Developing a Conceptual Model for Receiving and Authenticating Digital Badges in a Resource Constrained Environment

Matthéus Niemand
Monash South Africa

Dr Stella Ouma
Monash South Africa

Dr Adele Botha
CSIR Meraka
South Africa

Abstract

Gamification is a persuasive technology that functions by motivating individuals with the implementation of game design elements in non-gameful exercises. Gamification incorporates these game elements in an attempt to have individuals exhibit above normal levels of effort in completing exercises. Badges are a game design element that has both intrinsic and extrinsic motivational aspects, which is beneficial to gamified systems when considering how levels of motivation influences the level of effort individuals are willing to spend on completing exercises. Mozilla Open badges adds to standard digital badges by enabling Open Badges to be used as an alternate form of accreditation creating meaningful badges that are ideal for educational initiatives. The credibility of Mozilla Open Badges reside in the security that they employ to deter duplication or forgery of digital badges. The functionality of the Mozilla Open Badges system experiences challenges within resource constrained environments due to issues posed by users and the context of the environment. As the main contribution, this paper proposes a conceptual model for receiving and authenticating digital badges in resource constrained environments. The model has been constructed using a design science approach. Data collection was done through literature review and three open ended participant interviews. Data was gathered with regards to the intended users, the environmental context and the system functionality. The collected data was analysed using an inductive approach.

Keywords
ICT4D, Gamification, Digital Badge Model

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1. Introduction

Games are currently one of the most attractive forms of entertainment. Recently the NPD Group released statistics gathered from a mass survey amongst U.S. citizens that the average mobile gamer willingly spends more than 2 hours a day playing games (NPD-Group, 2015). Gamification attempts to harness some of the motivational aspects of games and apply them to non-gaming scenarios by implementing gaming elements (Deterding, Sicart, Nacke, O'Hara, & Dixon, 2011). These statistics might differ somewhat in a developing country like South Africa, but their impact cannot be ignored. The promise of additional task motivation is attractive to both companies and educational institutions (Lee & Hammer, 2011).

Individual motivation for participation within a gamification system relies on the game elements having a personal meaning to participants (Reiners, Wood, Gregory, & Teras, 2015). Most gamification design already includes badges as a game mechanic due to their intrinsic and extrinsic motivational factors and the ability to guide and motivate players toward a goal (Blohm & Leimeister, 2013; Hamari, Koivisto, & Sarsa, 2014). Digital badges are however currently limited in their recognition and only appreciated by individuals who are part of the system where they are implemented.

Mozilla Open Badges allow anyone to issue individuals with a digital representation of a skill they have earned (Mozilla-Wiki, 2015). These Open Badges are intended to serve as an alternate form of credential, a digital version of more traditional methods such as diplomas and certificates (Mehta, Hull, Young, & Stoller, 2013; Moore, 2013). Mozilla ensures that these Open Badges are locked to a specific individual once they are issued and all verification takes place online thus ensuring the authenticity and security of the process (Mozilla-Wiki, 2015). One of the core requirements of using Mozilla Open Badges is that users must be connected to the internet (Mozilla-OpenBadges, 2015). This challenges the use of Mozilla Open Badges in resource constrained environments.

The information communication technology for rural education development (ICT4RED) initiative is part of the greater Technology for Rural Education Development (TECH4RED) initiative which is a joint venture between major South African government departments to help improve the quality of learning and teaching in the Cofimvaba area of the Nciba district situated within the Eastern Cape province of South Africa. One of the core visions for the ICT4RED initiative was:

> ”Explore and Design approaches for Teacher Professional Development (TPD), towards the evolution of a more emerging teaching and learning engagement for the information age. This extends to the development of 21st Century teaching practises of teachers and 21st Century skills of learners.”
> (Herselman & Botha, 2014, p. 2)

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The ICT4RED initiative implemented a gamified teacher professional development program that initially sought to make use of Mozilla Open Badges as their main reward system (Botha & Herselman, 2013; Ford, Herselman, & Botha, 2014). Due to resource constrained environmental challenges such as a lack of consistent connectivity, the program could not employ Mozilla Open Badges and had to instead default to physical sticker badges (Botha, Herselman, & Ford, 2014; Botha, Salerno, Niemand, Ouma, & Makitla, 2014). The physical sticker badges were sufficient for the goals of the initiative, but resulted in increased levels of bookkeeping work for facilitators who had to keep track of badges they issued and did not offer the same level of security as Mozilla Open Badges to the receiving individuals.

The aim of this paper is thus to produce a conceptual model for receiving and authenticating digital badges mirroring the authentication capabilities of Mozilla Open Badges, but with a focus on resource constrained environments. The research question that this paper address is as follows: What are the user, context and system factors that contribute to the receiving and authenticating of digital badges in a resource constrained environment?

