A Mobile Game World for Māori Language Learning

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Abstract

This project involves the research, development and evaluation of a mobile assisted language learning tool that teaches some aspects of the Māori language within a virtual game world. The Māori language has been going through a process of rejuvenation since the mid-1900s. A wide range of multimedia resources have been created to support the process of language rejuvenation and there have been some effective digital resources created. Despite the ubiquity of modern games, computer games are a form of media that is under-represented in the wealth of Māori language resources and there are only a small handful of existing software tools for Māori language learning, of which few are game based.

There is growing interest in the application of modern game mechanics to other areas; popularly termed as gamification. This project aims to use the more dynamic features of modern games within a simulated game world to structure Māori language learning experiences. While globally there have been many computer assisted language learning tools and there is some research on virtual worlds and language learning, there have been few language learning tools developed within purpose built simulated game worlds.

The project is structured around the Design Science Research Process in which short iterative design cycles are applied to the development phase with prototypes being developed and tested with teachers, students and academics as design partners. The implementation of techniques in human centred design ensures that design partners are involved in the whole design and research process. In practice this involved testing early prototypes with educators then subsequently whole classes of students. In between testing the software was redeveloped based on the observations and feedback collected.

Classroom observations during the iterative development cycle showed the tool was both engaging and effective for vocabulary learning. Knowledge was generated about how a wide range of game mechanics can be used in a game world to structure mobile, Māori language learning experiences. The quantitative evaluation showed that students were able to learn vocabulary over a short time using the tool.

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Contents

1. Introduction

1.1 Overview

In this project the Design Science Research Process is used to create knowledge through artefact creation. Knowledge about the novel combination of a virtual game world and game based mechanics within a mobile, Māori language learning tool is created by iteratively developing and testing prototypes that contain these features followed by evaluation. Knowledge and concepts from related fields play an important part of the multidisciplinary research process. The research phases of proposal, development and evaluation bring in a range of concepts and research relating to relevant areas of learning, design and technology.

Relevant literature and existing applications were reviewed early in the project then a design science research process was chosen followed by researching and defining the tools, features and mechanics to be created in an early low-tech prototype and subsequent iterative development. This process of generating knowledge through artefact creation is ideally suited to new and rapidly evolving fields. In this project, the combination of features does not yet exist in mobile Māori language learning; design research creates possibilities for knowledge generation that would not exist through summative evaluation of existing applications or theories.

Relevant information and literature in fields relating to technology and language learning was reviewed along with more the specific fields of mobile technology, indigenous language learning and Māori language learning. Subsequently, a language learning method, language learning tasks, development tools and a foundation for the game world were developed to form a low-tech prototype from which to base the iterative development cycles. The iterative development cycles involved short cycles of design, development and evaluation in order to test the software as regularly as possible. Over the iterative design cycles, knowledge about the combination of game mechanics and game worlds applied to a mobile Māori language learning tool was generated. This knowledge was largely in the form of classroom observations relating to how users interacted with different variations of game mechanics as they were altered over separate iterations. Limited quantitative evaluations were carried out to test vocabulary acquisition within the last iterations.

1.2 The Importance of Māori Language Learning

Māori language learning is an important area in New Zealand. It is a language that has previously become endangered and is now in the process of rejuvenation. Because there was a period of time where Māori was strongly discouraged in New Zealand society and education, for a while few people growing up were given the opportunity to learn the language. In the early 1980s programmes like kohanga reo - immersion pre-schools - and kura kaupapa - immersion schools - were created. In 1985, the Waitangi Tribunal heard the Te Reo Māori claim which recognised te reo as a treasure that the crown was obliged to protect. There was growing awareness and resources around the rejuvenation of the language. Rejuvenating a language that is largely lost to a generation is a complex process. When the language is almost lost within its country of origin it is different to learning a language that has a large population of native speakers. In the case of teaching second languages to travellers and people living abroad you are preparing them to understand the wealth of existing human, written and multimedia resources that exist within that country. There is a natural progression between structured resources for second language learners and strategies to engage with the language in its natural state. In the case of language rejuvenation, growing the base of native resources in the language is equally as important as creating structured second language learning resources.

1.2.1 The Role of Media and New Media in Māori Language Rejuvenation

Written resources, television and radio have become a key focus for Māori language revitalisation. Securing broadcasting rights on television and radio have been a key step to ensuring the resources exist to help people learn, practise and maintain the language and culture. The new era of connectivity and mobile devices opens up new opportunities for Māori language content and learning resources. Interactive media and content for mobile devices holds great potential for both structured learning material and native content. The amount of time that young people spend consuming interactive media like games and other online content presents challenges and opportunities for language rejuvenation. On the one hand interactive media can potentially enhance

learning; however, the creation of some forms interactive media requires great expertise and/or expenditure so young people generally consume high budget, generic, international media. The relatively small population base is prohibitive to some models of monetising software and it is unlikely that market forces alone will result in industry creating large quantities of interactive media for language learning or general use. This means that the creation of resources is dependent on targeted and strategic planning.

1.2.2 The goal of this project

In the context of language rejuvenation and recent developments in interactive and instructional media, this project aims to create a learning tool that uses an interactive game world and game mechanics to teach basic vocabulary and sentence structures to Māori language learners. This is in part because of the popularity and ubiquity of games as a form of interactive media but also because of the huge potential of features of games and interactive media to be used as tools for learning. Game based mechanics offer opportunities for feedback and structuring learning in more differentiated, nonlinear,ways. Recently, several mobile applications such as Dragon Box Algebra (http://www.dragonboxapp.com/) and Duolingo (https://www.duolingo.com/) have used game based mechanics effectively to enhance their mobile learning tools and have been researched in academic literature; for example (Lin, 2014) and (Long, 2014).

1.2.3 Research Method

This project aims to use the Design Science Research model presented by Vaishnavi and Kuechler (2008) to create knowledge about game based learning tools and game mechanics applied to Māori language learning. The research process will involve the creation of a low tech prototype based on a review of literature and existing software tools that can be iteratively developed; this stage is followed by a subsequent iterative development phase in which the artefact is iteratively developed, tested and evaluated with students, teachers and tertiary academics as design partners. The combination of a game world and a range of game based mechanics applied to Māori language learning is new and the project is designed to create knowledge about this combination of features.

1.3 Research Questions

The primary research questions were:

- What existing software tools exist for Māori language learning and indigenous language learning on mobile devices?
- How can the combination of game mechanics and a game world be used to structure mobile, Māori language learning experiences?
- How can Māori language learning tasks be developed and structured effectively within this tool?

1.4 Background of Māori Language Revitalisation

Multimedia has long been an important part of Māori language revitalisation. A brief overview of Māori language teaching is included below followed by an overview of Moari content in multimedia, video games and mobile apps.

1.4.1 Māori Language Teaching and Learning

Māori language has been undergoing a process of rejuvenation since the 1960s. There have been a great many resources and strategies created to teach and learn the language. The most well known are organised community courses, lessons in schools, published instructional materials and multiple levels of immersion schooling. The creation of multimedia content, as detailed below, is also an important part of the language rejuvenation process. It is a bittersweet process as while there are more and more resources and structures for teaching and sharing the language and more people learning the language as a second language there are native speaking demographics which are diminishing. Creating opportunities for children to grow up with Māori as a first language has been an important part of the rejuvenation process as children internalise language structures and pronunciation much better than adults. Immersion schools and pre-schools known as kohanga reo / language nests were first created in the early 80s and have also focused on creating Māori space and ways of learning (Spolsky, 1989). It is as much a process of cultural rejuvenation as it is linguistic rejuvenation; even though cultural rejuvenation is not the focus of the current project;

the two are interlinked. By 2001, 17% of Māori school children were enrolled in some form of Māori medium education (May, 2006). In a review of Māori-medium education, May et al (2005) reported that the overall achievement in 20 years of Māori-medium education is remarkable and that there is occasional tension between wider goals of language revitalisation and the successful implementation of bilingualism and biliteracy; they also found that a portion of learners and teachers in Māori immersion programs in practicality still have English as their first language, creating a need for a mixture of methods relating to first language maintenance and second language acquisition in teaching programs; balancing immersion and second language learning content is also a relevant issue for interactive media.

In relation to written materials for learning Māori as a second language there are many resources including comprehensive written grammar guides; Biggs' *Let's learn Māori: A guide to the study of the Māori language* (1973) and the most comprehensive Bauer's *The Reed reference grammar of Māori* (1997) are two of the more well known ones. Most schools and universities have Māori as an optional subject. The Ministry of Education (2009) reported that since 2001, 100,000 learners enrolled in te reo Māori tertiary courses. Along with these courses there are structured study guides and resources. Adult community education courses also exist. Of particular relevance to the current project is Te Ataarangi which is a method of immersion teaching which involves the learner listening to and giving instructions related to coloured rods of different sizes; this method is relevant as it has been shown to be effective and it has aspects that are potentially transferable to interactive media. It is described in more detail further on.

1.5 Māori Content and Multimedia

An important part of revitalising languages and cultures is the creation and distribution of content through different forms of media. A short review of the development of Māori media resources and Māori in video games is included as it puts the development of app games and interactive media in context. Most language learners can eventually read and listen to a variety of media content in the target language; content that is not necessarily designed as a language learning resource. A big part of Māori language rejuvenation has been the creation of books, television and radio for fluent speakers and learners.

Māori radio content was broadcast as early as 1940 when Māori kaumatua/elders petitioned parliamentarians to broadcast significant Māori current events in te reo Māori. In 1978, Te Reo o Aotearoa was established, a station dedicated to Māori and Pasifika content. In 1984 a 5 year development plan for Māori television and radio broadcasting was created. Following increasing amounts of content being developed for television, Māori TV was launched in 2004. Written resources have also increased in variety and availability. Across different forms of media there has been a steady increase in the availability of Māori language resources which has been fought for and carefully created by many talented individuals. Importantly to language learning and rejuvenation, this provides opportunities for language learners and speakers to use the language in a wide variety of everyday settings. Multimedia is generally widely created and easy to come by in the 'dominant' language in most countries. In the case of language rejuvenation and endangered languages, the dominant language of the country normally permeates most forms of media and broadcasting; this represents a significant hurdle for language rejuvenation as learners and parents of immersion learners have a much smaller amount of multimedia in the target language.

1.5.1 Interactive Media and Māori Language Content

Video games and interactive media play a large part in many people's lives; subsequently, it is an important domain for language rejuvenation and a natural addition to the focus on television and radio broadcasting. It also presents challenges to language rejuvenation due to the scarcity of Māori language resources and the amount of time young people spend consuming interactive media. In a 2010 study of American youth it was found that 45% of media consumption time of 8 to 18 year olds was spent on computers or mobile devices compared to 6% radio, 6% print and 32% TV (see the Figure 1. below).

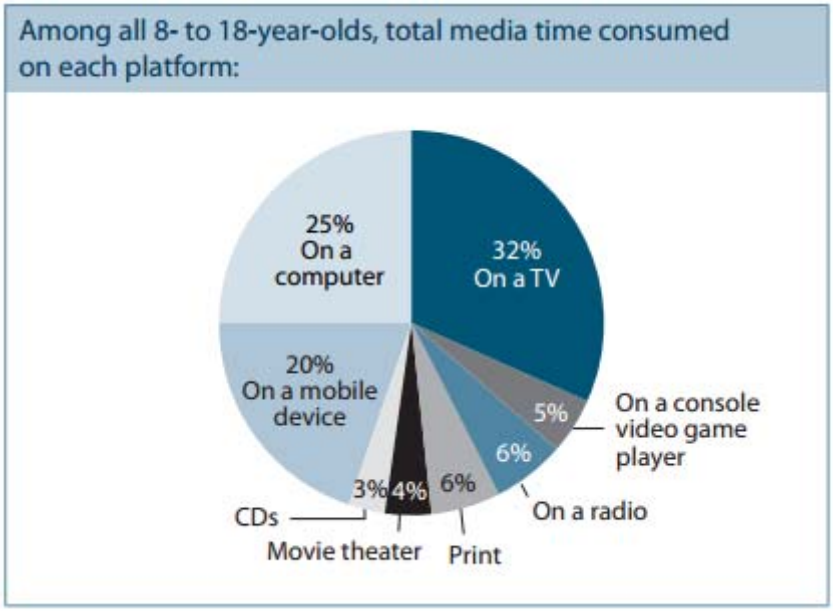

Fig 1. Media consumption 8-12 year olds in New Zealand (Rideout, 2010)

A New Zealand study in 2010 found that 91% of New Zealanders aged 6 to 15 years of age played video games and more than half of New Zealand gamers played every day or every other day (Clark, 2010). Vesterbacka (2013) reported that a number of studies in Finland found that Finnish boys speak better English than Finnish girls, the reason being attributed in a number of studies was the higher amount of video games played by boys which are in English. Digital media and video games represent a large amount of media content consumed by people and especially younger people; it should therefore be considered as area of increased focus in language rejuvenation especially because of the potential to have more dynamic content.

1.5.2 Māori Content in Video Games to Date

These forms of media have become an important part of Māori language rejuvenation; currently video games represent a widely consumed form of media that has very little Māori content. The current project involves the creation of a software tool for language learning but also is one of very few games that has Māori content.

Currently there are very few video games with a Māori focus or linguistic or cultural content. Of those that have some Māori content, several only include Māori characters or symbols in a very

shallow and superficial way. Mahuta (2012) conducted a review of Māori in video games and found that the use of Māori imagery in the video game industry is fairly limited. Two companies, Metia Interactive and Ignite Studios are working towards creating authentic Māori content in video games; however, Māori characters and content is often misrepresented in other games such as The Mark of Kri and Far Cry 3. The danger is that indigenous cultures will often only be represented as very basic stereotypes and there will be few authentic representations of indigenous cultures within video games. Mahuta (2012) concludes that indigenous peoples must claim digital spaces and inform them with culturally appropriate indigenous ways of knowing. A successful international example of a more culturally appropriate indigenous game is Kisimi Innitchuna / Never Alone which is game based in the Inuit language and culture; the game is a chapter based puzzle game which follows a young Inupiat girl and an arctic fox who are looking for the source of a blizzard that is threatening their community; importantly the game makers partnered with 40 elder storytellers who worked with the game developers to contribute their knowledge, culture and language to the game (DiCesare, 2015). Never Alone also explores the folklore of the Inupiat people to present a game that teaches and celebrates their unique culture and language; the creators plan to make a series of world games. Aside from the small amount of, mainly mobile, games listed in the literature review here, there are very few Māori video games. Although the main focus of this research project is not the effect of non-language learning video games on language acquisition, it is important to outline that there is relevance in creating Māori based video games whether the focus is specifically on language learning or not. The amount of time young people spend on video games represents a good opportunity for using the language; given there is already focus put on creating TV and radio content, focus could also be given to creating video games and other forms of interactive media. Regardless of the format of the media, reading and listening to content in the target language is an important part of language acquisition and practice. Additionally interactive media, including games, presents many opportunities for differentiated and adaptive content which will be outlined in later sections.

1.6 Māori Language Software Tools

There are a variety of software tools for Māori language learning available on a variety of different devices. Some are aligned with structured learning programs and others are straightforward vocabulary learning tools. Tools can loosely be grouped into reference tools and more structured

learning tools. There is also a distinction in literature between Computer Assisted Language Learning (CALL) and Mobile Assisted Language Learning (MALL) which is described in more detail later in the thesis. Even though this project is developing a MALL tool, the pool of Māori language learning software tools is small enough that it is valuable to review the wider range of software tools.

1.6.1 Web-based resources

Te Whanake (Moorfield, 2014) is a web based resource that follows a popular TV series and text book. It is based on a teaching program developed by Professor John C. Moorfield. The website offers a variety of content with interactive tests on each chapter. It also has podcasts, animations, a forum and a link to the main online dictionary. The interactive quizzes and podcasts offer some content that has been adapted for the web; technically the podcasts could be seen as a form of MALL.

Māori Dictionary (Moorfield, 2015) is a well-structured dictionary with example sentences for most words. It has been ported to an app for iPhone, iPad and Android.

Kupu o te Rā (Keane et al, 2015) is a website which runs a 'word-a-day' e-mail and facebook service and has structured tutorials for some areas of Māori grammar and vocabulary. The Facebook page hosts the daily words and discussions between learners; the page host regularly responds to questions. The page has 1,792 users as of 25/04/2014. Replies and posts on the Facebook page are frequent; in contrast the forum on the Te Whanake website is inactive, indicating the possible benefits of leveraging popular forms of social media.

