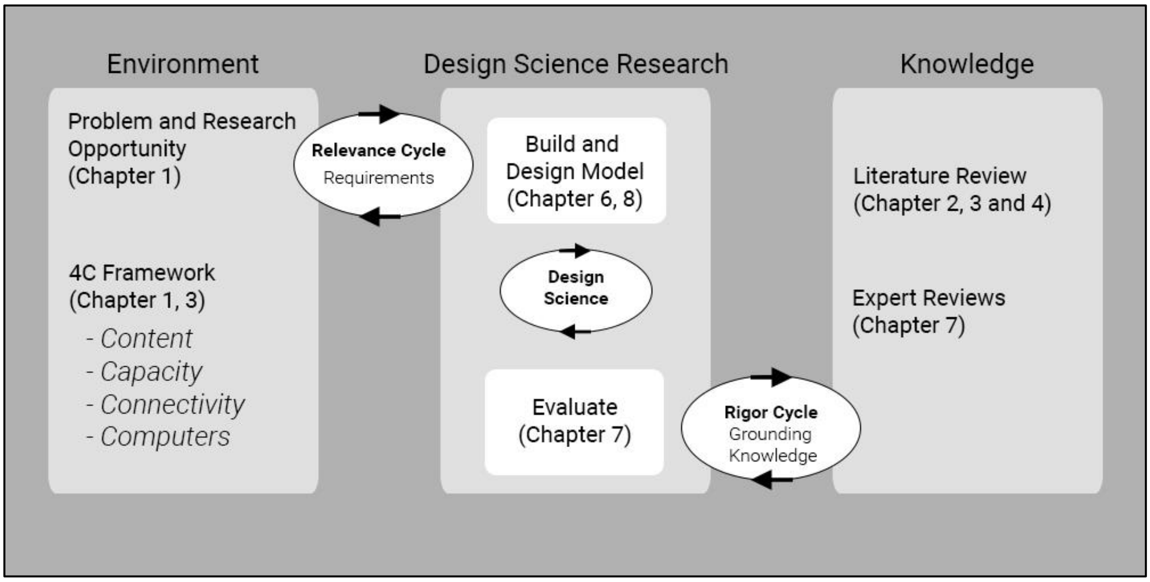


Figure 5.7 – Design Science Research Cycle, Adapted from Hevner et al. (2004)

5.4.1.1. Relevance Cycle

During the relevance cycle, the opportunities and problems of a system are identified, thus initiating completion of the research goal and the artefact design (Hevner et al., 2004).The problem identified in this research relates to the implementation of open badges in resource-constrained environments.

The artefact was designed through a review of literature relating to alternate assessment, open badges, and the Mozilla Open Badge Standards framework. The artefact design included barriers to the implementation of ICT4D initiatives. These barriers were identified in the contexts of content, connectivity, capacity, and computers within resource-constrained environments.

5.4.1.2. Design Cycle

The design cycle is focused on addressing the problems and opportunities identified during the relevance cycle. It attempts to ensure that the produced IT artefact fills the identified lacunae through a process of continuous evaluation and refinement.

The design cycle balances its efforts between firstly constructing and evaluating the research artefact (based on previous development) and secondly testing theories and practices, as outlined in the rigor cycle (Hevner et al., 2004). The research artefact produced by this study is a model for implementing open badges in a resource-constrained environment.

A conceptual model was evaluated by four expert reviewers, as detailed in Section 5.7.2. This helped in determining the effectiveness of the conceptual model as a solution to the research problem of this study.

5.4.1.3. Rigor Cycle

The rigor cycle contributes to the model by ensuring that past research and frameworks are taken into account when the artefact is constructed. This ensures that the produced model is innovative but still follows well-established methods and theories in its construction and evaluation (Hevner et al., 2004). As discussed above, this research is a form of exaptation, as it identifies new knowledge and research opportunities by using existing knowledge and solutions to address new problems (Gregor & Hevner, 2013).

As outlined in Section 5.7.1.2, this research used secondary data in its construction of a model to successfully address the problems and opportunities identified in the relevance cycle. In turn, this research produces new knowledge that can be used by future studies in a similar manner.

To ensure that this research produces a valid and effective solution, this study implemented the design process of K. Peffers et al. (2006), as outlined in Section 5.4.2.

5.4.2. Design Science Research Process

This research employed K. Peffers et al. (2006) design science process when producing a rigorous and complete model that could be used to address the research problem. The design science research process is divided into seven stages, which are illustrated in Figure 5.8:

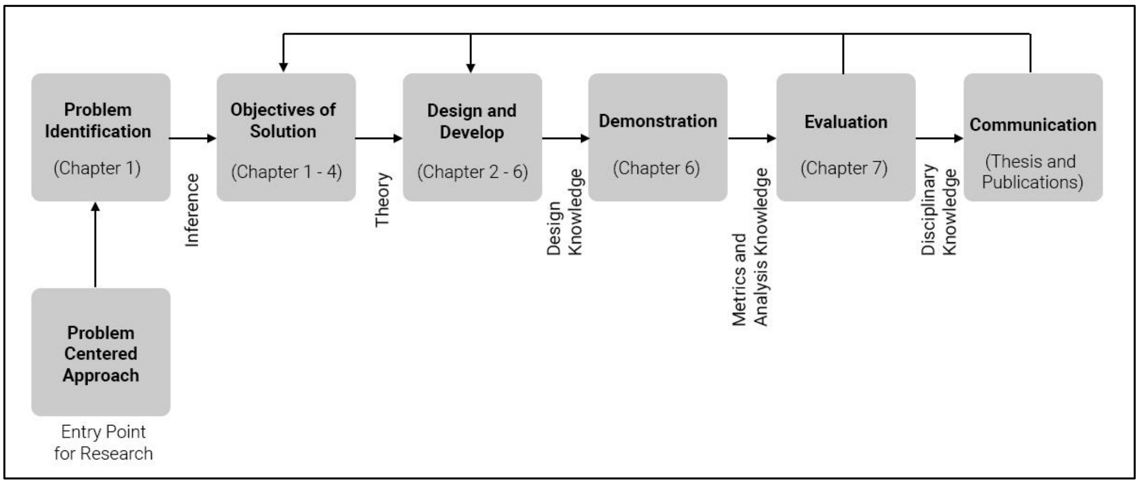


Figure 5.8 – Design Science Research Process, adapted from K. Peffers et al. (2006)

5.4.2.1. Problem Identification

This process ensures that the research focuses on a clear problem and understands what the design artefact will accomplish. K. Peffers et al. (2006) have explained that a well-identified problem helps to justify the need for a research. It also enables an understanding of the researcher’s subjective view of the topic.

These same authors have recommended atomising the problem and addressing it in sections to ensure that its complexity is understood. Therefore, although this research addresses one primary research question (Section 1.3) in order to solve the research problem (Section 1.2), this problem is atomised into three secondary research questions. This is done to ensure that the solution is effective. The problem is further expanded by examining relevant data that was gathered during the literature review (Chapters 2, 3 and 4) and expert reviews (Chapter 6).

5.4.2.2. Objectives of Solution

Design science ensured that the solution is suited to solving the problems that have been identified. Furthermore, it ensured that the produced artefact would be preferable to other currently existing theories and models. The lacunae in previous studies discovered during the literature review of current theories and existing models and practises were instrumental in the justification of the solution. The objectives of this research (Section 1.3) are designed to address these identified lacunae.

5.4.2.3. Design and Develop

The design and development of a generalised solution in the form of a research artefact is one of the core differences between design science and other research strategies. The artefact must be innovative in solving the identified problem, and it must build upon existing research (Gregor & Hevner, 2013; K. Peffers et al., 2006). This process most closely associated with the design cycle detailed in Section 5.4.1.2.

A search process is by definition a continuous pursuit of relevant knowledge when it is shown that current research does not solve a particular problem (Hevner et al., 2004). This continuous process of evaluation helps to ensure research rigor, as is required by the rigor cycle (Section 5.4.1.3).

Design science is used to produce research artefact. In the case of this study, the produced research artefact is a model for use in implementing open badges in a resource-constrained environment.

5.4.2.4. Demonstration

In the case of this study, demonstration of the produced artefact refers to the presenting of the artefact to expert reviewers for evaluation. Demonstration of the preliminary artefact enabled researchers to see how well it is suited to solving the identified problems and opportunities.

5.4.2.5. Evaluation

Evaluation of the preliminary artefact (seen in Chapter 6) was conducted by expert reviewers, as detailed in Section 5.7.2. The evaluation process helped to determine the effectiveness and efficiency of the produced artefact in solving the research problem. Recommendations made and additional themes and patterns identified by the expert reviewers were incorporated into the design of the final artefact (Chapter 8). This ensured that the design process was iterative, as required by the design research cycle outlined by Hevner et al. (2004). An evaluation of the design science research contribution of this research is presented in the conclusion (Chapter 9) of this thesis, and made use of the design science research contribution framework.

5.4.2.6. Communication

This research has to be communicated to interested parties. This study has done so by documenting its results and conclusions within this thesis.

During the course of this research, two papers were published in international conferences.

The following sub-section examines how the produced model contributes to the domain knowledge base.

5.4.3. Design Science Research Contribution

As mentioned in Section 5.4.1, the contribution of this research falls within the area of exaptation in the context of the design science research contribution framework. This sub-section supports this claim by investigating the current contribution framework and then classifying the solution maturity and application domain maturity of this research.

The design science research contribution framework was proposed by Gregor and Hevner (2013) to enable differentiation between novel and advanced contributions. As they explain, most new research is designed around something else or builds on some previous idea. Gregor and Hevner (2013) have proposed that, by measuring the problem (application domain) maturity and solution maturity, it is possible to classify research contributions, even if nothing new is being created. Figure 5.9 illustrates the design science research contribution framework.

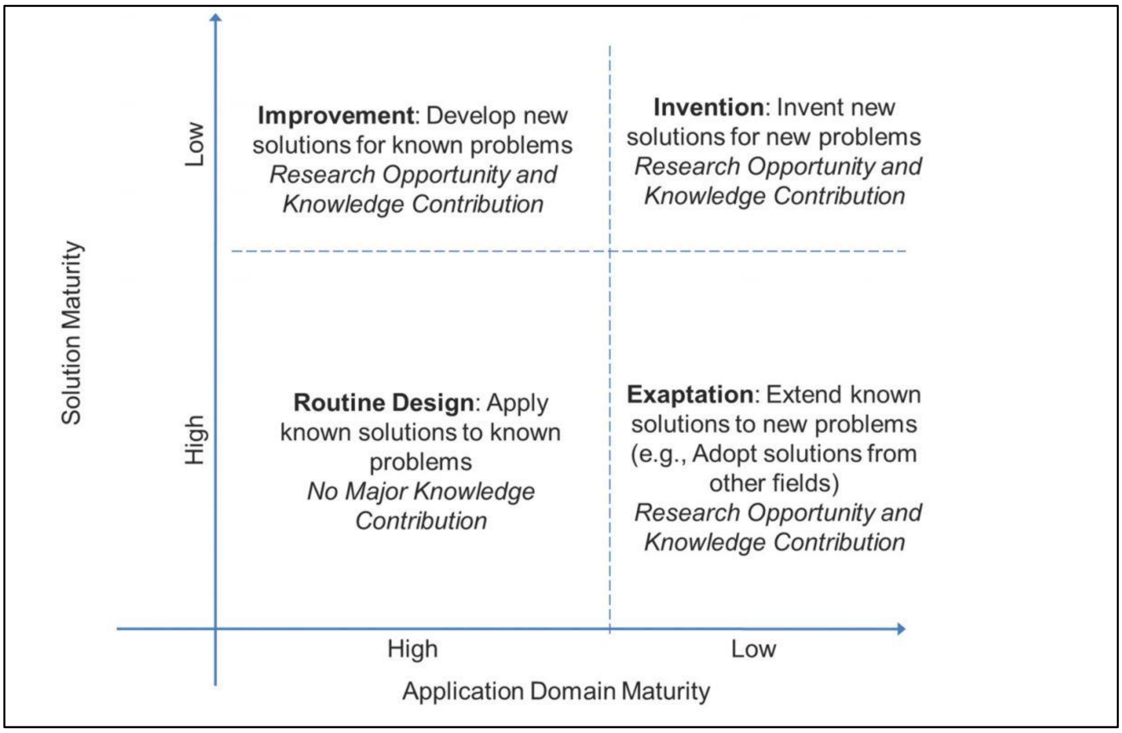


Figure 5.9 – Design Science Research Contribution Framework (Gregor & Hevner, 2013)

Sections 5.4.3.1 – 5.4.3.4 examine the four elements of this contribution framework. After this, this section concludes with reflections on how this research is positioned in the area of exaptation.

5.4.3.1. Invention

Invention is claimed to be the most important area of contribution within the above framework. It requires the production of a new solution that addresses a problem in an application domain that is not yet fully understood or defined. Gregor and Hevner (2013) have used Agrawal and Srikant (1994) landmark presentation of the first conceptualisation of data mining (along with their proposed implementation methods) as an example of such a contribution. As this research makes use of existing technologies, it cannot be seen as an invention.

5.4.3.2. Improvement

For a solution to contribute improvements to existing solutions, they must achieve quantifiable and measurable outcomes that illustrate that the produced artefact is more efficient and effective than the current system.

Such a solution involves a deep understanding of the application domain, meaning that this must be well defined. No current model exists for the implementation of open badges within resource-constrained environments. As such, this research cannot improve on an existing design.

5.4.3.3. Exaptation

In Exaptation research, known design knowledge is used to create a solution where the application domain is not yet well understood or defined. Such solutions are generally based on existing IT artefacts from previous research (frameworks/models/theories/application implementations) that are adapted to address problems unique to a domain.

Research has to be able to demonstrate problems or challenges with the implementation of an existing IT artefact designed outside the problem domain. Only once these challenges have been highlighted can the produced knowledge be thought considered to be nontrivial.

5.4.3.4. Routine Design

When the solution and application domain are both well understood and well defined, routine design takes place. This involves the use of existing artefacts to address known problems, which does not always culminate in a clear contribution to the knowledge domain.

Routine design should not be mistaken for professional/commercial system design.

Using exaptation, this research adapted both the current Mozilla Open Badge standards framework and the 4C framework proposed by Tongia (2005). This was done in order to design a model for use in implementing open badges in a resource-constrained environment (Chapter 8). This research has illustrated how the challenges of constrained environments resulted in the inability to employ current open badge systems such environments (Chapter 3), as was the case with ICT4RED's TPD program (Botha et al., 2014).

The next section of this chapter discusses the qualitative nature of this research.

5.5. Research Method

Examining the onion research model (Figure 5.1) proposed by Saunders et al. (2011), it is observed that research can make use of either qualitative or quantitative methodologies or mix them to varying degrees. However, this study is not concerned with employing multi methods or mixed methodologies, as it is only concerned with qualitative methods.

The interpretive philosophy (Section 5.2), the inductive approach (Section 5.3) and to a degree the data collection and analysis (Section 5.7) are all rooted in qualitative methodology. This research subjectively interprets words and meanings from the literature and expert reviewers to form new theory and knowledge.

5.6. Time Horizon

The time horizon of a research represents the overall timeframe in which a study takes place and how data is gathered over time (Saunders et al., 2011). Saunders et al. (2011) and Trochim (2006) have stated that a study can be either cross-sectional or longitudinal.

- **Longitudinal Studies:** Studies that make observations over a time period, incorporating the effects of time into the gathered data. While Saunders et al. (2011) have stated that longitudinal studies are feasible even if there are time constraints, Trochim (2006) has argued that longitudinal studies rely on many waves of measurement that could become time consuming. Longitudinal studies are usually reserved for researchers that want to measure the change of a phenomenon over a period of time (Ritchie, Lewis, Nicholls, & Ormston, 2013).
- **Cross-sectional Studies:** Studies that examine a particular phenomenon at a specific time. Cross-sectional studies are most frequently used if a time constraint is involved (Saunders et al., 2011). Ritchie et al. (2013) have stated that cross-sectional studies examine change on a macro level, focusing on a generalised context and not individual cases.

This research employs a cross-sectional time horizon, as change over time does not play a role in the solving of the research questions or objectives of this study. The model to enable the implementation of open badge systems within resource-constrained environments addresses a particular problem at a specific time. In line with Ritchie et al. (2013) above statement on the use of cross-sectional studies, this model is aimed at the generalised context of resource-constrained environments and not an individual case. A future study might be able to construct a version of this model that would allow longitudinal studies to measure the success of open badges in resource-constrained environments.

The following section discusses the data collection and analysis techniques used in this thesis, as well as the validation and ethical processes used in this research.

5.7. Techniques and Procedures

This section discusses the data collection techniques and analysis techniques employed in this research.

- The first sub-section examines how data is collected from expert reviewers as a primary source of data and from literature as a secondary source of data.
- The second sub-section discusses how the grounded theory was used to analyse the data collected.
- The section concludes by highlighting any ethical considerations.

5.7.1. Data Collection Techniques

Phenomena are examined by gathering and analysing relevant and credible data (O'Leary, 2004). Kothari (2004) has stated that data is either primary (if new and produced in the process of the study) or secondary (if the data has been recorded and interpreted by previous research). Kothari (2004) has also stated that methods used to collect data differ depending on whether the data is primary or secondary. The collection of secondary data is achieved by compiling works that contain data that has previously been collected and analysed. Therefore, the literature review of this study is composed of secondary data. The selection of secondary data is discussed in Section 5.7.1.2.

Kothari (2004), O'Leary (2004), and Saunders et al. (2011) have identified the following common primary data gathering techniques: interviewing, observation, and questionnaires. These techniques are summarised below and are followed by a discussion of why the questionnaire is the best-suited to this research.

- **Interviews:** This refers to the presenting oral-verbal open-ended questions with the expectation of receiving oral-verbal responses (Kothari, 2004; O'Leary, 2004). O'Leary (2004) and Saunders et al. (2011) have stated that there are three prevalent types of interviews: structured, semi-structured, and unstructured. The more structured an interview is, the more quantitative its expected result will be. Conversely, the more unstructured an interview is, the more its results can be expected to be qualitative (Saunders et al., 2011). Interviews used in qualitative studies are less structured (thus containing open-ended questions) and are well suited to exploratory studies where there is a need to refine the research context or research questions (Kothari, 2004; Saunders et al., 2011).

- **Observations:** This technique is based on researchers actively watching or noticing certain factors, thus gathering data through their senses (O'Leary, 2004). Kothari (2004) has stated that observational methods are commonly used in behavioural studies, as their advantages include their ability to eliminate subjective biases, their capacity to extract data from the subject regardless of subject willingness, and their relevancy at the time of the observation. Observational studies are ideal in examinations of phenomena within which subjects might have a defensive nature that makes it difficult to otherwise extract data (Saunders et al., 2011).
- **Questionnaires**: This refers to gathering information from a range of individuals by eliciting responses to a set of the same questions (O'Leary, 2004; Saunders et al., 2011). Saunders et al. (2011) have argued that, as with interviews, questionnaires can be classified as both quantitative and qualitative, depending on how open-ended the questions are. The more open-ended the questions, the more qualitative the results gathered tend to be. O'Leary (2004) has stated that questionnaires are effective in descriptive and exploratory studies when attempting to analyse relationships, correlations, and cause and effect.

The research questions of this study fall into the domain of exploratory studies, as all the research questions are designed to explore relationships between different phenomena and their context of use. Examining the above points, it can be concluded that both interviews and questionnaires would be usable in this study. However, a qualitative questionnaire is the best option due to its suitability to exploring relationships. The implementation of a qualitative questionnaire is discussed in the next section.

5.7.1.1. Primary Data: A Qualitative Questionnaire in the Form of an Expert Review

Design science research requires the implementation of a rigorous design process (Section 5.4.1.3) that effectively produces IT artefacts that solve the identified research problem (Hevner et al., 2004).

The IT artefact produced in this study is a model for use in implementing open badges in resource-constrained environments. A conceptual model has been constructed by identifying patterns within the secondary data derived from the literature review (Chapters 2, 3, and 4).

Jones and Gregor (2007) have emphasised the mutability of artefacts produced by design science research. To ensure the research rigor required by the design science research strategy, this conceptual model was presented to expert reviewers along with an open-ended questionnaire. The questionnaire was designed to help verify and validate the patterns derived from the secondary data, as well as to possibly identify new relationships between elements.

Kantner and Rosenbaum (1997) have justified the use of two to three expect reviewers to evaluate a model, as they would be able to identify the majority of the issues. While these same authors concede that additional experts could result in a higher number of identified issues, the resultant costs in time and resources would outweigh this benefit. By implementing purposeful sampling in the selection of participants as described by Coyne (1997), this study made use of four expert reviewers. These four were selected on the basis that they had relevant experience and knowledge in the areas of education, open badges, and ICT4D initiatives.

Utilising March and Smith (1995) evaluation criteria for design science research, the produced model is evaluated in terms of the following factors:

- **Fidelity to real-world problems** – How faithful the model is in addressing the identified research problem;
- **Completeness** – The design theory and elements have to be completely described to ensure internal consistency;

- **Level of detail** – Referring to the level of detail of elements and their relationships relative to the purpose and scope of the research;
- **Robustness** – The applicability of the model over a broad spectrum of scopes and purposes;
- **Internal Consistency** – Both theory from literature, and the usage of elements in the literature, have to be consistent with their use and definitions.

The above criteria are examined in greater detail in Chapter 7 when discussing the findings of the expert reviewers.

The questionnaire was designed to gather opinions and feedback from the interviewed experts as to how the model measured against the above criteria. As previously mentioned, an evaluation form containing a brief overview of the conceptual model and a summary of the various elements' characteristics and interrelationships were included with the questionnaire. The questionnaire required expert reviewers to examine this evaluation form before addressing the questions. The questionnaire was open-ended in nature, which was designed to allow for the production of high-quality qualitative data. The questionnaire also employed a rating scale for every evaluation criteria, ranging from 0-5. This enables quantifiable measurement of how well the model performed in a specific area. Copies of the questionnaire and the evaluation form can be found in appendices A and B, respectively.

5.7.1.2. Secondary Data: Literature Review

O'Leary (2004) has stated that in order to produce new knowledge, old knowledge must be incorporated into a study. In this study, secondary data was collected and analysed in the literature review found in Chapters 2, 3 and 4. The gathered literature was related to the topics of alternate assessment, the Mozilla Open Badge Standards framework, and ICT4D initiatives within resource-constrained environments. The following considerations, identified by Kothari (2004), were used to evaluate the selection of secondary data.

- **Reliability** – Data was primarily collected from peer-reviewed journals and books. If secondary data was gathered from websites, it was ensured that the website was up to date, relevant to the topics concerned, and professionally trusted (thus not a non-academic blog, a widely-disputed site, or a site that is identifiably biased).

- **Sustainability** – Only data related to this study's aim to answer its research questions was gathered. It was attempted to only use, analyse, or critique data in its original context. Data was thus not compared to non-relevant topics, and the scope, objective, and nature of the original source was taken into account.
- **Adequacy** – Secondary data was only considered if it was considered to be recent within its field. Journal entries in the field of information sciences and statistical data gathering were only considered if they were less than five years old. Books and historical documents were used if they were considered relevant by a substantial number of other researchers (cited by many academic papers) or if they remained the accepted and unchallenged norm.

The following section discusses the data analysis techniques used in this study with regards to the data collected.

5.7.2. Data Analysis Techniques

The objective of data analysis is the transformation of raw data into knowledge and meaning that address research questions (Kothari, 2004; O'Leary, 2004). Qualitative data is transformed by uncovering prevalent themes, relationships, and patterns within it (O'Leary, 2004).

Goldkuhl (2004) has proposed the use of grounded theory methods to evaluate the effectiveness of design science research solutions. Grounded theory relies on comparisons being made between primary data sources, such as questionnaires, and secondary literature such literature to reach higher levels of abstraction and advance conceptualisation (Gregory, 2011). This research employs Goldkuhl (2004) method of integrating grounded theory analysis within a design science strategy, as depicted in Figure 5.10.

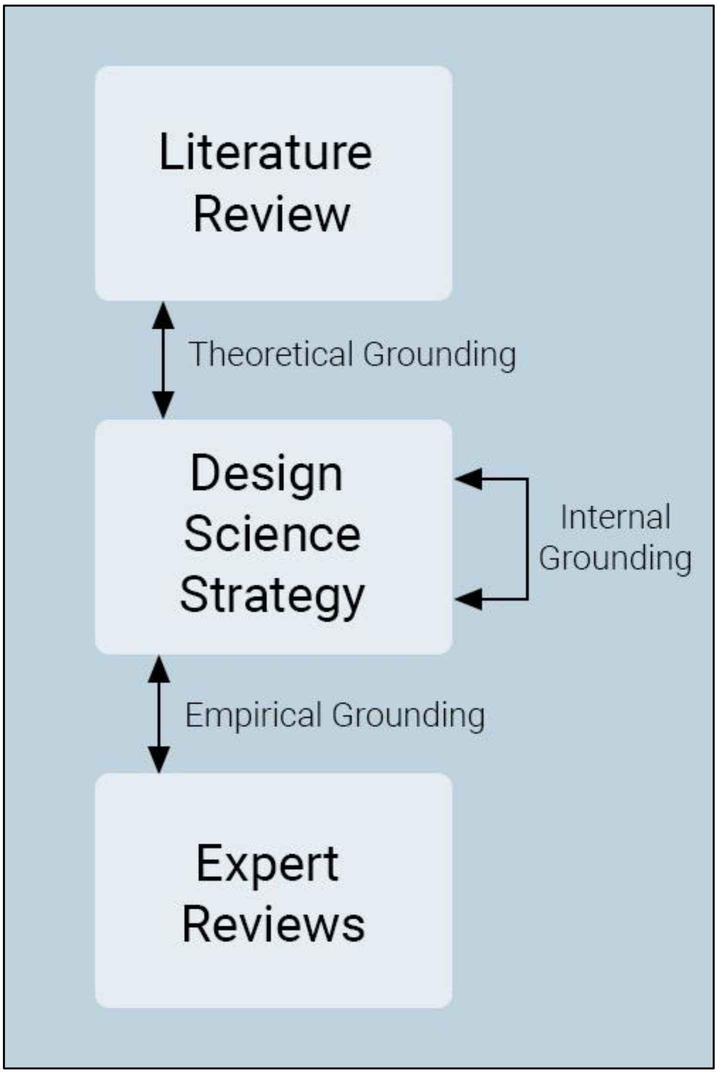


Figure 5.10 – Grounded Theory in Relation to Design Science Research, Adapted from Goldkuhl (2004)

Examining Figure 5.10, it is visible that three types of grounding are integrated into this study: theoretical grounding, internal grounding, and empirical grounding; which will now be examined as defined by Goldkuhl (2004).