2. Background Literature

This section will look at current literature to help define and contextualise gamification aspects that will be covered in this paper. Therefore this paper will cover the following:

- Due to the broad nature of gamification as a topic, this paper will only cover the motivational
- Motivational aspect that leads to the use of badges in a gamified system. Examine digital badges and their impact on the success of a gamification initiative as a multifaceted motivational tool.
- Digital badges compared to Mozilla Open Badges.
- Define resource constrained environments with a focus on the unique environmental factors that could potentially pose a challenge for ICT4D initiatives.
- Constraints of Mozilla Open Badges within resource constrained environments, thereby highlighting the research gap that this paper attempts to address.

An overview of gamification is presented in the next section.

2.1. Gamification

Gamification can be described as a persuasive technology, whereby inherently non-gameful exercises are modified to incorporate rewards and aspects of competitiveness to encourage and motivate users to go beyond their normal level of effort in completing their tasks (Blohm & Leimeister, 2013; Deterding et al., 2011). Deterding (2011) cautions that gamification is not a panacea for increasing individual participation and that the success of a gamification system relies on how effectively the game elements have been implemented.

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Blohm and Leimeister (2013) argue that gamified systems rely on individual's personal level of motivation and that game design elements motivate individuals differently. Incorporating a multitude of motivational affordances or a motivational affordance that targets a wide variety of individuals would be considered beneficial to a gamified system as it would be attractive to a larger user base (Reiners et al., 2015). Conversely it can thus be said that if a reward system within a gamified system does not function fully, it could potentially lead to individuals losing their motivation for participating in the exercise (Botha, Salerno, et al., 2014).

Given the wide variety of game mechanics that could be implemented to increase individual motivation, it could be hard to determine the correct mechanic for a particular system (Deterding, 2011). Hamari et al. (2014) observes that badges are one of the most popular motivational affordances. This is reinforced by Dale (2014)'s discussion on the importance of rewards such as badges and trophies in motivating individuals. The next section examines digital badges and how they could be used as multifaceted motivational tools in a gamification system.

2.2. Digital Badges

The idea behind badges as a motivational tool is not a new concept. Physical badges have been used by various military outfits during the middle ages as a symbol of rank, status and accomplishment (Gibson, Ostashewski, Flintoff, Grant, & Knight, 2013). More recently digital badges have been introduced in conjunction with gaming systems and gamified systems in various fields (Blohm & Leimeister, 2013; Deterding et al., 2011; Young, 2012). Digital badges or achievements feature in many of today's games and are a requirement for publishing on variety of current gaming consoles such Microsoft's Xbox One and Xbox 360 (Hamari & Eranti, 2011). Hamari and Eranti (2011) describe how digital badges are usually composed of a name, a visual image and a description on what is needed to earn the badge.

Blohm and Leimeister (2013) consider badges a multifaceted reward, as they cover many different aspects of motivation for individuals. Dale (2014) explains how rewards can either be intrinsic or extrinsic, but generally have to have some personal meaning to the individual to be effective. Blohm and Leimeister (2013) demonstrate how badges benefit from having both extrinsic and intrinsic reward factors. Blohm and Leimeister (2013) gives the example on how a badge is a physical representation that can be shown to one's peers, and as such badges could help motivate individuals who attempt to gain social recognition. Badges also have intrinsic factors such as motivating individuals who have a need for collecting, which in the realm of psychology is classified as a common human social behaviour where people enjoy collecting similar objects with the possibility of exhibiting them to others (McIntosh & Schmeichel, 2004; McKinley, 2007). The guidelines that indicate the steps needed to earn a badge could also be seen as an intrinsic factor for some individuals. These guidelines not only help motivate individuals by providing a clear

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indication of what is needed, but also indicates the potential level of difficulty that could be expected (Deterding et al., 2011; Gibson et al., 2013; Healy, 2011). Deterding (2011) adds that an increased level of difficulty could, for example, result in a greater sense of accomplishment when earning a badge.

Digital badges are used by a variety of popular websites that employ a gamification design (Duolingo, 2015; FourSquare, 2015; StackOverflow, 2015). These systems usually reward individuals for participating, achieving a goal or mastering a skill; however the digital badge is only valid within the context of that system. While individuals are often promoted to share their badges on social media, the badges themselves do not contain additional value outside that community. As will be discussed in the following section, Mozilla Open Badges adds an additional layer on the concept of digital badges with the ability to act as universally recognizable certification of skill (Mozilla-Wiki, 2015).