Kōrero Māori (Kōrero Māori, 2015) offers some basic vocabulary and phrases with some well-presented, interactive activities. Users can also click on words to hear audio. It also hosts a Māori Language Club in which members wear pins to identify themselves to each other so they can facilitate real world conversations.

Quizlet (Quizlet LLC, 2015) is a multi-purpose vocabulary learning website which has recently released an app. The website has 'gamified' vocabulary learning exercises which track high-scores

and support leaderboards. Because it allows sharing of user generated content it has a large amount of Māori vocabulary; it also officially supports Māori with the easy input of macrons on vowels. It supports teacher level users that can manage classes and class vocabulary lists. The University of Auckland even has a managed class with 10 vocabulary sets. As of March 2015 there were 2,554 sets that contained Māori as a keyword. Vocabulary lists and accounts link across mobile devices and desktop machines. Although Quizlet has not input any Māori words, through user generated content it is widely used for CALL in Māori and many other languages.

Hana Educational Publishing (Hana, 2015) has a variety of multimedia stories in Māori and English. Users can navigate stories with full audio. Other e-books and forms of digital stories have been created and represent a great way to distribute story based resources through computers and mobile devices; it also allows for the integration of audio and video.

1.6.2 Mobile Māori Language Learning Applications

Although some sites like Quizlet and Māori Dictionary have apps, there are also applications that exclusively exist as mobile apps. It is important to note that the common use of the term 'app' simply refers to applications that are optimised for use on mobile devices; however, as is detailed later in the sections on Computer Assisted Language Learning and Mobile Assisted Language Learning (CALL and MALL respectively), mobile learning is qualitatively different enough to justify the creation of field specific study and terminology.

'uTalk Māori' (EuroTalk, 2015) is a Māori vocabulary learner by EuroTalk Ltd, a company which has released similar apps in many different languages. It has pictures and audio for all words and has structured interactive 'flash-card' type activities for memorisation of vocabulary. It mainly focuses on single words rather than phrases.

Kaitiaki (Game and Learn Ltd, 2012) is not specifically a language learning app; however, it is an ecology app game for school students that is bi-lingual. It is relevant to the current project because it is game based and designed for younger students; many language learning apps are designed for self-motivated, adult learners.

Kura (Te Kura Māori, 2013) is a Māori language learning app that was designed by researchers at Victoria University. It is 'gamified' and users compete against other learners for places on leaderboards. It is designed more for immersion education than second language learning; however, it would suit intermediate to advanced users. It has a variety of activities that go beyond vocabulary learning. It teaches phrases by scrambling the words in the sentence for learners to re-organise. It has quizzes about New Zealand history in full immersion; users flick a rugby ball through the desired goal post to answer questions. It has vocabulary matching activities. It also uses game based mechanics like scores, customizable avatars and leaderboards to motivate users.

Puna (Te Kura Māori, 2015) is an app developed by the same researchers that created Kura and it builds on the effective features of Kura. It has more options for customising content and structures learning across levels that are laid out on a minimap. It allows users to listen to audio in male and female voices and has structured handwriting activities. It has a variety of other game based learning activities that utilise game mechanics to motivate and guide learners. Puna and Kura are currently immersion apps for learners with some existing knowledge of Māori but English versions for second language learners are in development.

Te Pūmanawa (Māori Multimedia, 2015) is a full online Māori language course that is available as an app for mobile devices and in browsers. It is free to download but users pay a subscription to access full content. It is designed to be a comprehensive beginner's course. It involves lessons, audio, learning management and the ability to record your own voice for practice.

Hika (Hika Group, 2015) is an app that is based around sentence construction. It splits the sentences into parts that the user can substitute to create different meanings. Users can then listen to the whole sentence or parts of it. It is split into 12 chapters that cover different areas. There are interactive quizzes in each chapter as well. There are two versions of Hika: a free version called Hika Lite and a subscription based version called Hika Explorer. Hika was created by a researcher at the University of Auckland who originally used coloured paper to mix and match pieces of sentences.

Table 1

Comparitive Summary of Māori Language Learning Software and Apps

Name	*Platform*	*Nature of tasks*	*Age range*	*Bi-lingual or immersion options?*	*Price*	*Aspects of gamification*
Te Pūmanawa	*iOS and Android app stores and browser*	*Comprehensive multi-level learning course with reference materials, revision exercises and assessments. Offers an option with marked exercises and accredited course.*	*Older child - adult*	*Second language learning*	*Free for first section. Various subscription options for full course. Starting at $199 for 12 months for individuals.*	*Many game-like activities within a structured course.*
Kūra	*iOS and Android app stores*	*Game based vocabulary and sentence building*	*Younger learners up*	*Immersion*	*Free*	*Mainly game based with points system, levels, character selection, online leader boards and other game mechanics*
Hika	*iOS and Android app stores*	*Sentence construction through vocabulary substitution*	*Adult learners*	*Second language learning*	*Free for limited content; subscription for full range of content $25-$75 per year*	*Not many of an aspects of gamification*
Kaitiaki	*iOS and Android app stores*	*Te reo Māori used in science based game*	*Children*	*Science curriculum with Māori language content*	*NZ$1.29*	*The stages of a crayfish's lifecycle are explained through interactive game levels.*
Te Kaitito	*Computer work stations*	*'ChatBot', typed dialogue with a computer*	*Adult learners*	*Second language learning*	*Unreleased*	*Mainly a technical learning tool.*
uTalk Māori	*iOS and Android app stores*	*Flash card and memory learning; some gamification*	*Older children upwards*	*Second language learning*	*NZ$11.13*	*Flash card like games with points and scoreboards.*
Puna	*iOS and Android app stores*	*Gamified vocabulary and writing skills*	*Younger learners up*	*Immersion and second language learning*	*Free*	*Scores and leader boards combined with structured levels and other game mechanics*
Māori Dictionary App	*iOS and Android – and original website*	*Reference resource*	*More advanced learners*	*N/A*	*NZ$5.29*	*N/A reference resource*

1.6.3 Other Māori Language Learning Software

A project from Otago University in New Zealand created and tested a dialogue-based learning application for teaching pronouns (Vlugter, 2009). The software was titled Te Kaitito and is so far unavailable for public use. They carried out controlled pre-testing and post-testing of the software on tertiary students at the university. Two groups had separate tutorials; one CALL based and one traditional. A third group had no tutorial. They found that the sample and control groups both improved by the same amount and that the control group improved much less. Interestingly they found that the CALL based tutorial group performed more poorly on a delayed post-test when compared with the traditional tutorial. They surmise that this is possibly a result of human based interactions being more easily retained in long-term memory. The software was mainly text based; users read and typed lines of text that simulated conversations that included multiple people so that a variety of pronouns could be used. Interestingly they found that during an early prototyping test users found it difficult to remember who was who in the dialogue so they added visual representations of the conversations. They also concluded that selecting from a menu of possible utterances instead of typing whole sentences may be another way of structuring the activity. While the results were comparable to results with a human tutor they identify that a CALL application does not have the same temporal and spatial constraints as a human tutor. The software was untested on school students and a typed dialogue based CALL may be less effective in a secondary setting. The results overall are very encouraging for CALL in Māori language learning as the software went beyond being a basic vocabulary learning tool; the CALL and non-CALL based tutorials involved detailed role-playing to simulate the concepts associated with the 11 different pronouns. The chat-bot based learning in Te Kaitito is a feature that is unique among Māori language learning tools; this study represents a type of interactive content that has seldom been developed. While the current project is investigating game mechanics and simulated game worlds that are quite different in nature; Te Kaitito is in some ways a simulated world, albeit through text based chat and static images, there are few other tools that have trialled this level of interactivity in software. The research model is relevant to the current project as it involved academic evaluation of the tool through pre-testing and post-testing of users.

There are a range of multi-media resources for Māori language learning and the Māori language in general. A small range of learning and reference applications have been created for modern mobile devices; as individuals and organisations increasingly use mobile devices, there will naturally be demand and potential for new types of applications. The range of features mobile applications can contain creates many types of tools that serve a range of users and needs. While comprehensive reference tools like the Māori Dictionary App or well developed course based tools like Te Pūmanawa provide high quality resources for a wide range of learners, there is also a demand for tools designed to engage and motivate younger learners. Innovative tools like Kura and Puna develop learning activities with a range of game mechanics and have been positively received by teachers and learners. The current project proposes to research the use of a virtual game world in which the user can complete learning tasks and explore by controlling a player character. The combination of this kind of virtual game world and game based mechanics in a mobile, Māori language learning tool presents a novel area for research.

2. Literature Review

2.1 Structure of Literature Review

As this Design Science Research project is multi-disciplinary there is a wide range of literature related to various aspects of the software. In the introduction existing mobile, Māori language learning tools and video games were listed. A more detailed review of relevant academic literature relating to Māori language learning and more general learning on mobile devices is included in the literature review. This is followed by a more general review of literature relating technology and indigenous language learning and more specifically mobile devices. A quantitative review and analysis of a large sample of existing indigenous language learning tools is included in order to create a general view of the nature of existing indigenous, mobile, language learning tools. Computer Assisted Language Learning and Mobile Assisted Language Learning are reviewed followed by wider language learning theories. Gamification and game theory are reviewed followed by a review of the use of virtual worlds in language learning.

2.2 Detailed Research on Māori Language Learning and Mobile Devices

Given how recently mobile devices have become common place, there is not a lot of literature specifically focused on Māori language learning on mobile devices. Specific tools were mentioned in the introduction as most of them are not directly related to any academic literature. The most relevant in depth academic studies of Māori and mobile devices are listed below; one of these is related to indigenous ways of learning for Māori on mobile devices while the other related to using a variety of tools on mobile devices for mobile assisted language learning.

An extensive study of how mobile devices can play a part in revitalising the Māori language was carried out as part of a doctoral thesis titled ‘The Challenges and Opportunities of Using Mobile Devices to Attain Māori Language Proficiency’ (McKenzie, 2014). The author of this thesis was also the lead developer of Kura and Puna mentioned in the previous chapter. Various aspects of mobile device use and effectiveness were investigated and it involved 46 educators who were

involved with language revitalisation as participants. The research mainly focused on adult participants who used iPods and iPads in various ways to improve language proficiency. A focus of this study was using audio and video functions of mobile devices; specific apps and web based tools were also investigated.

The key findings of the study were that the portability and discretion of mobile devices allowed for learning in a wide variety of contexts. The inbuilt audio and video functions were also very useful. It was found that regional dialects were important to most learners and that this was often an important consideration when looking at content that is available at a national level. It was noted that mobile devices were very helpful as content creation tools to easily create high quality regional content. The recording functions on tablets combined with the wide range of apps available makes creating, authoring and sharing content with video and audio easier than ever before. This fits well with the current phase of language revitalisation where there is a strong need for the creation of more regional resources to follow on from early resources that were normally created using one 'standard' version of the language.

As part of the research by McKenzie (2014), an online questionnaire collected information from participants about current usage of mobile devices in relation to Māori language learning. The questionnaire found that being able to use devices anywhere, revisiting content and the ability to repeat exercises without embarrassment were advantages to mobile learning. The study also tested the effect of mobile devices on writing and speaking performance with a pre-test and post-test. The findings showed that the highest improvement was shown by learners who had a low proficiency at the beginning. It was concluded that there could be several reasons for the higher improvement measured in learners who scored lower in the pre-test; the lack of good learning materials for advanced learners, the lack of motivation for those who had initially high marks and the inability to easily quantitatively test higher level skills were all proposed explanations. This was identified as an area for further investigation in future research and that the creation of challenging content for learners with higher proficiency levels is an area that could be further developed and investigated. The quantitative testing did show that out of 41 participants most participants increased their performance in written and spoken tasks; only 3 decreased and 2 showed no change.

This doctoral thesis is relevant to the current investigation as it is the most in-depth study to date relating specifically to mobile devices and Māori language revitalisation. The most important findings in relation to the development of a specific tool are the largely positive post-test results, the demand for regional content and that the recording and playback of audio and video can enhance learning in a variety of contexts. The need for specific regional content was also found to be important in the current project; ways of integrating it into the software tool are mentioned in Section 4.5.6. It is also notable that many learners in the study stated an advantage of mobile devices was the ability to repeat tasks at will in their own time. This is relevant to the current project as aspects of interactive learning tools potentially allow more differentiation for individual learners who need extension or more scaffolding of early learning. There seems to be scope to augment classroom teaching and out of class learning with interactive tools that have the potential to be adaptive or learner directed. The tool being developed in the current study also has the potential to address issues of regional content as interactive media can automatically substitute vocabulary on pages in a way that print media cannot; potentially content can be created once with the capacity to toggle dialects.

Timoko (2014) is conducting research on an indigenous model of effective mobile learning and the development of a mobile learning model adapted to meet the needs of teachers and students within a Māori environment in order to improve outcomes for Māori learners. Identified in this research was the observation that the combination of the proliferation of mobile technologies, uptake of mobile devices by youth and government focus on better education outcomes for target populations has created the need for a mobile learning model for Māori. Although this research investigates a wider learning model rather than specific software tools it does outline the need for the investigation of indigenous content and pedagogies on mobile devices; it also sets out to investigate a wider learning framework for a variety of tools and technologies.

These 2 studies represent the most relevant studies to Māori language learning on mobile devices. There are few existing mobile applications for learning the Māori language and little literature on it. There a few projects paving the way and developing valuable investigations into the creation of uniquely Māori pedagogies and approaches to developing mobile learning. In relation to tools

developed for Māori language learning, in the introduction most existing tools were described. Of the software tools that have been developed a small handful do make use of uniquely mobile functionality; however, many contain more traditional content optimised for mobile devices. A minority of the handful of existing mobile apps are game based and/or gamified. There is definitely room for the creation and evaluation of new game based and gamified mobile learning applications. Given the current lack of tools, a design research process, in which knowledge is created through artefact development, is definitely a practical option.

2.3 Indigenous Language Learning and Technology

Globally the study of indigenous mobile language learning tools is characterised by a range of studies spanning various disciplines; these range from more technology and design focused to fields focused on areas like pedagogy or language learning. There has been quite a lot of work done in the broader area of technology and indigenous languages not specifically focused on purpose built applications. Warschauer (2006) studied the role of technology in helping and hindering language revitalisation in Hawai'i and concluded that technology is neither neutral nor determinist in language revitalisation but is rather a site of social struggle in securing control over creation, distribution and usage of content.

Galla (2009) in a review of indigenous language revitalisation and technology concluded it was not new but that overall it was under-utilised and that there is a huge range of ways that technology has already been used to revitalise indigenous languages such as television programs, radio, audio books, CDs, DVDs, web-based products, on-line dictionaries, web radio stations, local news stations, language websites, movies, distance learning classes, search engines, electronic bulletin board systems, electronic libraries, music sites and audio podcasts. Galla concluded that the overall sense from published articles reviewing technology and indigenous language revitalisation was that there is a general contentment and satisfaction with what technology has provided but little data evaluating its effectiveness. It is notable that many of the forms of media listed by Galla are often simply used for the electronic or online distribution of more traditional resources; Galla did not outline large amounts of fully interactive or game based media. This reinforces the use of the Design Science Research Process incorporated in the current project as it creates a novel combination of features in artefacts from which knowledge can be created.

As early as 2007, before mobile devices existed in their current form, mobile learning technology was investigated as a way to counter inequality in education in indigenous communities in Latin America (Kim et al, 2008); it was found that the portability, low production cost, versatile features and significant memory space resulted in more scalable and economically viable development of education in isolated communities. While this study was not specific to indigenous language learning it did outline the ability to create specific and culturally sensitive content; the main relevance of this study is that it was among a significant number of studies based on early mobile devices that had limited functionality but still found that mobility in itself was held many benefits to learning. Mobility combined with the power and versatility of modern mobile devices has created a lot of opportunities for indigenous language learning on mobile devices.