- **Theoretical grounding** – This is external knowledge used in guiding practical knowledge-and-design decisions throughout the design science process. This could be themes, patterns, and relationships derived from the literature review.
- **Internal grounding** – The expert reviews and the literature reinforce the knowledge contribution of this research. The cohesion of knowledge produced by identifying themes and concepts from expert reviews and literature must demonstrate a clear and logical sequence in addressing the research question.

- **Empirical grounding** – This is the determination of whether the solution was effective and whether the research questions have been adequately addressed. The practical knowledge or solution (the model) is evaluated, producing empirical data.

Grounded theory makes use of coding, which is a technique that examines data by identifying prevalent themes, patterns, and relationships within research (Saunders et al., 2011). This study has made use of coding in both the literature review and the expert reviews. In accordance with Thomas (2006), coding was used for the following purposes:

- Condensing long data into summaries, which would pertain to the literature gathered as well as the expert reviews;
- Establishing links between objects and summarised data that is clear, transparent, and defensible;
- Developing a model from the data gathered, which would be the IT artefact produced by this study.

Firstly, theoretical data was gathered based on the topics of alternative assessment, the Mozilla Open Badge standards framework, and ICT4D initiatives within resource-constrained environments. Themes and patterns identified in this literature were used in the construction of a conceptual model for implementing open badge systems within resource-constrained environments. This conceptual model was then reviewed by experts in the relevant fields, as described in Section 5.7.1.1. The data that was gathered from these reviews was then also analysed in order to determine whether the themes, patterns, and relationships presented in the conceptual model were valid and effective in addressing the research questions of this study. After the literature review and expert reviews had been coded, a final model was constructed, as detailed in Chapter 8.

5.7.3. Ethics

Data was gathered in part from human subjects participating in this study. As such, a number of ethical considerations had to be addressed in order for the research to be thought of as valid and ethically sound.

In this regard, it is imperative that participants were not misled or abused in this study. No information of participants used in the construction of the research artefact was or will be disclosed, as agreed with the Council for Scientific and Industrial Research (CSIR). The raw primary data gathered will not be disclosed to anyone not directly involved with the research or analysis of the data. Participants were allowed to withdraw from the research at any point. Moreover, unless participants allowed the use of their data, their participation data was withdrawn from the overall results of the study. Final ethical clearance was sought from Monash University.

Under project number MUHREC-0314, this research was granted ethical clearance by the Monash University Human Research Ethics Committee. Any concerns or complaints about the conduct of the research should be raised with them.

A total of four participants were acquired for this research. The four expert reviewers were selected based on their relevant knowledge, experience, and qualifications in the fields of alternate assessment, open badges, and ICT4D initiatives. The data collected by these expert reviewers pertains to the validity and effectiveness of the conceptual model in implementing open badges in a resource-constrained environment. The information gathered from these experts was used to further refine the IT artefact. This was done to ensure that the design process was iterative in nature and conformed to the requirements of the design science strategy detailed in Section 5.4.1.3.

Data will be stored on a secure Google Drive for a duration of 5 years after the completion of the study. Only authorised persons (as described above) will be allowed access to the data.

5.8. Summary

This chapter has discussed the research methodology design of this study. It was shown that this research used Saunders et al. (2011) onion research model to explain and guide its choice of research philosophy, approach, strategy, method, time horizon, and techniques and procedures.

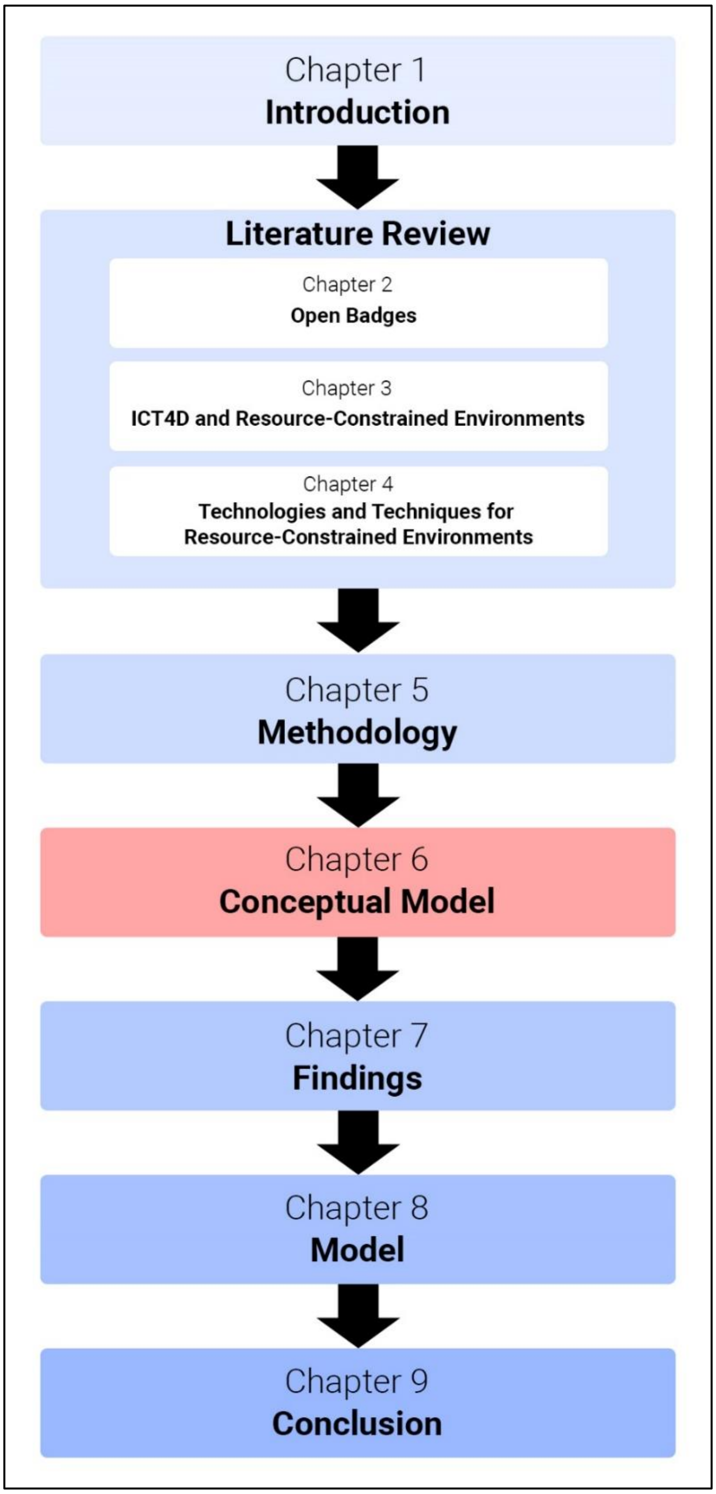
In summary, this research utilises:

- An interpretivist philosophy with an inductive research approach.
- The IT artefact to solve the research questions and objectives was constructed by implementing a design science research strategy.
- Qualitative data was gathered using a cross-sectional time horizon.
- Data was gathered through a literature review and expert reviews of the conceptual model.
- This data was analysed by employing the grounded theory methods of coding and pattern analysis.

The next chapter details the conceptual model that was produced from addressing the sub-research questions in the literature review chapters.

Chapter 6

Conceptual Model for Implementing Open Badges in a Recourse-Constrained Environment



6.1. Introduction

This chapter outlines the conceptual model that was presented to expert reviewers as described in the previous chapter. This model was constructed using knowledge and insights from research into prior literature and IT artefacts. This chapter employed the sub-research questions as discussed and addressed in the literature review chapters (Chapters 2, 3, and 4) to help identify elements to implement open badges in a resource constrained environment.

Gregor and Hevner (2013) express how a model is a representation of a problem and a possible solution; expressing elements and their relationships given a specific context. In this chapter, it will not be discussed how these elements and their relationships could be implemented on a more technical and detailed level; this was done in an attempt to preserve the mutability of models constructed using a design science research methodology (Jones & Gregor, 2007).

Having said that, there will be a more detailed overview on possible strategies for implementation, however that will only be discussed in Chapter 8 when the final model is presented.

This chapter serves as an explanatory segment on how the elements were identified in literature and then implemented in the construction of a conceptual model. This is the model that was sent to experts in the domains of: ICT4D, open badges and ICT educational initiatives. These experts critiqued the conceptual model and suggested improvements, which is detailed in the next chapter discussing findings.

The structure of the conceptual model in this chapter follows Tongia (2005)'s 4 areas of development: Capacity, computers, connectivity and content; also known as the 4C framework. It was felt that separating the model into sections to mirror the 4C framework would help highlight how the technologies and techniques identified (Chapter 4) could be utilised as solutions to overcome the challenges of resource-constrained environments discussed in Chapter 3.

This conceptual model aims to address issues and challenges which inhibit the use of open badges within resource-constrained environments. As discussed within the introduction chapter and then later in the methodology chapter, each of the literature review chapters focused on identifying different elements that would be required to construct the objective model of this research. Before the model is presented, and to aid in creating a well-defined context, the elements which were identified from literature are summarised in section 6.5.

While the elements present in the conceptual model were only summarised in this chapter; these elements will be expanded upon, detailing their characteristics and relationships, when encountered in Chapter 8.

The next section of this chapter serves as the first section analysing the elements identified from literature.

6.2. Identification of Elements Pertaining to Open Badges

In Chapter 2 of this thesis, the various components of an open badge were discussed within the Mozilla open standards framework. These components consequently require various elements to be present to allow for a badging process. The model produced by this research was constructed with the goal of enabling modular skill-based assessment in a manner similar to the existing Mozilla Open Badge systems.

In conceptualising elements for this model, elements identified from the Mozilla Open Badges process were used as a base. Referencing Chapter 2 of this thesis, the following elements were identified, as shown in figure 6.1.

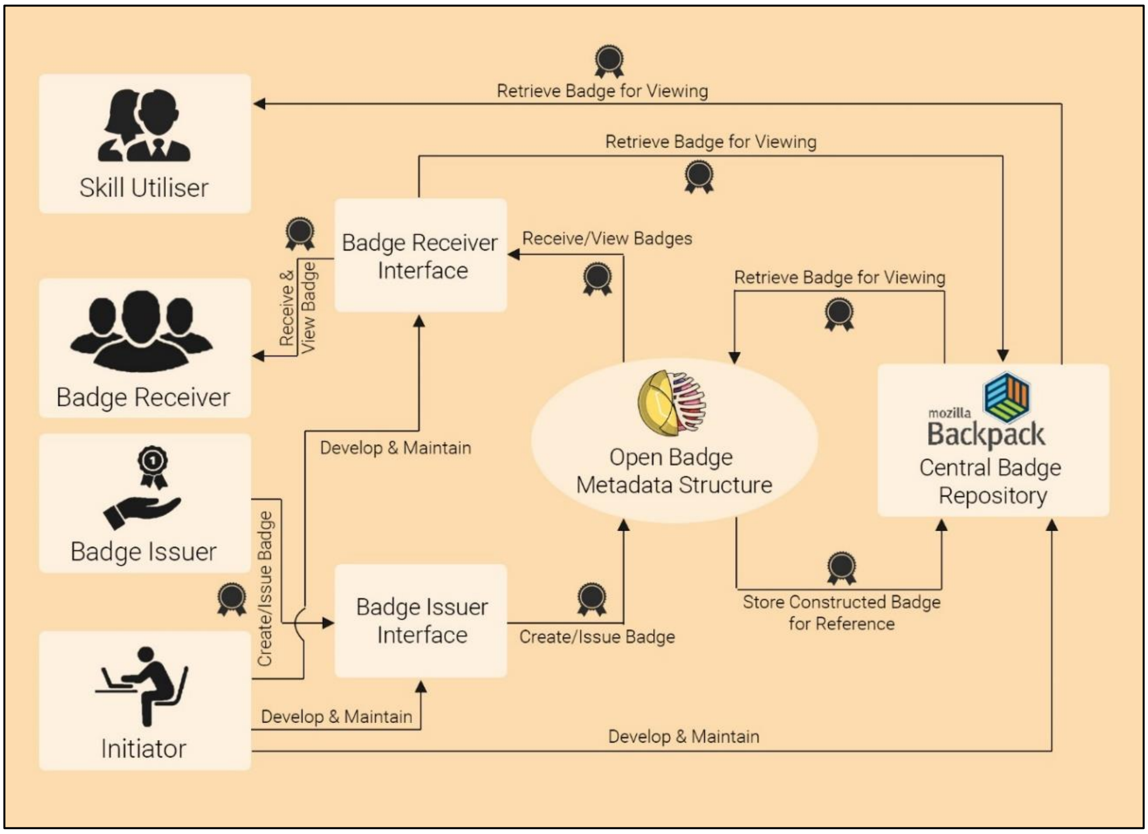


Figure 6.1 – The Mozilla Open Badge Process Adapted from Mozilla-About-Wiki (2017)

The elements of the Mozilla badge process model above is only briefly summarised as they were examined in detail within the second chapter:

- **Badge:** A digital representation of skill in the form of an image. This image is constructed using a standard set of metadata. When the badge is awarded to an individual, metadata is added to the badge as evidence to certify that the user has mastered the basics of that skill.
- **Issuer:** The issuer is someone who is able to create and issue open badges to individuals who can receive these badges.
- **Receiver:** An individual who can receive open badges by demonstrating adequate competency in a skill.
- **Utiliser:** The institutions, individuals or organisations that will accept and make use of the individuals who have earned badges. As long as the entity in question relies upon an individual's badge as a form of accreditation and competency in skill, they can be considered as utilisers.

- **Initiator:** Initiators are the individuals who create and maintain an open badge system/initiative. Additionally, as discussed in Chapter 3, initiators would generally have to be highly skilled individuals to perform their duties.
- **A Central Badge Storage (Backpack):** A storage repository for the received badges of individuals. Each individual has their own instance of a badge Backpack, which displays only their earned badges. Individuals should also be able to search for information on badges that exist, but that they have not yet earned.

The above elements had to then be modified and augmented to accommodate the challenges presented by resource-constrained environments. The next sub-section will examine these challenges identified in Chapter 3 of this research.

6.3. Challenges of Resource-Constrained Environments on ICT4D Initiatives Attempting to Implement Open Badges

Previously within literature (Chapter 3, section 3.3), it was demonstrated how the design and development of ICT4D initiatives have to reflect a multitude of ICT adoption factors, else they could result in an unsuccessful endeavour.

To aid in the development of successful ICT4D initiatives, Tongia (2005) proposes a 4C framework which separates the areas of development and allows for the addressing of resource-constraint challenges in a focused and delineated manner.

This section summarises challenges found within resource-constrained environments, and examines how these challenges impact the elements of the Mozilla badge process detailed in the previous section.

Chapter 3 already examined and detailed the various challenges that ICT4D initiatives face within a resource-constrained environment, so these challenges are only briefly summarised in relation to how they shape development in their respective areas:

6.3.1. Computers

Due to the lack of cheap and reliable Internet connectivity, as well as a steady supply of electricity, a majority of ICT devices are left in a non-functional or non-optimal state.

The issue of connectivity is addressed in the next sub-section discussing how technological innovation can overcome such challenges. However, the model produced by this research cannot address issues concerning electrical supply. In this research's model, it is suggested that mobile ICT devices are used as they are not affected as severely as fixed ICT devices.

Open badge systems could be designed for either mobile or fixed ICT devices, the only difference would be in the content delivery design (discussed in Chapter 4, section 4.4).

6.3.2. Connectivity

As stated in the above point, resource-constrained environments are defined by their lack of reliable internet connectivity. This is not to say that these areas are permanently devoid of all internet connectivity, especially during the course of an ICT4D project.

The issues arise with providing an affordable, sustainable and maintainable internet connection. Whilst designing this model, deliberation was given to the possibility that internet connectivity might become present at a later stage of a project, in which case the open badge process would directly mirror that of the existing Mozilla badge process.

The model proposed by this research contributes to this area of development by ensuring that the functionality of a produced system is not reliant on an internet connection.

6.3.3. Capacity

Examining the capacity of individuals located within resource-constrained environments (Chapter 3, section 3.4.2), it was noted that there could potentially be issues with ICT-confidence and English literacy. This should directly influence any design decisions for delivering and presenting content. Current Mozilla Open Badge systems often exclude considerations in this area, and are thus not suitable to be deployed in these environments without content modifications.

6.3.4. Content

Continuing with the above-mentioned points for designing with individual capacity in mind, the content produced for an ICT4D initiative must be tailored to overcome the capacity challenges of users, otherwise it faces the possibility of being deemed inaccessible. This model proposes specialised user interfaces, designed according to HCI and the user interface principles examined in chapter four.

The subsequent section discusses techniques and technologies that were selected to aid in overcoming the above-presented challenges.

6.4. Technologies and Techniques to Address Challenges of Resource-Constrained Environments

The adaption and use of existing technologies and techniques is critical not only in addressing the third sub-research question, but also in ensuring that this research adheres to the rigour cycle as proposed by Hevner et al. (2004).

Due to the overlapping resource-constrained challenges experienced in capacity and content, as well as with computers and connectivity, these sections were combined in chapter four. The same approach is used when summarising the selected technologies and techniques this conceptual model implemented. This approach also emphasises how relationships between entities often cross between various areas of the 4C framework as indicated in the following section when presenting the conceptual model.

6.4.1. Computers and Connectivity

As discussed in Chapter 3 and the previous sub-section, various connectivity issues inhibit the effective use of ICT devices within resource-constrained environments. When designing the conceptual model, technologies and techniques that emulate a connected environment were researched in order to help maintain a standard user experience regardless of the current environment.

To emulate the functionality of a connected Mozilla badge process, the receiver, issuer and utiliser must be able to continue with their expected tasks and not notice a change in system functionality. Utilising a mesh network between devices, and implementing a personal database on each ICT device, it is possible to create an asynchronous internet network. Each of the ICT devices which contain either a badge receiving or issuing application should be able to communicate with one another to allow the issuing or sharing of badges.

A personal database should then attempt to sync data with other connected devices if newly created badges are added to the program, or if a badge has already been issued to a user. This ensures that when new information is downloaded or added to one of the devices, it would eventually spread to other devices.

On a technical level this a highly complex process and depends on the implementation of various protocols which regulate the syncing of data and the communication between devices. This is discussed in more detail in Chapter 8.

6.4.2. Capacity and Content

Individuals located in resource-constrained environments face an uphill battle when learning to use ICT devices. To aid in the acceptance and usage of ICTs amongst these individuals, it was decided to examine HCI principals and user experience guidelines. Simplifying the application interaction process by designing an understandable and easy-to-use interface was deemed paramount for the acceptance of ICTs (Devezas et al., 2014).

Several frameworks suitable for this task were analysed in Chapter 4, however they are not discussed in detail concerning the level of their implementation so as to avoid removing abstraction from the artefact solution

For this chapter, it is important to point out that, due to the potential differences in usage and understanding of ICT between issuers and receivers of a badge system, it was considered more scrupulous for the conceptual model to implement a minimum of two different application interfaces.

The next section demonstrates the conceptual model which was presented to expert reviewers.

6.5. The Conceptual Model

Through the use of the literature presented in chapters 2,3 and 4; the previous sub-sections discussed elements of the Mozilla badge process, the challenges of resource-constrained environments, and the technologies and techniques that help overcome these challenges. In addressing the sub-research questions of this research, the following conceptual model (figure 6.2) is offered as a possible solution to the primary research question.

This conceptual model was sent to expert reviewers where it was critiqued and evaluated to ensure that the primary research question was adequately addressed. Any changes suggested by these experts will only be shown in the final model (Chapter 8), and thus this conceptual model reflects the demonstration stage of the design science research process (Chapter 5, section 5.4.1) of K. Peffers et al. (2006).

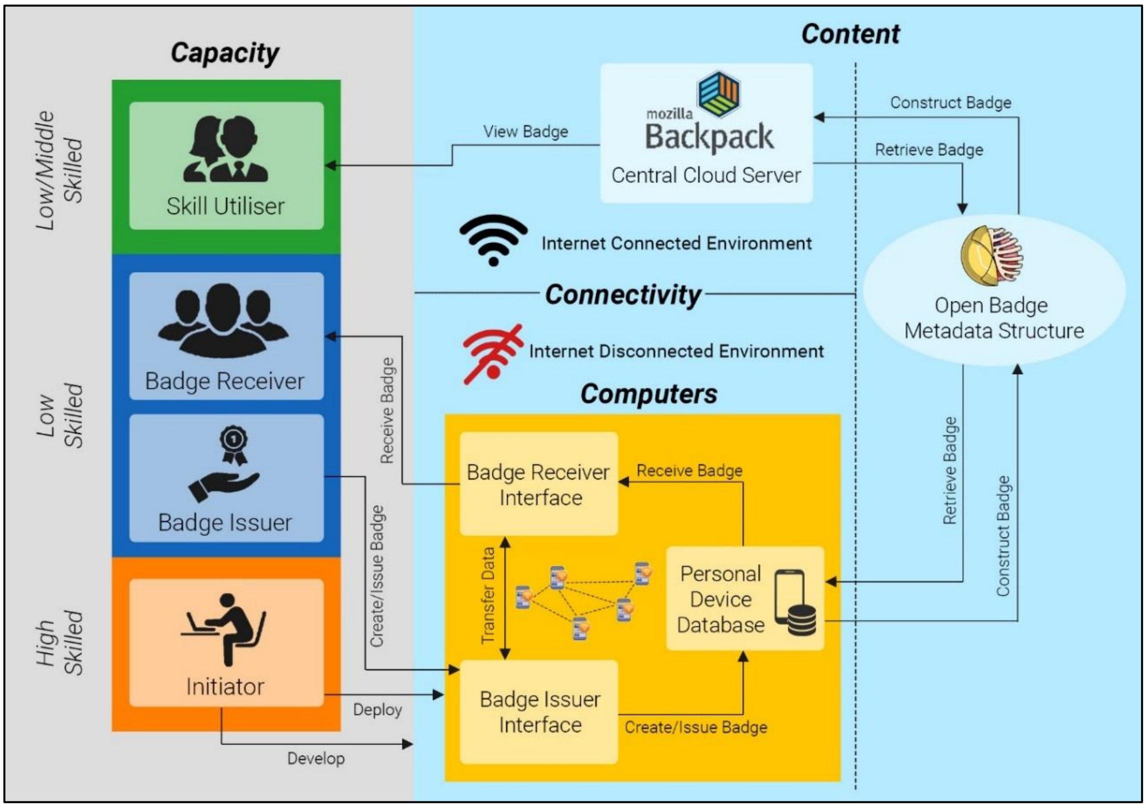


Figure 6.2 – The Conceptual Model for Implementing Open Badges in a Resource-Constrained Environment

As discussed earlier in the introduction of this chapter, this conceptual model adopted the 4C framework when identifying and addressing challenges of resource-constrained environments. The model is thus divided into four distinct areas, and while each area contains its own elements, there are multiple relationships between elements which can cross over into different areas. These relationships accentuate the model's internal consistency, as it is designed to be implemented en masse. While it may be possible for future research to add to this model, the current conceptual model is considered minimal in its current form, and cannot function with the subtraction of any of the elements detailed so far in this section.

Starting with the area of capacity, each of the elements' characteristics and relationships are presented in point-form summary.

6.5.1. Capacity

Examining the conceptual model presented at the start of this section, it can be observed that the area of capacity contains four user-role elements. These elements represent different user types which will interact with an open badge system.

To aid in emphasising some expected interactions, as well as some design decisions that need to be kept in mind, these elements have been further divided into three areas of potential skill level. These areas of skill level are only concerned with ICT and English literacy skills and should not be interpreted in any other context. Additionally, these classifications are only generally accurate at the start of ICT4D initiatives, as it is hoped that individuals gain more competencies and become more skilled in the concerned areas.

Table 6.1. below summarises the various characteristics and relationships of each of the capacity-area elements.

Element	Characteristics and Relationships
Skill Utilisers	• Any organisation or entity interested in utilising the skills earned by badge receivers. • May be situated within a resource-constrained environment. • Has the possibility to be non-ICT confident. • Has the possibility to possess low levels of English literacy. • May possess unique social and cultural values. • Has to determine the authenticity of the issuer and the validity of the skill accreditation. • Can view the badges online by accessing the central badge repository. • Can view the badges offline by being handed the ICT device where the badge is contained.
Badge Receivers	• Receives badges for demonstrating an aptitude in a skill from a badge issuer. • Situated within a resource-constrained environment. • High possibility to be non-ICT confident. • May possibly possess low levels of English literacy. • May possess unique social and cultural values. • Interacts with the badge receiver interface. • Can view all earned badges on the badge receiver interface. • Can view badges that can possibly be earned on the badge receiver interface.
Badge Issuers	• Issues badges for demonstrating an aptitude in a skill to badge receivers. • Is situated within a resource-constrained environment. • Possibility to be non-ICT confident. • Possibility to possess low levels of English literacy.

	• Interacts with the badge issuer interface. • Should be able to view all badges earned by a particular receiver, and not be able to re-issue an already unlocked badge. • Should be able to view all unearned badges of a badge receiver. • Could possibly create new badges for issuing.
Initiators	• Initiators of an ICT4D initiative. • Possess high levels of technical expertise in order to develop, deploy and maintain the various elements of the badging system. • Possess enough resources to successfully administer the ICT4D initiative. • Is most likely not situated within a resource-constrained environment, but rather aims to improve conditions in these environments. • Would have to develop and maintain the badge receiver/issuer applications • Would have to incorporate the open badge metadata structure and API into the design of the badging system. • Deploys and administers the required ICT devices.

Table 6.1 – Summary of the Characteristics and Relationships of the Elements Regarding Capacity

The next sub-section examines the elements within the area of computers.

6.5.2. Computers

As mentioned throughout various sections of this thesis (Chapter 3, section 3.4.4; Chapter 4, section 4.2; and Chapter 6, section 6.3), this model focuses on providing a solution for mobile ICT devices over that of fixed ICT devices. This decision was partially based on the current popularity of mobile devices used in ICT4D initiatives (discussed in section 3.4.4), and partly on the lack of HCI development guidelines developed for mobile interfaces. It was assumed that it would be easier to adapt the final model produced by this research to suite fixed ICT device interfaces as opposed to the reverse.

This section summarises the various interfaces that are suggested to be implemented, as well as the personal device database which is required to be present on every device to capture badge information locally.

As mentioned in section 6.4 and reflected upon during the previous section, due to the potential difference in badge receivers compared to that of badge issuers, it was decided that there is a need for separate interfaces to better address specific user-role challenges. These elements are summarised in table 6.2.