2.3. Mozilla Open Badges

Mozilla Open Badges can be seen as similar to standard digital badges in the sense that they contain the basic building blocks of digital badges (name, visual image and description) seen in Figure 1 below (Mozilla-FAQ, 2015). They also act as a representation that an individual has earned a skill or accomplishment. The difference between Mozilla Open Badges and standard digital badges is the existence of an additional layer of security and evidence based authentication, thus enabling Open Badges to act as a certifiable form of accreditation (Mozilla-Wiki, 2015). Most of this additional data is built into the Mozilla Open Badge as meta-data and ensures the badge credibility by enabling only the individual who has earned the badge to receive and unlock that badge for their account. This earned badge can then be inspected by other organisations who can judge the quality of work based on the evidence stored when the badge was created (Moore, 2013; Mozilla-OpenBadges, 2015).

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Anatomy of a Mozilla Open Badge

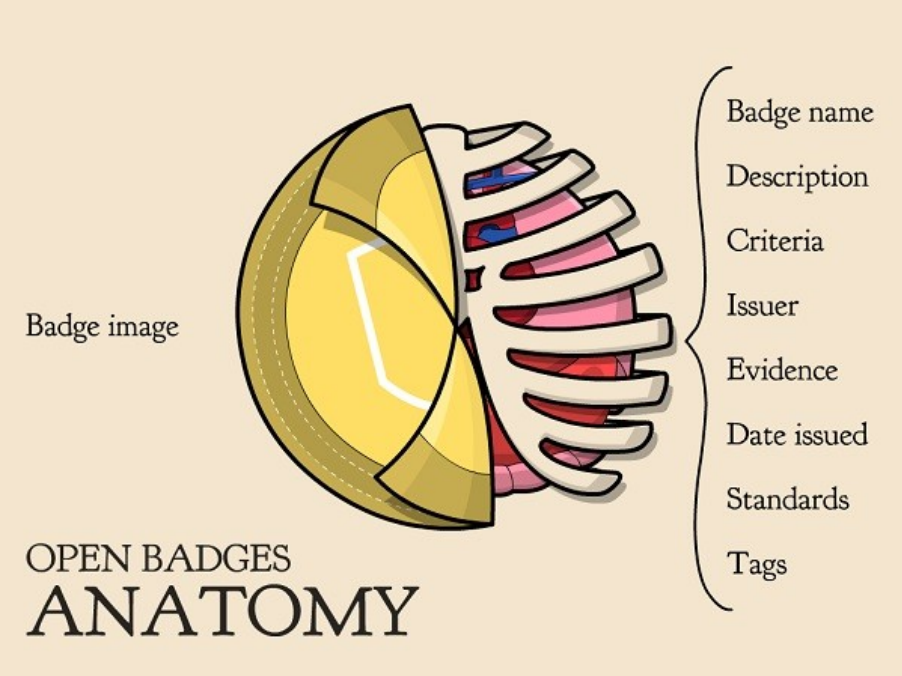

Figure 1. Anatomy of a Mozilla Open Badge (Mozilla-FAQ, 2015).

Mozilla Open Badges allow individuals to collect badges from anyone and to store these badges in a central repository called a “Backpack”. Once these badges have been earned individuals can then share these badges via social media, and if verified by a credible organisation, present them as certification to prospective employers (Mozilla-OpenBadges, 2015). An individual can easily register from the Mozilla Open Badges web page by making use of their personal email address which then creates their personal backpack (Mozilla-OpenBadges, 2015). This email address has to be personal as all the earned badges are sent to this address. Once the individuals have received their badges via email, they just need to log into their backpack accounts and open the badge image which contains all the meta-data (Mozilla-Wiki, 2015).

Mozilla Open Badges have been employed by Massive Open Online Courses (MOOCs) and Purdue University in gamified educational systems as an alternate method of certification in conjunction with more standard methods (Mehta et al., 2013; Randall, Harrison, & West, 2013). These initiatives show that Mozilla Open Badges have successfully been employed in developed countries. When examining developing contexts such as South Africa, unique problems arise with regards to the functionality of ICT within resource constrained environments. The next section defines resource constrained environments.

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2.4. Resource Constrained Environments

Resource constrained environments can be defined as areas that have: (1) a lack of infrastructural development, (2) technical limitations such as network availability or regular electricity and (3) socio-cultural constraints that provide unique challenges to ICT projects (Anderson, Anderson, Borriello, & Kolko, 2012; Kam, Ramachandran, Sahni, & Canny, 2005). Thinyane, Slay, Terzoli, and Clayton (2006) notes that compared to other developing countries, South Africa has a high monetary cost with regards to the installation and maintenance of physical and wireless broadband internet connections. This could contribute to the existence of socially and economically unbalanced areas of South Africa (Gardiner, 2008).