Begay (2013) completed a masters project reviewing the potential of modern mobile apps for indigenous language learning; it was found that mobile apps were an effective way to engage youth as youth can play and learn simultaneously while also being able to interpret content in their own way. Begay documented a range of mobile and nonmobile language learning software for indigenous languages. Nonmobile software included the Yup'ik bilingual CD-ROM in Alaska, the Tsi Karhakta CD-ROM for the Mohawk language and several other projects that involved using software to create audio books and movies with indigenous languages; Begay outlined that existing resources generally were either structured learning resources targeted at children or more advanced reference resources and wikis for older or more advanced learners; few game based resources were mentioned. The categorisation of resources as either reference or instructional has been used in a wider analysis of indigenous language learning resources. Begay listed a range of mobile apps for indigenous languages including Mohawk and Navajo apps in USA and the Australian Paakantyi and Ma! Iwaidja apps; the Ma! Iwaidja app contained a word maker that allowed users to conjugate verbs and create short phrases. In evaluating some of these apps, Begay found that the Navajo Toddler application received the most positive feedback which was attributed to the integration of audio, visual, textual and interactive media to create a very positive learning atmosphere. In mobile devices as with software there was a very clear divide reported between reference software and more interactive software. There are a reasonable amount of indigenous language apps that mainly fall within the two categories outlined by Begay (2013) a broad quantitative analysis of indigenous

language learning apps is included in the next section. An impressive example is First Voices (http://www.firstvoices.com/en/home) which has apps in 13 different indigenous languages from Canada; these were included in the categorisation of apps in figure 2.

A study in Argentina focused on a different aspect of mobile apps in relation to indigenous content. Wagner (2014) looked at indigenous media movements in relation to mobile apps produced within Argentina. They found that apps produced from within Argentina often had little contact with local audiences and had very little authentic local content; only 12 out of 124 Argentinian apps that were studied contained Argentinian contents and of those the majority were transport or sports related. In the study they related the previous movement to make radio a form of participatory media for the reclamation of indigenous languages to the current desire of indigenous groups to increase content within mobile apps. The reported problem was that current legislation governing fair and relevant production of media focused on TV and radio and did not extend to mobile apps. The study reports that the prestige, profitability and accessibility of the international market for apps left app developers focused on 'culturally neutral' products. This study from Argentina backs up literature from the educational sector that reports that economic constraints and market forces are a contributing factor to the lack of more specialist educational or indigenous software. The study concluded that a key goal for information inclusion for indigenous groups in Argentina was the diversification of mainstream media through the production and transmission of locally produced content and that further research should be carried out into how policy can foster mobile app production with a local and social orientation. This study does not focus specifically on language learning; however, it focuses on issues common to indigenous language rejuvenation and wider cultural rejuvenation. It is very relevant to the current study as New Zealand has a reasonable amount of traditional media resources with Māori linguistic and cultural content but it has a relatively small amount of interactive media resources.

The studies mentioned in this section are not an extensive list of research; however, they are indicative of the range of existing research. While there are a lot of detailed studies relating to technology and indigenous language learning, few of these relate specifically to mobile learning and there is no substantial body of literature relating to purpose built indigenous language learning apps. As will be shown in the next section, most indigenous language learning tools are reference

based and of the minority that are more interactive few use actual game worlds or game mechanics. This contributes to the lack of literature on mobile, indigenous, language learning as there are few existing tools to evaluate or research. This also supports the use of the Design Science Research process to create novel artefacts in order to generate knowledge about the use of novel features in indigenous mobile language learning; if there were wide bodies of existing literature or a large amount of existing apps to evaluate, creating new artefacts through design research would not be as important.

2.4 Quantitative Analysis of Indigenous Mobile Language Apps

There are a number of reports listing existing mobile apps with indigenous content; some are informal web based articles and others in published academic literature. A majority of English language studies on mobile indigenous language learning apps come from North America, Hawai'i, Australia and New Zealand; there are some from other areas too. A list on the Ethnos Project - (Oppenner, 2003) - compiled 32 different indigenous language learning apps that mainly taught languages based on the US and Canadian 40 different online dictionaries. Other websites and academic reports have compiled lists of indigenous language learning apps.

In order to get a broad view of indigenous language learning apps the collection and categorisation of existing apps was undertaken as part of the literature review. A categorisation and broad evaluation of 50 different indigenous language mobile apps were was made by categorising every app found listed in the Ethnos Project (Oppenner, 2003), an 'Indigenous Language Apps' blog post (Crump, 2014), a masters thesis that reviewed indigenous language apps (Begay, 2013), a search for Hawaiian language apps on the iTunes store and the list of Māori language learning apps presented in Table 1. There were other lists found when searching the internet but all contained the same apps that were included in the lists above. The search for Hawaiian language apps was made as it is an indigenous language undergoing a reasonably structured and resourced rejuvenation process; and consequently has a number of apps. Apps were classified as either 'multimedia reference', 'vocab activities with reference material', 'based in an interactive game world', 'substantially gamified', 'activities based in an interactive game world with substantial aspects of gamification' and 'other'. Substantial aspects of gamification mean several game based mechanics implemented widely across the app rather than the isolated use of a single mechanic

like a score counter in individual activities. The results are presented below; there were no apps that were categorised as using a proper virtual game world; the full list of apps and categories is included in Appendix A.

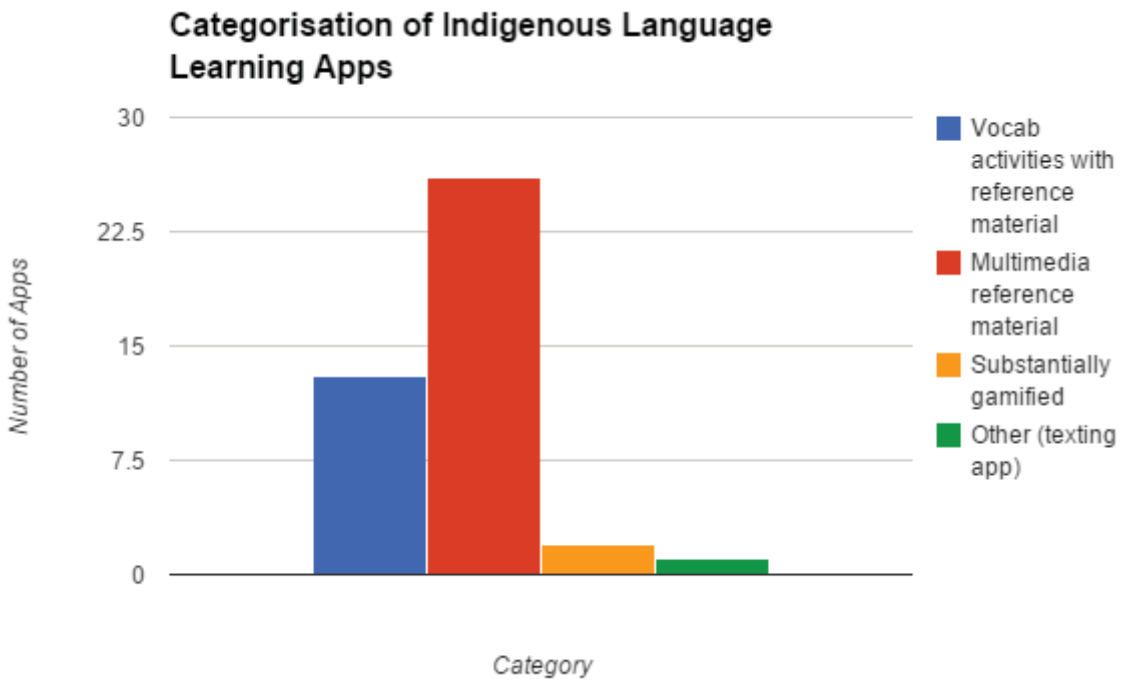

Figure 2. Categorisation of indigenous language learning apps see Appendix A for data table.

From reviewing readily available lists of indigenous language learning apps presented in Figure 2. above, it was found that there are very few gamified applications - 2 out of 53 - and a great majority are multimedia reference tools. The rest are learning tools with some interactivity but limited game mechanics. This is not necessarily a bad thing as a lot of learners find reference tools very useful and the benefits afforded by mobile technology allow for mobile, anytime access of valuable reference material; additionally many of these reference tools are multimedia - including audio, images and sometimes video - and some allow for the creation of user generated content.

Only 15 out of the 53 applications involved activities like quizzes, flashcards and vocab matching; although many of these did use audio, animations and images to make the content more dynamic and interesting. These tools were all very valuable resources, building listening skills and

associations between words and images rather than English translations is valuable to language learning. The ability of mobile apps to easily include multimedia like animations, images and audio is a strength. In this study, simple score counters within standalone activities are not classified as meeting the criteria for gamification; these quizzes and scores are valuable as they provide opportunities for practice and review for learners; however, they do not use game worlds or game mechanics to the extent that they could be classified as game based or gamified. This is an important distinction in this project as the current project is aiming to investigate whether an effective gamified mobile language learning tool can be developed within a simulated game world; it is therefore important to review existing apps that are similar.

The two apps that did include significant aspects of gamification - Kura and Puna - were also Māori language learning apps and have been mentioned earlier in the literature review. These two different apps are also produced by the same developers and academics from Victoria University. The fact that the only two apps categorised as gamified are also Māori language learning apps is possibly a result of the added focus on Māori language in this literature review; however, the descriptions of all of the apps on the list were read carefully and a targeted cross-section were installed and reviewed to investigate whether any were truly gamified or game-based; additionally targeted searches were made on the web and article databases to try to find more game based tools. The list in Appendix A. used to generate Figure 2. is not comprehensive but is believed to be indicative of the proportions of different types of apps available. Other gamified apps for indigenous language learning could exist or be in the process of being released at the time of publication. A search for ‘gamified indigenous language learning’ did turn up a result for a very well made game in Inuit - ‘Never Alone / Kisima Ingitchuna’ - that takes place in a superbly crafted game world; it is however not available on mobile devices so has not been counted in the review above; it is also not specifically a language learning tool.

The overrepresentation of reference based apps is thought to be in part because of reference based resources being one of the most fundamental needs in language learning and partly because they involve less coding and development relative to more interactive applications. Out of the 52 apps reviewed the 15 applications categorised as having ‘vocab activities’ contained varying degrees of interactive content. Most contained a fixed amount of vocabulary grouped into vocabulary sets

and fairly similar activities across the different sets. Overall the quality of resources is good given the amount of resourcing available to projects and the low user bases and often free apps. There is plenty of room to expand the scope of indigenous language learning apps; to date there is little dynamic content in the field like that which has recently been developed in successful, highly gamified apps like Duolingo and Dragon Algebra.

2.5 Indigenous Mobile Language Learning Software and Resourcing

The range of features implemented in existing indigenous language learning tools such as those reported by Begay (2013) and outlined in the quantitative analysis above is limited largely due to the amount of financial and human resourcing available. While heavily resourced commercial software is rapidly evolving, there will always be a wide range of features of interactive media that have not yet been implemented and tested in less heavily resourced educational projects. As Whitton (2012) concluded in a more general review of game-based learning, the resourcing in formal education is not always compatible with the cost and expertise involved in creating more interactive software. In the context of mobile language learning apps, this has meant that there is a disparity between the technology and resourcing that goes into the most successful commercial apps and the smaller niche projects that are often built from one off grants or passionate individuals. This disparity means that there is huge potential to further develop mobile apps for indigenous languages as the technology and techniques from larger commercial projects becomes available. Further to this, applications that integrate more interactive content have been reported to be positively received even though they represent a minority of existing apps and do not implement the most recent higher end features of popular interactive media.

In conclusion, there is no one field relating to mobile, indigenous language learning. It seems that the pressure to create authentic indigenous content on mobile devices, the scarcity of existing implementations and the resourcing required to make it has resulted in most work in the field being focused on creating the technology rather than comprehensively evaluating it. There is not yet the critical mass of implementations to conduct any detailed critical analysis relating to the overall

potential effectiveness or trends in implementations. If over several decades Computer Assisted Language Learning is still largely focused on what technology can do and lacks consistent field wide focus on theory or thorough analysis, something which is detailed in the next section, it is not surprising that studies involving indigenous language learning tools on mobile devices show a similar tendency to focus on individual implementations of the technology with little field wide consistent use of theory. Additionally, the pool of software and literature that does exist comes from a wide range of academic disciplines (e.g. computer science, education, language learning and design science) which results in a range of frameworks, concepts and vocabulary being used to conceptualise the tools and development.

2.6 Computer Assisted Language Learning

Indigenous mobile language learning apps are evolving within the context of wider applied and academic fields. Along with fields relating to technological development and indigenous language rejuvenation, there is the field specifically concerned with language learning on computers. Computer Assisted Language Learning (CALL) is a broad term that encompasses all language learning on computers. The term was first used at the 1983 TESOL convention; however, the practice has existed in different forms since the 1960s (Chaka, 2009). It has also been referred to as technology enhanced language learning (TELL) and computer assisted language instruction (CALI); however, CALL is the term that has been widely adopted in academic literature. The shift from the focus on instruction in CALI to learning in CALL was strongly linked to wider shifts in education theory.

Deriving a theory from CALL literature, that can be operationalised within the current study, is not straightforward. Hubbard (2008) conducted an extensive review of 25 years of publications in the CALICO journal and found that across hundreds of articles there were 113 distinct references to theory and only 17 specific theories were mentioned in three or more articles; he does outline that both cognitive theories (e.g., information processing) and socio-cultural theories (e.g., Activity Theory) are influential in CALL. Thorne (2011) reported that a variety of second language acquisition theories have been used to inform pedagogical practice and innovation but that many CALL specialists have exhibited the tendency to focus on technology while attending less assiduously to emerging trends and current findings in second language acquisition; Thorne also

reported that there has often been a bidirectional relationship between theories of second language acquisition and technological advances in CALL in that sometimes developments in CALL can potentially precipitate shifts in language learning theory.

2.7 Mobile Assisted Language Learning

Around 2004, a new term was developed as a result of the widespread use of modern mobile devices. Mobile assisted language learning (MALL) is the broad definition used to encompass language learning on mobile devices. The nature of learning on mobile devices is different enough to justify the use of a separate term. In review of recent developments in CALL and MALL, Chaka (2009) argued that the future of technology in language learning lies more with MALL than CALL because of the following characteristics of MALL: mobility, ubiquity, and connectivity; portability and 'handheldability'; convergence, multifunctionality, cross-platform blending, optionality, and convenience; access, accessibility, availability, and affordability; and context-awareness, personalization, and flexibility. Because MALL is in some ways a subfield of CALL and the links between language learning theory and CALL are more developed, a lot of CALL literature is still relevant. The nature of mobile devices and mobile device usage has been changing so rapidly that a lot of literature on MALL focuses on reviewing constantly evolving ways of learning on devices. Goodwin-Jones (2011) found that despite many second language learning applications existing for mobile devices there was little research on how they were used or their effectiveness. Storz et al (2012) identified that much of the literature on MALL discusses the potential for mobile phone use in language learning rather than how mobile access has actually enhanced learning; the study did find that there was a measurable improvement in English second-language learners who spent more time accessing English language content on mobile devices.

In 'Systematising the Field of Mobile Assisted Language Learning' (Viberg, 2014) MALL literature was extensively categorised and reviewed to both assess the extent of MALL studies to date and look at the current and future nature of the field. This study was useful because of the detail with which it reviewed both MALL software and literature. Key findings were that there was a general shift from early SMS-based systems to more intelligent learning systems and that descriptive small-scale experimental studies dominate the field. They found that to date there are

few MALL studies that develop wider approaches or frameworks specific to MALL and that the field in general draws from other learning theories. Out of 86 studies they categorised most were descriptive or applied an existing theory; none were 'theory generating'. Despite this, MALL is a well-established concept that is differentiated from CALL; this study seems to indicate that the field has scope to further develop theoretical frameworks specific to the area. It also reports that there is a lack of research that focuses on wider trends in MALL as opposed to specific case studies. Another key finding was that concepts and definitions varied widely between separate MALL studies and that theories are often mentioned in introductions but seldom operationalised within the research. The research concludes that there is a need to develop field specific models and theories and that there is a lack of empirical evidence to inform conclusions about mobile device use in language learning.

The current project involves the creation and testing of a very specific tool; the review of MALL research above is important to this project as it outlines that the current tool is being developed within a field that lacks any area specific or widely accepted theory. It is notable that many existing studies have applied theories very superficially to one section of the research without operationalising them throughout the research process. This means that part of the current research process is investigating what an operationalised theory would look like in a project and choosing a theory to operationalise; there is no field wide standard to follow. In the current project one of the main areas of inquiry is the combination of gamification and simulated game worlds applied to Māori language learning; the mobile aspect of the language learning is important but not the sole focus of the project. This means that reviewing concepts relating to other areas of the project like virtual worlds and gamification are equally important.

As CALL and MALL literature contains references to so many different theories with no consistent use between studies no attempt has been made in this literature review to comprehensively list the different theories; the main finding from CALL and MALL literature relevant to this study is that few theories are operationalised in research; the Methodology section outlines the specific theory and applied method used in this research; and how it is operationalised. This lack of field specific theory also means that it is important to review language learning theory that is not specific to computer or mobile assisted learning.