Element	Characteristics and Relationships
Badge Receiving Interface	• Designed with HCI4D and mobile HCI guidelines to address challenges presented by badge-receiving users with regards to low levels of ICT confidence. • Fully functional without Internet connectivity. • Notifies badge receiver of new badges they have been awarded. • Enables the Badge Receiver to view details of previous badges they have earned. • Enables the Badge Receiver to view details on badges they could potentially earn. • Utilises a personal devices database to retrieve details on previously received badges. • Utilises a personal device database to store metadata of badges that are awarded. • When a badge is being issued to the badge-receiving application, it must be able to connect to the correct issuer application via a mobile mesh network. • The application must periodically connect to other badge-receiver and badge-issuer applications in order to update the data of the personal device database.
Badge Issuing Interface	• Designed with HCI4D and mobile HCI guidelines to address challenges presented by badge-receiving users with regards to low levels of ICT confidence. • Fully functional without Internet connectivity. • Enables the badge issuer to view details on past badges they have issued. • Enables the badge issuer to view details on badges they could still issue. • Set up to interact with other mobile ICT devices over a mobile mesh network • Utilises the personal device database to view details on issued badges from that device. • Utilises the personal device database to view badges that can be issued. • When creating new badges, it stores new badge information on the personal device database. • When issuing a badge, the application updates the relevant badge information with new evidence and metadata on the personal device database, and then transfers the updated data to the relevant badge receiver interface via the mobile mesh network. • The application must periodically connect to other badge-receiver and badge-issuer applications in order to update the data of the personal device database.
Personal Device Database	• Is deployed on a mobile ICT device along with the badge-issuer interface or badge-receiver interface. • Is only accessible directly by the initiators. • Enables asynchronous internet connections by storing data until it can be sent over an internet connection. • Contains a constantly updating record of all badges earned or unearned, who issued them, and who received them. • This data is shared between all devices via a mobile mesh network. • If there is a steady internet connection available, a personal device database will attempt to sync data from the central badge repository of the ICT4D initiative.

Table 6.2 – Summary of the Characteristics and Relationships of the Elements Regarding Computers

The next sub-section examines the content area of the conceptual model.

6.5.3. Content

The content area of the conceptual model includes every element apart from the user elements (badge receiver, badge issuer, skill utiliser and initiator). This is because the content of an open badge system would involve all digital services related to the badging process including: 1.) the applications and their respective interfaces, 2.) the usage of the open badge metadata structure to create credible badges, and 3.) the implementation of a central badge repository which houses all of an initiative's badges.

Table 6.3, summarises only the open badge metadata structure and the Mozilla Backpack elements, as all the other elements have already been discussed in the previous sub-sections.

Element	Characteristics and Relationships
Open Badge Metadata Structure	• A requirement of the Mozilla Open Badge standard framework. • Requires the implementation of the Mozilla Open Badge API to conform to the Mozilla Open Badge infrastructure. • Composed of badge name, description, criteria, issuer, evidence, date issued, standards and tags. • Ensures badges can be authenticated by skill utilisers by requiring evidence to be presented when badges are issued. • Metadata cannot be removed.
Mozilla Backpack on Central Cloud Server	• Deployed and maintained by the initiators. • Stores all badges created during the course of the ICT4D initiative. • Enables badge receivers to still receive and collect badges in the central repository regardless of whether the issuer is located outside of the ICT4D initiative. • Allows badge receiver to benefit from already-established features of the Mozilla Backpack such as exhibiting earned badges on social media. • When Internet connectivity is available, the server sends new badge data to any ICT device that is connected, thus enabling that ICT device to synchronise with the ICT devices around it later.

Table 6.3 – Summary of the Characteristics and Relationships of the Elements Regarding Computers

6.5.4. Connectivity

The connectivity area of the conceptual model does not contain its own unique elements. As such, all the elements have been presented in the previous areas of the 4C framework.

To emphasise that some elements such as a central badge repository can only function optimally in a connected environment, connectivity is indicated as a dividing line between elements.

It is important to note that internet disconnectivity is just one of the characteristics of a resource-constrained environment, and the dividing line separating these states of connectivity in the model does not imply that one side of the model is designed for a different resource environment.

The model is designed to enable the implementation of open badges in a resource-constrained environment, and the design decision to include a connected environment was made to ensure that the solution is scalable enough that there exists the possibility that open badges can be transferred into an existing Mozilla badging system.

The connected and disconnected internet environment is discussed alongside the other model elements in Chapter 8. This chapter now concludes with a summary of what was discussed.

6.6. Summary

This chapter has presented an overview of the conceptual model and summarised the various elements put forth by this research to address the primary research question. The elements are better detailed in Chapter 8, and they were only mentioned in brief in this chapter to avoid reiterating the same arguments concerning design.

This model was constructed from elements identified during the course of addressing the sub-research questions. Section 6.2-6.4 was concerned with examining the results of each of the literature review chapters to help summarise and argue the conclusions that were made in this regard.

Table 6.5 presents a summary of the findings from research related to each research question used to construct the conceptual model.

Sub-Research Question	Findings from Research
Chapter 2 – Sub-Research Question 1 What are the elements of open badges that are critical to their functionality within the open badge standard framework?	• Badge • Issuer • Receiver • Utiliser • Initiator • A central badge storage (Backpack)
Chapter 3 – Sub-Research Question 2 How do resource-constrained environments impact the functionality of ICT4D with regards to the context of connectivity, content, capacity and computers?	**Computers:** • Lack of reliable internet connectivity • Lack of a steady supply of electricity • ICT4D shows preference to mobile ICT **Connectivity:** • Lack of reliable internet connectivity. **Capacity:** • Potentially low levels of ICT confidence. • Potentially low levels of English literacy. **Content:** • Designing with individual capacity in mind. • Must examine an individual's social and cultural understanding. • Requires specialised interfaces to aid in user acceptance.
Chapter 4 – Sub-Research Question 3 What current knowledge can be adapted and utilised to ensure the functionality of open badges within resource-constrained environments?	**Computers and Connectivity:** • Utilising a mesh network between devices to enable device communication. • Implementing a personal database on each ICT device to store information so that it does not have to be retrieved from outside sources when needed. • Synchronising the personal device database between devices on the mesh network would enable content to be up to date. **Capacity and Content:** • Implement HCI4D guidelines to design a simplified application interaction process. • Utilising mobile HCI heuristics to ensure content is delivered in an understandable and easy-to-use interface. • Addressing an individual's needs by comparing their social and cultural values against that of the intended system design.

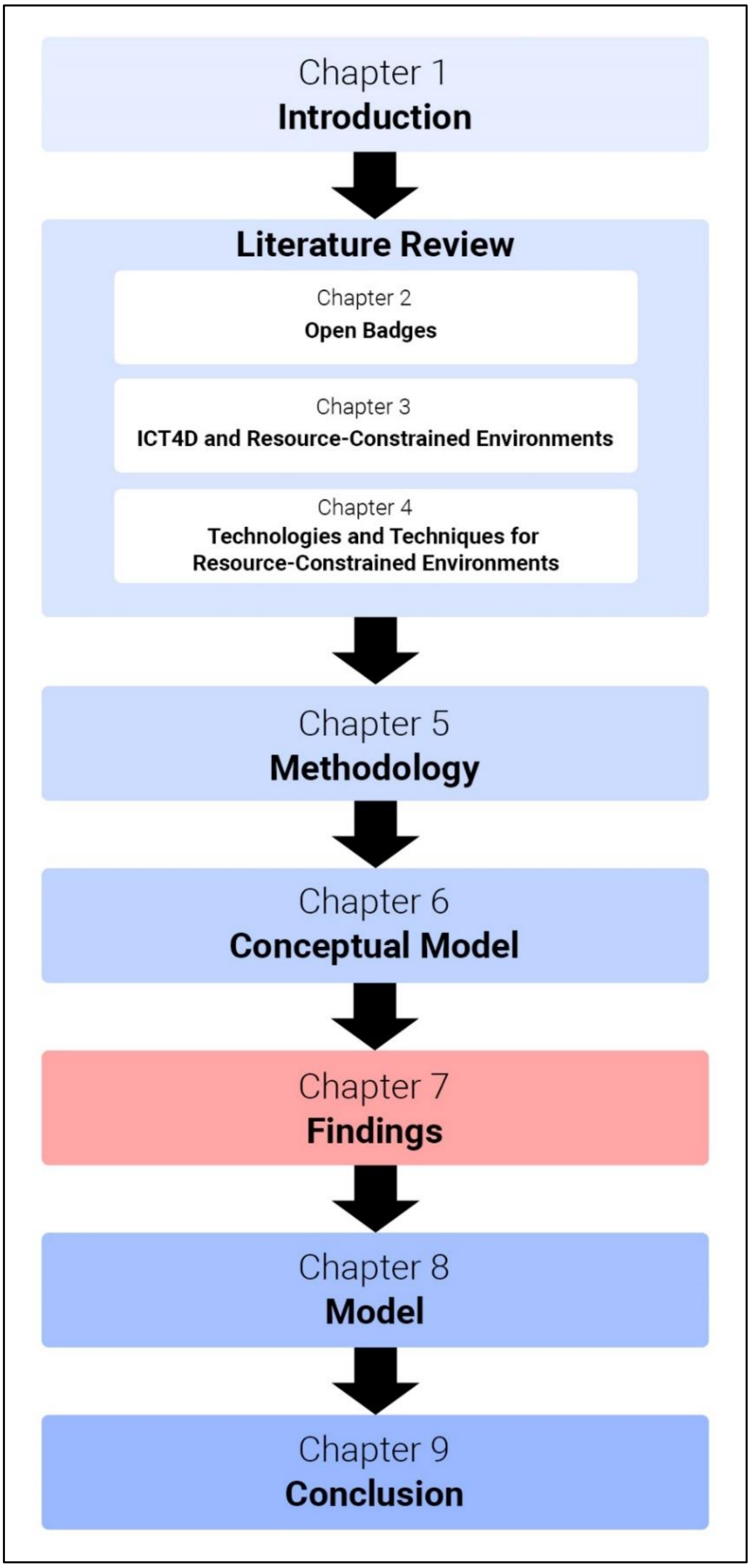
Table 6.4 – Summary of Findings from Literature Related to Research Questions

Once these chapters have been examined, an overview of the conceptual model was presented in 6.5 (as was seen in figure 6.2.), along with summaries of all the elements.

This conceptual model was presented to expert reviewers who critiqued it against March and Smith (1995) model evaluation criteria as was discussed in the methodology chapter (section 5.7.1.1). The next chapter documents these results and findings.

Chapter 7

Findings



7.1. Introduction

In ensuring the mutability of the IT artefact produced by this research, paramount importance was placed on implementing Jones and Gregor (2007) suggestion of a continuous cycle of redesign, a view echoed by Hevner et al. (2004) and K. Peffers et al. (2006). Such a cycle, which incorporates feedback and evaluation along with model redesign, would aid in producing a relevant solution that possesses a high level of fidelity to real-world problems.

Detailing the feedback of expert reviewers on the conceptual model (presented in the previous chapter), this chapter forms part of the evaluation step of K. Peffers et al. (2006) design science research process. This research made use of various methodologies to established the credibility of a solution, but focuses predominantly on March and Smith (1995) model evaluation criteria, as detailed in the methodology (Chapter 5).

Four experts were approached and information was gathered with the use of an open-ended questionnaire which was presented along with an overview of the conceptual model (Appendix A and B).

Before this chapter examines the expert reviewer feedback, it was felt necessary to first demonstrate the credentials of these specialists, thus ensuring that their evaluations are considered credible.

Once the expert reviews' credibility has been established, this chapter adheres to March and Smith (1995)'s five evaluation criteria to structure feedback in terms of comments and ratings in the following areas: 1.) fidelity to real-world problems, 2.) completeness, 3.) level of detail, 4.) robustness, and 5.) internal consistency. Finally, this chapter concludes with a summary of the sections mentioned above and details a brief list of issues that the experts raised.

The subsequent section now illustrates the biography and credibility of the expert reviewers.

7.2. Expert Reviewers: Selection Process and Biographical Information

Kantner and Rosenbaum (1997) state that while an increased number of experts could potentially help in identifying additional issues or concerns, it is possible to produce effective and valid results with the use of only two or three experts.

This research sought the expertise of several reviewers, however due to: 1.) the time constraints of this research, 2.) a small number of reviewers in the required domains of expertise, and 3.) the lack of willingness from reviewers mentioned in the previous point; this research could only make use of four expert reviews.

Before discussing the feedback given by these reviewers, this section demonstrates the suitability and validity of the experts' opinions. As described by Coyne (1997), by making use of purposeful sampling to select individuals, questionnaires can result in a higher yield of useful information while reducing the cost in time and resources. Purposeful sampling, in the case of this research, would be defined as selecting specialists in the domains of ICT4D, open badging systems, and ICT initiatives that focus on education. There was no discrimination in the selection of these individuals, and the only criteria was certifiable proof of domain expertise.

To establish the credibility of these experts, this section submits a brief biographical summary of each reviewer and their experience in the above-mentioned domains. There is no mention of the sex, race or religion of these experts as it would not affect the credibility of the findings. Furthermore, to avoid any potential bias arising from the selection of these experts, all participants in this research remain anonymous. Below is a summary table detailing biographical information related to this research which is discussed in the sub-sections that follow:

Expert	Highest Awarded Degree	Years of Experience in the Relevant Domains	ICT4D Initiatives Experience Level	Open Badges Experience Level	ICT Educational Initiatives Experience Level
Expert 1	Doctorate	10	Expert	Expert	Expert
Expert 2	Doctorate	10	Expert	Beginner	Expert
Expert 3	Masters	20	Expert	Beginner	Intermediate
Expert 4	Masters	15	Expert	Beginner	Beginner

Table 7.1. – Reviewer's Information on Time and Experience Levels in the Required Domains for this Research.

7.2.1. Expert 1

Expert 1 is currently involved in the academic field of computer and information sciences, and has lectured at various tertiary institutes across South Africa. They have been involved in extensive research in the ICT4D domain over the last decade, focusing on educational initiatives such as those implemented by the CSIR's (Council of Science and Industrial Research) Meraka Institute. These projects were based in the Mafarafara and Cofimvaba districts in the Eastern Cape of South Africa which are considered resource constrained (R. E. Anderson & Kolko, 2011; Botha et al., 2014).

Another prominent South African project that was mentioned by the expert was their involvement in the Digital Doorway project which was a joint directive of the South African department of science and technology and the CSIR.

The expert has been published in numerous journals and presented insights at a variety of conferences gleaned from their experiences with the projects mentioned above. All of the projects were ICT4D based and most involved ICT educational objectives, and (in the case of the ICT4RED's TPD project) open badges with gamification.

7.2.2. Expert 2

Expert 2 is also currently a professional and highly acclaimed (having won numerous awards) academic lecturing at a South African university. They have pursued and completed their doctor of philosophy degree, contributing knowledge to the fields of ICT4D and ICT education. Their research was primary concerned with the Digital Doorway project in South Africa and they have published numerous papers on ICT4D focusing on education, and how ICT devices can be used as educational tools.

Expert 2 describes their research interests as involving teaching, learning, and communication with the aid of ICT. They have also been active in the professional software development domain for the last two decades and can be described as a highly competent software and solutions developer.

7.2.3. Expert 3

Currently pursuing their doctorate in computer and information sciences, expert 3 has a master's degree and is an academic that has lectured and studied at various South African universities.

The field of their doctorate research is in the domain of ICT4D, focusing on ICT educational initiatives. This expert has described themselves as being heavily involved in analysing the barriers and challenges of ICT in resource-constrained environments and has extensive experience in factors influencing the adoption of ICT in these environments. For the past two decades, they have assisted with a variety of student-level projects conducted by various non-governmental organisations based in South Africa, most of which focused on community development and communications within the realm of ICT.

7.2.4. Expert 4

Expert 4 describes himself as a specialist in data warehousing for business intelligence, databases and systems analysis and design and has a master's degree in informatics, majoring in business systems. Given their speciality, they state that they have been extensively involved with various ICT4D projects across Africa, often being personally involved in the design and development phases.

Expert 4 has over a decade and a half of experience in the field of ICT4D, driving the school of thought that other fields of research must be incorporated regardless of specific developmental or environmental needs. Expert 4 does admit that there were some areas outside of their expertise when it came to badging, and instead addressed these elements from the perspectives of the work-process theory and knowledge management.

Even though this expert had some areas of weakness in the domains of open badges and ICT educational initiatives, the feedback they provided was in line with the other experts and significantly contributed to the evaluation areas of the fidelity to real-world problems, the completeness, and the robustness of the model.

Having provided some biographical information on the expert reviewers (that this research believes to prove the validity and credibility of their criticisms and comments) the next sections explore and analyse their feedback. As mentioned in the introduction section of this chapter, the reviewer feedback is structured according to March and Smith (1995) model evaluation criteria.

The next section offers expert feedback regarding the model's fidelity to real-world problems.

7.3. The Model's Fidelity to Real-World Problems

Gregor and Hevner (2013) state that an artefact produced by design science research must be able to demonstrate that it is valid, useful, of high quality and sets out to do what it intends.

During the evaluation, expert reviewers were tasked to critique the model against their own experiences, and indicate if it could be applied in designing a system to enable the usage of open badges in a resource-constrained environment.

7.3.1. Reflection on Addressing Real-World Problems

Expert 1 referred to elements in the model as representing a: "True depiction of the research domain". Expert 1 was satisfied that they found all the elements they were expecting present when examining it against the standard definition of a computer system (Hardware, software, people procedures, data and connectivity). They also reflected on their experiences during the ICT4RED's TPD project (discussed in section 2.4.4) concerning how the challenges they encountered within resource-constrained environments matched those depicted by the badge receiver and issuer user elements.

Expert 2 was of the opinion that the elements depicted in the model were all necessary to address the challenges of resource-constrained environments. There were comments made on the possible expansion of the model, and that if it were to ever broaden its scope to also address additional educational initiatives, new elements in the fields of teaching and learning would have to be added. The expert does, however, reflect that altering the scope in such a way might change the research objectives and most likely significantly expand the scale of the research as a whole.

Both Experts 1 and 2 agree that badging has the potential to add an additional layer of motivation to educational initiatives, as long as it is not implemented forcibly in a system that is not suited to it, and that users find the system easily accessible.

Expert 3 comments on the model possessing a high fidelity to real-world scenarios. They added that they found it was often the case that ICT4D initiatives would employ already-designed systems (designed in well-developed environments). They remarked on how this produces a variety of unexpected problems with the system and user acceptance, confirming Heeks (2002) argument on design versus reality gaps discussed in Chapter 3 (section 3.3). Expert 3 remarks how this generally leads to logistical issues in a project, and that such a failure in an initiative utilising something like open badges (attempting to award legitimate certification of skills) could create an issue with the trustworthiness of badges issued.

Expert 4 said that the model was a "relevant and necessary research addition to the ICT4D field that can be tested and implemented to bring change in resource-scarce environments". Expert 4 was concerned that there was no clear indication of a possible end user environment. The design and implementation of a clear end user environment would however remove much of the required abstraction that a design science research model requires and be closer to the realm of a situated implementation of an artefact (Gregor & Hevner, 2013). Expert 3 raised a similar point to this, stating that if a more micro-level model was suggested or designed, it would only need to discuss one of these areas and the challenges therein.

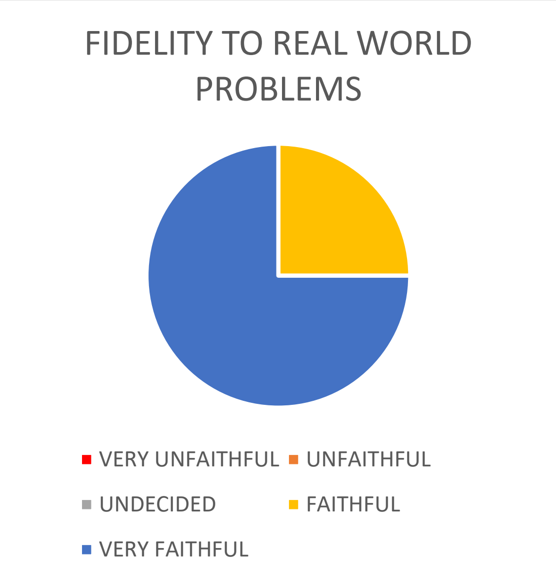
7.3.2. Additional Challenges Posed by Resource-Constrained Environments

Experts 1, 2, and 4 provided no additional comments for consideration. While it was mentioned earlier that expert 2 proposed the inclusion of teaching and learning elements, they declare that it was only to account for any possible expansion into future research.

Expert 3 suggested that the willingness of participants to adopt ICT needs to be highlighted. This relates to the acceptability of ICT4D and would involve the badge receiver, issuer, and utiliser elements. This research felt that it was not exactly a challenge but rather an effect of not addressing the identified challenges. Tongia and Subrahmanian (2006) and Heeks (2008) investigated the challenges of designing sustainable solutions to address the digital divide and both found that accessibility (users' ability to use technology) was one of the main contributing factors to a lack of adoption in constrained environments. Willingness can be seen as a symptom rather than a cause. Addressing the issue of user accessibility by designing a functioning and understandable system on a reliable and robust ICT device was deemed a pre-emptive solution to this potential challenge. It would require a different type of solution, potentially in other fields of expertise (such as marketing, psychology or social sciences) to address challenges related to users who demonstrate a complete unwillingness to be part of an ICT4D initiative. There could most likely be a drive to enrol new users and participants in an ICT4D initiative, but it would be considered unethical to force individuals to participate.

7.3.3. Rating the Fidelity to Real-World Problems

Experts were asked to review the model on a scale from one to five, where one was considered a very low fidelity and five was considered a very high fidelity, on how reliable the conceptual model was in addressing real-world problems. As observed in figures 7.1 and 7.2, the expert reviewers had a favourable opinion on how well the model addressed real-world problems. There was overall satisfaction on the use of the Tongia (2005) 4C framework to contextualise the model and allow for the addressing of similar challenges. Only Expert 3 was of the opinion that the model was not entirely reliable in addressing real-world problems.



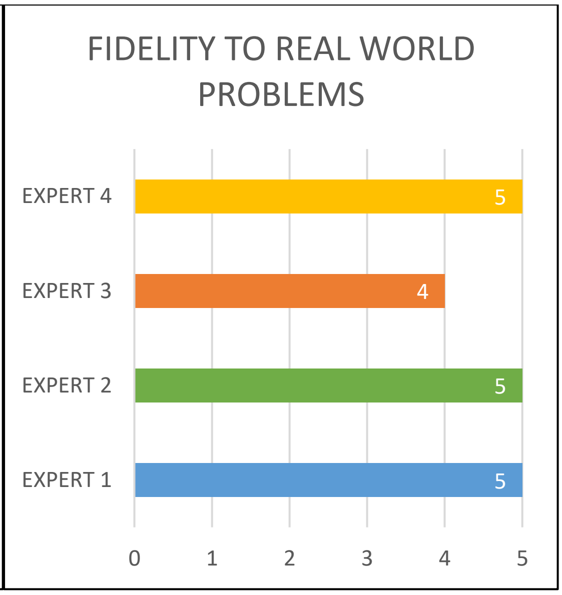


Figure 7.1(Left) and Figure 7.2 (Right) – Details Concerning the Results of the Expert Rating on the Fidelity of the Model to Real-World Problems.

Expert 1 praised the clear demarcation of the model context and how it addressed only the research problem defined at the start of this study. Throughout this chapter, expert 1 made multiple references to the importance of developing a simple and easy-to-understand model to help ensure its feasibility in design science research. They also remarked that relationships between the elements helped enforce their opinion and had there been any 'loose hanging' elements, it would have been a clear indication that the model attempted to address a problem that was not well defined or understood.

Given expert 3's opinion that the characteristic of willingness was absent from user elements, they felt that the model was not entirely correct as it did not account for that potential challenge. Expert 3 also attributes the lower rating to the lack of an application implementation, as that might have helped identify additional challenges that were not detailed in prior research.

7.4. Completeness of the Model

Related in part to the third and last evaluation criteria (level of detail and internal consistency), the completeness of the model examines how well the characteristics and relationships of elements function together to produce a cohesive whole.

Cleven, Gubler, and Hüner (2009) state that there must exist a level of balance where some elements can be explicated while others have to be abstracted. Expert reviewers were asked to identify additional elements that they felt might have been left out of the model, or remove elements that bloated the model.

7.4.1. Elements Present in Model

Not attempting to provide any additional elements, expert 1 stated it would not have helped with completeness of the model. They insisted that the model was already suitable in its current state and additional elements with regards to logistics and maintenance would risk cluttering the model. This, they felt, would remove the abstraction required by a model, and instead become a single context implementation.

Expert 1 referred to the model and elements as: "Extremely complete and extensively described", stating that simplicity and focus were the primary measurements in their opinion. They said that generally when a model lacks a clear focus, elements can end up "all over the place".

Expert reviewer 2 stated that a singular database design with sweeping permissions could potentially create issues from a data integrity point of view. This view was taken under advisement and was incorporated into a more detailed design description of the device database element presented in Chapter 8 (section 8.4.3). Other than that point, they describe the elements as: “Explained and addressed well”.

While expert 3 did indicate their satisfaction with existing elements, they did suggest the addition of a skill utiliser interface, which is discussed in the next sub-section

Adopting a work process theory perspective, expert reviewer 4 found that elements such as customers, processes and activities, products and services, participants, information, information technology, environment, strategy, and infrastructure are all present to some degree when examining the elements in this model.

7.4.2. Suggestions for Additional Elements

Expert 3 argued the need for a skill utiliser interface element. Expert 3 stated that if skill utilisers wanted to search for particular badges, and they were located in a resource-constrained environment, a dedicated interface would be able to assist them. As discussed in Chapter 8, it was considered more feasible to simply repurpose a badge receiver application, as that would be designed with the correct features and account for the potential user challenges of individuals located in constrained environments. From an ICT4D-initiative perspective, skill utilisers would be considered external stakeholders, and not necessarily the primary benefactors of such an initiative.

7.4.3. Rating the Completeness of the Model

Again, experts were asked to rate the model on a scale from one to five, where one was very incomplete and five was very complete. As presented in figures 7.3 and 7.4, results similar to the previous evaluation criterion can be observed. Three quarters of the experts were very satisfied with the completeness of the model elements. Expert 1’s largest contributing factor to their rating was the “narrow, clear focus.”, that the model exhibited.

Figure 7.3(Left) and Figure 7.4 (Right) – Detail of the Results of the Expert Rating on the Completeness of the Model

Experts were thus pleased with the elements identified from literature. Additionally there was seen to be an overlap between existing frameworks in different domains, as indicated by expert 4. This could be an indication of a general list of development guidelines when identifying elements. The only criticisms were a potentially missing interface element for utilisers (this element would be similar to the existing elements of the badge receiving and issuing interfaces) and a lack of technical detail concerning the functionality of the database element.

7.5. Model's Level of Detail

Gregor and Hevner (2013) stress the need to adapt evaluation criteria to suit the artefact produced by design science research. March and Smith (1995) explain that the level of detail can only be evaluated against that of the research's goals and objectives.