A network infrastructure might not be present due to high implementation and operational costs and could aversely be affected by factors such as a lack of electricity (Thinyane et al., 2006). Further to this it stands to reason that technical limitations such as a lack of internet connectivity or regular electricity have a direct negative impact on fixed ICT devices such as desktop computers by rendering them useless or unreliable, barring the implementation of costly power generators or uninterrupted power supply units. Mobile ICT devices have a higher probability of being usable with intermitted electricity disruptions, provided the interruption is not overly long; however mobile devices would suffer in a similar manner to their fixed counterparts when considering the overall lack of network availability.

Apart from the infrastructural and technical limitations, inhabitants of resource constrained environments present unique socio-cultural constraints to ICT projects. Metaphors are often used in human computer interaction design to symbolise actions in place of full words or descriptions. While this approach often works within ICT confident groups, it is near impossible to develop an application, program or system that would inherently be understood by all remote cultures who have rarely experienced ICT (Dray, Siegel, & Kotzé, 2003). Additionally not all metaphors or words have the same meanings and not all societies have equal understandings of topics as was seen when Mudziwepasi, Nomnga, Ntsizi, Scott, and Sibanda (2014) attempted to analyse the effects ICT had on the Dwesa community.

Cullen (2001) and Kanagawa and Nakata (2008) observe that inhabitants of resource constrained environments have a generally low level of ICT-confidence and English literacy. The low level of ICT-confidence can be attributed to the difficulty in distributing and operating ICT devices within these environments due to the technical and infrastructural limitations mentioned earlier. One Laptop per Child (OLPC) which is active in various resource constrained environments, experienced initial issues with the low level of ICT-confidence and English literacy of individuals in these environments (Kraemer, Dedrick, & Sharma, 2009, 2011).

Summarising the above points, this research identified the following factors that could affect ICT4D initiatives in resource constrained environments:

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- Intermitted to no internet connectivity
- Potentially low level of English literacy
- Low level of ICT proficiency

The next section will examine how these factors influence the functionality of Mozilla Open Badges in resource constrained environments, highlighting the gap in research that this paper addresses.

2.5. Gamification and Digital Badges in Resource Constrained Environments

There is currently a dearth of peer reviewed and credible articles on gamification initiatives within resource constrained environments, specifically focusing on the South African context. The ICT4RED's teacher professional development initiative is the only well documented and recent case within South Africa.

Employing background literature from section 2.1 to 2.4 above, Table 1 below summarises issues for consideration when designing a conceptual model for receiving and authenticating badges within resource constrained environments. These issues have been classified into the design spheres of user, the context and system:

Design Sphere	Identified Issues for Consideration
Users	Mozilla Open Badges rely on users who can open and maintain their own email addresses, while individuals in resource constrained environments have a low level of ICT proficiency.
	The Mozilla Open Badges Backpack is an English only website, and inhabitants of resource constrained environments might potentially have a low level of English literacy.
Context	Resource constrained environments are not guaranteed to have an internet connection, which challenges the functionality of Mozilla Open Badges as it is an online service.
System	Gamification is facilitated by implementing badges as a game element, as badges have both intrinsic and extrinsic motivating factors.
	Mozilla Open Badges allow only the intended user to receive and unlock the authorised badge.

Table 1. Background Literature Summarised and Compared to Mozilla Open Badges with regards to Users, Context and System.

A proposed solution for resource constrained environments would be a system that mirrors the Mozilla Open Badges system. Ensuring that badges are digital and remain secure, and that the system would be usable with minimal ICT proficiency, and no internet connection. The contribution of this paper lies in the production of a model that enables the production of a disconnected badge system which allows the receiving and authenticating of digital badges in resource constrained environments.

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3. Methodology

This section will discuss the methodology applied in this paper to produce the conceptual model as laid out in section 5. The methodology includes an interpretive philosophy, a design science research approach, and inductive data analysis on data collected.

3.1. Research Approach

A design science approach was used in creating the conceptual model as proposed by the authors Peffers, Tuunanen, Rothenberger, and Chatterjee (2007). Employing an interpretive research philosophy as described by Klein and Myers (1999) to analyse and investigate previous literature and data from interviews, this paper produces an IT artefact in the form of a conceptual model for receiving and authenticating digital badges in a resource constrained environment.

Hevner, March, Park, and Ram (2004) proposes that such an IT artefact could be tested to ensure that it is in fact a solution to the problem by making use of the three design cycles:

- Relevance Cycle - Identifying problems and opportunities of research. This is done within section 2.5 of the background literature, where it is identified that digital badge systems such as Mozilla Open Badges experience challenges within a resource constrained environment. Thus these connected badge systems cannot aid in a similar ICT4D initiatives that employ badging. This problem was reiterated by the participant interview findings in section 4 where environmental constraints led to the use of a physical badge system which presented non-ICT related issues.
- Design Cycle – Once the problems have been identified a solution will be proposed, in the case of this paper the solution will be in the form of a conceptual model, seen in section 5, to help receive and authenticate digital badges in a resource constrained environment.
- Rigor Cycle – Ensures that past literature and well established methods are used in the construction of the IT artefact. This paper makes use of the design of the Mozilla Open Badges system detailed in section 2.3 as both a tool to identify problems and an indicator to a potential solution. Background literature from section 2 is consulted to asses whether the solution proposed by the model is adequate.