2.8 Wider Language Learning Theory in Relation to the Project

As there is little consistency in the use of theory in CALL and MALL it is necessary to briefly look at wider theories of language learning and review the place of language learning theory in the project. In the methodology section there is a more thorough explanation of the specific applied method of language instruction that is used in this project and the theory that this method is based on.

The fact that CALL is a field that has existed for more than 25 years and there is still no consistent use of theory points to a complicated relationship between language learning theory and developments in CALL. A key question is whether theory should play a more pivotal role in research and development and if so how a good theory should be operationalised in research. In an extensive book on second language learning theories, Mitchell et al (2013) described the major theoretical approaches to second language learning; they believed that the most important and active theories were the universal grammar approach, cognitive approaches, the interaction hypothesis, meaning based perspectives, sociocultural perspectives and sociolinguistic perspectives; and concluded that they were left with a continuing impression of great diversity in the range of theories. It was concluded that each of these approaches is a result of different traditions in second language learning research and that second language learning is a modular phenomenon with different theoretical approaches and research programmes addressing different aspects of language learning. The finding that across the field different theories address different aspects of language learning supports the notion that there need not be a single universal theory in MALL or CALL; the important thing would be finding a language learning theory that can be operationalised in the development and evaluation of a tool and contribute to development.

Additionally to the wide diversity of theories, Mitchell et al (2013) outline that there is also a gap between ‘practical theories’ and more abstract ideas deriving from programmes of research which results in there not always being a shared agenda between teachers and researchers. Another finding was that, despite diverse theories continuing to be simultaneously well supported and

applicable to different aspects of language learning, larger meta-theories that combined several areas did not seem to be widely supported. In relation to second language learning theories applied to classroom teaching, they describe diverse perceptions in the level to which theory should guide applied practise; some believe scientific theories should completely guide applied practice while others believe the findings of second language acquisition research are not sufficiently secure and uncontested to provide straightforward prescriptive guidance for teachers. It was concluded that there can be no 'one best method' but that the rich variety of concepts can serve as a guide to help teachers make sense of experiences and broaden the range of pedagogic options available to them. This same finding can surely be applied to the areas of CALL and MALL; language learning theories should not necessarily completely guide applied development in all cases.

These findings are relevant to the current project as CALL and MALL studies often focus on technology not theory and very seldom have operationalised theories. Selecting and applying a theory for a language learning tool could be viewed in a similar context to how Mitchell et al (2013) describe selecting a theoretical approach to apply in classroom practices; the theory should help guide the development of the tool and explain the pedagogical processes involved. Further information on the specific theory in the current project and the pedagogy behind it will be explained in the Methodology.

2.9 Gamification and Game Mechanics

Gamification is the use of game based mechanics in a non-game context. It is a relatively new term; Deterding et al (2011) dates its first documented use to 2008 and widespread adoption in 2010; it is reported that discontent with current implementations and, oversimplifications and interpretations have led some to coin different terms for similar practices to avoid confusion and ambiguity. In this thesis, the term game mechanics has been used in other sections to refer to the features and composite parts of gamification. The term gamification can often be misinterpreted as no more than placing educational content within a game or the basic implementation stars and badges. In a comprehensive meta-analysis of gamification, Hamari (2014) described individual aspects of gamification as motivational affordances and categorised them into the following categories: points, leader boards, achievements/badges, levels, story/theme, clear goals, feedback, rewards, progress and challenge. Reeves and Read (2009) describe successful elements of games

as: self-representation with avatars; three-dimensional environments; narrative context; feedback; reputations, ranks, and levels; marketplaces and economies; competition under rules that are explicit and enforced; teams; parallel communication systems that can be easily configured and time pressure. Robinson (2013) categorised features of gamification into seven categories: general framing, general rules and performance framing, social features, intrinsic incentives, extrinsic incentives, resources and constraints, and feedback and status information. Each of these seven categories have several different types of features.

Gamification is a relatively new term and there is no one standard definition or definitive list of features. The range of features listed by different authors above shows a general consensus in relation to the types of features of games that define gamification. Notably, more abstract concepts like progress and challenge have also been listed alongside more observable features like badges and leader boards. While instructional software and educational games have existed for many years, the recent wide spread use of the term gamification has also coincided with the creation of modern mobile devices and modern, mobile, app game formats. Apps and mobile devices created a new way of using and purchasing software which has helped create new contexts for applying game mechanics to other areas. Most features of gamification pre-date the wide spread use of the term; the term was created as a result of the increasing trend in applying these features to non-game contexts.

Gamification has become a concept of great interest to industry and academia; a lot of misinformation and poor implementation has also come with its buzzword status. Gamification in instructional design and learning tools is important to the current study. Learning tools can be gamified to varying degrees and not all gamification has measurable benefits to learning so it is important to review how the different aspects of game mechanics detailed above can help shape learning experiences that align with learning outcomes in the software. The balancing of mechanics within games is also crucial to user engagement, motivation and retention; ideally games should be learnable and playable without formal instruction; more traditional classroom activities have the benefit of being able to be scaffolded by teachers. The range of mechanics in games has continually increased with the development of the field and technological advances.

The way games carefully balance a wide range of features to craft the user experience offers solid models for instructional design in other fields. The development of mobile applications, casual gaming and the resulting usage patterns has resulted in the refinement of game mechanics over recent years. The rise of free to play games in which users do not pay up front has meant that there is a huge vested interest in developing mechanics that retain a wide range of users over a long period of time; these two features are important in education.

2.9.1 The Evaluation of Gamification in Educational Software

Existing educational software incorporates game mechanics to varying degrees; it is not yet possible to summatively evaluate the potential benefit of gamification to instructional design. Some educational software is developed for very specific learning outcomes on a very tight budget; in many cases few aspects of gamification are introduced and those that are have limited effect on the user experience. In the short time that gamification has existed, the effectiveness of gamification in education has been qualitatively and quantitatively evaluated in a reasonable number of academic studies; however, the maximum potential benefit of gamification to instructional design is still impossible to measure as it is a young field under rapid development. If the most effective implementation of gamification has not yet been developed, we are only measuring the effectiveness of existing implementations not the potential effectiveness of gamification. This is important to outline as there are cases in the field where the effect of a feature is quantitatively measured while effectiveness could still be further developed. Evaluation and creation have a complex relationship in the field; while the evaluation of existing tools is essential, it cannot be assumed that it is a measure of potential effect in new tools being created. This point has been outlined as the current project aims to create knowledge about a combination of mechanics and features that are novel in the context of Māori language instructional; it would not be possible to evaluate the potential effectiveness of these features without first creating them; therefore, the symbiotic and iterative process of design and evaluation within the Design Science Research Process is a suitable framework.

Figure 3. from Hamari et al (2014) reinforces how recent the concept of gamification in academic literature is and puts existing evaluations of its effectiveness in context.

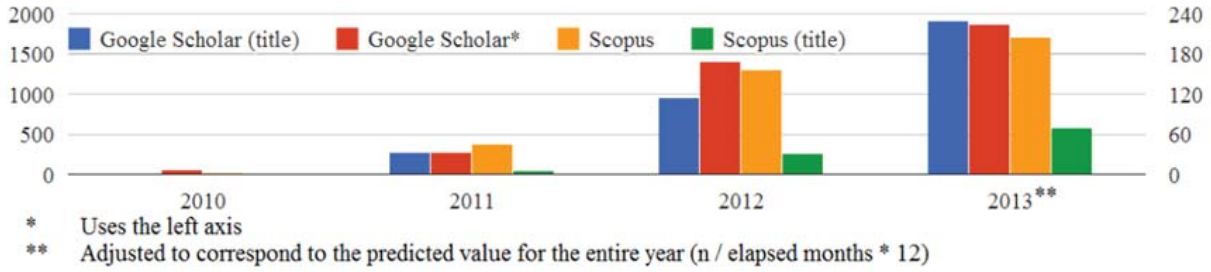

Figure 3. Search hits for "gamification" from Hamari et al (2014)

As shown in the figure virtually no references to gamification were present in academic literature before 2011 with that number steadily climbing over the following years. Repeating the search at the start of 2015 for this research, showed that Scopus (title) search hits had risen to 340 from around 35 in 2013 while keyword search hits have risen to 752 from around 200 in 2013. Google Scholar showed similar increases from 1,900 to 11,400 keyword search hits and from 230 to 1,460 title search hits. The trend towards increasing reference to gamification and focus on gamification in modern literature has clearly continued.

If the concept has only existed in academic literature since 2011, evaluations of existing implementations of the concept should be considered as formative rather than summative. Despite gamification applied to instructional design and educational software being a new field under progressive development, there have been a range of evaluations of existing tools and studies on its effectiveness. In the article the graphic above came from, Hamari et al (2014) reviewed literature on gamification by narrowing down hundreds of article database search hits to a subset empirical studies that analysed the effectiveness of gamification; while results varied between studies the general finding was that gamification did work despite some caveats existing like some users being averse to game mechanics involving competition with other users. Hamari et al (2014) also concluded that gamification as a phenomenon is more diverse than studies often assumed pointing to an oversimplification in the way some research defined and measured the phenomenon and that more rigorous methodologies ought to be used in further research on gamification.

2.9.2 Gamification and Instructional Design

There are increasing implementations of gamification in educational software and instructional design. Kelly (2012) outlined features of Angry Birds that were relevant to instructional design:

- It is easy to pick up and explore
- There is no single right answer
- There's opportunity and incentive to practice
- It's accessibility is in its mobility
- Its learning is paced and builds upon itself
- It incentivises better performance

There are many specific game mechanics that create these features and these features can fulfil needs that are present in many learning programmes. In the context of angry birds, 3 star systems create differentiated achievement goals that incentivise repetition and perfection of tasks. It is very effective at encouraging users to repeat and perfect tasks. Mobile learning tools such as Dragon Box Algebra and Duo Lingo utilise these and other systems to offer a variety of incentives and feedback to users. Repetition is not necessarily important in all forms of learning but it definitely is in areas that have some aspect of memorisation like languages and math. Similarly, bonus levels and rewards are opened up by gaining certain numbers of stars across levels. In popular mobile games the user interface is easy to use; rather than reading instructions about how to play the game the user views short tutorial videos then learns through doing; this is potentially transferable to language learning and is similar to the language learning theory and applied method within which the learning tool is being created - the fundamental concept of 'learning by doing' is not new but it is in contrast to forms of learning and software that require users to read lengthy explanations before being tested. Other features include the variety of scores, ranks, currencies and grouping levels in chapters. Chunking tasks into smaller parts and providing progressively cumulative measures of progress are mechanics that are potentially beneficial to instructional design. Although these mechanics aren't overly complex they are quite different to a lot of instructional media that only has limited implementation of a few mechanics like interactive quizzes and score counters.

Ongoing developments in mobile games are creating more innovations and strategies to retain users over time and encourage repetition. Daily, weekly and monthly repetition is beneficial to language learning. When games were sold in boxes on shelves, users often bought games and

played them through once; many games had a chapter based format with limited opportunities or incentives for repetition of tasks. Today, the most successful mobile games are free to play; profit is made by advertisements or in-app purchases. Time limited content, continually updated content and essentially infinite rewards within games offer valuable tools for the retention of even the most frequent users. The structure of software can be designed to reinforce effective learning patterns in a similar way to how a teacher can encourage and train students to use flash cards and post-it notes on a regular basis then create new ones regularly followed by tests to provide feedback and feedforward. It would be foreseeable that educational software and games could scaffold effective learning strategies similar to how a human tutor can teach learners how to learn.

2.9.3 Game theory and Flow Channel

The flow channel from game theory is very relevant to the gamification of learning. Flow channel is a concept that comes from game theory. Flow channel is a gaming specific theory based on the psychological theory of flow created by Csíkszentmihályi (2014). The general theory of flow relates to motivation and engagement in life and specific tasks; optimal flow is created by a balance of skill in the individual and challenge in tasks. In games, flow channel conceptualises the balance between anxiety and boredom that a user/player experiences as they progressively solve challenges and gain skills. It is particularly relevant to gamification of learning as diverse learners will experience different levels of boredom or anxiety depending on how easy or hard they find the learning experience. It is also important as it conceptualises the link and balance between increasing skills and increasing challenge. Modern mobile games provide challenge through a variety of features which can potentially decrease boredom and increase the amount of opportunities for skill development. It is in part because of this widening of the flow channel that modern mobile games provide a better model for learning and instructional design than some more traditional games. Many traditional games have little diversity in the way users can experience challenge or progress through levels; levels often have set tasks required to progress rather than diversity of challenges across levels. Much educational software that is partially gamified seems to follow a more rigid chapter based format where there are few features of gamification that structure challenge and skill development. Some educational games only have one measure of success and don't offer progressive and varied rewards across levels. The potential of gamification

in learning is to diversify the ways in which different users can experience challenge in order to minimise boredom and anxiety; it could be viewed as keeping learners within the 'flow channel'. While some games can justifiably be designed to cater to a particular skill level and have a narrow flow channel, it is harder to justify with educational software as it should structure the learning to support as many learners as practically possible. Jungho et al (2010) reported that their assessment of a computerised security guard training program found that mobile activities could prove a better learning experience by providing the conditions for optimal flow when compared to non-computerised learning experiences.

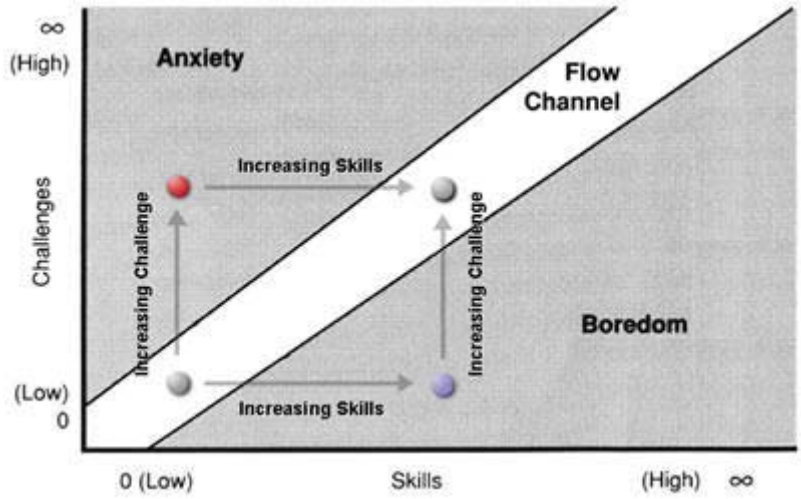

Figure 4. Diagram of flow channel (Csikszentmihalyi, M. 2014).

A wide flow channel is observed in modern mobile games and provides a sense of progression most users while still providing challenges at most skill level. Stars, bonuses, points, in-game economies, achievement badges and other game mechanics that have been mentioned earlier all provide diverse forms of challenge which conceptually widen the range of challenges and skill development available to different users; additionally they provide valuable forms of differentiated feedback, feedforward and next learning steps. These mechanics have not been tailor made for differentiating learning; they have been developed for the purpose of making games widely accessible and playable to a range of users. Because of the resources and time put into highly commercial games it is a valuable pool of mechanics which are potentially transferable to creating highly differentiated learning experiences within one tool.

2.10 Game Based and Simulation Learning

As the learning tool being developed in this project uses a simulated game world, game based learning and simulation learning are important areas to review. Learning games and simulation learning are different from the general gamification of learning tasks. Game mechanics have been applied to various types of instructional software. A minority of gamified learning tools are actually games themselves and simulated game worlds are seldom utilised in educational software tools. Kapp (2012), outlines that gamification can provide a realistic context in which actions and tasks can be practiced; this points to some blurring in the use of terminology between game based learning and gamification as practising actions and tasks in a realistic context would generally be considered closer to simulation or game based learning than gamification by many other authors. Despite some applications combining both game mechanics and game worlds the two also exist in isolation; you can have a simulated game world with no game mechanics and you frequently find game mechanics applied to content that is in no way a simulated game world. This is an important distinction as the impression is often that there are many 'learning games' when a lot of these would be classified as learning software with game mechanics.