The level of detail section of the questionnaire tasked experts to evaluate the elements of the model in terms of their suitability to the research problem (section 1.2) and the degree in which these elements address the primary research question (section 1.3).

If expert reviewers requested additional information on this study due to a lack of information or simply to obtain a better understanding of the objectives undertaken and questions asked, they were provided with a research proposal. This research proposal provided a high-level overview of this study and briefly described the motivation, context, problem, research questions and objectives, summary of methodology and overview of important literature.

7.5.1. Identification of Elements from Literature

Expert 1 expressed some reservations with including the initiator element in the model, indicating that while support, maintenance, and logistics play a key role in the success of an ICT4D initiative, they should not be featured in this model when addressing the research question. They stated that the model should not attempt to address these issues too deeply as it would fall out of the scope of this research.

Considering the critical role that initiators played when examining the various open badge systems in Chapter 2 (section 2.4), as well as expert 3's earlier comment on the possible implications a logistical breakdown can have on the trustworthiness of open badges (section 7.3.1), this research maintains that initiators should have an element in this model.

Expert 1 did later concede that, if the initiator element is not too technically detailed, it would not be incorrect to account for its role in the continued development and maintenance of a badge system. Expert 1 also indicated a possible avenue for future research which investigates case studies on how external project-managing stakeholders could affect an ICT4D open badging initiative.

While expert 2 was satisfied with the level of detail, they again referred to their earlier point on the possible inclusion of teaching and learning elements if the scope of the research were to ever increase.

Expert 3 stated that they had found all the elements they expected, however they identified an error in the relationships of these elements. In the model figure (figure 6.2), there was a missing relationship between the badge-receiving interface element, and the skill-utiliser element. This relationship, however, was described in the model description of elements and should have been present on the figure. This has been corrected in the final model.

7.5.2. Meso-Level Design of the Model

Jones and Gregor (2007) emphasise how models produced by design science research must be suitable to adaption or evolution. If a model is too specific, there might not be the possibility of adapting it, and instead it would become more feasible to design a new model.

Often described as a risky factor in the construction of effective models, expert 1 placed emphasis on developing for meso-level design. Expert 1 stated that models of design science should aim for simplicity and abstraction to increase general applicability. Meso-level design, as defined by the expert, is a design implementing mid-range elements between that of macro and micro level design. Too micro-level a design, they stated, would increase the level of detail, but remove any design science choices at implementation level. Comparing this statement with the design science research knowledge contribution framework of Gregor and Hevner (2013), it can be observed that such a micro-level artefact would be closer to a system implementation or more suited to “route design” research. Expert 1 does caution that most micro-level models can be too specific in context and as a result end up being a one-time use. This reviewer was most pleased with the meso-level design they observed in this model.

Regarding the research problem and the suitability of the elements in addressing this problem (apart from the error in the model with regards to the one missing relationship), expert 3 described the level of detail as “quite good”.

Expert 4 was satisfied with the meso-level design of this model, but did voice their preference for having ICT4D design incorporate other fields when new systems are developed. Expert 4 emphasised the ability for a model to be abstract enough to be implemented regardless of specific developmental or environmental needs.

7.5.3. Ratings on the Level of Detail

There was unanimous agreement by experts that this model had a very high level of detail with regards to the elements addressing the problem statement and research question of this study.

Having been tasked to rate the model in terms of the level of detail, where one is very undetailed and five is very detailed, figure 7.5 and 7.6 reveal that all experts gave a rating of 5—very detailed.

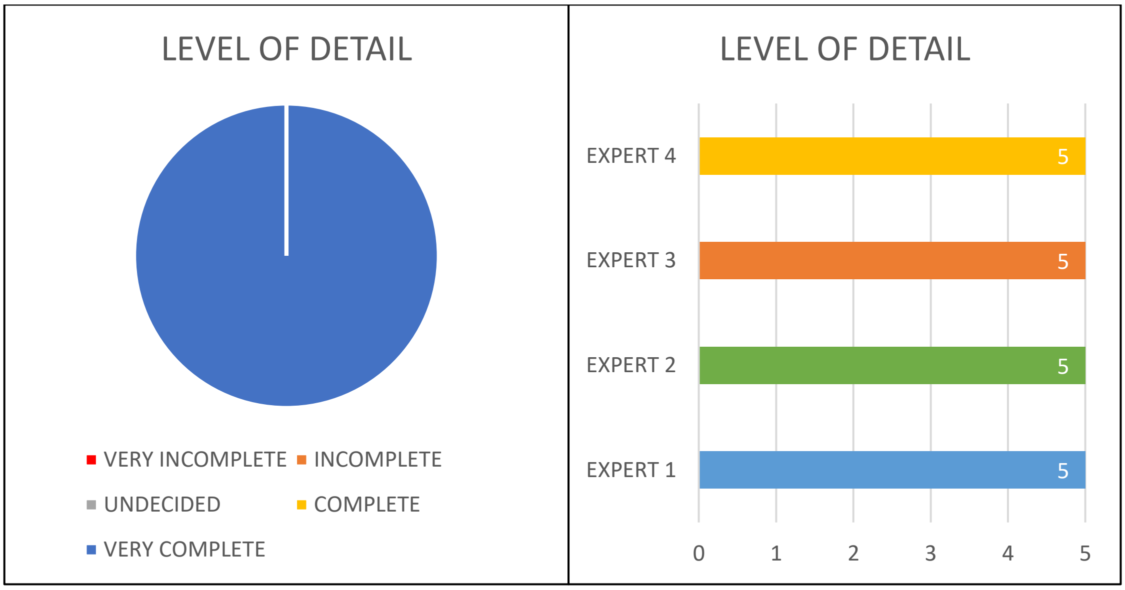


Figure 7.5(Left) and Figure 7.6 (Right)—Detail of the Results of the Expert Rating on the Level of Detail Exhibited by the Model

7.6. Robustness of the Model

Carlson and Doyle (2002) define the robustness of a model as the ability to maintain the functionality and effectiveness of an artefact even if there is a change in environment. March and Smith (1995) definition of robustness concerning design science research, includes the applicability of implementing systems described by a model, though not always in the expected environments. This research thus presented the model's robustness to experts as a potential implementation of a system in a different scope, such as incorporating the original non-constrained environment of the Mozilla open standards framework.

7.6.1. Model's Capability to be Implemented

Addressing earlier comments, expert 1 confirmed that, when designing an implementation from a model, it was preferable to not have too many technical details given by the model. They state that technical elements could easily "clutter" a model and impede robustness by delivering an overly contextualised solution which cannot be adapted. The expert admitted that it was acceptable to use unified modelling language to help demonstrate processes and relationships between elements, but it was still important to not get too technical and remove all design choices.

Given expert 2's background in software development, they remarked on how developers would not have problems understanding the current layout or design of the model, along with its motivations.

Expert 3 stated that they believe the model would lead to a feasible implementation or construction of a system. They also remarked on the clarity of the model as a blueprint to help establish a route to follow. Examining the characteristics and relationships of system elements, expert 3 suggests how there was an indication of the architectural choices that would have to be made when implementing a system.

Whilst in agreement with the other experts, expert 4 suggests the implementation of UML and process models to help aid developers in understanding some of the more abstract relationships. Expert 4 agrees with the general consensus that the model contains enough requirements and details for it to be used to develop a system, but stated that developers rely heavily on UML diagrams, process models, and database principles.

After having taken the comments of the experts under advisement, the final model presented in Chapter 8, contains some high-level process models in order to help explain some of the more abstract features such as the synchronisation between databases, and the issuing and receiving of badges over a mesh network. This is a high-level overview and, to avoid a high degree of contextualisation, does not become too technical.

7.6.2. Model's Contribution to ICT4D and Open Badges

When addressing the robustness of an implementation in resource-constrained environments, expert 1 remarked on how "hindsight is an exact science", and that, with this model addressing challenges encountered during the ITC4RED's TPD project as well as incorporating the functionality of the existing Mozilla standard framework, the model seemed to possess a significant amount of robustness. The expert also mirrored expert 3's earlier point (section 7.3.1) regarding how implementing existing systems designed in developed environments in an ICT4D initiative often get severely hampered by challenges that these environments have which were not accounted for in the design. Expert 1 remarked interestingly that the opposite was not always the case. For example, this model is designed by adapting already-established frameworks, thus it should be possible to transfer the IT artefact into a developed environment with minimal problems.

Expert 2 was satisfied that the model would positively contribute to the construction of a system that would allow the sending and receiving of open badges in a resource-constrained environment.

Raising the possibility of challenges for utilisers in determining accreditation, expert 3 continues their earlier point (section 7.4.2) of implementing a dedicated skill utiliser interface.

Expert 4 stated that while this model highlights a constrained environment and the challenges that might be present, developers will only be able to use this as a guideline, as new challenges and issues could arise with the introduction of new technologies.

All the experts agreed that this model would be an ideal starting document and that this model addressed a gap in the ICT4D field concerning designing a model to implement open badges in resource-constrained environments.

7.6.3. Rating the Robustness of the Model

The rating of the model's robustness was generally quite high, with only one reviewer giving a 4 out of 5. This aberration was as a result of what the expert believed to be a missing element (the skill utiliser interface, previously discussed in section 7.4.2). It is examined in greater detail in Chapter 8 when presenting the updated elements of this model. Figures 7.7 and 7.8 depict the ratings of robustness offered by the expert reviewers.

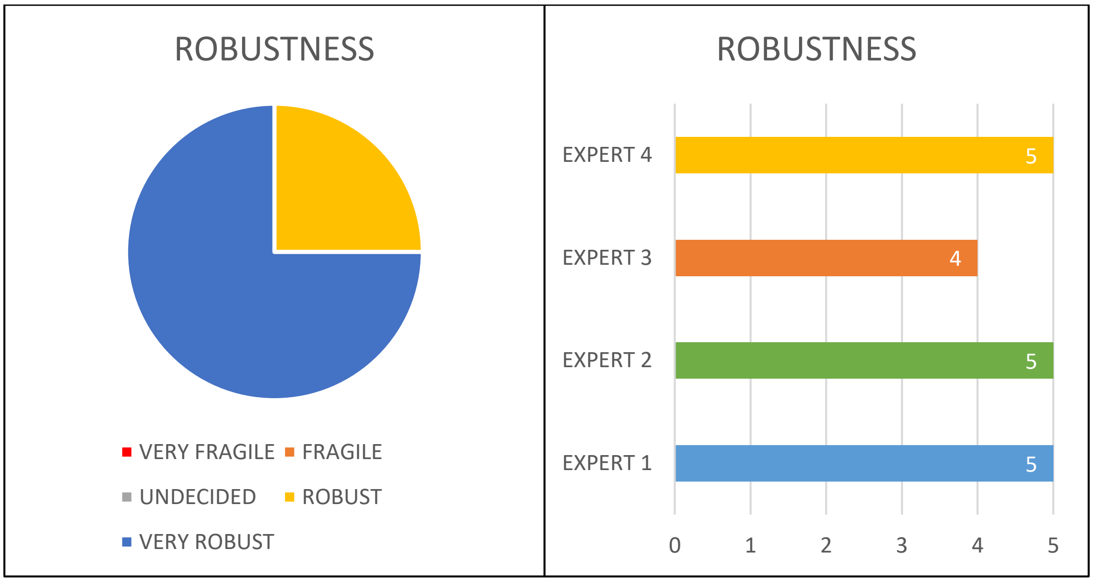


Figure 7.7(Left) and Figure 7.8 (Right)—Details of the Results of the Expert Rating on the Robustness of the Model

7.7. Internal Consistency Between Elements of the Model

7.7.1. Naming Convention of Elements

Expert one emphasised the importance of the naming of elements. They stated that naming was a critical factor in the process of understanding both the elements and the model. Expert 1 and 2 did not present any issues with the names of the elements. Expert 4 stated that the internal elements had been implemented and described in a consistent manner, and there were no issues with ambiguity. Expert 3, however, expressed confusion over the variety of the element-naming conventions employed.

The first issue was with the computers area of the 4C framework. They felt that there was an unavoidable connotation attached to the word computer, and the implication that it is referring to a fixed ICT device. Expert 3 suggested using the term computing devices instead, which would still follow the "4C" naming convention but clarify any unnecessary correlation.

The next naming conventions were minor details to the experts, but they mentioned that it would be less misleading when referring to app instead of interface when focusing on delivering a mobile-content solution, as this model did. There was also a misleading implication in the term cloud server as it was depicted as a single badge repository system, not spread out over multiple networks.

Expert 3 indicated lastly that they originally understood the personal device database element to be a database of all the personal devices taking part in the initiative. The element's function only became clear after they examined the description of the element.

7.7.2. Characteristics and Relationships between Elements

Echoing the credibility issues discussed in Chapter 2 (section 2.5.2), expert 1 expressed concern about the clear and apparent flaws of Mozilla Open Badges when validating issuer credibility. Expert 1 correctly assumed that since the model produced by this research implemented the Mozilla open standard framework, these issues would be present as well.

As pointed out during Chapter 2, there is a possibility for future research which aims at producing a feasible method of asserting the credibility of issuers. In Chapter 8, this research suggests a short-term solution by having only initiators create open badges at the beginning of an initiative, similar to how the ICT4RED's TPD project ensured the validity of their issued badges. Initially, only experts in the field of education were allowed to create badges. These badges could then only be issued by individuals that the project authorised. Expert 1 remarked on how any long-term solution would have to be scalable and effective, most likely requiring a redesign of the current Mozilla open standard framework.

While expert 1 stated that the lack of a validation system for issuers was beyond the scope of this research and not directed at the current model per se, the lack of such a framework would eventually impede any serious progress in this field, always casting some doubt on the trustworthiness of open badges.

Expert 3's earlier point (section 7.5.3) was again echoed in this section, describing the missing view relationship between the skill utiliser and badge-receiving interface elements. Again (section 7.4.2), expert 3 raised the possibility that skill utilisers would require their own interface.

7.7.3. Rating on Internal Consistency between Elements of the Model

Employing the standard measurement scale seen in all the previous evaluation criteria sections, this section made use of a one to five rating, where one was very inconsistent and five was very consistent. Expert reviewers were asked to rate the naming conventions and expected usages of the elements in the model.

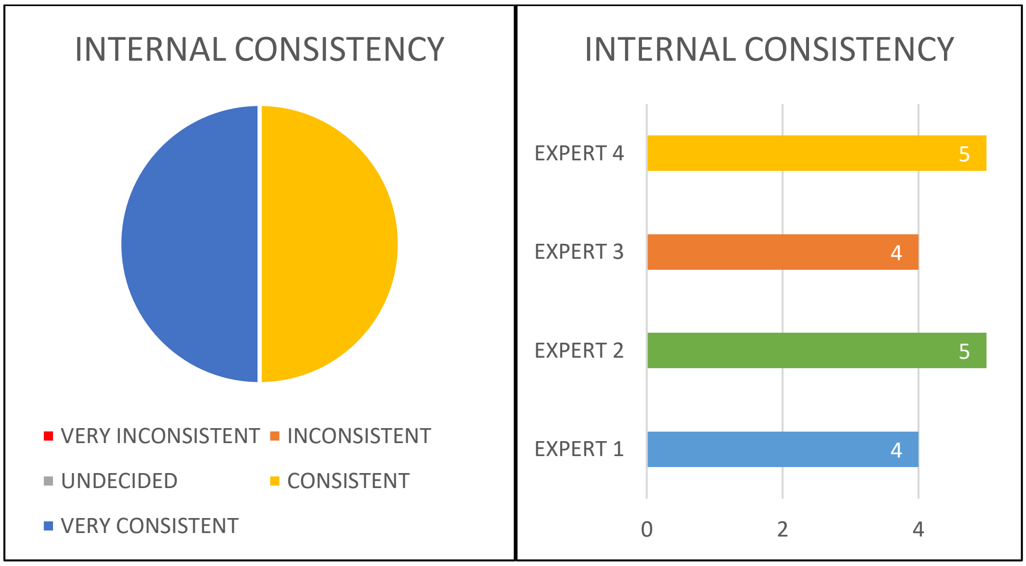


Figure 7.9(Left) and Figure 7.10 (Right)—Details of the Results of the Expert Rating on the Internal Consistency of the Model

The internal consistency between elements of this model received the lowest rating. Expert 3 expressed minor concerns with the naming conventions of certain elements such as the personal device database and the use of the term interface instead of app. Overall however, the internal consistency of the elements was still regarded as acceptable, with the other experts not indicating any dissatisfaction.

This chapter has now discussed all the evaluation criteria that were employed during the review process, and will now summarise and briefly reflect on the feedback in the next section.

7.8. Summary

This chapter presented and discussed the expert reviewer feedback of the conceptual model.

Before any of the feedback was presented, this chapter introduced and demonstrated the specialist knowledge which made the experts eligible to critique this model.

The feedback was structured in terms of March and Smith (1995) model evaluation criteria and in each of the sections there was a criteria acceptance rating. Figure 7.11, below, averages all these ratings in a single graph:

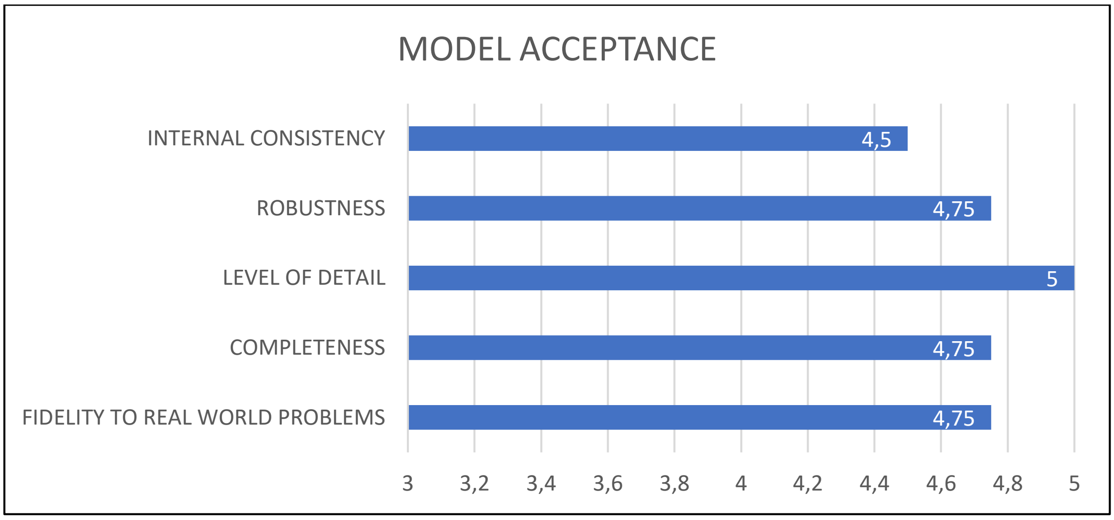


Figure 7.11 – Averages of Model Evaluation Criteria Ratings, Indicating Model Acceptance

Observed from this figure, there is a high level of satisfaction regarding the model's elements from the expert reviewers. The lowest assessed evaluation criterion was the degree of internal consistency demonstrated by the elements of the model. The degree of internal consistency still managed to achieve an average rating of 4.5 out of a possible 5. While this still indicated an acceptance by experts, there was valid criticism regarding the naming convention of the personal device database element and the computer area of the 4C framework, which might have an unintended connotation.

A summary of criticisms and comments raised by the experts can be observed in table 7.2 below:

Evaluation Criterion	Expert 1	Expert 2	Expert 3	Expert 4
Fidelity to Real-World Problems	• Very faithful • Close indication of challenge they personally experienced in resource-constrained environments	• Very faithful • Suggested the inclusion of learning and teaching elements if the scope of the research were to increase.	• Faithful • Indicated the possible inclusion of willingness to adopt ICT as a challenge in ICT4D initiatives.	• Very faithful • Indicated a possible design choice to make the model more specific and discuss technical end user environment details
Completeness	• Very complete • Enjoyed the simplicity and clarity of the model. • Stressed that the level of detail required for implementing the initiator element must remain minimal.	• Very complete • Expressed concern with database-design permission.	• Complete • Indicated the possible exclusion of a skill utiliser interface element.	• Very complete • Could relate the 4C framework and the identified elements to the work process theory.
Level of Detail	• Very complete • Cautioned against implementing initiators in too detailed a manner	• Very complete • Suggested the inclusion of learning a detaching element if the scope of the research were to increase.	• Very complete • Pointed out an error where there was the exclusion of the view relationship that was mentioned.	• Very complete • Satisfied by the meso-level design, and emphasises the need for an implementation to be exclusive of any environmental or developmental needs
Robustness	• Very Robust • Enjoyed simplicity. • Cautioned against a technical design that would limit implementation contexts.	• Very robust • Indicated ease for adaption to design a system	• Robust • Reiterates need for a skill utiliser interface	• Very Robust • Provides a useful blueprint, but might need to include some process modelling on abstract elements

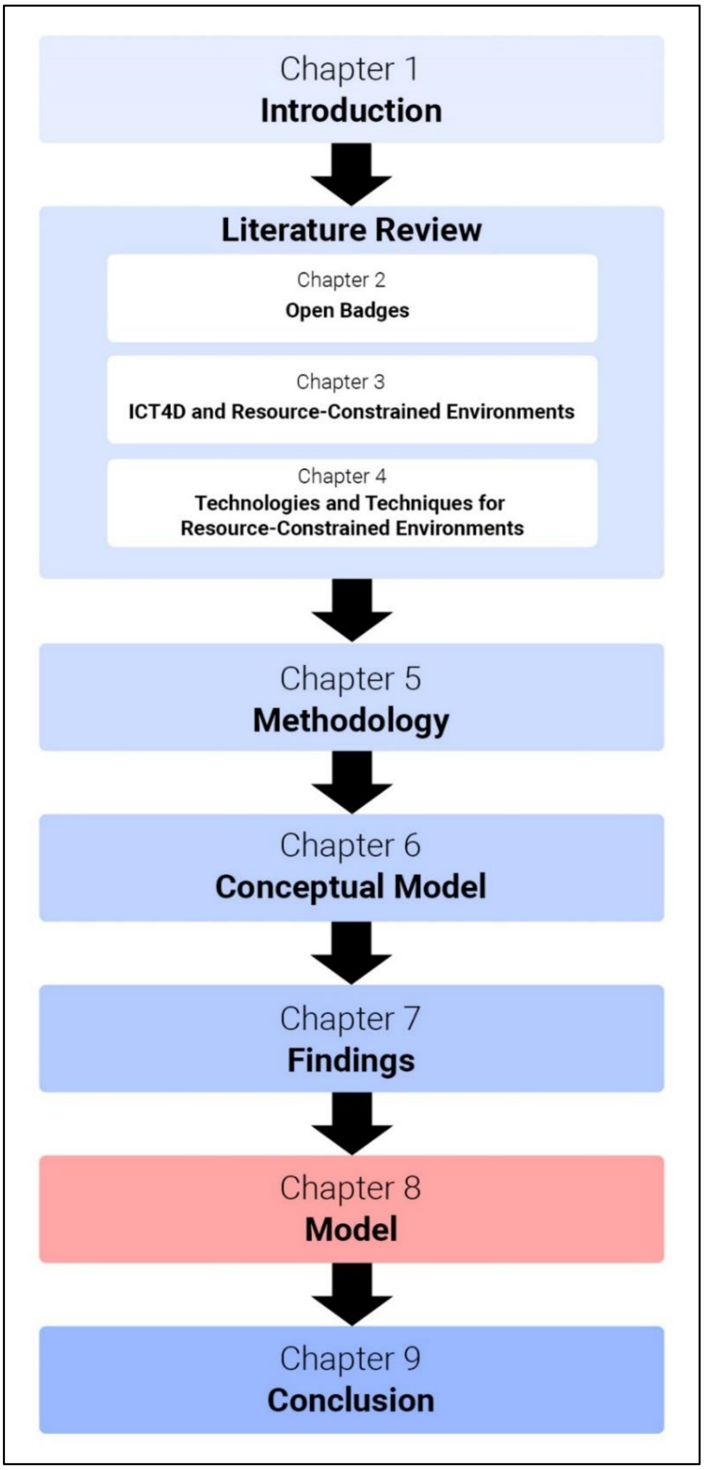
	• Discusses the model's suitability for implementation in ICT4D initiatives like the ICT4RED's TPD project.			
Internal Consistency	• Consistent • Naming conventions related to element interpretation • Indicated an issue with the credibility of open badges related to the Mozilla open standard framework, however admitted it was beyond the scope of this research.	• Very consistent	• Consistent • Confusion with the term personal device database and central cloud storage, and the use of interface instead of application when referring to mobile content delivery • Suggest that computer as a term implies a fixed ICT device and 4C framework should be adjusted to computing device	• Very consistent

Table 7.2 – Summary of Expert Reviewer Feedback

Discussed in the following chapter is the incorporation of this user feedback in the construction of a final model implementing open badges in a resource-constrained environment.

Chapter 8

Model for Implementing Open Badges in a Recourse-Constrained Environment



8.1. Introduction

This chapter presents the final model correlating to the main research objective of this study. The research objective of this research is to produce a model for implementing open badges in a resource-constrained environment and is related to the primary research question:

Research Question (RQ)*:*

> *What are the elements of a model to implement open badges in a resource-constrained environment?*

This chapter presents the culmination of extensive research incorporating feedback from experts in the domains of ICT4D, open badges and ICT educational initiatives (proffered in the previous chapter). This final model is constructed with suggestions from the expert reviewers, and presents a detailed view on the characteristics of and relationships between elements.

It is important to note that while this chapter does become technical on some theoretical design decisions and processes, Jones and Gregor (2007) remark on how a model should be indicative rather than detailed to be considered feasible in a design science research endeavour. This model will thus ultimately maintain an adequate level of abstraction even when discussing potential implementation techniques and processes.

This chapter is structured according to Tongia (2005) 4C framework, and examines elements within their development area. Each element is analysed according to its final characteristics and relationships, and thus incorporates the expert reviewers' feedback. Any expert review suggestions that were not incorporated, were discussed in the relevant element section. Regarding the alteration in the naming of computers to computing devices, this was one of the expert reviewer suggestions and is discussed in section 8.4.

The elements presented in this chapter are used to address the primary research question of this study.

Before discussing the elements, this chapter first presents the final IT artefact that addresses the research objective. This model is presented in section 8.2

The remaining sections discuss the elements in the order of:

- Section 8.3: Elements related to the capacity of individuals
- Section 8.4: The computing device elements
- Section 8.5: The remaining content elements
- Section 8.6: The division between internet-connected and disconnected environments.

The next section details the final model which was developed with the aid of literature and expert reviewer feedback.

8.2. A Model for Implementing Open Badges in a Resource-Constrained Environment.

The IT artefact presented in this section addresses the primary research objective of this study: producing a model to implement open badges within a resource-constrained environment.