While background literature plays an important role in identifying factors that could challenge the reception and authentication of digital badges in resource constrained environments, additional factors could be identified by making use of participant interviews from project experts who were involved in ICT4D initiatives in such areas.

3.2. Data Collection Process

Data was gathered from both background literature and participant interviews. Background literature was collected with regards to the user, context and system:

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- User - Information pertaining to the state of users within resource constrained environments such as socio-economic issues of users that challenge the functionality of ICT4D initiatives.
- Context – Challenges posed by the context of the environment. These challenges affected the implementation of ICT systems within resource constrained environments.
- System – Describes the intended functionality of the system. Features and concepts that are required to be implemented to ensure that the system is functional.

In conjunction with background literature, participant interviews were conducted with projects experts who were involved in the ICT4RED initiative that took place in the Cofimvaba area. The project interviews were conducted to gather additional information with regards to the users, context and system to reinforce issues identified from background literature.

Making use of established guidelines detailed by Turner III (2010) standardised open ended interviews were constructed and carried out either in person or over secure VOIP technology at a location and time of the participant's choosing. The interview sessions were recorded and then later meticulously transcribed. The participants were all interviewed separately and presented with 17 open ended interview questions in a written format, which were sequentially and identically read out by the researcher during the interview process.

3.2.1. Participants

This study made use of purposeful sampling in the selection of participants as described by Coyne (1997). Participants were chosen on the basis that they have been involved with a gamified ICT4D program that employs the use of badges and is situated within a resource constrained environment. This was done in the anticipation that participants would be able to identify issues with current badge systems used in resource constrained environments.

Three project experts of the ICT4RED's teacher professional development program were selected as participants all having extensive backgrounds in the fields of education and ICT training. Participant 1 helped co-write the course material that was employed within the ICT4RED TPD program and has over 15 years' experience as a teaching and learning specialist in the field of ICT. Participant 2 is an educational technologist and has been in the academic field for the past 6 years, including being a computer engineer for the last decade. Participant 3 is also an academic by profession, but has experience in facilitating ICT teacher professional development projects for the last 10 years.

3.2.2. Ethics

Participants for this study were chosen on project experience in the field of gamified ICT4D programs. While participant experience has been detailed, participants will remain anonymous so as to minimize influence on this study's findings. All participants consented to being verbally recorded for data collection purposes.

Participation was of own violation and no incentive for participating was given. Participants were allowed to suggest a method of meeting either at a time and place of their convenience or over a suitable technology such as VOIP when they have adequate time and data allowance. Participants were allowed to step out of the interview at any point, were afforded breaks between questions and were not pressured to answer any question within a given timeframe.

3.3. Data Analysis

This study makes use of the inductive approach as discussed by Thomas (2006) for analysing raw data collected from background literature and interviews to extract prevalent themes and concepts to produce a relevant model.

The questions for the interviews were devised around extrapolating information on; (1) the context of the environment, (2) the users, and (3) the functionality of the system. The participant interviews were examined using content analysis as defined by Krippendorff (2012) to help identify prevalent themes and concepts that might help in the construction of the conceptual model and laid out in section 4.

Once all prevalent themes and concepts were identified, triangulation between the interviews and background literature data was used to compose a set of 8 elements for the conceptual model within the three design spheres of user, context and system, as can be seen in section 5.1 to 5.3.

4. Findings

In the results and discussion section of this paper, the participant interviews were examined in terms of themes and concepts that were identified from the raw interview data.

The interview questions were structured around gathering information from participants who were actively involved with a gamified ICT4D project that took place within a resource constrained environment. The questions were split into the following sections from which content and themes were derived from the raw data:

- Users
- Context
- System

4.1. Users

4.1.1. Teacher Participants

Although P1 stated earlier that teachers living in the area had a low morale, generally due to their environmental circumstances and the hardships they have to endure on a daily basis, they added that teachers were “eager” and ‘enthusiastic” to learn how to use ICT devices and take part in the program. All the participants mentioned that time factor was a major constraint for teacher participants, and that

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teachers would have to sacrifice their time after school to participate in the program. This implied that the teachers generally showed a great amount of dedication towards completing the TPD program.