Simulated game worlds present a different way to structure learning experiences and there has been interest in education as to how they can be utilised for learning. The fast pace at which the game industry is developing and the high costs and expertise involved in creating more in depth simulated game worlds means that high overheads are prohibitive to producing detailed game worlds to deliver educational content. This means it is far more feasible to apply selected aspects of games to more traditional learning experiences. As a result there is a lot of research and interest in the area but relatively few true learning games based within game worlds. Studies on using games that are not specifically educational for learning have also been carried out. Whitton (2012) reviewed games in education and summarised that the economic constraints in education may outweigh the theoretical benefits of games created specifically for learning but outlined other ways computer games could be integrated into education such as educators using game development engines to create low-tech games, getting students to design games and using commercial games in educational contexts. The major inhibiting factors reported in these approaches are that

commercial games are unlikely to easily match intended learning outcomes and the cost, time and expertise involved in creating commercial quality educational games means it is difficult for educators to produce them. These factors coupled with the fact that there are reservations as to the effectiveness or practicalities of implementing educational games in formal education result in few truly educational games. Adding game mechanics to non-game based learning activities is therefore much more common. However, technology and perceptions of games are evolving so rapidly along with the nature of education it is likely that game-based learning will increase; it is a field with great potential especially as it is now easier than ever to create games. Both Whitton (2012) and De Freitas (2006) reported that the modification of existing games and game engines allows the creation of customised content within game worlds without the financial or time commitment required to make a game from scratch; modern 3D engines like Unity 3D make creating customised content easier than ever. Additionally the new style of games popular on mobile devices present a successful medium that is potentially easier to create content for than other styles of games.

2.10.1 Learning Games that use virtual worlds

Currently there is a small range of educational software that utilises game worlds. Whitton (2012) reported that there were few and most educational games were in areas such as engineering or computing and were projects of individual enthusiastic teaching staff. Dawley et al (2014) conducted a review of the range of presently available learning tools that used virtual worlds and their effectiveness and concluded that virtual worlds can be an important and engaging component in an educational program for various reasons and purposes and that it is an area ripe for future research; Dawley lists 14 virtual world based learning tools that structure learning in various ways but still concludes that overall adoption in educational settings is limited. One of the commonly reported benefits of a virtual world is the simulated space it situates the user in; Schwienhorst (2002) defined this as virtual presence and outlined benefits such as higher cognitive engagement and improved interaction between participants; similarly, Dawley et al (2014) use the term virtual embodiment and describe how it gives the user the sense of “being there”.

2.10.2 Virtual Worlds and CALL

There are studies of virtual worlds in relation to language learning; most of these relate to the use of virtual worlds for language learning rather than virtual worlds that are specifically designed for language learning.

Schwienhorst (2002) specifically reviewed virtual worlds in relation to CALL and concluded that it provided an array of tools for awareness raising activities and critical reflection. Zheng (2011) researched virtual learning environments and language learning and concluded that 'Language learning in virtual worlds calls for design that prioritizes opportunities for distributed meaning-making and coaction in values-realizing activities that go beyond task-based learning, autonomy, and construction of a second language identity'; Zheng outlines the need to design for non-linear experience and a rethinking of pedagogies in relation to the nature of learning in virtual worlds. Rankin (2006) looked at Ever Quest 2, an online role-playing game, and investigated whether ESL students improved their English while interacting with other players and missions within the game. They found that students increased their vocabulary by 40% and that intermediate and advanced students showed a 100% increase in chat messages sent to other players over eight playing sessions. There are several other articles that outline the use of massive multiplayer online role playing games as language learning tools. The software Second Life has been shown to have benefits in language learning by various authors such as Warburton (2009), Stevens (2006) and Cooke-Plagwitz (2013); the latter concluding Second Life was proving to be an important tool for foreign language education and promoted social presence. Second life also offers language based communities in which users can practise the target language. Another game that is of particular relevance to this study is Scribblenauts as it is based in a 2D platform world. In Scribblenauts users create content in the game by writing it in a notepad; interestingly the actions, size, colour and other qualities of the objects change depending on adjectives and verbs that are used. Campos et al (2013) outlined how Scribblenauts along with two other games could be used for English language learning; Wario Ware Smooth Moves is one of the other games mentioned as it involves users carrying out actions with a Nintendo Wii remote based on instructions given by the game. Begay (2013) reviewed the use of virtual worlds in relation to indigenous language education and

concluded that there it is a topic that has yet to reach indigenous communities but worth considering for its educational possibilities.

The bulk of studies relating to virtual worlds and language learning investigate the use of virtual worlds that aren't specifically designed for language learning. Virtual worlds in which the nature of tasks and game mechanics are specifically tailored to language learning are rarer as most software specifically designed for language learning uses other formats and tasks to shape the learning experience without a true virtual world. It would seem that there is room for the creation and evaluation of purpose built language learning tools within virtual worlds.

2.10.3 Purpose Built Language Learning Tools That Use Virtual Worlds

Most of the purpose built language learning tools and Māori language learning tools reviewed earlier present learning experiences in a variety of ways but do not truly utilise virtual worlds. There are very few virtual worlds created specifically for language learning. One of the few examples is a game called Influent, a language learning game which is structured within a 3D game world. It is built using a 3D game engine; users learn vocabulary by interacting with 3D objects in the game world and matching vocabulary with 3D objects. There are gamified aspects in which the user must find objects in the world within a certain timeframe and earns points while doing so. Howland et al (2012) reviewed the effectiveness of the tool and found that all test subjects enjoyed the game and were able to learn 70%-90% of 10 word vocabulary sets. Influent is one of the few virtual worlds built specifically for language learning. Virtual worlds built for the purpose of CALL and general virtual worlds used for the purpose of CALL represent two quite distinct categories. The commonly reported advantage in literature relating virtual worlds and language learning is the ability of users to interact with other humans which results in a large amount of user-generated interaction and content in the target language. This is something that is absent from purpose built language learning tools that do not utilise multi-user environments; however, structured content and game mechanics that scaffold specific language learning skills are easier to apply to purpose built software. It appears that the combination of putting purpose built language learning experiences that involve aspects of gamification into virtual worlds is under-represented in literature and that there are opportunities for further development in the area.

2.11 Findings of Literature Review

From reviewing literature on key areas related to the mobile language learning there are several clear findings. CALL and MALL studies are often focused on technology and despite a long tradition of CALL there is little field wide use of theory. There is one in depth study related to mobile, Māori language learning (McKenzie, 2014) that outlined the many benefits of mobile devices including recording, playback, portability and the ability for learners to learn and redo lessons in their own time; this study also recorded significant improvements between pre-tests and post-tests of learners who were using mobile devices. In relation to the more general application of gamification to instructional design, published research on gamification was found to be rapidly increasing since 2010 when it was virtually non-existent. Gamification has many proposed benefits to instructional design and meta-analyses of quantitative, evaluative studies have shown there is generally a positive effect on learning. While gamification is widely applied to learning, purpose built virtual worlds for language learning were virtually non-existent. Several studies did outline the use of non-purpose built virtual worlds used for the purpose of language learning and reported generally positive results. In relation to the combination of features being investigated in the current Design Science Research Process, there are few tools that combine virtual game worlds with gamification for the purpose of language learning; there is also little literature investigating the combination of these areas. Importantly mobile devices, gamification and virtual game worlds by themselves all have documented benefits to language learning.

3. Methodology

3.1 Outline of Methodology

In the methodology design research models are reviewed followed by an outline of the design research model used in this project. Mobile game design tools are reviewed in relation to the needs of the current design research objectives; additional software tools used to develop the software are also outlined briefly. This is followed by a section outlining the process behind defining the nature of the game world that was created.

3.2 Design Research Models

Research about design and design as a research process are separate fields. There are several models of how to use design as research process. The Design Science Research model outlined by Vaishnavi et al (2008) breaks the design science research into 5 phases of awareness of problem, suggestion, development, evaluation and conclusion. More specific detail on this process is given in the method section. Peffers et al. (2008) present an alternative model which merges suggestion and development into a single phase but recognizes 4 different contexts for the initiation of research; problem centred initiation, objective centred initiation, design and development initiation and client and context initiation. Purao (2002) presents a further model in which outputs of the design science research are conceptualised according to their level of abstraction; specifically whether they create knowledge about instantiations, models or theories relating to the phenomenon being researched. Hevner et al. (2004) presented another research framework in which iterative loops between environment and knowledge base were proposed in which business needs were derived from the environment and applicable knowledge was derived from the knowledgebase; more theoretical constructs were categorised as coming from the knowledge base while practical and applied factors from the environment. In the centre of Hevner's conceptual framework is the bidirectional/iterative relationship between 'develop/build' and 'justify/evaluate'; this is similar to other frameworks relating to iterative cycles of creation and evaluation.

Table 2

Rubric summarising 4 different Design Research Frameworks

Design Research Model	Conceptual Framework of Design Research Process
Vaishnavi et al. (2008)	The progression between the 5 phases of Awareness of Problem, Suggestion, Development, Evaluation and Conclusion
Peffers et al. (2008)	Six phases of identifying the problem, defining objectives, design and development, demonstration, evaluation; and communication. Recognizes 4 different contexts for the initiation of research; problem centred-initiation, objective centered initiation, design and development initiation and client and context initiation
Purao (2002)	Conceptualises design research in relation to the level of abstraction relating to outputs; e.g. implementations, principles or theories
Hevner et al. (2004)	Iterative loops between environment and knowledge and a central iterative loop between development and evaluation

3.2.1 The Most Suitable Design Research Framework for the Current Project

Evaluating the frameworks in Table 2 for implementation into the current research process was fairly straightforward. The key question was which one could be most effectively operationalised in this particular design science research project. The two that were easy to rule out were Purao and Hevner. While Purao offers a very valuable conceptual framework in which knowledge creation can be categorised according to its level of abstraction, it does not offer much of a framework for structuring the research process which creates the knowledge. The Hevner model was ruled out because the three overlapping fields of environment, research and knowledge base did not offer enough of a linear framework from which to structure the current thesis project. The Vaishnavi model presents a linear process that can be conceptually aligned with the requirement of Masters level research; the Peffers model also follows a similar structure but breaks the framework down into more subsections; potentially too many to operationalise within the structure

of the current project. The Vaishnavi model is also the chosen model for the Association for Information Systems.

3.2.2 Design Science Research Applied in the Current Project

The design science research process was based on the Design Science Research Methodology as outlined by Vaishnavi et al (2008). Within this methodology, the iterative process of design and evaluation was structured as a symbiotic relationship between the creation of knowledge and artefact; specifically, the abstracted knowledge about concepts related to the learning application was both derived from and contributed to the process of creating the software tool. This process is outlined by Vaishnavi et al (2008) as learning through building/artefact construction.

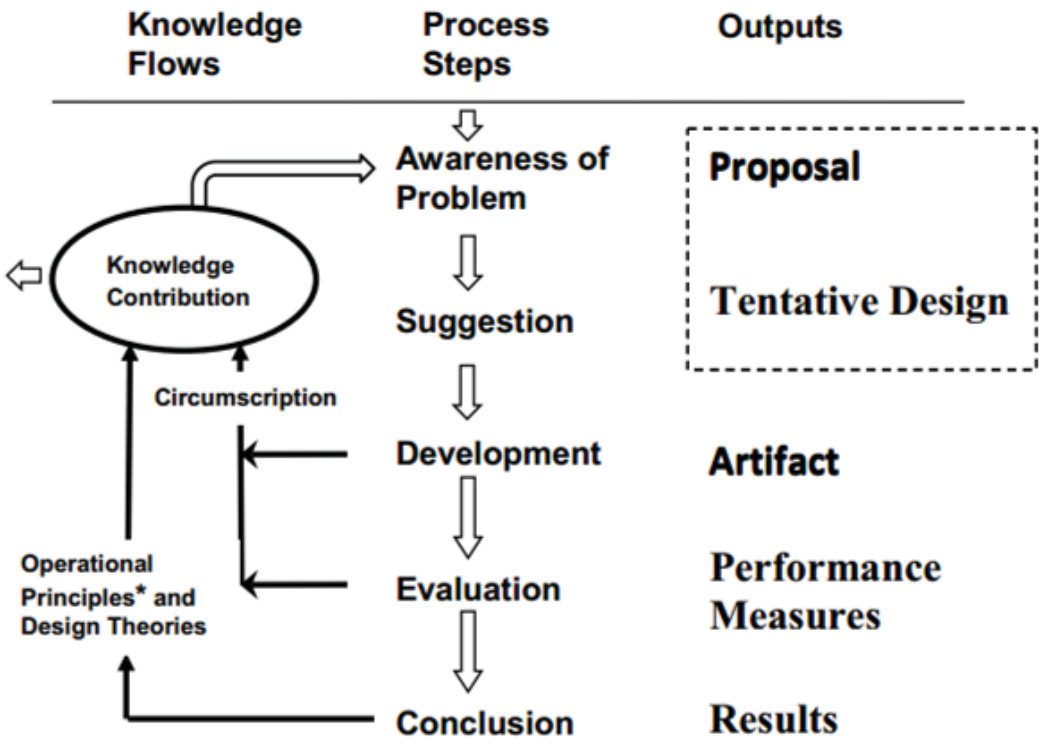

Figure 5. Design Science Research Process Model (Vaishnavi et al, 2008)

The Design Science Research Process Model in Figure 5 above structures the process into the stages of awareness of problem, suggestion, development, evaluation and conclusion. Importantly the artefact is a stage in the process that supports the creation of conclusions that contribute towards

the creation of operational principles and design theories. The process can be cyclic in nature and evaluations and conclusions can lead back to the awareness of new problems that start another cycle.

3.2.3 Design Science Research, Design Science and Design Practise

In the past Design Science Research was not a labelled field that was distinct from general Design Science; Design Science being the study of the science behind the practice of design Vaishnavi et al (2008). Now, there is a subtle but important distinction between Design Science and Design Science Research with the latter having relatively more emphasis on the creation of knowledge than the artefact. Design Science Research can potentially involve the creation of an artefact purely for the process of knowledge contribution.

3.2.4 The Value of the Design Science Research Process

In the current project, the primary focus is on knowledge contribution, on creating abstractable knowledge about how the game world and game mechanics created can contribute to structured learning experiences within the tool. As mentioned in the literature review of existing indigenous language learning tools and Māori language learning tools, there are few existing tools that use a similar combination of mobile mechanics, game mechanics and game worlds. The combination of little research in the field and few artefacts to research, makes Design Science Research a potentially valuable process. The alternative approach of more insular design and evaluation is not necessarily ideal in new fields where there are limited designs to evaluate. The obvious question is why not start with pure software design (that involves iterative cycles of design and evaluation anyway) until there is an artefact to evaluate and then carry out a summative evaluation. In other words; is there any advantage to following a more research focused design process to any other modern design process. Despite similarities in the processes there is still a functional difference. The most important distinction is that when Design Science Research Processes are properly operationalised, knowledge creation is given preference over artefact creation; through this prioritisation of knowledge, qualitatively different artefacts can be created to expand specific areas of knowledge that may not have been created otherwise. In more traditional design, knowledge may well be created in the process but with the overall goal of improving the design and the

completion of the end product. When prioritising goals in Design Science Research you could justifiably choose goals which did not favor the completion of software if it increased the knowledge gained about concepts in the software.

The distinction between Design Science Research, Design Science and Design Practice has been useful in this project. When creating and evaluating a software tool within the scope of a masters project it is important to review the balance between creation and evaluation; Design Science Research contains valuable frameworks and concepts that can be operationalised in the research process.

3.3 Phases of the Design Science Research Process Operationalised in the Current Project

The current project involves the very clear operationalisation of the 5 parts of the Design Science Research Process Model; details for each part are given below.

3.3.1 Awareness of Problem

Vaishnavi et al (2008) describe that in this phase the awareness of a new and interesting problem may come from multiple sources including new developments in industry or in a reference discipline. In this study the awareness of the problem comes from the recent development of modern mobile devices and game mechanics. This development combined with the need to find new ways to engage people in language learning creates a clear base to form a proposal for the new research effort.

The proposal was to develop a mobile Māori language learning application that uses a simulated game world and modern game mechanics. These features were chosen because simulated game worlds and the extensive implementation of modern game mechanics were clearly shown not to have been implemented in many Māori language learning apps; these were also the new and

interesting possibilities created by modern mobile devices. The literature review above represents an important part of this phase as a reasonably detailed overview of existing software and literature was undertaken.

3.3.2 Suggestion

The suggestion phase involves the creation of a tentative design and normally a basic / low-tech prototype. From this tentative design and prototype problem solving through new functionality is envisaged. In this step emphasis is put on creativity and finding a problem solution through design.

In the current project the tentative design came in the form of the first low-tech prototypes in which a basic 2D platform game template was created. Several features of the game world and mechanics were proposed and prototyped at this stage such as the user interface, style of levels and basic game mechanics. This also involved testing similar games to review different ways of allowing the user to control a character in the game world. During this phase informal user testing was done; this did not involve any learning tasks. This stage is similar to early stages of iterative software engineering in which early prototypes are developed and tested as early and efficiently as possible to create a base for subsequent iterative development.