Section 2.3 identified a need for a modularised accreditation system such as that offered by Mozilla Open Badges. It was unfortunately deemed infeasible to implement existing open badge systems into resource-constrained environments (Botha et al., 2014) which are still prevalent in developing countries.

This model was adapted from the conceptual model presented in Chapter 6 and incorporates the feedback received from four specialists in the domains of ICT4D, open badging and ICT educational initiatives.

This model is depicted in figure 8.1 below. The elements of this model are discussed in the remaining sections of this chapter. Each element is examined within the relevant area of development.

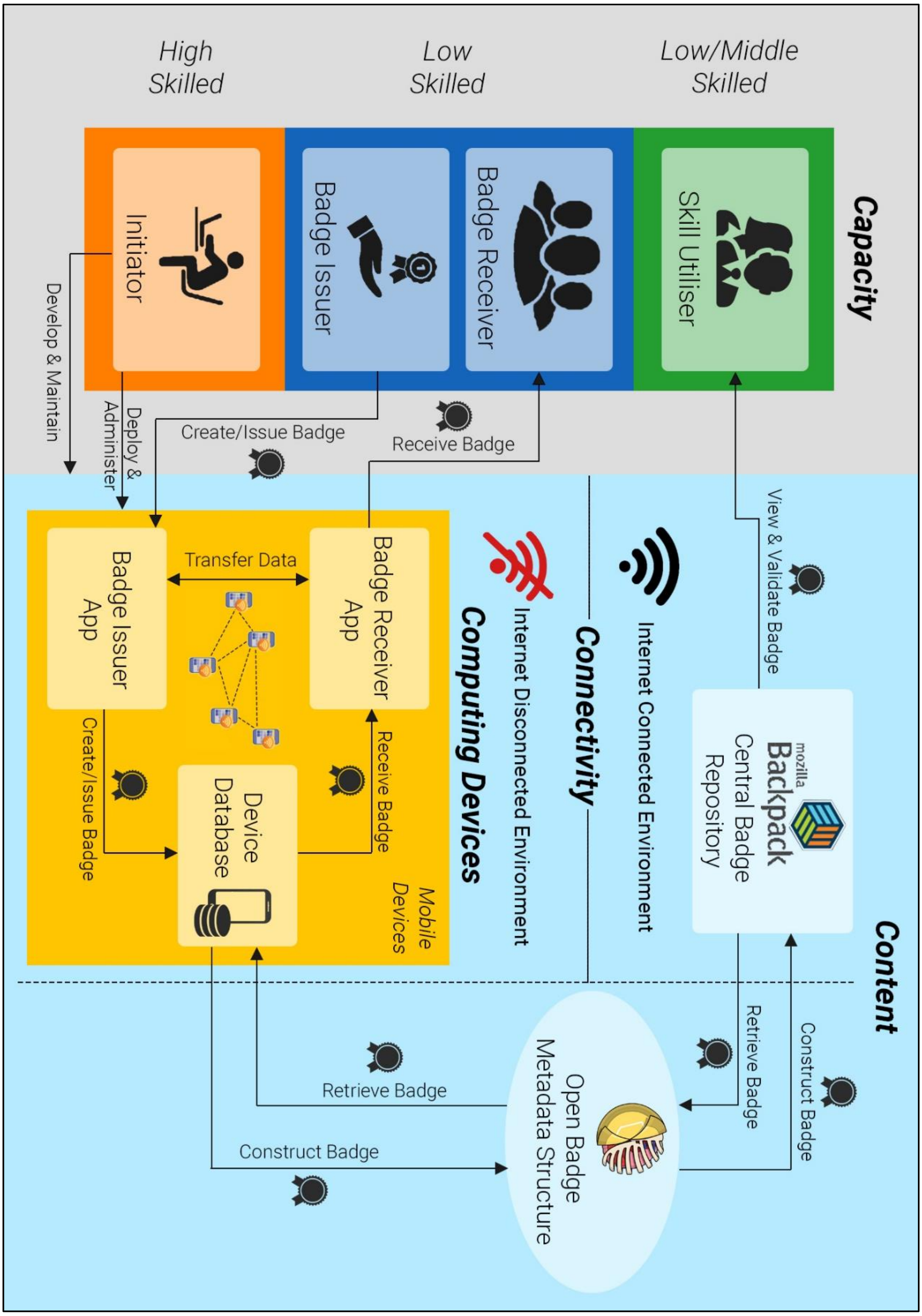


Figure 8.1—A Model for Implementing Open Badges in a Resource-Constrained Environment

8.3. Capacity

The model proposed by this research still contains the four user elements (badge receivers, badge issuers, skill utilisers and initiators) that were originally presented in the conceptual model in figure 6.2 (Chapter 6).

Expert reviewers identified three primary issues with the conceptual model when examining capacity user elements:

1.) Expert 3 pointed out a missing relationship between skill utilisers and the viewing of badges on the badge receiving application element.
2.) Expert 1 cautioned against a too-detailed implementation of the initiator element.
3.) Expert 3 suggested that the willingness to adopt ICT should be included as a challenge to capacity.

Implementing the first point above was executed without any argument. There was an oversight in the conceptual model, and even though the relationship was mentioned, it was not added to the model diagram. This has now been corrected and the relationship is present in the final model (section 8.2).

With regards to the second point, ensuring that the initiator element was not too technically detailed was already one of the requirements when the model was constructed, adhering to Gregor and Hevner (2013) required level of abstraction in IT artefacts such as models.

While initiators are described and defined, their roles can be large and varied. This model does not attempt to dictate the processes that need to be followed when funding, gathering resources, or analysing data gathered through the course of an ICT initiative. Instead, this model only includes provisions to indicate a relationship of continuous development and maintenance is present between initiators of ICT4D initiatives and the content and computing devices of an open badge system.

The last suggestion which was point 3, has been considered and it was decided that it should not be implemented as a challenge of human capacity. Heeks (2008) and Tongia and Subrahmanian (2006) do mention that the accessibility of ICT can be comparable to the willingness of individuals to make use of ICT to address their problems. It can be argued that Deterding et al. (2011) consider badges as motivational tools in educational initiatives and therefore there is some sort of impact on individuals' willingness. However when examining Tongia (2005) area of capacity, the definition is centered around individuals' inherent capabilities to effectively implement ICT rather than a lack of motivation. This research is of the opinion that willingness and motivation is a by-product of using ICT rather than an initial challenge. This point is echoed by Medhi et al. (2011) when discussing how a negative user experience could lead to demotivating an individual from using an ICT device again. The willingness of individuals located in resource-constrained environments certainly affects their future usage of ICT, but that is not something that this research could improve without additional knowledge and experience in the domain of human psychology. Implementing a solution to such a problem would possibly require a deeper investigation into the gamification elements of open badges and the design of an educational initiative to successfully incorporate these elements.

Having examined expert feedback in the area of capacity this section now discusses the various characteristics and relationships of each of these elements, starting with skill utilisers.

8.3.1. Skill Utilisers

In the context of this model, a skill utiliser can be considered any party that actively makes use of or benefits from individuals who have received badges. Skill utilisers would in most cases be thought of as external stakeholders, however with the implementation of the initiator element (which may also, in some cases, be considered an external stakeholder) this research attempted to avoid any ambiguity by separating overlapping characteristics.

Skill utilisers are grouped as low to moderately skilled individuals at the start of an ICT4D initiative due to their potentially being located within resource-constrained environments. It stands to reason that an ICT4D initiative will first attempt to convert local entities and organisations to be early adopters of an open badging process, before expanding the process further into outlying areas, as was the case with the ICT4RED's TPD program (Botha et al., 2014). Utilisers situated within these constrained environments will thus face the same capacity challenges identified in Chapter 3. Even when located within developed areas, skill utilisers cannot be assumed to be highly skilled due to the fact that any new system requires some time for adoption and mastering. Figure 8.2 presents the characteristics of a skill utiliser element:

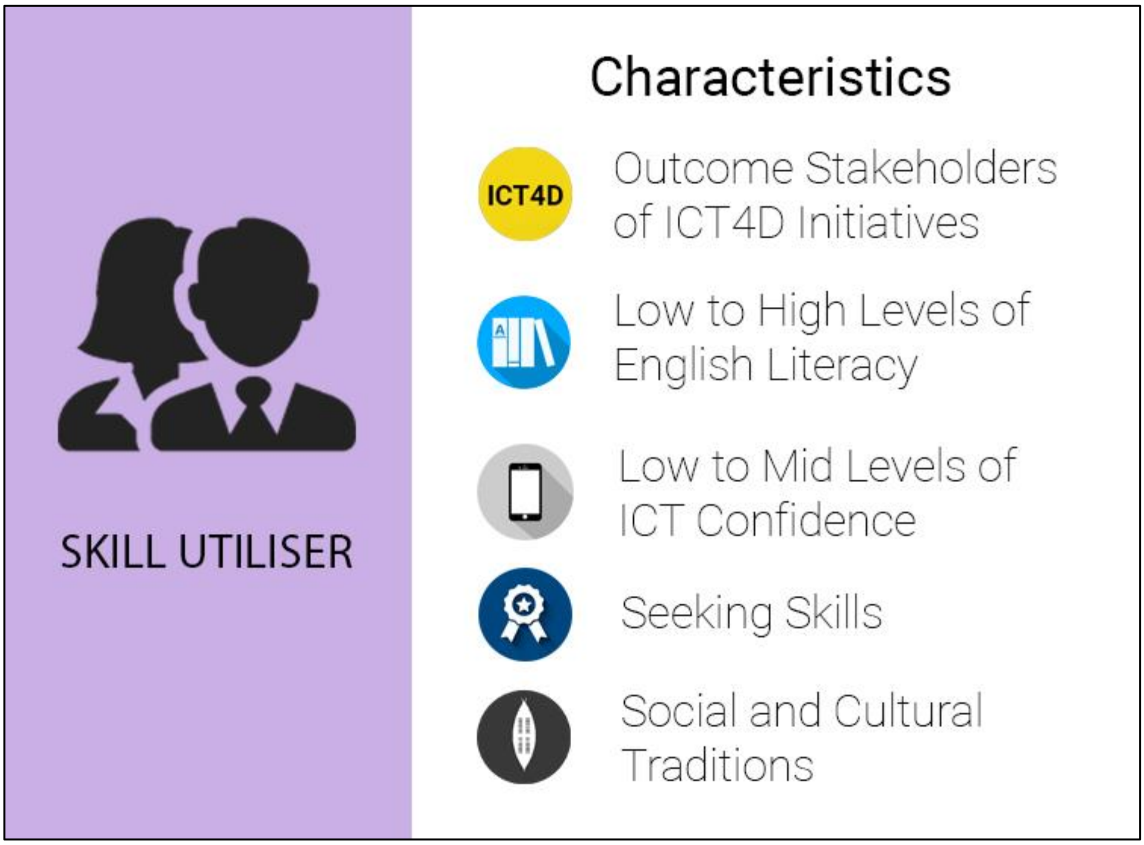


Figure 8.2—Characteristics of a Skill Utiliser Element

During the ICT4RED's TPD program, participants in this program were provided with ICT devices as they could not be expected to purchase their own (Niemand et al., 2015). Skill utilisers might play an integral role in an open badge system, but that does not imply that ICT4D initiatives can feasibly cater for them as they are not the primary participants. The primary participants in the case of the ICT4RED's TPD program, were the teachers who received badges, and ICT4D champions/heroes (also teachers) who issued these badges. As stated at the start of this section, anyone who wants to make use of some individual who has earned badges in a badging process could be considered a skill utiliser. Given the sheer number of potential people that could meet this criterion, it would be unrealistic for an ICT4D initiative to attempt and provide ICT to all these individuals as was done for issuers and the receiver in the ICT4RED's program.

As discussed in section 2.5.2, Goligoski (2012) and Jovanovic and Devedzic (2014) state that the current Mozilla open standard framework relies on skill utilisers to verify the credibility of badges by examining the attached evidence. This process is not altered in this model and, as a result, the skill utilisers require the ability to view badges. This can be done by: 1.) interacting with the Mozilla Backpack (which is a central badge repository) if the skill utiliser is located in a connected environment, 2.) by being physically shown the badge by a receiver, or 3.) by being provided with their own badge-receiving application which enables them to search for receivers and the badges that have been awarded.

8.3.2. Badge Receivers

Badge receivers are individuals who, by demonstrating adequate levels of competency in a skill, are awarded badges by issuers. This role is identical to the role of a badge receiver in the original Mozilla open standard framework, with the addition that badge receivers are located within resource-constrained environments and present unique challenges to the standard system. It was demonstrated earlier, in Chapter 3, that individuals located within resource-constrained environments present a variety of challenges to the adoption of ICT.

Cullen (2001), Firdhous et al. (2013) and Kanagawa and Nakata (2008) examine how a lack of social services, coupled with poverty, healthcare issues and unemployment could impact individuals located in these environments. While not necessarily the case with all individuals, it would be beneficial for development and design decisions to assume that users from constrained environments have a shortage of ICT skills and low-levels of English literacy. Figure 8.3 details the characteristics of a badge receiver.

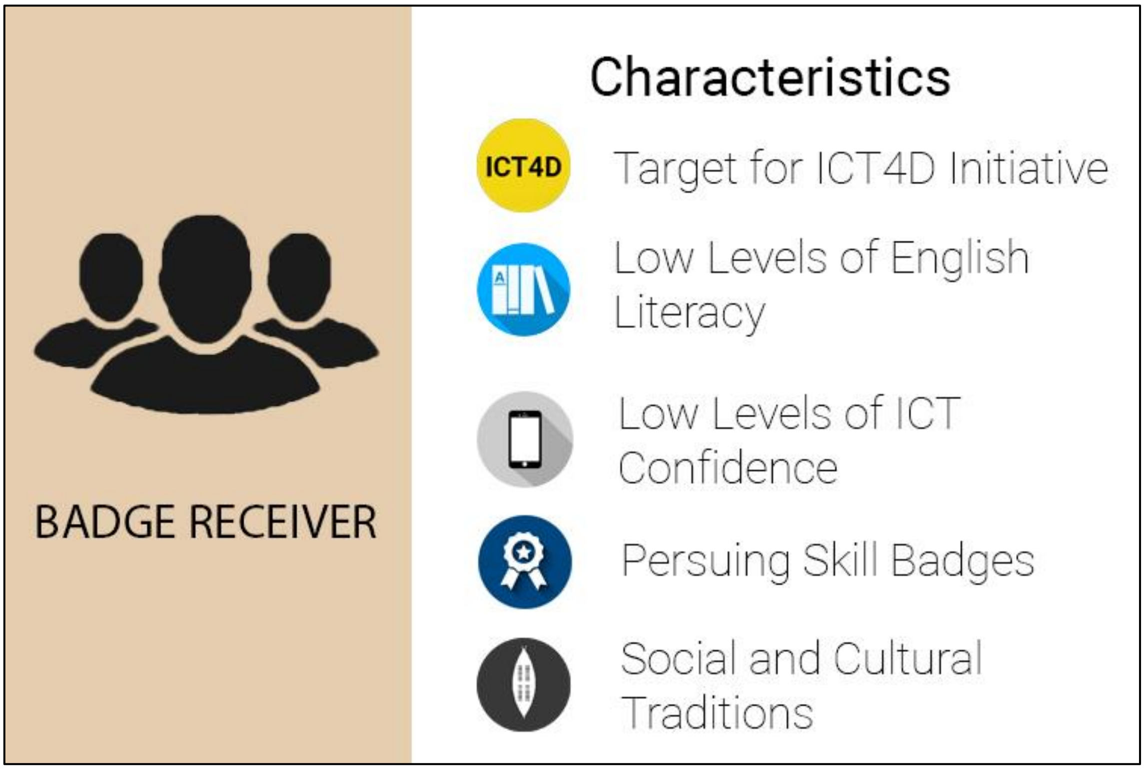


Figure 8.3—Characteristics of a Badge Receiver Element

Using the badge-receiving application, which has an interface designed to combat the above challenges, badge receivers should be able to receive new badges, view previously earned badges and search for any unearned badges.

8.3.3. Badge Issuers

In the final model, badge issuers share many similarities to badge receivers when examining challenges presented to ICT4D initiatives. The ICT4RED's TPD program indicated how badge issuers could be champions of the ICT4D initiative. However, if that is the case, it must be considered that resource-constrained environments impacted these individuals in the same manner as the badge receivers discussed in the previous section. It can be assumed that ICT4D champions/heroes would possess slightly higher levels of English literacy and ICT confidence, but it would still be unreasonable to not account for any possible challenges due to an assumption.

The difference with badge issuers is their role within a badging process. Issuers are individuals who have the authority to certify that others have demonstrated competency in a skill. The characteristics of badge issuer elements are detailed in figure 8.4.

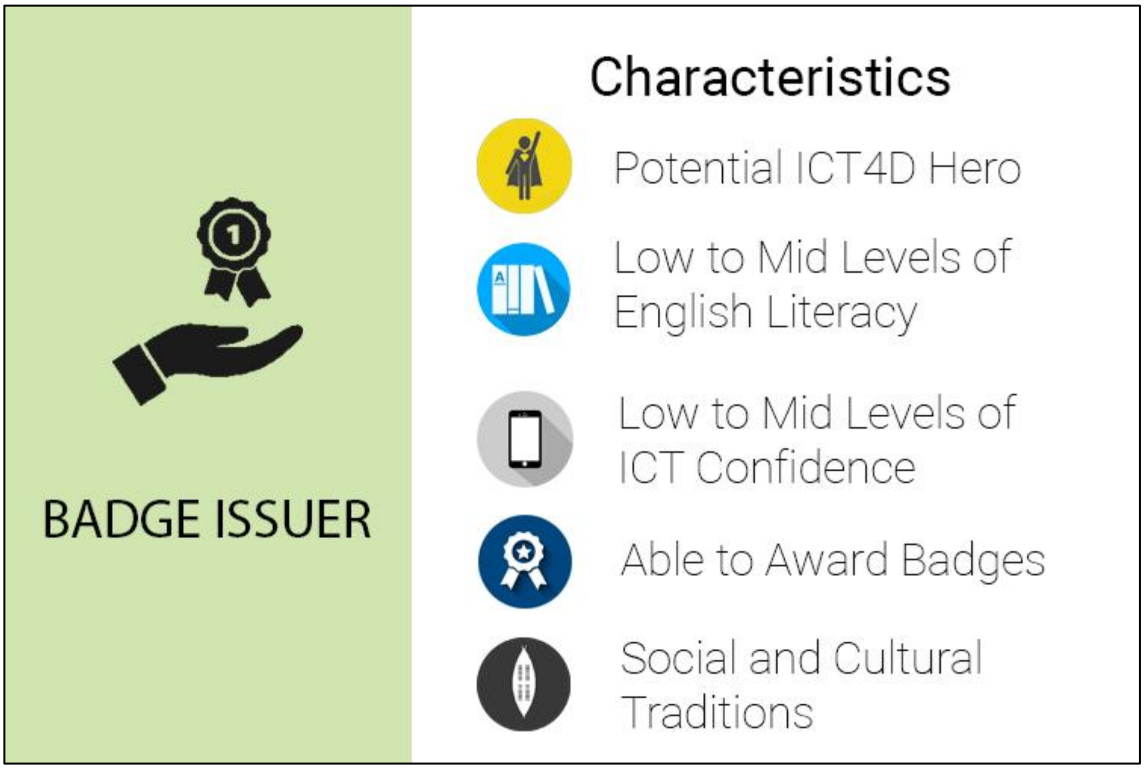


Figure 8.4—Characteristics of a Badge Issuer Element

The primary role of an issuer is thus to evaluate a potential receiver, and if satisfactory evidence is presented, this evidence is attached to the badge and awarded to the receiver.

Expert 1 indicated an issue with the ability of issuers to be able to freely create and then issue badges, stating that this could compromise the validity of the accreditation received. While already stated (section 2.5.2) that this research would not be able to address this issue within the currently demarcated scope of this study, there exists an avenue for future research which proposes a framework to allow for the validation and certification of issuers allowing only the accreditation of certain skill badges.

To aid in this process, this model suggests a dedicated issuing application (discussed in section 8.4.2), which is designed separately from the receiving application. Badge issuers would require the ability to not only issue badges, but to also view all unearned badges individuals can obtain. To avoid errors such as re-issuing, it could be beneficial to display already-earned badges but disable the ability to issue them to a previous recipient.

8.3.4. Initiators

As opposed to external stakeholders who are concerned with utilising badge receivers in an open badging system (skill utilisers), initiators are stakeholders that provide support to the ICT4D initiative to attempt to ensure its continued success.

Initiators can be seen as any stakeholder who develops, funds, regulates, maintains or manages an open-badging initiative. This requires a high level of ICT skills to be able to understand and design such an initiative. Moreover, initiators require an adequate amount of resources such as time, money and workforce to be able to maintain the continued functionality of an ICT4D initiative.

It would be the responsibility of these individuals to develop and maintain the various elements of this model required for the implementation of open badges within resource-constrained environments. Figure 8.5, below, details the characteristics of an initiator element.

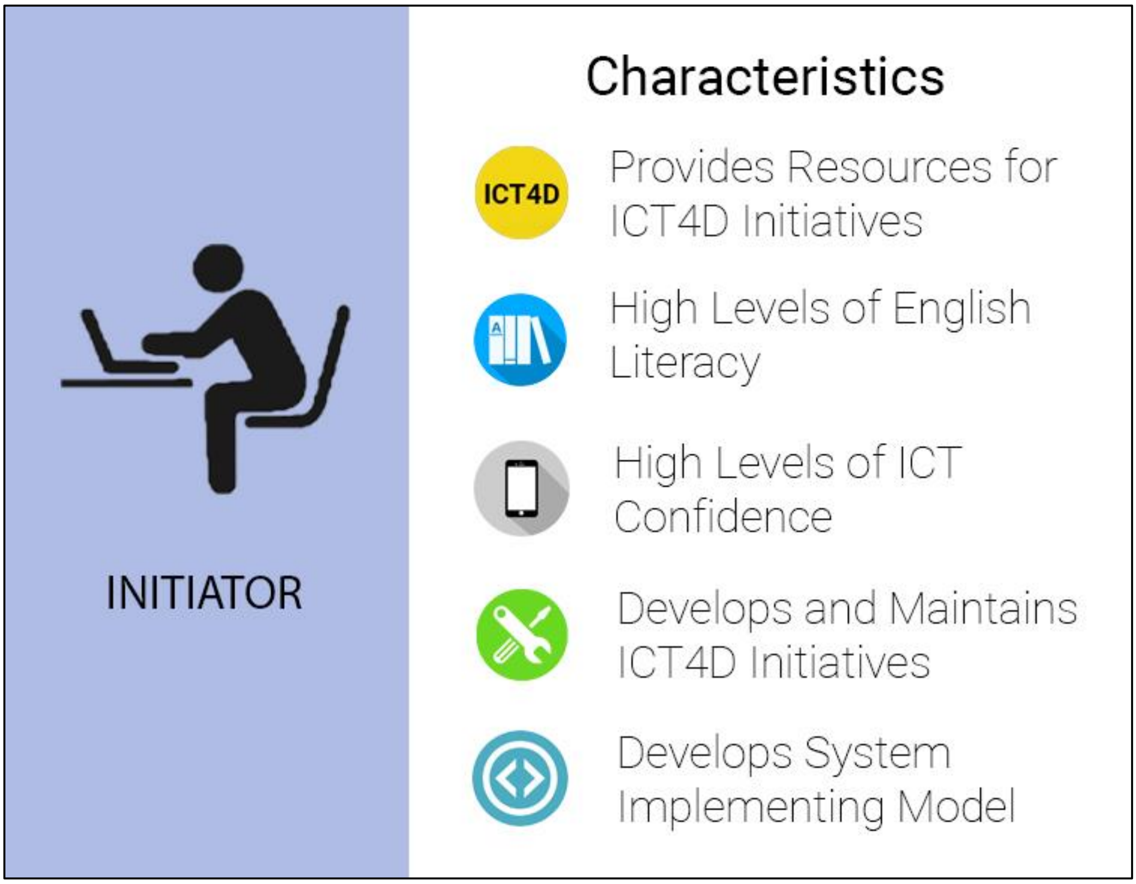


Figure 8.5—Characteristics of a Badge Initiator Element

The next section examines the elements within the area of computers.

8.4. Computing Devices

This section details the computing device (previously computer) elements of the model. The renaming of the area of computers to computing devices was one of the suggestions received from the expert reviewers.

This model focuses on providing a solution for mobile ICT devices over that of fixed ICT devices. Expert reviewers identified several naming conventions that had to be altered to align the model with providing a clear indication of this fact. Expert 1 placed great importance on utilising clear and well-defined names for elements.

The changes suggested by expert reviewers are as follows:

1.) Expert 3 desired the implementation of a dedicated skill utiliser interface.
2.) Expert 3 indicated that there is too much ambiguity with the name personal device database.
3.) Expert 3 indicated the use of "app" (short for application) instead of "interfaces" would allow the model to clearly exhibit the preference for providing content for mobile ICT devices.
4.) Expert 3 indicated the problem with the term computer and its correlation to a fixed ICT device.

Concerning the first point of the expert reviewer feedback for this area, expert 3 was of the opinion that skill utilisers had to be provided with their own application. Given the exact same functionality as a badge-receiver app, it would be more practical to simply provide them with this badge-receiving app. Otherwise an ICT4D initiative could simply repurpose the badge-receiving app to suit skill utilisers, as opposed to designing another application altogether.

Points 2, 3, and 4 however were seen as valid and they have been implemented in the final model construction.

This section now discusses the various applications, as well as the device database which is required to be present on every mobile ICT device. The first subsection discusses the badge-receiving app which is designed for a badge-receiving user.

8.4.1. Badge-Receiving App

The badge-receiving app would be the primary method of participation for badge receivers. The challenges badge-receiving users present within the context of this model are discussed in the previous section.

To aid in addressing possible issues with accessibility, this badge-receiving interface must incorporate various HCI4D and mobile HCI design guidelines. This helps ensure that, regardless of an individual's ICT confidence level, they would still experience a positive user experience and not feel intimidated by the use of ICTs (Devezas et al., 2014; Ho et al., 2009).

The functionally of the badge-receiving application is focused on: 1.) notifying users that new badges have been received, 2.) actually receiving and storing the required badge data from a badge-issuing application, 3.) displaying earned badges and all relevant information such as the attached evidence, and 4.) displaying unearned badges with their required criteria. Figures 9.5 and 9.6 demonstrate the processes described above in abstract sequence diagrams.