Participants all agreed that the teachers participating had near zero experience or ICT confidence at the start of the project. P3 described the teachers' ICT skills as "Non-existent", while P1 describes it as "limited to none", which was confirmed by P2 who stated:" …if I could attach a percentage score to it was like 10%".

The English literacy level of teachers differs according to participants. P1 mentioned an interesting point being: "… as we went further and further into the rural [areas] I can tell you for sure that the English literacy was a problem. - A big problem." showing that the deeper the project moved into rural and the resource constrained environment of Cofimvaba, the lower the level of English literacy became. P3 did not answer the questions related to teachers' English literacy and P2 stated that teachers had a reasonable level of English literacy.

4.2. Context

4.2.1. Resource Constrained Environment

Participants were requested to point out the constraints found within the Cofimvaba area that might affect ICT projects. The participants immediately mentioned that the main constraint was the disconnected nature of the environment. Participant 3 attributes the lack of internet primarily to the lack of network coverage and the difficulty of installing cellular or Wi-Fi points, which was confirmed by Participant 2 who describes the geographical environment as physically challenging and hard to reach.

Throughout the interview all three participants agreed that the Cofimvaba area suffers from a lack of basic infrastructure such as running water, constant electricity and maintained roadways. P2 describes Cofimvaba to be more 'backward" than other resource constrained environments they visited. P3 mentions that "…the most highly skilled people ran to the cities…" while participant 1 states that:"…the moral of the teachers was terrible, the children, you know…" which both participants attribute to the lack of infrastructure making daily lives of the inhabitants a challenge. P3 did indicate that there is a high level of poverty and that inhabitants of the area cannot afford data charges from cellular carriers even if they were available.

4.3. System

4.3.1. Security Needs for Badges

Not all participants believed that there were glaring security issues with the distribution of physical badges, however P2 does mention "They've got their badge book where we put their badges. Badges [are] just a piece[s] of paper with a specific design, so that can actually be created, so anybody who actually didn't earn a badge, if smart enough could create a badge on his own and put it on his own

paper.” implying that teachers could produce their own badges. P1 did not believe that teachers have the required ICT proficiency nor equipment required to duplicate badges “And I don’t think any of my teachers there had the know how to do that yet.”.

Lost or stolen badges again raise concerns for P2 and P3, while P1 is assured that adequate documentation is kept to be able to reissue missing badges. P3 does however state that: “…in fact we have had cases whereby some of the facilitators would misplace the sheets, the documentation where they have recorded the results or the badges issued”, which directly contradicts P1. P2 shares P3’s concerns and states that the process of recovering lost badges would be difficult due to the accreditation attached to the badges. P2 states: “…you could lose the whole badge book and then you would need to... I mean if someone wants to verify the badges... because you see these badges are not just... although they are ordinary paper badges, but there are some things attached to it, like from the department... let’s say credits attached to it from the department of education…”, implying the grave security risk that existed in losing the official badge issuing documentation.

All the participants agree however that the use of digital badges would increase portability, and at the same time reduce the risk of losing badges.

4.3.2. Badges Supporting Gamification

Gamification had both advantages and disadvantages when used in the ICT4RED’s TPD project according to the participants. All participants agreed that gamification and the use of badges as a reward system had the desired effect of motivating teachers, with P1 even stating that: “Honestly, I would say it was the holy grail of the project.” and that: “I never in my wildest dreams, could think badging could make such a big difference”. P2 stated that the use of gamification in an education initiative adds a sense of accomplishment to participants:” I like a reward system because at times when we are learning, one of the things that makes learning a bit boring is you think you don’t get anything out of it “. Given that badges inform the teachers of the requirements needed to earn them P3 states that the value of badges lie with identifying gaps in knowledge: “I would say extremely valuable. - It allows one to track individual progress and also identify gaps or lack of understanding in a certain topic.”

The disadvantages of employing gamification in the ICT4RED’s TPD program stem from friendly competition that could run out of control. While competitiveness is a gamification factor that could motivate participants P1 and P2 were concerned that if the competitiveness was not strictly controlled teachers became rowdy and acted up against each other. P1 recounted a story where a team did not attain the desired outcome which resulted in what could be described as a demotivated behaviour: P2 also noted that the goal of the exercise could be forgotten in the spirit of the moment: “But one of the disadvantage I could see, is that you could get carried away if not

properly planned in the first place, it could end up being a jumble, rather than education."

4.3.3. Badge Receiving Application

During the interview participants were asked to rank features in order of importance for a potential badge receiving application. While all the features are critical to the function of the application, it is important to ascertain the perceived value that participants place on selected features. Table 2 details the order of importance that the participants place on application features where 1 is the most important and 6 is the least important:

	P1	P2	P3
Simplistic Clean Design	5	5	1
Viewing Badge Requirements	1	2	3
Viewing Uncompleted Badges	6	3	5
Viewing Completed Badges	4	1	4
Unlocking Badges with a Short Code	2	4	6
Use of Images	3	6	1

Table 2. Rank of Application Feature Importance

As can be seen in Table 2 above, the participants do not agree on the importance of application features enough to highlight any one feature as absolutely vital, leading to believe that the order of importance is evenly spread between features and would differ between individuals.