The transition to iterative design cycles was made when there was a definite base for the program to be developed on, learning tasks were implemented into the game world and there was enough content to start designing, planning, testing and evaluating every week.

Creativity in this step involved trialling a range of more creative and experimental features of the Software Development Kit to investigate potential directions for the tool.

3.3.3 Development

The development phase involves the development of the tentative design into a functional artefact; the Design Science Research model outlines that at this point the novelty is primarily in the design not the construction of the artefact; in other words, the artefact may not contain any completely

new technology or features but the design has novel applications of features and technology that solve a problem in a new way.

In the current project the early low-tech prototype was developed into a fully functioning application with a limited amount of content that could be tested with learners. The particular combination of language learning tasks, game mechanics and the simulated game world was novel even though no composite part of it was particularly new. Following on from the low-tech prototypes in the suggestion phase the development phase involved repeated iterations of development using an industry standard SDK (Corona - see details in the section on SDKs) and evaluation of a fully functional build of the software with students. The development phase of the Design Research Process involved iterative development cycles similar to those used in software engineering; more detail about this process is given in a separate section below.

3.3.4 Evaluation

In the evaluation phase of the Design Science Research process, the artefact is evaluated according to criteria in the proposal/awareness of problem phase. In this part of the process quantitative and qualitative observations are made relating to deviations from expectations. The evaluation phase must involve an analytic subphase in which hypotheses are made about the behaviour of the object (Vaishnavi et al, 2008). The creation of hypotheses at the evaluation phase is similar to the use of hypotheses in more traditional positivist research; however, the difference in Design Science Research is that the hypotheses in the evaluation phase are usually used for information gathering and the implementation of another round of suggestion and development. This is the aforementioned similarity to iterative software engineering.

In the current project structured cycles of suggestion, development and evaluation were run over 8 weeks of term time in order to maximise the amount of information gathering. After each evaluation, observations about effective and ineffective aspects of the software were used to structure the next round of suggestion and development through reviewing current literature and mobile applications related to the design elements of interest. Because of time constraints, there

was a predetermined time at which a final evaluation was made before moving on to the conclusion phase.

3.3.5 Conclusion

In the conclusion phase, Vaishnavi et al (2008) categorise knowledge that is gained as either ‘firm’ or ‘loose ends’. Firm knowledge is knowledge that can be repeatedly applied or behaviour that can be repeatedly invoked. Loose ends are anomalous behaviour that defies explanation and may warrant further research.

In the current project a reasonable amount of firm knowledge is created relating to the implementation of specific game mechanics in learning programs. Most of this relatively firm knowledge is created as a result of the iterative nature of the research by observe the result of specific game mechanics being varied between different evaluation phases. Although largely qualitative evaluations the knowledge is believed to be relatively firm as it is supported by other literature in the field relating to similar game mechanics.

3.3.6 Similarities Between Design Science Research and Iterative Design Cycles

There are similarities between the iterative nature of Design Science Research and iterative design processes in software engineering. The two are linked in both fields as more knowledge creates more effective artefacts and more effective artefacts create more opportunities for knowledge creation. Some academic projects have involved more general iterative development rather than Design Science Research (Walsh et al, 2010), (Kam et al, 2007). The current project incorporates some concepts from iterative design, especially in the development phase; the key distinction being that across the project priority has been given to the evaluation of key mechanics and features in the context of existing research in the field rather than completing a finished artefact.

3.4 Codesign

During the development phase of the Design Science Research Process co-design was used to incorporate students, teachers and academics into the design process. Codesign is a significant part of the research process as the principles behind cooperative development were applied to the development phase of the research. In this phase rather than developing and preparing a tool to be tested and evaluated on students, the tool was iteratively developed and tested over short cycles in order to involve students, teachers and other design partners early in the development process. This process is a practical process to employ in the development phase of the wider research process due to exploratory nature of design research. A detailed background of co-design is given below to put it in context and outline the principles that guide this part of the process.

Co-design, co-operative design, participatory design, co-creation and user-centered design are terms used to encompass the idea of involving the user in the design process. Codesign is an important part of the design phase of the current research project as it involves users actively in the development of the artefact. While most artefacts are designed with users in mind; the concepts of co-design and participatory design relate to users being active in the design process. Sanders (2008) identifies that co-designing is not new but has taken distinctly different paths in the US and Europe with the participatory approach (i.e., "user as partner") primarily in Northern Europe and the user-centered approach (i.e., "user as subject") primarily in the US. In 1971, the general concept of co-design was discussed in some detail at the *Design Research Society's Conference* with Cross (1972) referring to it as design participation or "user participation in design".

Some of the very earliest examples of co-design came from projects in Norway, Sweden and Denmark in the 1970s in which researchers followed and supported the attempts of local trade unions to influence the use of technology at work (Bødker, 2000). One of the most notable projects that followed from these was the Utopia project in which researchers and designers worked closely with graphic workers' unions in order to create user friendly software. Bødker (2000) reported that, as a result of the project, end users, interface designers and developers were put on an equal footing in the design process and that the graphic workers better understood the pros and cons of the emerging technology and most importantly, the Utopia project helped to create a methodology that involved end users in the design process and added to the Scandinavian IT Design Model.

In practice the Scandinavian codesign project involved a cooperative laboratory with low tech prototypes, a graphic workstation and wax cards for modelling. The AT project is a more recent example of Scandinavian design given by Bødker (2000) that built upon the Utopia project; cooperation was enhanced in this project by workshops for everybody, access to prototypes and a newsletter. Another early example of computer aided participatory design was the creation of a software tool to promote design participation in buildings by allowing users to layout future building designs on a computer terminal; Coleman (1973) reported that the program was an effective way of involving more people in design and decision making and surmised that it could ultimately result in a more socially evolved architecture. Value laden terms related to political and social ideals like democracy and equal footing are often used in relation to the conceptual shift in design processes.

In a review of Scandinavian design approaches, Floyd (1989) reported that common features were efforts toward humanization and democratization as overriding design goals, in keeping with the aim of building an egalitarian society. This is partly a result of the fact that early computer programs were more often tools for pre-existing professions than luxuries that consumers could choose to buy or not; this is evident in the importance of trade unions as a transformative force in early forms of cooperative design. By the 1990s cooperative design practices had extended beyond Scandinavia and beyond solely research supported projects. Muller (1993) reviewed participatory design outside of Scandinavia and reported growing uses in commercial projects but also a great variety of issues within the scope of PD; participatory design conferences were held in the US in 1990 and 1992. Muller (1993) categorised many projects to date into more than 20 types of cooperative design techniques; these included cooperative prototyping, cooperative evaluation, low-tech prototyping, customization, structured conferences, mock-ups and storyboard prototyping. More recently, design has focused more on the user experience. Sanders (2008) attributes part of this shift to the stagnation of the technology push giving the example of car designers finding it hard to compete on technical quality looking towards users rather than the product. These historic developments in design science are not entirely irrelevant to contemporary software development in education; as the shift from ‘designing for’ to ‘designing with’ is similar to the general shift towards co-construction in education.

Just as cooperative design and early computer software were strongly linked, the development and spread of the internet both aided and created the need for further developments in cooperative design. ‘Web 2.0’ is a concept that refers to web content that has higher levels of user generation. The general shift towards higher levels of collaboration and sharing has added to ways in which software can be cooperatively developed by small and large teams of developers and academics. Nemes (1996) outlined early ways in which the internet aided cooperative design and listed the ability to hold development data and design logs online as being transformational to the practice of cooperative design in engineering. There is a bi-directional relationship between cooperative design theory and practice and it is developing rapidly; just as there is research that has not been widely implemented there are implementations of cooperative design that have preceded theory and not been widely researched. For this reason this section will include some examples of cooperative software design that are not based on academic research but represent significant developments in design practice.

Currently, various cooperative design techniques are used in the development of educational software. Some of these used well established and clearly defined techniques. Druin (2010) outlined how partnerships between adults and children can create new technologies through a variety of cooperative inquiry methods; these included sticky note frequency analysis, low-tech prototyping and most importantly elaboration. In elaboration the focus is not on children being simply a “sample” or “subject pool”; all parties come up with ideas and elaborate the ideas of others. It is not possible under all cooperative design processes for all participants, especially younger ones, to add brand new ideas; elaboration offers a framework for cooperatively elaborating on ideas from all participants. Layered elaboration is a specific type of elaboration in which participants write down elaborations of ideas on transparent materials so earlier ideas and ideas of different participants can be continually revisited; participants can be split into groups to allow large amounts of people to have input within a short amount of time. Walsh (2010) reports on using layered elaboration as a form of low-tech prototyping involving student participants; they found that the iterative nature of the technique allows a large number of design partners to provide input and ideas in a short amount of time; this was helped by low-cost materials and the ability to non-destructively write over story-boards. A detailed study into software to support classroom

assessment used teachers as design partners; in a three phase cooperative process involving ethnographic research, co-design and field testing Penuel (2005) used a variety of cooperative design processes.

In the context of this research project some of the principles of codesign are applied to the development phase of the Design Science Research Process. Wider principles of codesign have been examined as they provide the conceptual and historical framework for the applied codesign processes implement during development. The Design Science Research Process outlined by Vaishnavi & Kuechler (2008) does not prescribe techniques for the development phase and state that they will, of course, vary depending on the artefact created from which knowledge is to be gained. As the end goal of the research process is to create knowledge about the use of a tool optimised for young learners of the Māori language, principles from codesign were operationalised in the iterative development cycles. If knowledge is to be created about the effective implementation of gamification and a simulated game world in a learning tool codesign is a valuable framework to incorporate.

3.5 Game Design Tools

To create the learning tool in this project during the iterative design cycles in the development phase of research, there must be a set of software tools to create the functioning software and all of the assets within it. There are currently a wider variety of tools available for creating software and games than ever before. In order to assess potential tools the basic criteria for the software needs to be defined. The most important thing is that it is for mobile devices which excludes game development tools designed specifically for desktop applications or consoles. Secondly, the software has to be interactive and feature a virtual game world with dynamic content that is animated which rules out some of the more simplistic tools for creating basic apps that are essentially web pages ported to mobile devices.

There are many tools that allow the creation of interactive content on mobile devices. A lot of tools are advertised as being very effective and versatile creation tools but have poor functionality, support and user communities. A quick review of blog and forum posts in which experienced

developers list and rank the most commonly used tools along with their pros and cons narrowed it down to a small pool of commonly used tools that would be suitable for developing content.

3.5.1 App development tools for Android and iPhone

The first two SDKs worth mentioning are the Android and iPhone native development tools. Android Studio (Google Inc, 2015) is the Anroid native development tool; this allows users to create apps optimised for Android in the native development environment. Advantages of this is the ability to easily access native functions on Android devices and guaranteed support for Android. Xcode (Apple Inc, 2015) is the native development environment for iPhone applications; similar to the Android native development environment it allows the easy access of native functions and guarantees support for the device. The main drawback of developing within these environments is that it is practically impossible to convert an app from one to the other; developers can use common assets but that is all. Native development is ideal for those who want to develop specifically for one platform or have the resources to have two separate native development projects.

Cocos 2D-x (Cocos2D-x, 2015) is an open source project which allows users to code once and deploy to Android and iPhone. It is coded in C++ and is suited for people with some programming knowledge. Cocos 2D-x is reliable; however, it does require quite a lot of coding to create content. On the other end of the spectrum there are tools like GameSalad (Game Salad Inc, 2015) and Construct 2 (Scirra Ltd) that allow users to create apps for both Android and iOS with little to no coding. Both of these are reliable, well supported pieces of software that do what they say which is facilitate the creation of app games through a graphical user interface and very little coding. The disadvantage is that for certain more specific, customised features code can be the most efficient way to create dynamic content. Tools like GameSalad or Construct 2 are ideal for rapid prototyping or people who want to create content without code. Construct 2 does support customised scripts as well which mean it does have potential for more complex projects. Construct 2 and GameSalad both have free and paid options depending on what features are used.

One tool which is important to mention is Unity 3D (Unity Technologies, 2015) Unity is the fastest growing and widely supported 3D game development that exists. It also allows the development of content for Android and iOS along with most other devices, consoles and operating systems. It has huge potential and allows the creation of content through a purely graphical user interface and also scripts in several different languages. Unity does allow the creation of 2D content; the only drawback being that it is essentially 3D content constrained to 2 dimensions while a lot of the interface and settings are optimised for 3D editing; however, this does not restrict what can be created in 2D within Unity. Unity has free and paid options.

The final development kit that will be reviewed here is Corona SDK (Corona Labs, 2015). Corona allows the user to code once and build apps for Android and iOS. It is similar to Cocos 2D-x but uses a much simpler language; Corona also has a lot of libraries that minimise the amount of code needed to create fully functional apps. The libraries that build the content for iOS and Android work very well and content runs well on both platforms. Corona is a good middle point for those who want the versatility of code over a purely graphical interface but also want work quickly or not work with the more technical aspects of setting up content to display on different screens and devices. Corona has many libraries that handle display settings and native device functions; it does also have libraries that support the customisation of screen settings.

Table 3

Rubric evaluating different development kits

SDK	Advantages	Disadvantages	Pricing
Android Studio	Optimised for Android allows easy access to native functionality of Android devices	Does not allow development or easy porting for iOS applications and involves quite complex coding	Free
Xcode	Optimised for iOS allows easy access to native functionality of iOS devices	Does not allow development or easy porting for Android applications and involves quite	Free; $99 charge to register as an Apple developer to test on devices and deploy to App Store

		complex coding	
Cocos 2D-x	Code once and deploy to Android and iPhone; is open source so developers are free to deploy and monetise as they please	Involves the creation of very complex code to create applications when compared to other SDKs with many pre-made functions and libraries	Free and Open Source
GameSalad	Easy GUI for creating iOS applications with little to no coding	Limited to iOS and does not allow the easy creation of more advanced functions	Freemium - free for basic version; $US 299 per year for full version
Construct 2	Easy GUI, create once and deploy anywhere including in browser or packaging as an app for iOS or Android	The development environment and HTML5/JavaScript base of Construct 2 means it may not be the best environment for developing customised dynamic features through code	Freemium - free for basic version, $US 129-429 for a variety of versions
Unity 3D	Heavily resourced SDK that allows 3D content creation through scripting and GUI; support for deployment to multiple platforms	3D content takes more time to create. While unity supports 2D content it is still based on the 3D interface so it is not the most straightforward way to create 2D content	Freemium - free for basic version, $US 75 monthly or $US 1,500 license; variety of other pricing for platform specific development kits
Corona	Code once deploy to multiple devices; comprehensive pre-made libraries that speed up development, a GUI under development a good simulator	More complex development environment than some heavily GUI based development environments	Freemium - free for basic version, $US - $US 199 for monthly subscription.

3.5.2 The Use of the SDK and the Current Project

The goal of the project was to investigate the combination of game mechanics and an interactive game world developed within a Māori language learning tool. The project also requires the creation and evaluation of a working prototype over iterative design cycles. This meant that a balance had to be struck between efficient development and being able to create dynamic, interactive content. From reviewing the wide range of development kits available and the potential dynamic content each can create it was concluded that Corona SDK would be used. Corona is optimised for 2D applications and allows the easy addition of a physics engine. It also allows the creation of original functions and code to create new features in the software more easily than some more graphical tools that do not fully support scripting. The other major feature of Corona is that it allows for software to be programmed and deployed to Android, Windows Phone 8 and in the future Mac and Windows desktop. This feature cannot be overlooked as it is hoped that eventually a finished version of the software can be widely distributed to a range of devices; many other development kits are only optimised for one platform.

3.5.3 Additional Software that Supports the Creation of the App

As this project involves the creation of all of the aspects of a fully functioning app, it is important to create a workflow that allows the creation of dynamic content quickly. Specifically images, animations and levels need to be created and positioned in a time efficient manner. Because Corona was chosen as the development kit, file formats that work well with Corona had to be created. Corona works with PNG sprite sheets for still images and multi-frame animations to economise processing power by loading single sheets with multiple images rather than large folders of individual image files. Adobe Photoshop and Flash Professional - https://creative.adobe.com - are used to create images and animations respectively. This creates individual PNGs that are then packed into sprite sheets by Texture Packer - https://www.codeandweb.com/texturepacker. As the levels are complex and contain many different sprites, another software tool is used to position the sprites within the level; Level Director - http://www.retrofitproductions.com/level-director/. Sublime text - http://www.sublimetext.com/ - is then used to edit the code that creates the software. The development pipeline connecting the different software tools used to create the mobile learning tool is shown in Figure 6 below.