Figure 8.6, presents a potential sequence that could be implemented when issuing a badge. This sequence would hold true for both the receiver and issuer apps, but is only demonstrated in this section. When the following sub-section discusses the issuing process, it would follow the same sequence revealed by the figure below:

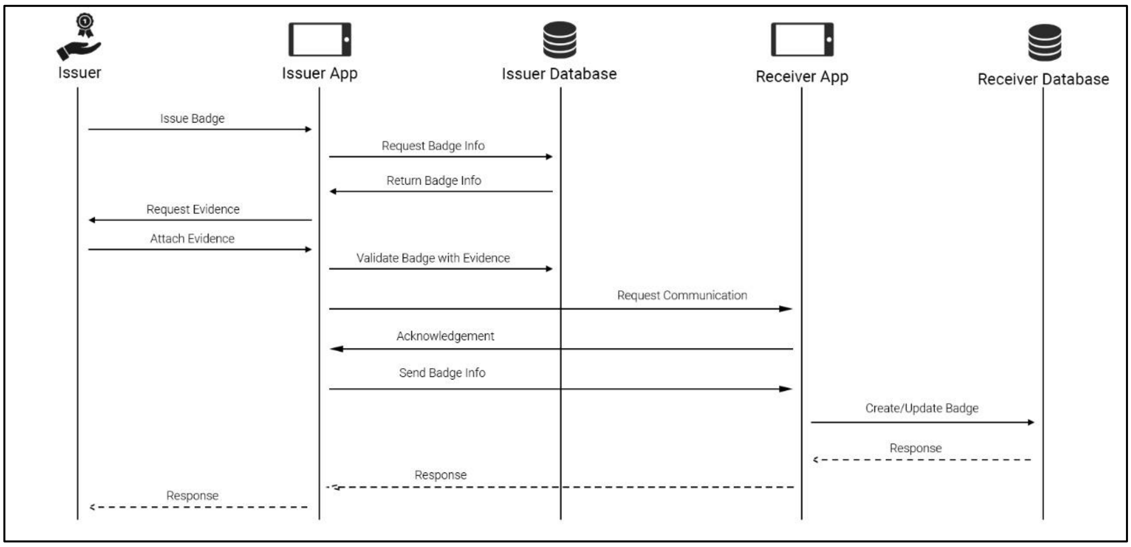


Figure 8.6—Abstracted Sequence Diagram Detailing a Potential Sequence for Issuing Badges from a Badge-Issuer App to a Badge-Receiving App.

Figure 8.7 is also applicable to both this sub-section and the next, as it displays the sequence that could be implemented to view badges on both the badge-receiving and issuing applications

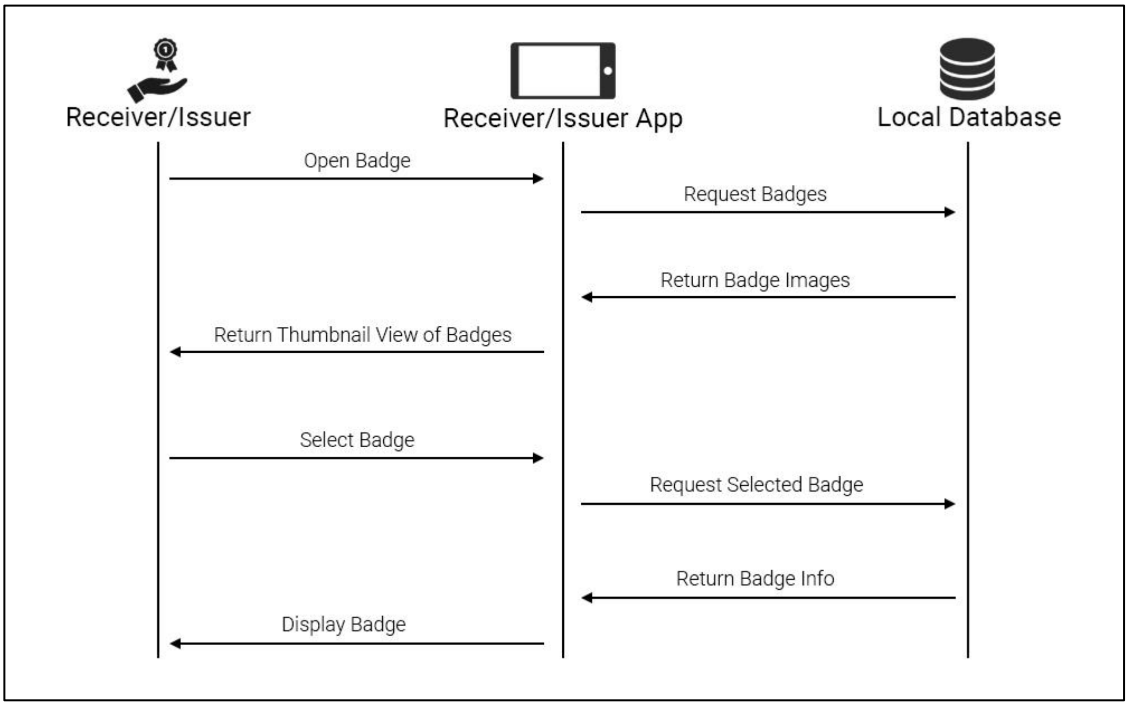


Figure 8.7—Abstracted Sequence Diagram Detailing a Potential Sequence for Viewing Badges on a Badge-Receiver/Issuer App

Implementing a mesh network and a device database, the badge-receiving application attempts to simulate on online environment with the ability to interact with a badge-issuing application. With an ideal design, the badge-receiving user would never notice a difference in the application's functionality regardless of their ICT device's current connectivity status.

In order for the badge-receiver application to update itself with the latest information on newly created badges, the application must be able to connect and receive data from other badge-receiving and issuing applications. This functionality can be achieved by implementing a synchronisation protocol to update the device database in conjunction with the standard connection between ICT devices that a mesh network could provide. Figure 8.8 demonstrates a sequence diagram of what such a synchronisation process might look like:

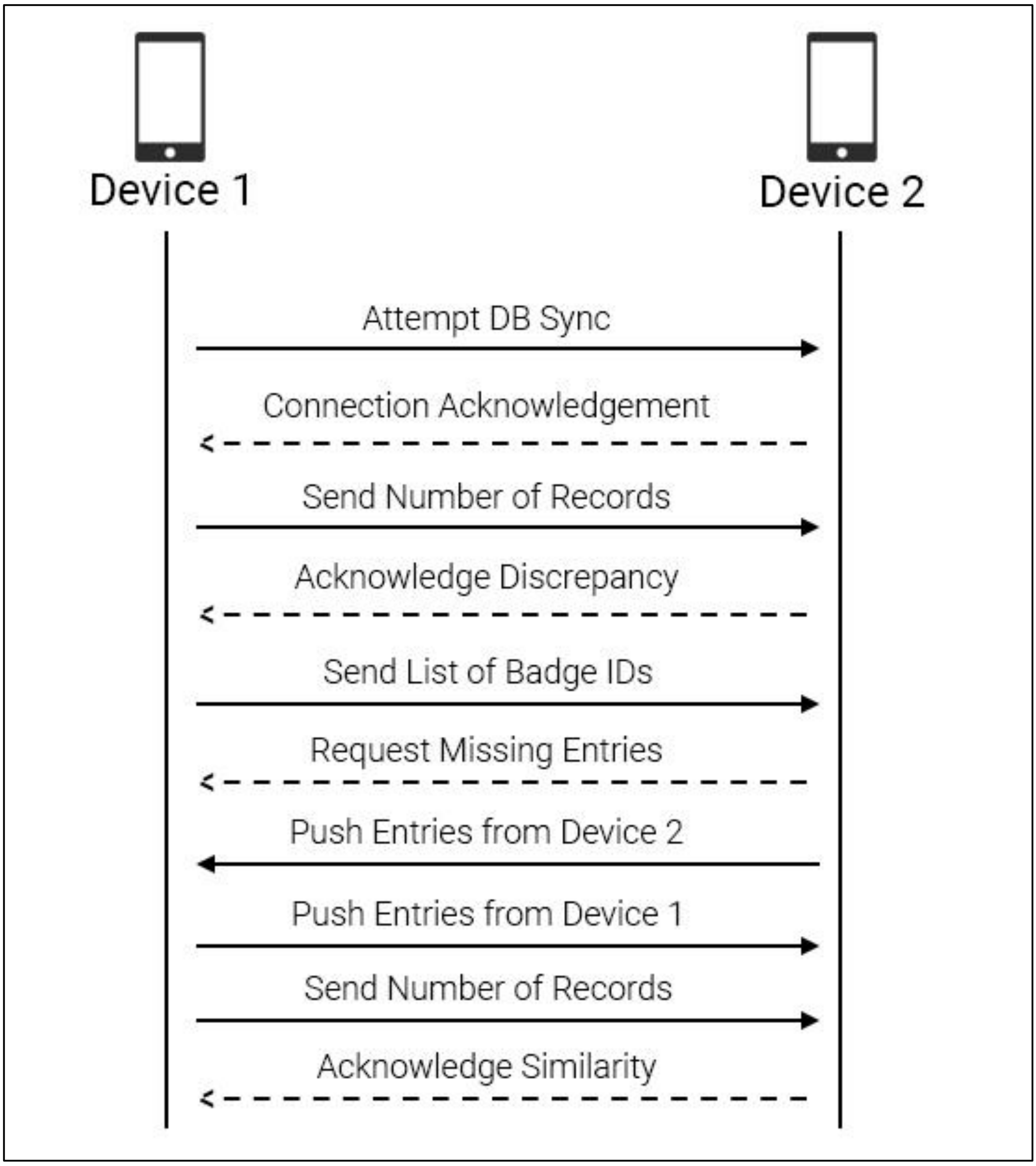


Figure 8.8—Abstracted Sequence Diagram Detailing a Potential Sequence for Syncing Badge Data Across Computing Devices

Further expanding on this functionality of synchronisation, it would be possible to design a protocol which would allow the synchronisation between a centralised badge repository which is housed in a connected environment. Whenever a badge-receiving (or issuing) application has access to internet connectivity, it would attempt to synchronise the device database with that of the central repository. Any data received from this central repository would then eventually be transferred to the surrounding ICT devices until all devices connected in a mesh network have been synchronised.

8.4.2. Badge-Issuing App

Badge-issuing applications would share many design features with those of badge-receiver applications discussed above. The key differences, which ultimately resulted in the decision to have this model propose separate apps, is based on the fact that: 1.) these applications have to cater for different functional roles, and 2.) the possibility that issuing users, while situated in the same environments as badge-receiving users, may possess different capacities. The same case could not be made for a skill utiliser app which would share all functionality with the badge-receiver app.

Similar to the badge-receiving app, the badge-issuing app has to be designed following mobile HCI and HCI4D guidelines. While the difference in application functionality might not warrant a unique app, the capacity of badge issuers might differ substantially enough to make an argument for this design. This conclusion in user capacity differences is drawn from various points in literature which refer to the implementation of ICT4D champions (Botha et al., 2014; Heeks, 2008). It should essentially be possible to offer a more technical design which would cater for a wider range of interaction options, provided that issuers are selected from ICT4D champions who have already gone through the badge-receiving process. Unfortunately, this cannot be assumed to always be the case and it would thus be beneficial to design a multi-faceted interface which could allow for the more technical interaction skilled users expect, while also providing a simplified interaction process for users who have a low level of ICT confidence. Figure 8.9 demonstrates a potential sequence for creating new badges, discussed more below.

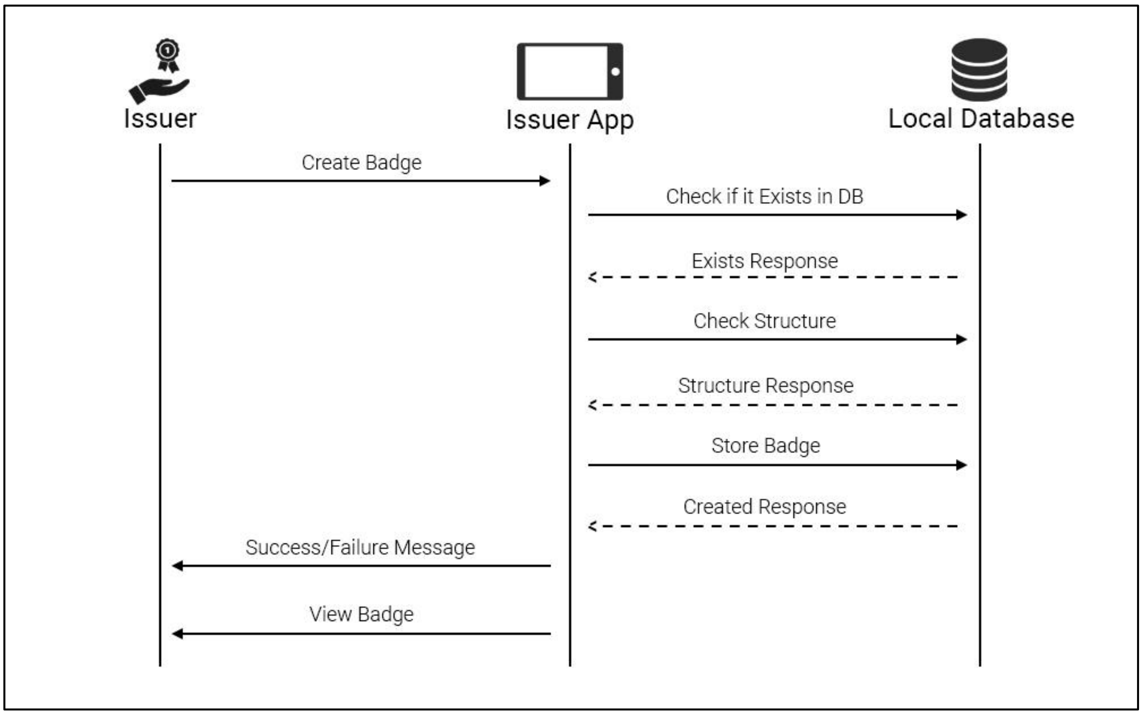


Figure 8.9—Abstracted Sequence Diagram Detailing a Potential Sequence for Creating a Badge with the Badge-Issuer App

The functionality of the badge-receiving app should allow for the ability to: 1.) view the earned and unearned badges of a specific user, 2.) issue previously unearned badges to a specific user who has demonstrated adequate competency in a skill, 3.) record evidence and attach it to the issued badge, and 4.) be able to create new badges (indicated in figure 8.9 above).

Referencing figures 8.6 and 8.7 in the previous sub-section aids in explaining these processes. Figure 8.10 demonstrates the process presented in figure 8.6, but only as a graphical overview of the data exchanges that occur.

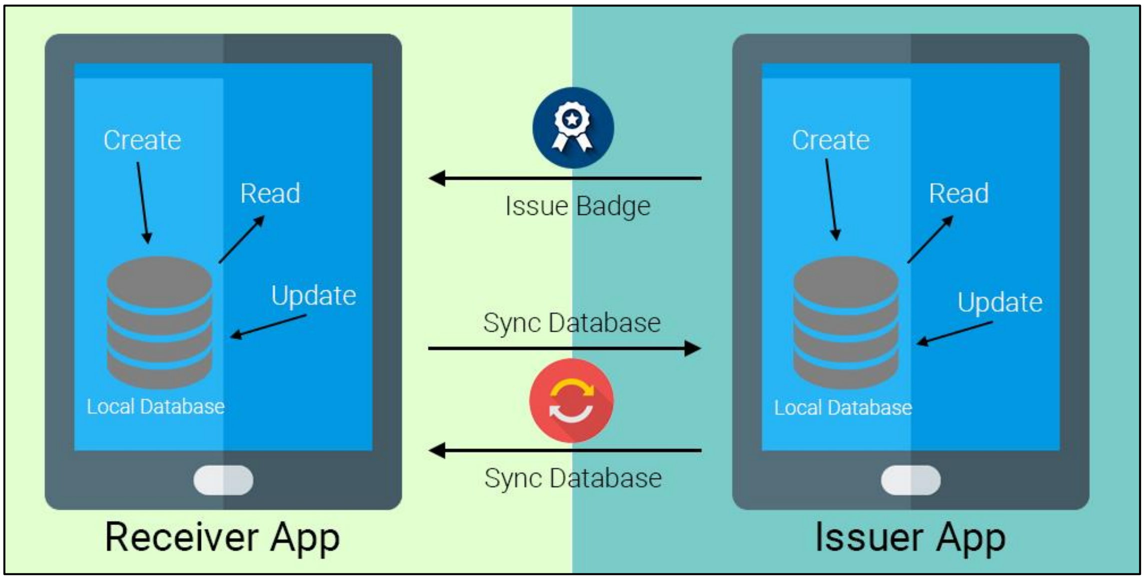


Figure 8.10—Demonstration of Data Exchanges Involved When Issuing a Badge

Figure 8.10, above, also indicated the database permissions required by the applications to enable the functionality of syncing badges.

The badge-issuing application would require the exact same functionality and design specifications as the badge-receiving application with regards to: 1.) the implementation of mesh networks, and 2.) device databases to address the challenges experienced by a lack of internet connectivity.

8.4.3. Device Database

The device database refers to a local database present in all badge-issuing and receiving applications. Each local database must have the ability to store all the badges that are used during the course of an ICT4D initiative, as well as information related to which users have issued and received badges. This design is suggested to help enable the syncing of data between devices to emulate a connected environment. Figure 8.11 demonstrates the data exchanges as well as the database permissions required by the badge-receiving and issuing applications required to sync data with the central badge repository.

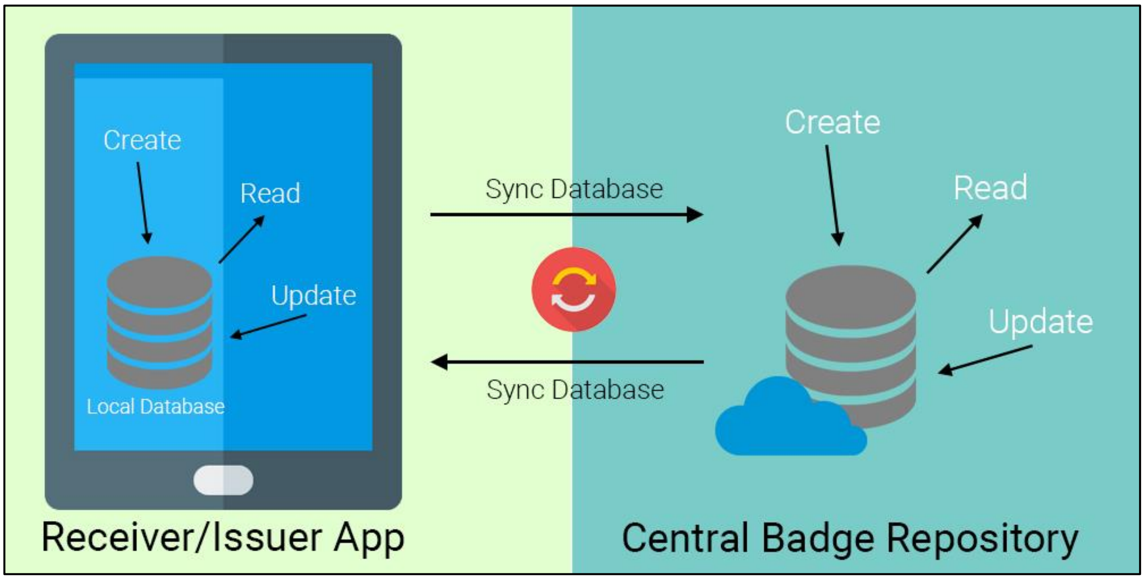


Figure 8.11—Demonstration of Data Exchanges Involved When Syncing the Badge Issuing/Receiving Applications with the Central Badge Repository

Due to the possible sensitivity of data, this data has to be directly accessible only to the initiators of the project. A possible assumption to make would be that the technical knowledge required to directly access and manipulate application data would be too high level for the intended participants of an ICT4D initiative. However, to ensure the validity of open badges, the restriction and prevention of direct data manipulation by non-initiators must be an assured fact. How this security rule is enforced will be left up to the implementers of this model, as it becomes too technical for this research and falls outside the scope of this study. Yadav et al. (2010) mention that individuals from resource-constrained environments place fewer expectations on security and privacy issues with regards to ICT devices, often being willing to freely share personal information.

As discussed in the previous sub-sections, both the badge-receiving and issuing applications require a personal database that contains the latest badge information to enable the functionality of their various services. The idea behind implementing a mobile mesh network and a standardised database design present on all devices is to enable the above-mentioned requirement. Whenever an application connects to the central badge repository, or another application, the databases will be compared. Any missing records will then be shared between devices, and in that way newly created data will be able to spread to surrounding devices. Figure 8.12 presents a process flow diagram of how such a record check can be implemented.

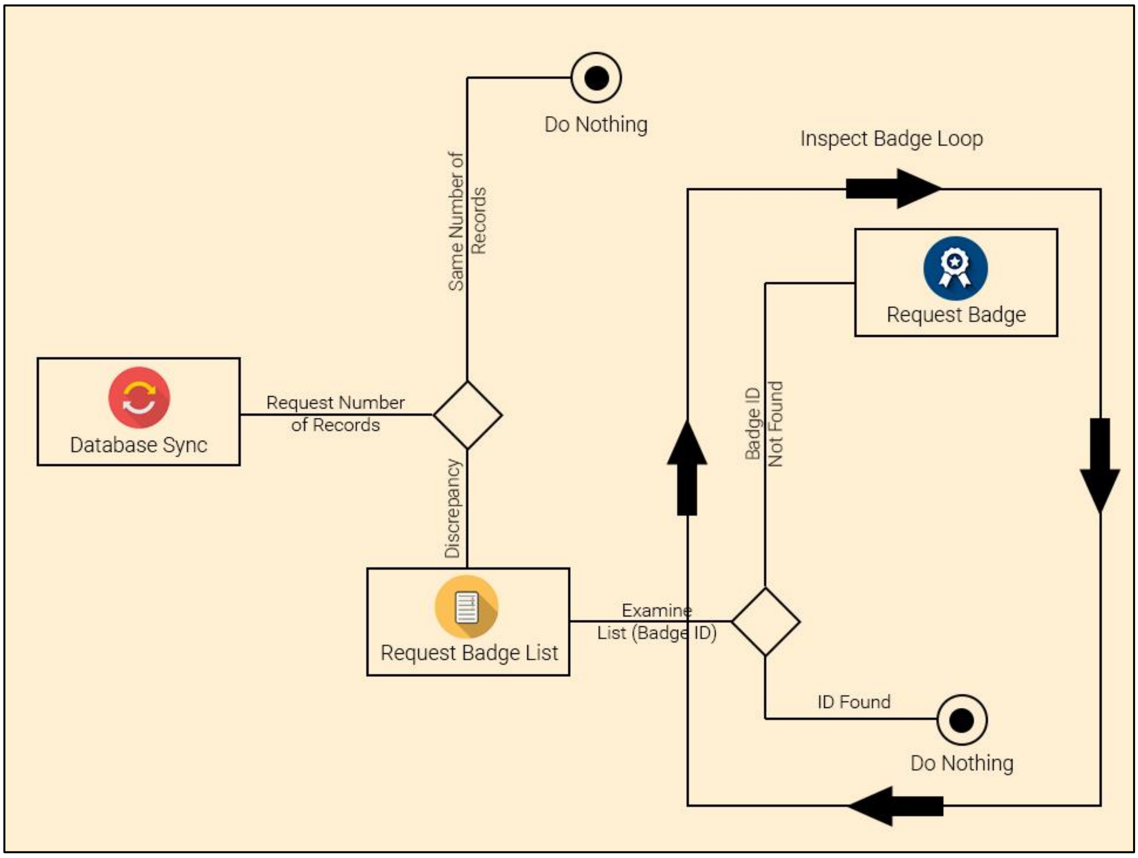


Figure 8.12—Process Flow for the Synchronisation of Badges Between Devices

The next section of this chapter discusses the content area of the conceptual model.

8.5. Content

As mentioned in section 6.5.2, the content area of the model includes every element except the user-related one. In a similar approach to how Chapter 6 addressed the content area, this section only discusses the open badge metadata structure and the central badge repository elements, as all the other elements have already been discussed in previous sections.

There was little expert feedback on these elements, with only expert 3 commenting on the mismatch of terming the badge repository a cloud server if it was not guaranteed to be implemented as such a service. The name on the model was updated to account for this change.

8.5.1. Open Badge Metadata Structure

The Mozilla Open Badge metadata structure is a data structure design by Mozilla to ensure that open badges are created and stored in a standard and expected manner. Given a defined set of data fields that need to be present at the creation of an open badge; the metadata badge structure helps ensure that even if open badges are created and distributed by a variety of different institutions/organisations, they can be:

1.) Stored in a central database without having to account for multiple outlying data fields,
2.) Users are able to learn and understand a single badge design applicable to all badges,
3.) Utilisers would be able to validate badge credibility by checking if all data fields are present and then examining the badge evidence.

Badges that are created by the issuer application would have to implement this Mozilla metadata structure. If fields are left empty, the badge should not be created and the issuer should be notified of the problem. Figure 8.13 indicates the required database permissions required by a badge issuer to create a new badge. This figure also depicts using the badge metadata structure in the creation of a badge.

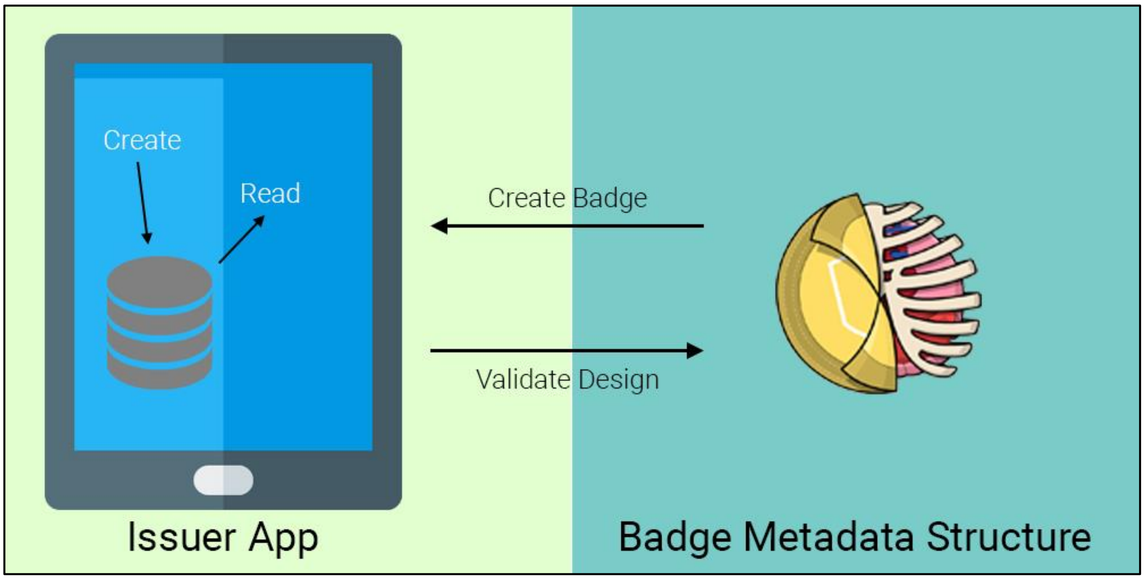


Figure 8.13—Demonstration of Creating a Badge with the Badge Issuer App

As indicated in Chapter 2, section 2.5.1, the Mozilla metadata structure is composed of the following fields: badge name, description, criteria, issuer, evidence of date issued, standards and tags.