5. Discussion

This section discusses a conceptual model for receiving and authenticating digital badges in a resource constrained environment.

Figure 2 details the proposed conceptual model for receiving and authenticating digital badges in a resource constrained environment. The model was designed using a design science approach as laid out in section 3.3. Major components with regards to the users, context and system have been based on findings that have been discussed in section 2 as well as section 4 of this paper. These components are further discussed in section 5.1 to section 5.3.

Section 5.4 and 5.5 discuss the general application development idea that was used.

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Proposed Conceptual Model for Receiving, Authenticating and Storing Digital Badges within a Resource Constrained Environment

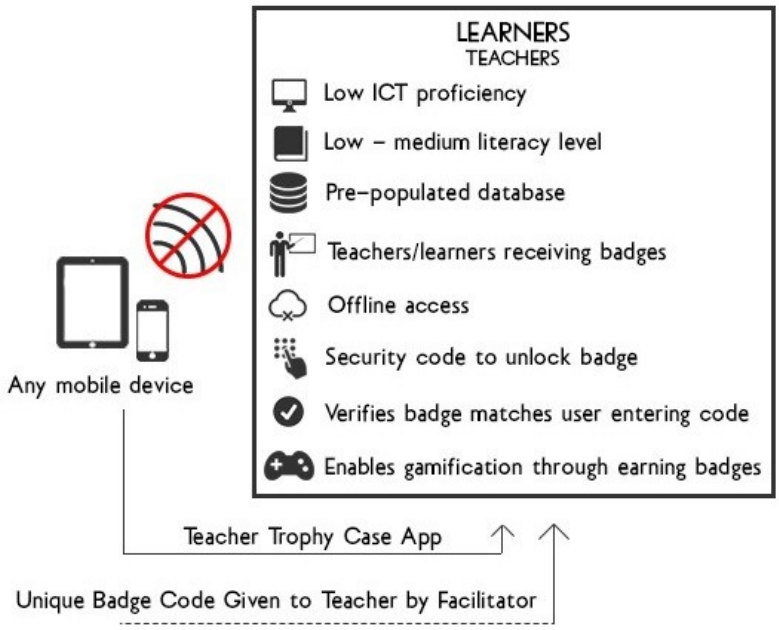

Figure 2. Proposed Conceptual Model for Receive, Authenticating and Storing Digital Badges within a Resource Constrained Environment

This conceptual model ensures that the system functions mitigate the user and context challenges identified from background literature and participant interviews.

5.1 User

5.1.1. Low ICT Proficiency

The literature indicated that there is a general low level of ICT proficiency among individuals situated in resource constrained environments (Anderson et al., 2012; Cullen, 2001; Kanagawa & Nakata, 2008). Similarly in section 4.1.1 it can be seen that all the participants concur that the initial ICT proficiency level of teachers involved in the ICT4RED's TPD project was low.

When developing applications for non-ICT confident users, it is advised to design applications with a simple clean design that would not be misleading to users (Carvalho, 2011). Users should be able to easily recover from errors, and should not be discouraged from experimenting and exploring (Deterding et al., 2011).

5.1.2. Low to Medium English Literacy Level

Participants views were divided in their assessment of the English literacy level of teachers in resource constrained environments and P3 abstained from answering leading to an inconclusive result.

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The literature however indicates that there is a tendency for a general low level of English literacy as it is considered an additional language (Anderson et al., 2012; Cullen, 2001; Kanagawa & Nakata, 2008). This applies to communities that are deeply situated within rural environments, which see little need to actively practise a second language with little use in their already challenging environment.

Ensuring that the model caters for the highest level of usability and that all potential risk factors are taken into account, it would be beneficial to design an application assuming that a part of the user base has a low to medium level of English literacy. Human computer interaction (HCI) guidelines for application design suggest the use of images and culturally prevalent metaphors when designing an application for such users (Carvalho, 2011; Chetty & Grinter, 2007).

5.2. Context

5.2.1. Pre-Populated Database

A design decision was made to incorporate the use of a pre-populated database for storing badge information, and teacher or learner information. This was done in an attempt to mirror online functionality as all relevant information is available to the system.

The badge information would relate to the name, image and requirements needed to unlock the badge. Since there is no way of transmitting this information via the internet, the information must then already be present with the deployment of the application.

Similarly since badges are only to be unlocked for a specific teacher or learner, the most accessible method of authentication relies on knowing unique individual information such as a name and surname combination.