Figure 6: A diagram of the development pipeline used to create working prototypes

3.5.4 Defining the Nature of the Game World

The basic nature of the game world had to be defined quite early on to have some basis for creating a low-tech prototype. As one of the goals of the project was to develop and evaluate software that utilised the more dynamic features of modern software it was essential that some kind of game world be used. 3D was ruled out early on as it would involve the creation of more detailed assets that would not be able to be created within the timeframe of the project. 2D games are also very popular on mobile devices; mobile devices have smaller screens and less options for user input than consoles or computers. It was also decided very early on that the game had to involve a player character to give the user a feeling of virtual presence in the game world. A quick review of different 2D game genres that had a player character was undertaken to look at the advantages and disadvantages of each genre.

Table 4

Rubric evaluating different types of 2D games

Rubric of Popular 2D Game Formats		
Format	Advantages	Disadvantages
Top down Games viewed from a birds eye perspective	Allows the viewing and exploration of wide spaces; is good for games that require discovery.	It is not ideal for representing objects relating to vocabulary for language learning

Isometric A 3D perspective created with 2D graphics by showing all 3 dimensions; usually an aerial view pointing diagonally downwards	Creates the illusion of 3D with simpler 2D graphics; it can represent objects better than top down	It is not ideally suited to more action intensive single player gaming; it is more often used for games that involve building or controlling multiple characters; isometric views of some objects can be more complicated than simple 2D objects
Side on A side on perspective in which a user can move up, down, left and right	Allows for more action intensive game play; objects can easily be displayed; it is a popular genre that is easy to control the player character	Limits some representation of depth; movements are limited to left and right

Side on was decided upon as the format for the game; this was because it allowed the easy controlling of a player character and more action intensive game play. Top down and isometric games are ideally suited to certain genres as they allow the representation of large areas. In the current game it was hoped to hold player engagement by including faster paced game elements that involved the careful movement of the player character; top down and isometric games can involve elements of this but it was decided that more action intensive elements of side on games would be better. The most common genres of side on games are 'platformers' and 'side-scrollers'; these games offer a reasonably close-up perspective involving real time user interaction to do things like avoid obstacles and collect bonuses. Mechanics from these games can potentially enhance user engagement and motivation. The representation of space in side on games is also ideal for representing objects and concepts in language learning as the perspective allows for the representation of smaller objects and positions above and below other objects more easily than top down views.

3.6 Ethics

A Low Risk Ethics Notification was sought for the project. The research fell in this category as it only involved anonymous user testing of the software; it did not involve any individual grades

being kept that related to students and it did not interfere with their existing learning program. The most common data collection method was qualitative results relating to how students were using the software. As most students were under 16 permission was sought from their parents to have students use software in the classroom. The low risk ethics notification is included in Appendix B.

3.7 Language Learning Tasks and Theory in the Research

Finding a theoretical basis for the language learning tasks developed in the research was essential. As outlined in the literature review, many CALL and MALL studies simply outline or evaluate tools without any significant use of theory and very few theories are operationalised. In this research project, criteria for operationalising a theory in the research was created before identifying a theory to use. A theory was then identified followed by defining the areas of language learning to focus on. The nature of the language learning tasks were then determined in relation to the theoretical approach.

3.7.1 Operationalising Language Learning Theory in Research

In the literature review the lack of field wide use of theory in mobile language learning was outlined. Despite this it is generally considered that a language learning tool should have a theoretical base. A meta-analysis of CALL showed that very few studies properly operationalised theories; generally they used ad hoc references to theory to describe results or theories played little formative role in development (Viberg et al, 2013). The first step to operationalising a language learning theory in this study was outlining a working definition of an operationalised theory that plays a formative role in development should do. It was decided that a theory that plays a formative role in developing a MALL tool should:

- conceptualise what is happening to users
- define measurable phenomenon
- have a formative role in development
- help realise new applications and innovations
- offer and idealised view of the end user experience

These features of an operationalised theory were reviewed in relation to the range of language learning theories in CALL and MALL. A substantial problem was presented by the fact that there is no consistent field wide use of theory in CALL; as mentioned earlier, in 25 years of CALICO journal publications there were only 113 distinct references to theory and of those only 17 theories were mentioned more than twice (Hubbard 2008). Due to the lack of established theories in the field, focus was given to investigating what language theory could contribute to the specific artefact being developed and knowledge about that artefact. Theories were then examined in relation to:

- the implementation and design of modern gamification/game mechanics in a Māori language learning tool
- the implementation and design of a simulated game world in a Māori language learning tool

This combination of features was chosen as a new area of knowledge creation as the review of current literature clearly showed that there was a lack of highly gamified indigenous language learning software and even fewer that utilised virtual game worlds. Game mechanics themselves can be applied to a huge range of learning experiences and tools so it was the implementation of the virtual game world that presented clear areas for development that could be supported by an operationalised theory.

From reviewing the literature on virtual worlds in learning the concept of virtual presence and other similar terms outlined in the literature review was a key feature of the tool proposed in the preliminary phase of the research. The users feeling of presence in the game world can potentially create the illusion of presence in space and carrying out actions. The next step was to find a language learning theory that related to the concept of virtual presence and carrying out learning tasks within a simulated world.

3.7.2 Caleb Gattegno's 'The Silent Way' and Te Ataarangi

When investigating Māori language learning methods an effective method was found that had many conceptual and structural similarities to the potential concepts and structures of tasks afforded by a virtual game world. Te Ataarangi is one of the well established Māori language learning techniques in New Zealand, Te Ataarangi, was modeled on 'The Silent Way' method established by Caleb Gattegno. As part of this technique learners listen to instructions relating to actions they carry out with coloured rods called Cuisenaire Rods and then give the instructions to other learners. The three major features of The Silent Way as summarized by **Richards et al** (1986) are:

- Learning is facilitated if the learner discovers or creates
- Learning is facilitated by accompanying physical objects
- Learning is facilitated by problem solving involving the material to be learned

A key part of this is that learners relate the instructions they are giving and receiving to physical actions carried out on real objects by themselves and other learners. A specific example of this would be asking a learner to pick up 4 orange rods and place them on top of green rods. In full immersion of the language being learnt and without assistance or translation the learner then has to carry out the instruction followed by giving the instruction to another learner. Through demonstration and observation the learner can create meaning without instruction in the first language and without relying on complex explanations from the teacher. This concept of the learner creating understanding through their own actions rather than interpreting teacher's explanations or reference material is valuable in the context of modern mobile learning tools. More interactive learning tools often minimise instruction and reference material and place the learning within more dynamic tasks that the user perceives as game like and creative.

The concept of learners learning through following instructions in the target language is not a complicated idea but it differs greatly from many other established methods of language instruction and has been proven to be effective. Importantly the concepts behind it can be easily implemented and potentially augmented by the more dynamic features of mobile devices. The decision to base the tasks in the learning tool on this applied method comes from it being an approach that fits well with a learning tool based in a simulated game world. Just as Te Ataarangi and other methods

utilising Cuisenaire Rods build associations between the placement and the movement of objects a, 2D physics engine can create a similar representation of space and movement.

Cuisenaire Rods in The Silent Way method play a fundamental part of the applied method in that they facilitate the learning with physical objects. Conceptually, game objects in the software tool being developed and investigated in this project are being used in place of the physical objects in The Silent Way method. This applied method is important to the current project as many language learning activities that relate to various theories may use physical props; what The Silent Way method does is lay out a very clear format and conceptual framework for how and why the rods should be used. The interaction with physical objects through structured activities is seen as instrumental to the mental processes the learner goes through in constructing their own understanding of the target language. By giving the learner the time and physical space to solve the problem or task presented by the teacher themselves, the learner is believed to learn the conceptual understandings in the target language more effectively.

3.7.3 Theoretical Basis of The Silent Way and Te Ataarangi

The theoretical basis for the applied methods Te Ataarangi and The Silent Way is constructivism. Constructivist approaches to teaching outline that facilitators should avoid direct instruction as much as possible and focus on guiding users own discovery. This fundamental feature of constructivism alone makes it ideal for computer based instruction in which a human tutor does not exist; while a computer program can potentially give ‘direct instructions’ it cannot assess whether learners understand them until there has been some form of user input. Making the user input and interaction a key conceptual part of the learning process rather than conceptually viewing it as a way to assess their learning is key to constructivism and is one of the strengths of operationalizing this theoretical approach in simulation based learning. Kaufman (2012) reported that constructivism has been implemented in the creation of technologically enhanced microworlds and that it will likely play an increasing role in language education. The most important principle of constructivism to operationalise in the development of the software tool is that of the learner having time to explore and create their own knowledge. Exploration is something that can be

enhanced in a virtual game world that is not easy to implement in some more traditional learning programmes.

3.7.4 Determining an Area of Language Learning to Focus on

One of the first steps to creating the tool is determining a clear area of language learning to focus on that has easily measurable learning outcomes and relates to the nature of the tool being developed and the theoretical framework behind it. A small subset of language skills were listed – shown in table 5 - and evaluated for potential use in the program. It was desirable to develop skills beyond simple vocabulary acquisition and practice so as to test the potential of the tool to teach more complex language skills.

Table 5

Evaluation of Potential Areas of Language Learning

Language skill	Reasons for teaching of this skill within the software	Reasons against the teaching of this skill within the software
Vocabulary/nouns	Nouns associated with tangible objects are some of the most fundamental words and also can be easily represented by game objects	Teaching nouns by themselves is simple vocabulary learning and consequently involves few of the more dynamic features of modern mobile devices
Pronouns	Māori pronouns are more varied than English pronouns; graphical representations of the different groups relating to different pronouns could aid learners' conceptual understanding	The necessary groups of characters in game required to teach pronouns - speaker, listener and other; singular, dual and plural - would be difficult to integrate into a highly gamified application; it is also potentially confusing to a user to interpret the difference between listening characters and 'other' characters within a simple simulation
Tenses (past, present, future)	Māori uses tense indicators that are separate to English ones; requiring users to identify tenses in sentences relating to the order of events in the timeline of the	Implementing activities that involve the interpretation of various different tenses is complex as they would strongly relate to the order of events;

	game could enhance understanding of these	it would not be the easiest initial concept to test and evaluate
Locative prepositions	Locative prepositions relative to the relative positions of two different objects; 2D games can effectively scaffold the movement and relative position of different objects	Manipulating one object in relation to another could create potential problems in a game interface if the player is already controlling a player character; manipulating other objects could be overly complicated on a small screen
Adjectives	Adjectives are a good option to teach within a simulated game world as they generally describe qualities of objects that can be viewed; the visual nature of simulated game worlds is ideal for teaching the differences in visual qualities of objects	Adjectives also require associated nouns; it can be difficult to display a range of qualities like sizes as they are relative; widely implementing colours also requires the careful selection of objects that can readily be displayed in different colours
Verbs	Actions involve movement and can easily displayed with animations on screen; users could build associations between animations on screen and the meaning of verbs	The difficulty with including verbs in the learning tool is the question of how to include them in tasks; it could either involve the user carrying out the actions associated with the verb which would require the necessary controls and mechanics to do so; alternatively, it could involve the user observing other in game characters and reacting to different actions which would potentially be quite complex
Adverbs	Similarly to verbs, adverbs could potentially be represented with animations showing differing variations of actions	Adding adverbs to the game mechanics would pose similar problems to adding verbs in that there would have to be a way for users to create or react to a variety of actions which would involve potentially complex mechanics

Upon reviewing these different areas of language learning it was narrowed down to vocabulary/nouns, locative prepositions and adjectives. This area was chosen for several reasons. Firstly; locative prepositions combined with adjectives represent a key part of Māori language

learning as further detailed in the next section. Secondly, when reviewing the other potential areas of development locative prepositions fitted better with features of the 2D game world. Pronouns, verbs, adverbs and tenses presented potential challenges to easily teach within an interactive game world; for early development of the learning tool at least, it was planned to stick with an area of language learning that complemented the functionality of the engine and most importantly lent itself to user friendly interaction with the tasks. Further developments to how objects were positioned relative to each other by the user within the game world are detailed within the iterative development cycles below.

3.7.5 Nature and Theory of Language Learning Tasks

While early tasks in the learning tool in this project focus on teaching the learning basic nouns through vocabulary matching activities, there is a progression towards teaching concepts and sentences as the learner progresses through the app. In early levels the learner learns basic nouns by following instructions to go to a range of objects that are distributed around the level. While the software tool does track the amount of wrong word matches the learner can still learn the words through trial and error. The learner is then encouraged to redo the level by offering a variety of incentives to complete levels with no errors being made. This follows the conceptual approach in the The Silent Way in that it allows the user to learn through discovery with intermittent feedback. In The Silent Way an instructor may use Cuisenaire Rod activities in a similar way by instructing a learner in the target language only to pick up a specific quantity or colour of rods and perform an action with them. The user is only corrected with a limited amount of subtle gestures in an effort to encourage them to create meaning in the target language without relying on explanations in their first language. The software tool in this project encourages this through the way the software structures learning tasks; learners read the word in the target language and need to look around the level for it without seeing English translations. When users make an incorrect word match they are unobtrusively corrected so they can keep discovering what the actual word is if they do not know it.

3.7.6 Teaching Sentences Within the Software Tool

The main area of the language that was determined to be developed within the game template was nouns, adjectives and locative prepositions; progressively scaffolding towards tasks which involve constructing sentences with locative prepositions; the vocabulary needed to participate in the tasks is also scaffolded in earlier levels. There were several reasons that sentences with locative prepositions were chosen to be the main focus of the software. A 2D platform game template is well suited to building an understanding of locative words and sentences as it has a clear spatial component in which learners can physically move objects. Locative prepositions are an important part of language learning and sentence structures with locative prepositions differ greatly from English to Māori. An example is this sentence from Bauer (1997) with both a literal word by word translation and a translation of the meaning.

Kei roto te miraka i te pounamu
at(pres) inside the milk at the bottle
'The milk is in the bottle'

The order of the words is changed significantly from English. A second aspect of sentence structure and vocabulary that will be developed within the same activity is placement of adjectives. The reason for including this is that the adjectives change position relative to the noun. A sentence with locative prepositions and adjectives for both nouns then represents a further change from English sentence structures. An example of a sentence like this is provided below.

Kei runga te hoiho pango i te maunga teitei
at(pres) top the horse black at mountain high
'The black horse is on top of the high mountain'

The main skills chosen to be scaffolded in the mobile learning tool were ones which require the user to make meaning from sentences like these and complete a task based on their understanding of them; this idea was developed from reviewing the types of tasks developed in the applied method on which the language learning is based. 'Make meaning' specifically refers to creating a

functional understanding of the sentence so that the learner can complete a task based on the content of the sentence. The aim is to structure the content in such a way that learners need to make meaning from increasingly complex sentences containing locative prepositions in order to progress through the levels. Other features of common ‘app games’ were chosen to be used to manage motivation, feedback and feedforward so that the tool is not dependent on teacher input; these features are detailed in a later section.

The major features in the silent way can be seen in the structure of learning experiences and tasks in the mobile application. In The Silent Way learning is facilitated by accompanying physical objects, generally Cuisenaire Rods, in the game world these can be substituted for representations of relevant objects. An important concept in The Silent Way is the early focus on Cuisenaire Rods to teach an understanding of the deeper structures of the target language rather than specific vocabulary. Learners are unlikely to start up conversations about rods outside of the class; however, they can easily substitute the vocabulary later. It is regular practise in Silent Way classrooms to progress from sentences about rods to real objects around the room or outside in order to apply the sentence structures learnt by substituting different vocabulary. This is in contrast to some approaches to second language learning that solely focus on useful phrases to beginning learners. Focus is given to practising important sentence structures repeatedly with the Cuisenaire Rods; the aim being that the learner constructs their own understanding of the sentence structures through interaction with the physical objects. In the learning activities in the current app it was decided in the second iterative development cycle that users would create meaning from sentences with locative prepositions by moving rideable objects to positions relative to other objects in the sentence; the computer then provides feedback but, if incorrect, gives the learner time to keep searching for the right answer similar to a teacher in The Silent Way. Similar to The Silent Way, the activities involving sentence structures are not designed to teach practical sentences that one could immediately use in conversation; they are designed teach the structures so that learners can later substitute vocabulary. The approach aims to focus on propositional meaning before communicative value. Because this is a key part of the applied methodology, it offers some key concepts that can be applied to the development of the software tool. The concept of focusing on propositional meaning over communicative value is important as it provides a framework in which learning in a virtual world need not be constrained to phrases that can easily be used in

conversations; importantly it provides a conceptual understanding of the deeper learning processes that are happening when activities focus on learning the propositional meaning first.