Uploading badges into a Mozilla Backpack repository requires the use of the Mozilla Open Badges API, which 'bakes' a badge. This essentially creates the badge by providing all required metadata fields, and implements this data as a JSON blob into a PNG file. This research suggests storing the badge information in a standard database schema as well, to aid with syncing the local databases of the issuer and receiver applications to the central repository. Storing badges in a database might require some additional fields to aid in data tracking. Figure 8.14 demonstrates how the original metadata is preserved. Additional data fields are used, however, in the construction of these badges, which would allow for better data management.

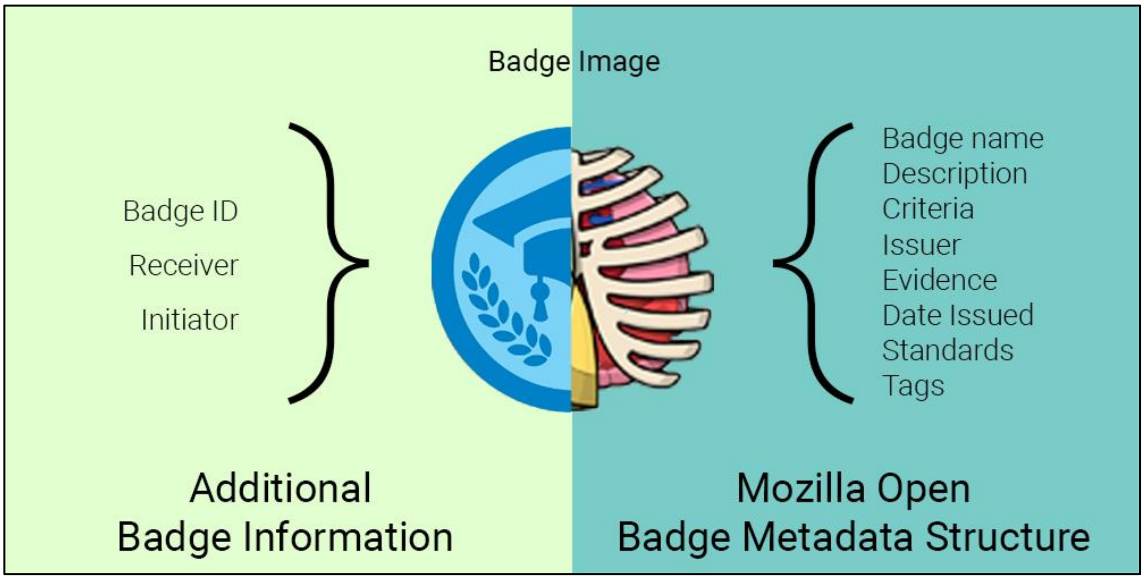


Figure 8.14—Demonstration of an Open Badge Containing Additional Data Fields to Allow for Database Storage.

Using the standard Mozilla method of storing badges, in other words implementing a Backpack which stores these PNG files, enables the ability of the system to expand and add standard Mozilla Open Badge systems.

8.5.2. Central Badge Repository

As stated at the start of this section, the Mozilla Backpack on the central cloud server was later renamed the central badge repository to aid with element-naming conventions as suggested by the expert reviewers. The idea behind a central server remained the same but the link to cloud computing that this original name implied did not conform to the disconnected solution that this model implements.

This server could be located in either a connected or disconnected environment, but this research suggests implementing the server in a connected environment. If the server is located in a disconnected environment, it would be accessible to the participants located in this environment, but not any of the outside stakeholders. This would also limit the expansion of the ICT4D initiative into other resource-constrained environments, as the server structure would have to be recreated in the new environment and a link established between these servers.

Alternatively, creating this server structure in a connected environment would make it harder for participants from disconnected environments to connect, but easier for outside stakeholders (such as skill utilisers located in connected environments). The badge system within the resource-disconnected environment would still be functional using a mesh network and local device databases, which occasionally sync with the central repository when connectivity is available. This would also allow the expansion of the initiative to include existing Mozilla badge systems which are connection reliant. Existing systems could then be used to award badges to individuals situated in disconnected environments. The individual will not be notified of this award, but the badge will exist in the repository, which the user may one day be able to access.

By utilising a standard client-server model, the issuing/receiver applications, or any Mozilla Open Badges issuing interface, would be required to pass through a central server before being able to access data. This implies client requests (regardless of if it is the conceptual model's issuer/receiver applications or another issuing/receiving system) enter a single-entry point. This server would house the logic required to: 1.) sync data between the application database and the central repository database, 2.) create/bake new badges, 3.) store the badge information in the correct locations (which could be a multitude of databases or file systems), and 4.) retrieve badge information from the correct locations.

8.6. Connectivity

As discussed in Chapter 6 (section 6.5.4), the connectivity area of the conceptual model does not contain its own unique elements. All the elements have already been discussed and there is no further expert feedback remaining.

This section describes the characteristics of the two states of connectivity regarding open badges and how they influence different elements already discussed. The first sub-section discusses the standard internet-connected environment.

8.6.1. Internet-Connected Environments

Current Mozilla Open Badges systems should have full functionality when in an internet-connected environment. Internet-connected environments are areas which have a steady and reliable connection gateway to the internet available for ICT to utilise.

These internet-connected areas will not be found in resource-constrained environments and, generally, the solutions and systems developed with internet connectivity as a given will not function optimally outside of these connected environments.

When adding a central badge repository to an open-badging system design, a connected environment would be the ideal area to implement it. This would allow the central badge repository to function with existing Mozilla badging systems and still be utilised in an ICT4D initiative as described with the data synchronisation process in the previous section.

8.6.2. Internet-Disconnected Environments

Internet-disconnected environments remain a considerable difficulty for ICT4D initiatives (Brewer et al., 2005; Straumann, 2015). Challenges arise in transmitting data to or from such an area (Brewer et al., 2005). Coupled with a lack of network infrastructure, it is entirely possible for ICT devices to not have any connection at certain points during an ICT4D initiative (Botha et al., 2014), which could severely impact the effectiveness of such a communication-reliant device.

The incorporation of mobile mesh networks would enable the ICT devices to at least communicate with one another, and thus enable some data communication (discussed in Chapter 4, section 4.2). By utilising this communication route, as potentially chaotic as it might be, it is entirely possible to convey information from one device to another. While this communication might not be as instantaneous as expected, the usage of a local database on each device (which syncs data with surrounding devices) would still allow for reliable data transmission.

This model relies on Brewer et al. (2005) idea of an asynchronous internet connection to help combat the effects of an internet-disconnected environment. As previously discussed, implementing online functionality in the applications enables a few instances of stable internet connectivity to spread updated information to a large network of mesh-connected devices located in an area that is generally not connected to the internet. If the environment has absolutely no internet whatsoever, it would be required for the initiators to travel on occasion to a connected environment and have an ICT device synchronise with the central badge repository. Once this device has updated, it must just reconnect to the mesh network and eventually other devices will also be updated.

Having discussed all the elements present in the final model, the next section presents a summary of this chapter.

8.7. Summary

This chapter presented the model for implementing open badges in a resource-constrained environment.

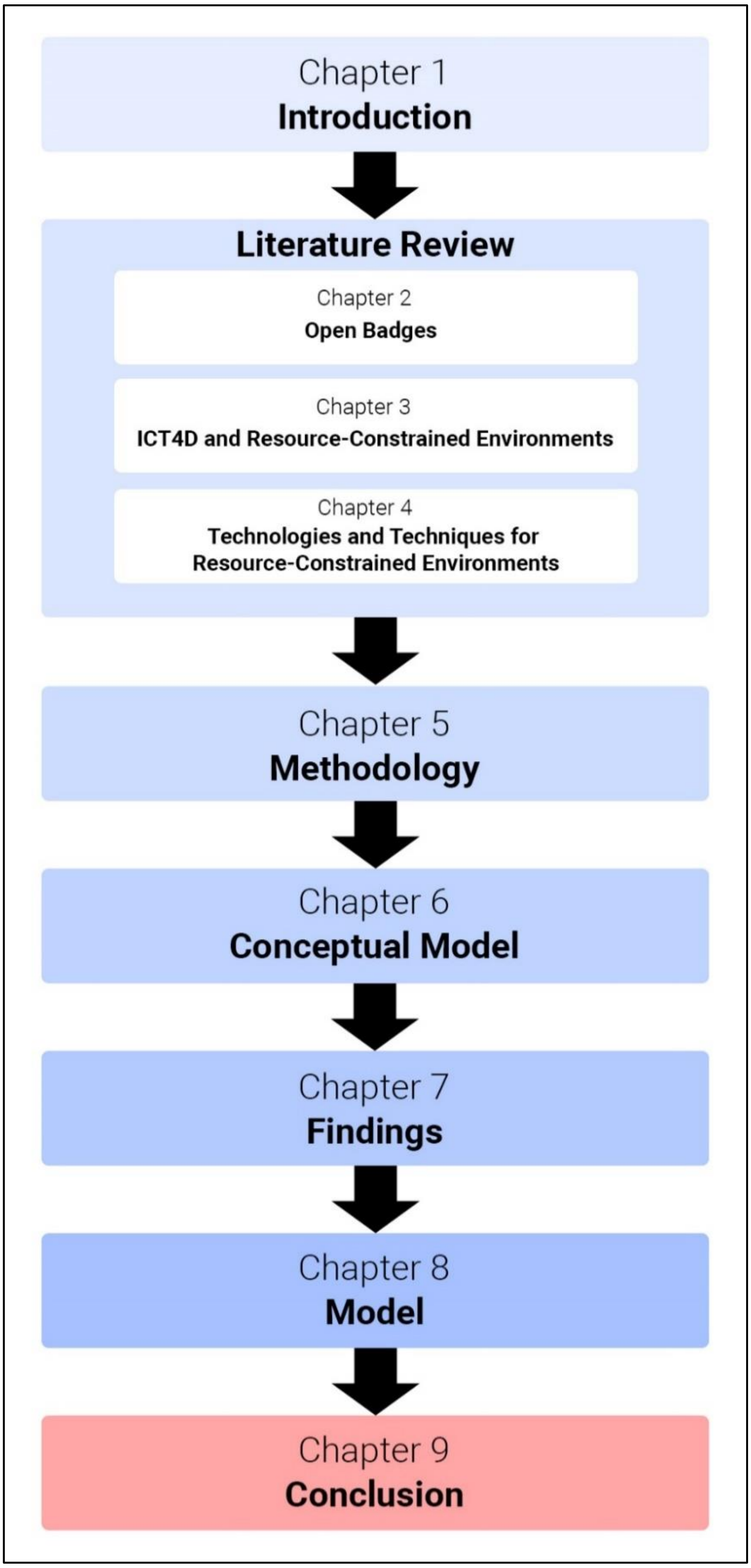
This chapter first introduced the model in section 8.2, before describing the various elements in sections 8.3-8.6 according to the 4C areas of development. These elements were originally present in the conceptual model, however expert reviewer feedback was incorporated and any required changes were implemented.

- **Capacity**: Discussed the four user elements: skill utilisers, badge receivers, badge issuers and initiators.
- **Computing Devices**: Outlined the use of a different badge issuing and receiving app, described the usage of the device database element.
- **Content**: While all except user elements feature in this area, to eliminate repeated arguments only the open badge metadata and central badge repository elements were discussed.
- **Connectivity**: This area had no remaining elements to discuss, however it presented an overview of how the different connected environments can influence solution design.

The next chapter concludes this research.

Chapter 9

Conclusion



9.1. Introduction

The objective of this research was to produce a model to implement open badges in a resource-constrained environment. This model was intended as a theoretical contribution in the domains of ICT4D and open badging. Using a design science research methodology, an IT artefact was produced which was constructed from existing literature and frameworks, and evaluated by experts in the concerned domains.

There is demand for a modular skill-based accreditation system such as Mozilla Open Badges. However, the current Mozilla open standard framework does not account for a variety of challenges concerning ICT in resource-constrained environments. This research addresses this lacuna by proposing the model detailed in the previous chapter. It is hoped that this model would aid in the development of open badge systems implementable by ICT4D initiatives.

This is the final chapter of this research and provides a summary of the objectives, research process and findings presented in this study. The following is discussed in this chapter:

- A research overview which briefly examines the structure of this thesis and what has been done in each chapter is presented in section 9.2.
- Section 9.3 reflects on the research questions, and whether they have been addressed adequately as defined by the implemented research process of design science.
- The research contribution that this study makes to the knowledge base of design science is examined in section 9.4, followed by
- Section 9.5 which details the limitations of this research and the effects these limitations had on the study.
- Before concluding this research with a summary, this chapter explores possible avenues of future research in section 9.6.

The next section presents the research overview.

9.2. Research Overview

This thesis consists of nine chapters. The first chapter served as an introduction to this research and detailed the need for and context of this study. In the first chapter, the problem statement was outlined, along with research questions and objectives.

The next three chapters presented the literature review of this research. Each chapter was focused on addressing a single research question, and together they were used to address the primary research question. The literature review served as secondary data gathered to help identify elements critical to the functionality of open badges, the challenges of resource-constrained environments, and the technologies and techniques that could be employed to overcome the challenges of constrained environments.

In Chapter 2, the literature focused on examining the background of badges, the current demand for open badge systems, investigations into four different Mozilla open badging systems, and an analysis of the current Mozilla open standard framework.

Once open badge elements had been investigated, the next chapter of the literature focused on identifying challenges of ICT4D initiatives based in resource-constrained environments. This involved first defining resource-constrained environments in the context of this research, then investigating the need for ICT4D, the development approach in addressing the digital divide, the suitability of the 4C framework for this research, and finally the challenges of constrained environments viewed through the lens of the 4C framework.

The final literature review chapter was focused on identifying technologies and techniques to implement the elements identified in Chapter 2 in order to overcome the challenges identified in Chapter 3. Chapter 4 discussed how various solutions which are already well understood and can be adapted to address the research problem. This chapter examined mesh networks and the use of local device databases to simulate a connected environment, how HCI and HCI4D design guidelines can be used to overcome social and educational challenges present in constrained environments, and finally why mobile ICT devices were the preferred content delivery device in this model's design.

Chapter 5 of this research detailed the methodological processes that were followed to best address the problem and the research questions. This chapter made use of the onion research model and systematically explored this research's choices on selecting the: interpretivist philosophy, inductive research approach, a design science methodology, the gathering of qualitative data, the use of a cross-sectional time horizon, the use of literature as secondary data and expert reviews as primary data, and finally how data were analysed, employing the coding and pattern analysis methods from the grounded theory.

The conceptual model was presented and described in Chapter 6. It was detailed how this model was composed of elements gathered from literature before giving an overview of the model. This chapter then discussed all the model elements' characteristics and relationships within the 4C framework.

The feedback gathered from expert reviewers who evaluated the conceptual model was presented in Chapter 7. This feedback was structured using the model evaluation criteria described in the methodology chapter and utilised in the questionnaire.

The last chapter before this conclusion presented the final model, which was constructed using an iterative design science process of continuous research and feedback. Chapter 8 was concerned with addressing the primary research question of this study and detailed all elements required for a model to allow the implementation of open badges in a resource-constrained environment. This chapter discussed the model in a structure similar to Chapter 6, but made reference to relevant literature points and expert feedback when discussing any changes. This chapter also presented a slightly higher level of technical detail regarding some elements where experts noted any lack of clarity.

The subsequent section discusses reflections on the research questions and the research process of this study.

9.3. Reflections on the Research Questions and the Research Process

In addressing the research questions and objectives of this study, this research made use of a design science research process proposed by K. Peffers et al. (2006) and examined in Chapter 5.

First, this sub-section compares the research process of this research against the guidelines set forth by K. Peffers et al. (2006) to ensure that the research process matches that required by design science research. Once the process has been examined, this section then demonstrates that there is a valid design science research contribution by making use of Gregor and Hevner (2013) design science research knowledge contribution framework. Finally, this section concludes with reflections on the research questions of this study and how they have been addressed.

9.3.1. Reflections on the Research Process.

This section now examines K. Peffers et al. (2006) design science process as implemented in this research and detailed in figure 9.1 below. This study entered the research process from a problem-centered approach.

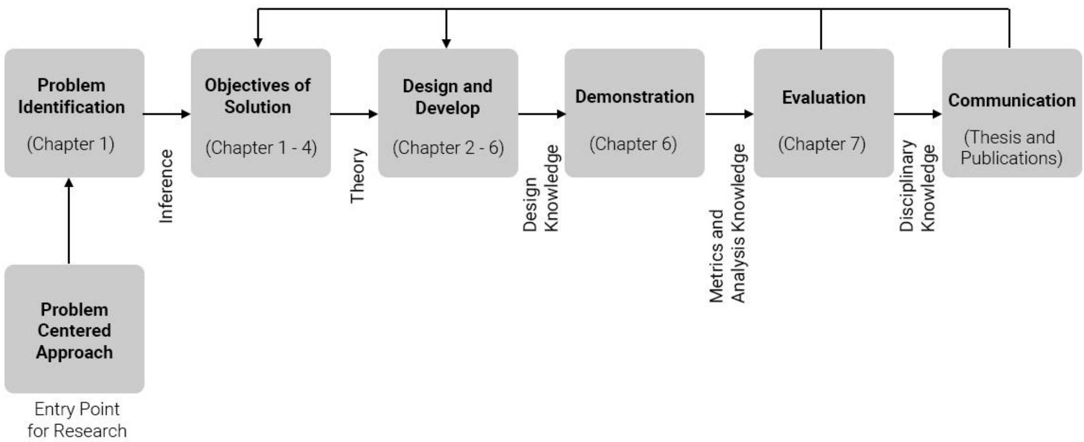


Figure 9.1—Design Science Research Process Adapted from Peffers et al. (2006).

9.3.1.1. Problem Identification

Aim: Define a specific research problem and justify the solution.

Application: This research identified a specific research problem in Chapter 1 (section 1.3). This problem resulted in the creation of one primary research question and three sub-research questions. The value of a solution was introduced in Chapter 1, and detailed in Chapter 2 (section 2.3).

9.3.1.2. Objectives of Solution

Aim: Define the objectives of the research to achieve the solution.

Application: A model to implement open badges in resource-constrained environments was proposed as an objective of this study (section 1.4). Having achieved this objective, the research will have addressed the research problem. Additional sub-objectives were identified, each related to one of the sub-research questions.

9.3.1.3. Design and Develop

Aim: Create the artificial solution.

Application: The conceptual model was created through a process of identifying elements in the literature review chapters (2, 3, and 4), each chapter addressing a sub-research question. During the construction of the conceptual model (Chapter 6), if there was found to be any lack of clarity or weak relationships between the elements, additional literature was gathered and later implemented. This ensured a continuous process of design.

9.3.1.4. Demonstration

Aim: Demonstrate the efficacy of the artefact.

Application: The conceptual model was discussed within Chapter 6, where all the characteristics and relationships between the elements were summarised after literature had been discussed. Every element was positively linked to prior literature research which indicated a certain level of research maturity. This discussion was enforced by the fact that when solutions were sought, it was from well-established theories and frameworks.

9.3.1.5. Evaluation

Aim: Observing how well the artefact addresses the problem.

Application: The conceptual model was submitted to experts in the domains of ICT4D, open badges, and ICT educational initiatives. These experts provided feedback in their analysis of how well the model addressed the problem identified. This feedback was presented in Chapter 7 and the implementation of the feedback can be seen in Chapter 8.

9.3.1.6. Communication

Aim: Communicating the problem, the artefact, and the value of the artefact.

Application: This is accomplished with the publication of this thesis, or making this thesis available when requested.

The next sub-section further demonstrates the validity of the research process by examining the model produced by this research in relation to the design science research knowledge contribution framework.

9.3.2. Validity of Research Process According to the Design Science Research Knowledge Contribution Framework

Gregor and Hevner (2013) design science research contribution framework classifies this research as a form of exaptation extending known solutions to new problems. They state that the research needs to demonstrate: 1.) the extension of knowledge into a new field is not trivial, and 2.) the new field exhibits some challenges that were not encountered when the system was originally applied.

9.3.2.1. Nontrivial Extension of Know Knowledge

During the course of this research, no known model or framework was encountered to allow for the implementation of open badge within resource-constrained environments. Adapting the existing Mozilla open standard framework along with the 4C framework of Tongia (2005), this research was able to produce a model that would allow for the above-mentioned implementation and still retain the validity of open badges' certification.

9.3.2.2. The New Field Exhibits New Challenges Not Originally Encountered

The current Mozilla Open Badges systems are not designed with resource-constrained environments in mind. As was examined in the ICT4RED's teacher professional development project (section 2.4.4), numerous challenges were encountered when attempting to implement a Mozilla Open Badges system in such an environment. This research examined the Mozilla open standard framework and determined that it does not incorporate many of the necessary elements required to allow the feasible implementation of open badges within resource-constrained environments.

9.3.3. Reflections on the Research Questions

There was one primary research question and three sub-research questions put forth at the introduction of this research:

- **Research Question:** What are the elements of a model to implement open badges in a resource-constrained environment?
- **Sub-Research Question 1:** What are the elements of open badges that are critical to their functionality within the open badge standard framework?
- **Sub-Research Question 2:** How do resource-constrained environments impact the functionality of ICT4D with regards to the context of connectivity, content, capacity and computers?

- **Sub-Research Question 3:** What current knowledge can be adapted and utilised to ensure the functionality of open badges within resource-constrained environments?

Through systematically answering the sub-research questions, starting with sub-research question 1, research into literature enabled the addressing of the primary research question. Due to the iterative design cycle that is implemented by design science research, the sub-research questions and ultimately the primary research question were also addressed by feedback from expert reviewers.

Sub-research question 1 was answered in Chapter 2, investigating literature on open badges. The elements for an open badge system were determined by analysing the current Mozilla open standards framework and four case studies of open badge systems. These elements were presented to expert reviewers, but no additional elements were identified as was demonstrated in Chapter 7.

The next sub-research question was addressed in Chapter 3, which examined resource-constrained environments and the ICT4D initiatives developed to bridge the digital divide. In answering this question, the research employed the 4C framework proposed by Tongia (2005), which enabled the classification of challenges based on their effect on one of the areas of development (connectivity, content, capacity and computers) for ICT4D design. Later, during the expert review process, a modification to the naming convention was made in renaming computers to computing devices to aid in the clarity of elements.

Sub-research question 3 involved the research of technologies and techniques to overcome the challenges presented by resource-constrained environments (as identified in sub-research question 2) to enable the implementation of elements identified in sub-research question 1. Chapter 4 details these technologies and how they are to be used to alleviate the effects of the resource constraints. This list was not expanded upon during the expert review process, but more detail on possible implementation methods was presented in Chapter 8.

Only after having addressed all the sub-research questions, was it possible to answer the primary research question. An answer to the primary research question was originally attempted in Chapter 6, which produced a conceptual model, but was only answered in full in Chapter 8 after the addition of the expert reviewer feedback. All elements required for the implementation of open badges within resource-constrained environments were detailed in the final model, detailed in figure 9.3 below.

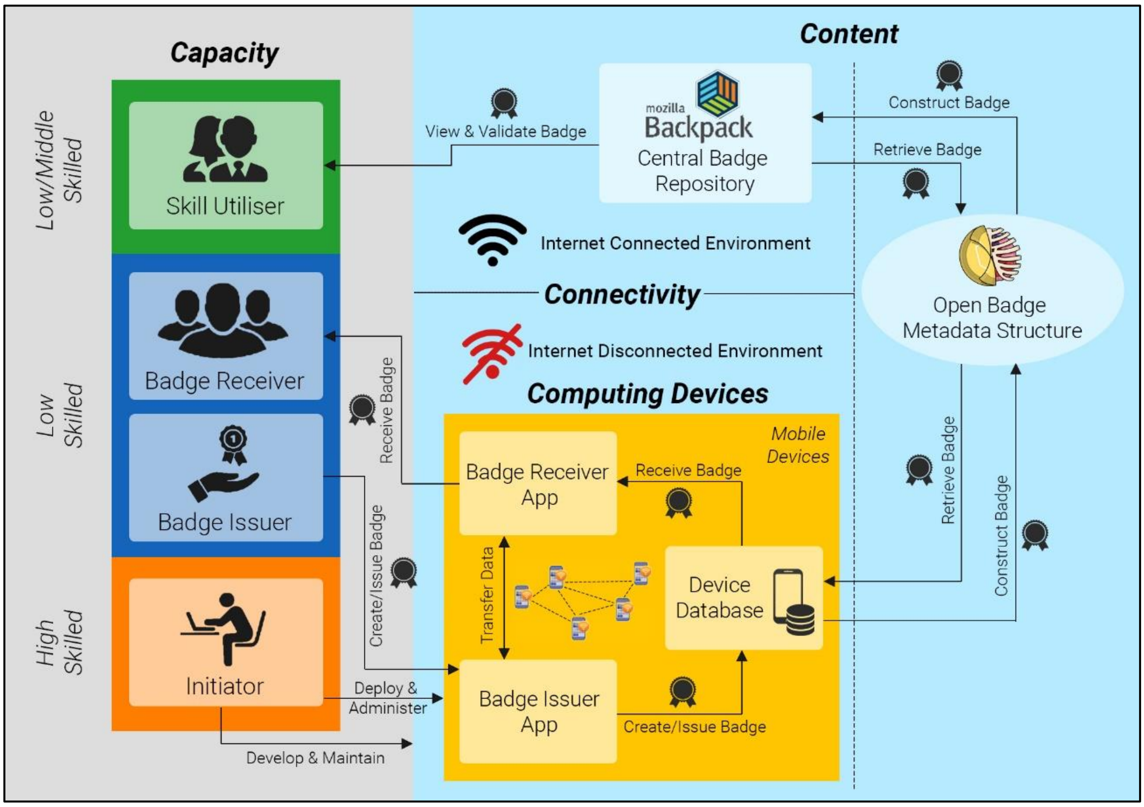


Figure 9.3—A Model for Implementing Open Badges in a Resource Constrained Environment

Having demonstrated the adherence to the design science research process and the addressing of all the research questions put forth by this research, the next section can now examine the contribution of this research.

9.4. Contribution of Research

The goal of this research was to provide a model to implement open badges in a resource-constrained environment. This study was rooted in the domains of ICT4D (examining challenges encountered by ICT4D initiatives, and technologies and techniques to circumnavigate these challenges) and open badges (specifically, modularised skill accreditation with the use of Mozilla Open Badges). All the information gathered from the literature review and expert evaluations was with the intent of addressing the main and sub-research questions.