Thus when adding or removing teachers, learners or badges from the project, the database would have to be updated and without any connectivity or wireless communication enabled. This update would require the redeploying of the application to each affected mobile device.

5.2.2. Offline Access

Examining the disconnected nature of a resource constrained environment as identified in literature as well as by the participants in the interview process, applications require full offline functionality (Anderson et al., 2012; Thinyane et al., 2006).

The Mozilla Open Badge Standards require the use of an email address and then a connection to the internet for every badge that is authenticated. As discussed earlier, by making use of a pre-loaded offline database, all the required information is

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present on the mobile device and all application functions can be completed locally on the device.

5.3. System

5.3.1. Teacher/Learners Receiving Badges

The main function of the application would be the ability for teacher/learners to receive badges. Teachers have to feel that the application is not complicating their learning process or presenting an unexpected challenge.

Due to the resource constrained nature of the environment there is no way to automate this process with the transmission of codes that authenticate to a central online server. It can also not be assumed that the badge issuing and badge receiving devices would be the same and able to communicate with one another without the intervention of someone with a reasonably high level of ICT proficiency.

To overcome these obstacles, using a short digital code that is issued to teachers or learners which unlocks the correct badge for the designated user only, might be optimal. This code can then be transmitted either orally or via more traditional forms of communication such as letters and when possible SMS, but has to be considered legible and easy to understand for the teacher/learner.

5.3.2. Security Code to Unlock Badge

There is also a need for a security code to unlock a specific badge for a particular individual in an attempt to mirror the security offered by the Mozilla Open Badges.

As stated earlier in section 4.3.1, the participants have identified potential risks to the security of physical badges such as the loss, theft or unauthorised cloning of physical badges. These issues should not exist with the use of digital badges, and could be solved by implementing a secure code that contains both the badge and the user information.

However due to the potentially low ICT and literacy level of individuals within resource constrained environments, we propose that such a security code should not be overly long as it would propagate errors.

5.3.3. Verification of Badge Matches User Entered Code

Linked to the previous aspect, by incorporating both user and badge information in the use of a security key, identify authentication can ensure that only the designated user can unlocked the issued badge. Identity based encryption stems from using unique details of an individual in conjunction with traditional encryption methods such as hashing to generate a unique key that is tied to that individual (Delerablée, 2007). Users would thus not be able to share codes among themselves because each code is unique to the user.

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The information required to implement identify based authentication is contained within the pre-populated database.

5.3.4. Enables Gamification through Earning Badges

The effects of gamification on the TPD program were evident in the participation interviews and mirrors the motivational influence described in literature (Dale, 2014; Deterding et al., 2011). This was reiterated by the participants praised the positive effects that badges had with regards to motivating teachers.

The mobile application should naturally facilitate gamification by enabling teacher or learners to receive badges.

5.4. Teacher Trophy Case Application

The trophy case application is produced when implementing the 8 elements of the conceptual model found above in section 5.1 to 5.3. The main functionality of this application would be the ability to unlock badges for non-ICT confident, low English literacy users within resource constrained environments.

5.5. Any Smart Mobile Device

The 8 elements of the conceptual model above are generalised and do not incorporate or make use of any device specific features. This ensures that the mobile application is designed to function on any smart mobile device. Due to the variety of ICT available, a generalised conceptual model is applicable to a greater number of ICT4D initiatives, as opposed to initiatives that make use of only a particular ICT.

6. Limitations

This research paper proposes a general model that can be used when designing applications on a wide variety of mobile ICT devices, not limited to a specific brand or software. Due to the general nature of the proposed model it does not take into account brand or operating system specific technologies that might enable different ways authenticating or receiving badges.

The proposed model also assumes that all participant information of a particular initiative is known when readying the deployment of the applications, as this information has to be pre-loaded into every device's database to enable the identity based unlocking of badges. This issue enables future research on devising efficient ways of updating various different device within resource constrained environments.

A final limitation is that the scope of this research only discusses the receiving and authenticating of badges and not the issuing of badges. While the identity based encryption has to be present on both issuing and receiving applications, the users that facilitate the issuing of badges might not necessarily have need of the same design considerations.

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7. Conclusion

In this study it was identified that there is currently a research gap when employing gamified systems which make us of digital badges, such as the Mozilla Open Badges system, in resource constrained environments and as such proposed a conceptual model. The model was constructed using a design science research approach and inductive analysing techniques on past literature and open ended interviews with purposeful participant sampling. The proposed conceptual model provides key elements that affect mobile applications designed to receive and authenticate digital badges in resource constrained environments.

Future research focuses on implementing this conceptual model to produce a badge receiving application and then to testing the application in a resource constrained environment. This would aid in the construction of a final model.

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