The IT artefact produced by this research is considered a contribution to nascent design theory, and classified as a form of exaptation (combining mature solutions to address a new problem). March and Smith (1995) state that contributions to the knowledge base of design science research is evaluated by the novelty of the produced artefact and the improvement on existing artefacts.

March and Smith (1995) argue that a valid contribution cannot only be a significant contribution to knowledge, but must build on established knowledge by incorporating existing artefacts. During the course of this research, existing frameworks were investigated to help identify open badge elements and aid in designing an effective and efficient solution for resource-constrained environments. The model produced by this research was constructed by adapting the Mozilla open standard framework and structuring the elements according to the development areas of Tongia (2005) 4C framework.

The contribution to the design science research knowledge base is a model proposed for implementing open badges in a resource-constrained environment. This model provides a list of elements that are required for the functioning of open badges in these environments. The elements of the model are discussed in Chapter 6 and 8, detailing their characteristics and relationships to other elements. The model elements have been evaluated by experts in the domains of ICT4D and open badges, and were determined to be adequate in addressing the primary research question of this study.

Having examined how the proposed model fills the identified gap in knowledge and thus contributes to the knowledge base of design science research, the next section examines the limitations of this research.

9.5. Limitation of Research

There are several limitations that are identified regarding this research. This section scrutinises the following limitations detailed in the sub-section below:

- The number of expert reviewers.
- The quality of data provided by the expert reviewers.
- The theoretical nature of the model, without implementation.

9.5.1. The Number of Expert Reviewers

This study made use of four experts in the domain of ICT4D. Kantner and Rosenbaum (1997) justify the usage of two to three experts to produce credible results, however they admit that additional experts would result in a higher yield of identified issues.

While this research could have benefitted from additional reviewers, there was found to be a shortage of individuals that exhibit willingness to participate and still meet the required criteria to be considered experts in the domain.

9.5.2. The Quality of Data Provided by the Expert Reviewers

Reviewers were required to be experts in the field of ICT4D and open badges. Whilst it is definitely the case that all the experts were deeply involved in the domain of ICT4D, there is only a connection to open badges specifically.

As open badges are a relatively new idea, it was impossible to find experts that specialised exclusively in that domain. Instead it was considered acceptable to include experts who have experience in the domains of digital badging, education initiatives implemented with gamified badges, and educational initiatives focused on upskilling or skill accreditation.

9.5.3. The Theoretical Nature of the Model and Lack of Implementation

Using March and Smith (1995) model evaluation criteria, the IT artefact produced by this research is considered a valid contribution to the knowledge base of design science research. However, from a practical point of view, it would have been beneficial if a system implementation could have been designed based on this model. Additional data could have been gathered from field tests. Unfortunately, due to time and resource constraints, this was not possible and so fell beyond the scope of this research.

9.6. Future Work

During the review of literature and the design of the research model, a number of topics were found that were of interest as possible areas of future research. The following areas and topics were identified:

9.6.1. A Model to Assess the Validity of Open Badge's Accreditation

There currently exists a framework that enables anyone who can implement the Mozilla API and a badge repository to issue badges. It is then up to the utiliser of these open badges to validate their accreditation. This is done by examining and verifying the adequacy of evidence in an issued badge. This process currently has a flaw where non-certifiable individuals can issue badges, and put pressure on the open badging community. A model to aid in the validation process could help address this issue.

9.6.2. Designing a Model for the Cost-Effective Implementation of Open Badge in a Resource-Constrained Environment

The model produced by this research is focused on implementing open badges in resource-constrained environments, but not in the most cost effective manner. It was felt that due to the continued progress in the field of ICT, any such consideration would quickly become outdated as the prices of ICT are constantly fluctuating when new technologies are introduced. There exists the opportunity, however, to adapt the model presented by this research to include these considerations.

9.6.3. The Implementation of this Model

As discussed in the previous section of limitations, the proposed model of this research was never implemented. Jones and Gregor (2007) examine how implementing a model with testable propositions along with a system or tool that can produce quantifiable results could aid in justifying the claim of knowledge contribution.

This presents the opportunity for future research to implement and test this model. This could most likely lead to improvements of the existing elements or in the identification of additional elements.

9.6.4. Investigating External Stakeholders' Effects on Open Badging Systems

Raised as a possible avenue of future research by one of the expert reviews, the expert believed there currently exists a need to investigate, potentially with a case study, the effects that external stakeholders can have on open badging systems.

This future research will have to analyse the motivational factors between various external stakeholders, and then define elements which contribute to either the success or failure of an open badging initiative. This future research could be linked to the previous avenue identified above, and would most likely start gathering data during the implementation of this model.

The next section summarises this conclusion chapter of the thesis.

9.7. Summary

The conclusion chapter demonstrated how this research produced a model to implement open badges in a resource-constrained environment. The model was detailed in Chapter 8, but was designed by addressing research questions first with the aid of prior literature (Chapters 2,3, and 4) and then with feedback from expert reviewers (Chapter 7).

Section 9.2 of this chapter presented a general research overview, followed by section 9.3, which examined reflections on the research process and research questions. The contribution of this research was then highlighted in section 9.4, before discussing the research limitations in section 9.5. Finally, this chapter provided a list of possible avenues for future research in section 9.6.

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Appendices

Appendix A – Evaluation Questionnaire

MONASH South Africa

A campus of Monash University Australia

Evaluation Questionnaire – Expert Reviewers

Title of Project: A Model for Implementing Open Badges in a Resource Constrained Environment

Name of Researcher: Mr Matthéus Daniël Niemand

This questionnaire serves as an evaluation of the model proposed by this research. This questionnaire is distributed with an Evaluation Form which contains a figure of the model as well as a table detailing all the characteristics and relationships between the elements of the model.

This questionnaire utilises the following evaluation criteria set forth by March and Smith (1995)'s for the evaluation of a model designed with a design science research strategy:

- **Fidelity to Real World Problems** – How faithful the model is in addressing the identified research problem.
- **Completeness** – Design theory and elements have to be completely described, or it will lack internal consistency.
- **Level of Detail** – Referring to the level of detail of elements and their relationships relative to the purpose and scope of the research.
- **Robustness** – The applicability of the model over a broad spectrum of scope and purpose, thus defining the model's scope and purpose.
- **Internal Consistency** – Theory and elements have to be consistent with their use and definitions.

Establish expert credibility

1. Can you describe your area of expertise and highest position/award achieved in this area?
2. How many years of experience have you had in your area of expertise?

3. Have you been involved in ICT4D initiatives? Can you briefly describe the goal each ICT4D initiative you were involved in and your role?

Evaluation of the proposed model to Implement Open Badges in a Resource Constrained Environment

Fidelity to Real World Problems

1. The proposed model is divided into four aspects (capacity, connectivity, content, and computers) to help structure a development framework. Do you feel that these aspects accurately reflect the necessary development areas and challenges found within resource constrained environments when designing ICT4D applications?

    1.1 If so, please indicate if you could have added another area?

    1.2 If not, please explain which area(s) are inadequately represented or erroneous?

    1.3 Can you think of any challenges that resource constrained environments might pose to ICT4D initiatives that were not mentioned?

    1.4 Please rate the model in terms of fidelity to the real world problems from 1 to 5, where 1 is very unfaithful and 5 is very faithful. Please motivate your answer.

Completeness

2. The proposed model lists a number of elements contained within the various areas of development. Do you feel that elements were completely described with regards to their characteristics and relationships to one another?

    2.1 If so, can you think of any additional elements that might suit the model? Please motivate new elements with possible characteristics and relationships within each area of development.

    2.1.1 Connectivity.

    2.1.2 Capacity.

    2.1.3 Content.

    2.1.4 Computers.

    2.2 If not, what elements are lacking detail? Please motivate with suggesting possible gaps as well as element characteristics and relations you feel are not present or ill fitting.

    2.3 Please rate the model in terms of completeness from 1 to 5, where 1 is very incomplete and 5 is very complete. Please motivate your answer.

Level of Detail

3. This research proposes a model to implement open badges in a resource constrained environment. The areas of research for this study were identified as follows: ICT4D including development techniques and technologies thereof, and Mozilla Open Badges. Do you believe that these fields were the most relevant in the construction of the proposed model?

   3.1 If so, can you suggest any related topics that might be of interest in discovering new elements or reinforcing existing elements? Please motivate with any examples you can think of.

   3.2 If not, which areas of research would you suggest be the most suitable in the construction of the proposed model? Please also motivate why you felt the topic areas were not the most relevant to the construction of this model.

   3.3 Please rate the model in terms of level of detail from 1 to 5, where 1 is very undetailed and 5 is very detailed. Please motivate your answer.

Robustness

4.1 Do you think that the current proposed model would aid in the construction of application that would allow for the sending and receiving of open badges in a resource constrained environment? Please motivate your answer.

4.2 Do you think this model shows a clear contribution to the field of ICT? Please motivate your answer.

4.3 Do you think the model is detailed enough to be understood by developers without large amounts of additional research? Please motivate your answer.

4.4 Please rate the model in terms of robustness from 1 to 5, where 1 is not robust and 5 is very robust. Please motivate your answer.

Internal Consistency

5. When examining the elements do you think that they are named appropriately and descriptive in their role?

   5.1 If so, could you think of synonyms to better describe each element?

   5.2 If not, can you think of any elements used erroneously or could lead to misunderstanding.

   5.3 Please rate the model in terms of internal consistency from 1 to 5, where 1 is very inconsistent and 5 is very consistent. Please motivate your answer.

Appendix B – Evaluation Form Containing Model

MONASH South Africa

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Evaluation Form – Expert Reviewers

Title of Project: A Model for Implementing Open Badges in a Resource Constrained Environment

Name of Researcher: Mr Matthéus Daniël Niemand

This form serves to identify relevant elements, their characteristics and relationships in a Model for Implementing Open Badge in a Resource Constrained Environment. Figure 1 shows the proposed Model for Implementing Open Badges in a Resource Constrained Environment. Table 1 describes the characteristics and relationships between the different elements within the model.

1) Please examine the model in Figure 1 carefully.

2) Read through Table 1 detailing the characteristics and relationships of elements found on Figure 1.

3) You will be given a separate assessment questionnaire which will require you to answer questions relating to this model.

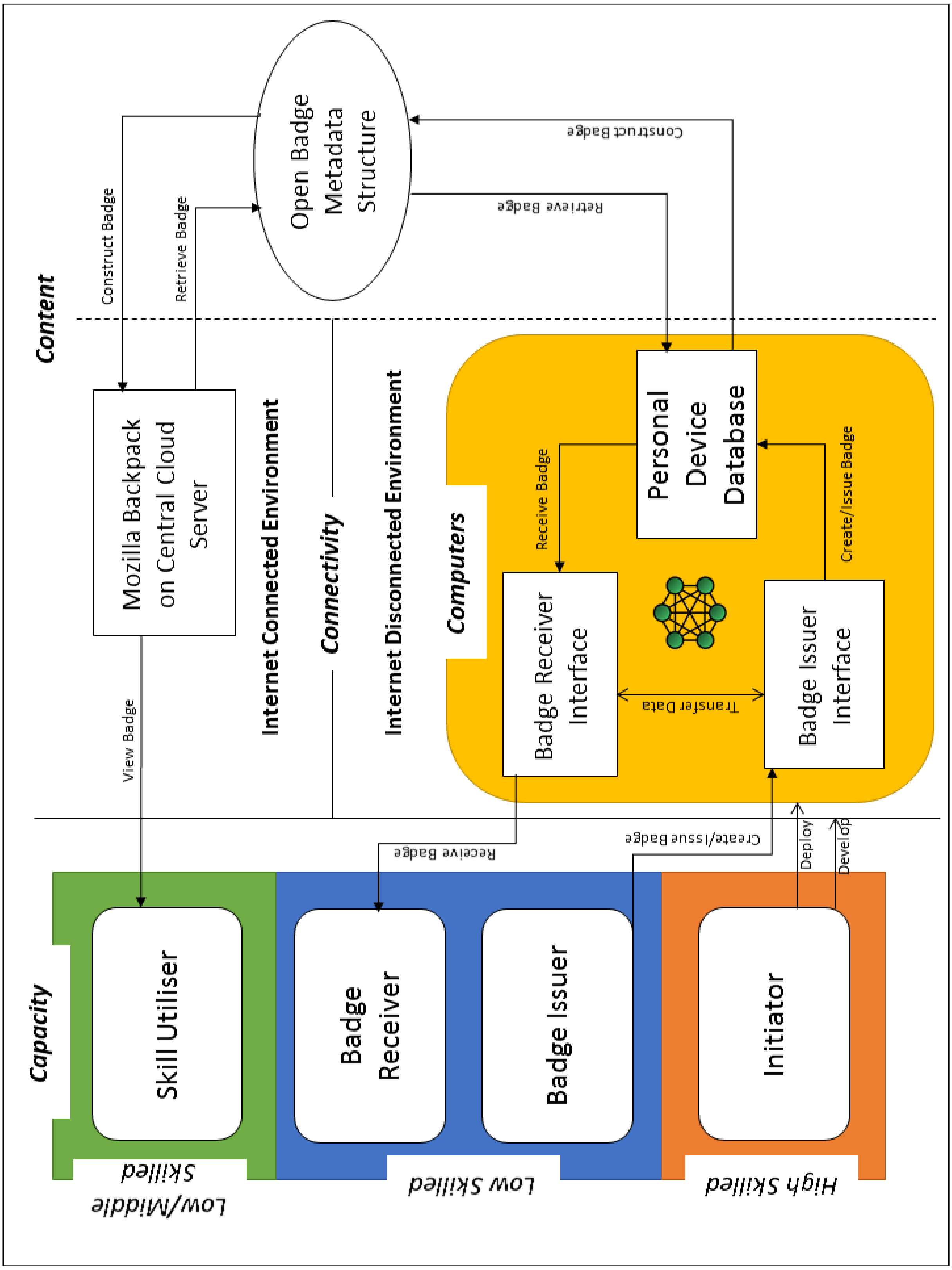

Figure 2 – Model for Implementing Open Badges in a Resource Constrained Environment

Capacity	
Skill Utilisers	**Characteristics** • External party interested in utilising the skills earned by Badge Receivers. • May be situated within a resource constrained environment. • Possibility to be non-ICT confident. • Possibility to possess low levels of English literacy. • May possess unique social and cultural values. • Has to determine the authenticity of the issuer and the validity of the skill accreditation.
	Relationships • Views the badges that have been received by individuals. • Can view the badges online by accessing a relevant link or website. • Can view the badges offline by being handed the ICT device where the badge is contained.
Badge Receivers	**Characteristics** • Receives badges for demonstrating an aptitude in a skill form Badge Issuers. • Is situated within a resource constrained environment. • High possibility to be non-ICT confident. • Possibility to possess low levels of English literacy. • Possess unique social and cultural values.
	Relationships • Interacts with the Badge Receiver Interface. • Receives badges from Badge Issuers through the Badge Receiver Interface. • Can view all earned badges on the Badge Receiver Interface. • Can view badges that can possibly be earned on the Badge Receiver Interface.
Badge Issuer	**Characteristics** • Issues badges for demonstrating an aptitude in a skill to Badge Receivers. • Is situated within a resource constrained environment. • Possibility to be non-ICT confident. • Possibility to possess low levels of English literacy.
	Relationships • Interacts with the Badge Issuer Interface. • Issues badges from Badge Issuers Interface to the Badge Receiver. • Can view all earned badges of a Badge Receiver. • Can view all unearned badges of a Badge Receiver. • Can create new badges to issue to Badge Receivers.
Initiator	***Characteristics*** • Initiators of an ICT4D initiative (Developers, Managers, Funders, Regulators). • Possess high levels of technical expertise in order to develop, deploy and manage the system. • Possess enough resources to be able to initiate the ICT4D initiative (Time, Money, Skills). • Is not situated within a resource constrained environment.
	Relationships

<table>
<tr><td></td><td>

• Develops the original system which forms the basis of the Content.
• Would have to develop the Badge Receiver/Issuer Interfaces
• Would have to incorporate the Open Badge Metadata Structure and API into the design of the system
• Deploys/Provides the Computers.</td></tr>
<tr><td colspan="2">Computers</td></tr>
<tr><td rowspan="2">Badge Receiver Interface</td><td>Characteristics

• Is deployed on a mobile ICT device.
• Designed to with HCI4D guideline to accommodate low levels of English literacy and non-ICT confident users.
• Designed with mobile HCI guidelines to ensure a good user experience.
• Fully functional without Internet connectivity.
• Notifies Badge Receiver of new badges that they have been awarded.
• Enables the Badge Receiver to view details on past badges they have earned.
• Enables the Badge Receiver to view details on badges that they could potentially earn.
• Set up to interact with other mobile ICT devices over a Mobile ad-hoc Network</td></tr>
<tr><td>Relationships

• Utilises the Personal Devices Database to view details on received badges.
• Utilises the Personal Device Database to store badges that have been awarded.
• When a badge is being issued the Badge Receiver interface connect to the Badge Issuer Interface via a mobile Ad-hoc network. The awarded badge information is received from the Badge Issuer and stored in the Personal Device Database.
• Connects to other Badge Receiver Interfaces and Badge Issuer Interfaces to update data on Personal Device Database with regards to new badges that have been created and can be earned.</td></tr>
<tr><td rowspan="2">Badge Issuer Interface</td><td>Characteristics

• Is deployed on a mobile ICT device.
• Designed to with HCI4D guideline to accommodate low levels of English literacy and non-ICT confident users.
• Designed with mobile HCI guidelines to ensure a good user experience.
• Allows Badge Issuer to create new badges to issue following the Mozilla Metadata Structure.
• Enables the Badge Issuer to view details on past badges they have issued.
• Enables the Badge Issuer to view details on badges that they could still issue.
• Set up to interact with other mobile ICT devices over a mobile ad-hoc network</td></tr>
<tr><td>Relationships

• Utilises the Personal Device Database to view details on issued badges from that device.
• Utilises the Personal Device Database to view badges that can be issued.
• When creating new badges, it stores new badge information on the Personal Device Database.
• When issuing a badge, updates the relevant badge information with new evidence and metadata on the personal device database, and then transfers the updated data to the relevant Badge Receiver Interface via the mobile ad-hoc network.
• Connects to other Badge Issuer Interfaces and Badge Receiver Interfaces to update data on Personal Device Database, sending data on newly created badges.</td></tr>
</table>

Personal Device Database	**Characteristics** • Is deployed on a mobile ICT device along with either the Badge Issuer Interface or Badge Receiver Interface. • Is only accessible directly by the Initiator/s. • Enables asynchronous Internet connections by storing data until it can be sent over an Internet connection. • Contains a constantly updating record of all badges created, issued, or received. • This data record is shared between all devices that can connect to via a mobile ad-hoc network and posses with either the Badge Issuer Interface or Badge Receiver Interface. • The data record is formatted to match the Mozilla open badge metadata structure and will not store entries that do not match this structure.
	Relationships • If the Personal Device Database is located on a mobile device with the Badge Issuer Interface it should allow the creation and storage of new badges that meet the metadata structure requirements. • If the Personal Device Database is located on a mobile device with the Badge Issuer Interface it should allow the updating of data entries of badges to reflect that they have been issued to a specific Badge Receiver. • If the Personal Device Database is located on a mobile device with the Badge Receiver Interface it should allow the not allow the user to personally update any data records, and only allow the retrieval and viewing of a data record. • A Personal Device Database will sync records with other Personal Device Databases if there is a mobile ad-hoc network available with other Receiver/Issuer Interface devices present. • If there is a steady internet connection available, a Personal Device Database will attempt to retrieve badges from the central Mozilla Backpack Server of the ICT4D initiative. • If there is a steady internet connection available, a Personal Device Database will also attempt to construct (bake) badges that have been issued and newly created to the central Mozilla Backpack Server of the ICT4D initiative.
Content	
Computers	**Characteristics** • A mobile ICT device. • Implements a mobile ad-hoc network. • Contains the Personal Device Database. • Runs the Badge Receiver/Issuer Interfaces.
	Relationships • Is deployed by the Initiator/s. • Contains content developed by the Initiator/s. • Connects with other ICT devices via a mobile ad-hoc network. • When Internet connectivity is available the ICT device attempts to connect to the central Mozilla Backpack Server of the ICT4D initiative.
Open Badge Metadata Structure	**Characteristics** • A requirement of the Mozilla Open Badge Standard Framework. • Requires the implementation of the Mozilla Open Badge API's to conform to the Mozilla Open Badge Infrastructure.

	• Composed of badge name, description, criteria, issuer, evidence, date issued, standards and tags. • Ensures badges can be authenticated by Skill Utilisers by requiring evidence to be presented when badges are issued.
	Relationships • Required for the Personal Device Database to construct badges and store them on the central Mozilla Backpack Server of the ICT4D initiative. • Required to send badges from the central Mozilla Backpack Server of the ICT4D initiative to the Personal Device Databases of the ICT devices.
Mozilla Backpack on Central Cloud Server	**Characteristics** • Deployed and maintained by the Initiator/s. • Stores all badges created during the course of ICT4D initiative. • Stores the badges received by Badge Receivers in each individual's account. • Enables Badge Receivers to still receive and collect badges in a central repository, regardless if the issuer is outside of the ICT4D initiative. • Allows Badge Receiver to benefit from already established features of the Mozilla Backpack, such as exhibiting earned badges on social media.
	Relationships • Is deployed by the Initiator/s. • Is developed by the Initiator/s. • Has to be accessible to Skill Utilisers who which to retrieve and view badge data of Badge Receivers. • ICT devices attempt to connect to the central server when they have a steady Internet connection. • When Internet connectivity is available the server sends new badge data to any ICT device that is connected, thus enabling that ICT device to later sync up with the ICT devices around it. • When Internet connectivity is available the server receives badge data on newly created badges and issued/received badges.
Connectivity	
Internet Connected Environment	**Characteristics** • Internet connectivity available. • Most likely not located in a resource constrained environment. • Operational zone for the Mozilla Backpack on Central Cloud Server • Ideal environment for data sharing between ICT devices and any Internet connected environment
	Relationships • Skill utilisers may be located in Internet connected environments, and would require access to traditional online services such as the Mozilla Backpack via a website.
Internet Disconnected Environment	**Characteristics** • Located in a resource constrained environment. • Inhibits data sharing between ICT devices and sources located outside the environment. • Requires alternate data sharing solutions. • A challenge for many ICT4D initiatives.

	Relationships • Providing Internet connectivity is a large scale endeavour and thus has little to do with many ICT4D initiatives. • ICT devices and services have to function within an Internet disconnected environment

Appendix C – Consent Form for Expert Reviewer Participation

MONASH South Africa

A campus of Monash University Australia

Consent Form – Expert Reviewers

Title of Project: A Model for Implementing Open Badges in a Resource Constrained Environment

Name of Researcher: Mr Matthéus Daniël Niemand

1. I confirm that I have understood the Explanatory Statement that was explained to me with regards to the above study and have had the opportunity to ask questions.
2. I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason.
3. I consent to interviews being audio-taped.
4. I understand that I will be referred to by pseudonym or as anonymous in any publications arising from the research.
5. I agree to take part in the above study.

________________________	__________	____________________
Name of Participant	*Date*	*Signature*
________________________	__________	____________________
Researcher	*Date*	*Signature*

Appendix D – Explanatory Statement for Questionnaire

MONASH South Africa

A campus of Monash University Australia

Explanatory Statement –Expert Reviewers

Title of Project: A Model for Implementing Open Badges in a Resource Constrained Environment

Researcher Details:

Name: Mr Matthéus Daniël Niemand

[redacted]

[redacted]

A researcher from Monash South Africa, the South African campus of the Australian university, Monash University is conducting research for his Master's degree of Computer and Information Sciences on creating a model for implementing open badges in a resource constrained environment. The investigator for this research project is Mr Matthéus Daniël Niemand

You are invited to participate in this project by answering a few questions. The whole exercise should not take more than an hour. The goal of this project is to provide a model that would allow the successful implementation of an open badge system within a resource constrained environment by overcoming various technical and social challenges posed by such an environment.

Participation is optional and on a voluntary basis. You are under no obligation to participate. Should you agree to answer the questions, you would still have the right to withdraw at any stage of the interview. If you for some other reason would prefer not to answer one or more questions, it is your full right to refuse.

Your privacy will be protected at all cost. You will not be referred to by your name in any publications resulting from this research.

If you would like to be informed about the outcomes of the study, you can request a copy of the results to be sent to you by contacting the researcher directly. A summary of the main findings, along with the exposition of the methodologies that were used will be mailed to you. Alternatively, you will be able to find a summary of the research outcomes on the Monash South Africa website.

This research was granted ethical clearance by the Monash University Human Research Ethics Committee (MUHREC – Project Number 0314). Should you have any concerns or complaints about the conduct of the project, you are welcome to contact the Executive Officer, Monash University Human Research Ethics Committee (MUHREC):

Executive Officer
Monash University Human Research Ethics Committee (MUHREC)
Room 111, Building 3e
Research Office
Monash University VIC 3800

[redacted]

Signature: …………………………………………… Date: ………………………..

Appendix E – Ethics Approval Certificate

MONASH University

Monash University Human Research Ethics Committee

Approval Certificate

This is to certify that the project below was considered by the Monash University Human Research Ethics Committee. The Committee was satisfied that the proposal meets the requirements of the *National Statement on Ethical Conduct in Human Research* and has granted approval.

Project Number:	0314
Project Title:	A Model for Implementing Open Badges in a Resource Constrained Environment
Chief Investigator:	Ms Stella Ouma
Expiry Date:	31/08/2021

Terms of approval - failure to comply with the terms below is in breach of your approval and the *Australian Code for the Responsible Conduct of Research*.

1. The Chief Investigator is responsible for ensuring that permission letters are obtained, if relevant, before any data can occur at the specified organisation.

2. Approval is only valid whilst your hold a position at Monash University.

3. It is responsibility of the Chief Investigator to ensure that all investigators are aware of the terms of approval and to ensure the project is conducted as approved by MUHREC.

4. You should notify MUHREC immediately of any serious or unexpected adverse effects on participants or unforeseen events affecting the ethical acceptability of the project.

5. The Explanatory Statement must be on Monash letterhead and the Monash University complaints clause must include your project number.

6. Amendments to approved projects including changes to personnel must not commence without written approval from MHUREC.

7. Annual Report - continued approval of this project is dependent on the submission of an Annual Report.

8. Final Report - should be provided at the conclusion of the project. MUHREC should be notified if the project is discontinued before the expected completion date.

9. Monitoring - project may be subject to an audit or any other form of monitoring by MUHREC at any time.

10. Retention and storage of data - The Chief Investigator is responsible fo the storage and retention of the original data pertaining to the project for a minimum period of five years.

Thank you for your assistance.

Professor Nip Thomson

Chair, MUHREC