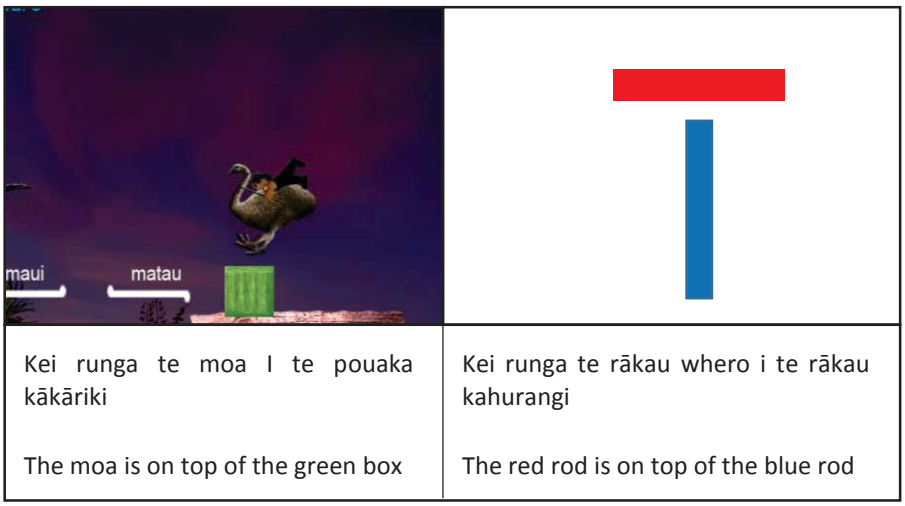

Figure 7. Diagram demonstrating the similarities between The Silent Way and activities in the software tool

The diagram above demonstrates the similarities between a task that is often carried out in The Silent Way method and a task carried out in the virtual game world. The perception of space and virtual presence in the game world can conceptually create similar learning experiences to those created by the use of physical aids.

3.7.7 Summary of Language Learning Theory in the Project

Given the lack of field wide consistent use of theory in MALL, it was decided to establish a criteria for what role an operationalised theory should do in research. Given that different theories can support different aspects of learning and different types of learning experiences Mitchell et al (2013), focus was put on finding a theory that helped describe, shape and guide the development of learning experiences that were proposed in the current design research. The applied method of The Silent Way has a way of conceptualising the user's individual construction of understanding through interaction with physical objects that can help understand and shape the language learning experiences that are developed within the game world.

4. Design and Development Phase

The development phase of the project involved 3 main phases: prototyping and discussion with design partners; iterative development cycles; and a quantitative evaluation. The early research phase involved looking at existing software and discussing with design partners how software and mobile devices are already used by students for Māori language learning. Feedback was gathered on what learning tools exist and what learning experiences students are currently having on computers. At the early stage before low-tech prototyping and iterative development, information was gathered through interviews with a small group of teachers and academics involved in Māori language learning and computer assisted language learning.

4.1 Low-Tech Prototyping

The low-tech prototyping phase involved researching an initial design that was the starting block for iterative design and development phases. The low-tech prototyping marks the start of the development phase in the Design Science Research Process. The process of selecting the foundation for the game world, language learning and software development tools is detailed in the Methodology, Chapter 3, above. It was important to define a starting point for the software tool so that iterations could build upon a carefully chosen foundation.

4.2 The Development Phase and Iterative Design Cycles

4.2.1 Iterative Design

Iterative design was the main method used in the development phase of the Design Science Research Process. Strongly iterative design repeats the composite parts of the iterative design process - design, development and testing - in short cycles to ensure the final product is tested and redeveloped as often as possible in response to observation and feedback.

The theoretical opposite of iterative design is the more linear waterfall where all aspects of the design process are followed in one linear and sequential iteration towards a final product; it is generally used for small projects with no uncertain requirements. Pure waterfall design is rare these days and unsuitable for novel applications that have uncertain aspects. Academic evaluations of

completed applications that do not involve design of the artefact they are testing as part of the research process do have some things in common with more linear models of development; the depth of analysis involved in many academic evaluations would also be valuable to the development process. When academic evaluations are applied to software that has been created in an entirely separate, software engineering process; there is a general underlying structure (design then evaluate) similar to the linear nature of waterfall design.

A commonly used adage in iterative design is 'fail fast, learn fast' which relates to the short amount of time between design, development and testing. Due to there being little existing software with the same features in the target learning area these short cycles were ideal for the current project because of the amount of uncertain requirements. Conceptually the iterative development phase could almost be seen as looping back through the Awareness of Problem and Suggestion phases of the Design Science Research Process; however, these two phases in the Design Science Research Process have unique features that relate more specifically to the early phases of academic research than the shorter iterative design phases do.

Iterative design fits well into design research; the Design Research Process is a broad conceptual model that does not prescribe detailed applied methods; for this reason processes from software engineering were also implemented into the suggestion and development phases of the academic research. Principles of cooperative design were used in order to make users play a more active role at all stages of development; as opposed to only being involved in the evaluation and testing phases.

4.3 Nature of Iterative Design Cycles

The iterative development cycle involved testing with small groups of students and teachers then collecting, collating and evaluating feedback. As the researcher was the primary developer of the software it enabled a relatively quick development cycle. Software was tested in one session with design partners; usually on the same day. The software was then designed and developed in the following days and the modifications were then shown to the same design partners within a week. The relatively quick turnaround was key to developing the design partners as active participants.

The short timeframe between iterations meant that design partners could remember previous conversations, view their impact and value in the design process and be more motivated to continue contributing to the software tool.

In total 10 iterative design cycles were run. In these cycles certain aspects of the software were constructed and then tested; this was done over the course of one week in most cases. The first two cycles involved seeking feedback from educators in the subject area in order to identify possible directions for development. The next 8 cycles involved testing the software with students. The last two involved quantitative pre-testing and post-testing when students used the software. Qualitative feedback along with observations were collected throughout the process.

While using the software, students' verbal feedback tended to focus on aspects of the actual game rather than the learning; while this was a valuable insight into the user experience and aspects that affected motivation and engagement it did not necessarily provide information that related to the effectiveness of the learning tool. Observation of usage patterns and preferences provided valuable insight into how effectively students were learning and how they responded to different features. For example, in some iterations, students who were choosing to repeat levels to gain 3 stars needed to match up to 12 words with no errors in order to do so; additionally they were never prompted to do so; observing this type of user behaviour gave more insight into how much students were learning than a lot of the verbal comments. Students were asked questions that related to what they thought would help them learn more and from this feedback it was decided to develop more opportunities to view the vocabulary and practise it before entering levels.

4.3.1 Summarisations of Iterative Design Cycles

In this section, summaries of the 10 iterations are provided in tables to give a broad overview of development. These summaries provide rough notes set out in 7 different categories that list the format and key findings of each iteration. More detail about the nature of the game mechanics that were developed from the iterations is provided in Section 4.5.

Table 6

Summarisations of The 9 Iterative Design Cycles

Iteration 1
Mode of Testing
• low-tech prototype tested with other teachers • discussion about potential directions for development
Features Tested in Iteration
• 2D game world • single level • basic user interface • player controlled character/avatar • demonstration of potential features and directions for development • basic instructions and tasks • tasks relating to the relative placement of objects to teach locative prepositions • most tasks related to teaching the user how to interact with the level
Aspects of Theory Employed
• virtual presence created by player character and virtual world • learner creating conceptual understanding through discovery • learner is facilitated by accompanying physical objects – game objects replacing Cuisenaire rods from the Silent Way method • low-tech prototype
Game Mechanics Developed
• 2D platformer obstacles like platforms, walls and bouncy mushrooms • physics objects
Key Observations
• the controls worked well • a level of virtual presence was created through the ability to explore the level • the user • long written tutorials presented as tasks were overly complicated and could be replaced by labelling the buttons or visual cues • the actions involved in moving and position objects were overly complicated and hard for users to interpret
Feedback from Testers
• reported a preference to have points and reward systems included in future versions

• reported that students engaged better with existing learning tools when there were points and rewards systems
Action taken
• tasks were simplified • a basic score counter was added

Iteration 2
Mode of Testing
• modified low-tech prototype demonstrated and tested by a tertiary level Māori language lecturer • discussion about potential directions for development and the nature of language learning behind the tasks
Features Tested in Iteration
• single level with interface and character controls mentioned in previous iteration • more focused and simplified tasks relating to users identifying nouns by moving their character to them • tasks relating to the relative placement of objects to teach locative prepositions
Aspects of Theory Employed
• virtual presence created by player character and virtual world • learner creating conceptual understanding through discovery and action in the game world • learning facilitated by accompanying physical objects
Game Mechanics Developed
• 2D platformer obstacles like platforms, walls and bouncy mushrooms • physics objects • score counter
Key Observations
N/A as it was more of a discussion than play testing
Feedback from Testers – in this case cooperative planning discussions with tertiary design partner
• the linguistic content of the tasks was narrowed down to set phrases relating to finding nouns, adjectives and positioning nouns

- mechanics behind positioning objects discussed and changes planned

Action taken

- tasks were simplified
- a basic score counter was added
- specific wording of tasks was planned
- ridaeble objects were added in place of carryable objects in order to improve the user interface and complexity of controls

Iteration 3

Mode of Testing

- test of fully functioning proto-type with a junior class
- 4 students at a time on test devices

Features Tested in Iteration

- a single level with 10 objects
- basic instructions sending students to objects
- randomly generated questions
- rideable objects that did not yet relate to language tasks

Aspects of Theory Employed

- virtual presence created by player character and virtual world
- learner creating conceptual understanding through discovery and action in the game world
- learning facilitated by accompanying physical objects

Game Mechanics Developed

- obstacles and physical objects like platforms, walls and bouncy mushrooms
- a basic score counter

Key Observations

- student users were very engaged by the physical game world
- users could find words through the process of elimination but they generally tried to find the nouns mentioned in the sentences without errors once they had started to learn them
- the range of ways users could move around the level and interact with objects meant that users kept using the software even when they had seen the full range of content in the tasks

Feedback from Testers
• users expressed a desire to have more areas to explore • users expressed a desire to have more levels and different types of levels to play •
Action taken
• multiple levels planned • different types of levels planned • progressive incentives to avoid using trial and error and encourage memorisation of vocabulary were planned

Iteration 4
Mode of Testing
• whole class in groups of 4 testing a 3 level progression
Features Tested in Iteration
• 3 level progressions • 10 different words on each level plus a 4 of the words being randomly repeated for revision • 3 star system rating level performance based on correct and incorrect matches • level icon system that displays 3 star system and locks levels users haven't yet achieved
Aspects of Theory Employed
• virtual presence created by player character and virtual world • learner creating conceptual understanding through discovery and action in the game world • learning facilitated by accompanying physical objects • differentiated learning through different levels of achievement
Game Mechanics Developed
• levels • 3 star ratings • level selection screen with locks and display of star ratings • score and error counters •
Key Observations
• students strongly motivated by having to unlock new levels • star system created different challenges for different ability levels • 10 words within 1 level appeared to be too many as they had trouble perfecting all 10 words to gain 3 stars
Feedback from Testers

- students verbally expressed dislike and confusion at having to repeat words they had already connected within one level
- students expressed a desire to have more levels and a larger variety of content in levels
- students expressed a desire to have more challenging obstacles like enemies

Action taken

- in order to chunk the vocabulary into smaller pieces and increase the users perception of progress it was decided to create more levels with fewer words in each
- enemies were planned

Iteration 5

Mode of Testing

- whole class in groups of 4 testing a 4 level progression with enemies and points

Features Tested in Iteration

- 4 levels with 7 words on each
- mosquitos included as obstacles and enemies
- same 3 star system as previous iterations

Aspects of Theory Employed

- virtual presence created by player character and virtual world
- learner creating conceptual understanding through discovery and action in the game world
- learning facilitated by accompanying physical objects
- differentiated learning through different levels of achievement

Game Mechanics Developed

- levels
- 3 star ratings
- level selection screen with locks and display of star ratings
- score and error counters
- enemies to avoid

Key Observations

- smaller vocabulary lists on each level made it easier for students to memorise the words, achieve 3 stars and have a sense of progress
- more regular feedback created by chunking levels into smaller groups
- enemies increased provided challenge, increased repetition of levels but also caused frustration when repetition was too regular
- absence of tools to help learners learn and view the vocabulary present in different levels
- once students had a strong sense of progress across levels they were more likely to persevere if they found something difficult

Feedback from Testers
• students expressed a strong desire to be able to attack mosquitos rather than simply have to avoid them • students still expressed a desire for more different types of content and more levels
Action taken
• planned development of an introduction screen before each level which showed users the vocabulary that was to be matched and learnt on the level • variation between levels; shorter vocabulary lists for learning and combined vocabulary lists for revision were planned as users would be likely to persevere with more difficult tasks once they had a sense of progress

Iteration 6
Mode of Testing
• Whole class in groups of 4 testing a 5 level progression
Features Tested in Iteration
• 5 level progression • variation of 5 words on early levels progressing towards levels that reviewed combined lists of 10 words • less enemies that were killable
Aspects of Theory Employed
• virtual presence created by player character and virtual world • learner creating conceptual understanding through discovery and action in the game world • learning facilitated by accompanying physical objects • differentiated learning through different levels of achievement
Game Mechanics Developed
• levels • 3 star ratings • level selection screen with locks and display of star ratings • score and error counters • killable enemies
Key Observations
• even shorter levels engaged students more effectively as they had a rapid sense of progress • the repetition of words between levels with 5 words and 7-10 word review levels improved students ability to match words without errors and gain 3 stars • users enjoyed having enemies they could defeat • students became frustrated at enemies when they caused them to repeat the level too often

• the enemies did create intermittent repetition which is useful for memorising vocabulary
Feedback from Testers
• students reported a
Action taken
• the amount and placement of enemies was reviewed • the format of levels was retained – smaller vocab sets progressing towards larger revision sets • with the general format functioning well focus was turned to testing the teaching of locative prepositions

Iteration 7
Mode of Testing
• whole class in groups of 4 testing a 6 level progression
Features Tested in Iteration
• the pre-existing level progression • a more advanced level that used rideable animals that could be used as nouns placed relative to other nouns and adjectives; in this case coloured boxes • users had to make meaning from instructional sentences that referred to the relative position of two objects one with an associated adjective
Aspects of Theory Employed
• virtual presence created by player character and virtual world • learner creating conceptual understanding through discovery and action in the game world • the movement and relative positioning of animals relative to other objects with corresponding adjectives was used as a substitute for Cuisenaire rods from The Silent Way method • learning facilitated by accompanying physical objects; the relative position of • differentiated learning through different levels of achievement
Game Mechanics Developed
• levels • 3 star ratings • level selection screen with locks and display of star ratings • score and error counters • killable enemies
Key Observations
• learners who already had a partial understanding of locative prepositions and adjectives were engaged by the tasks and focused hard to complete them

- the ability of students with a partial understanding of locative prepositions to complete the tasks was taken as proof of concept for teaching locative prepositions in that way
- younger learners who lacked an existing understanding of sentences with locative prepositions and adjectives found the levels difficult as there were too many combinations of rideable objects, boxes and relative locations for them to complete the tasks and learn the concepts through elimination
- the introductory vocab learning screen was used by some users while others skipped past it

Feedback from Testers

- users who were able to complete the tasks in the final level that involved locative prepositions reported it as challenging but enjoyable
- users who were unable to complete the tasks in the final level did not perceive it positively

Action taken

- it was identified that the locative prepositions would need to be heavily scaffolded over many preceding levels in order to teach the more complex sentences that involved the relative position of 2 objects with adjectives
- given the quantity of levels required to scaffold the teaching of locative prepositions it was decided that these type of tasks would not be included in subsequent iterations
- focus in the next iteration was put on improving and testing the interface and other game mechanics

Iteration 8

Mode of Testing

- whole class in groups of 4 testing a 6 level progression

Features Tested in Iteration

- locative preposition and adjectives removed to return focus to the more structure and game mechanics
- a vocabulary learning screen which showed users pictures of each word next to their definitions
- the level of achievement required to unlock the next level was raised from 1 star to 3 in order to encourage users to use the introductory vocab learning screen that preceded each level meaning the users had to complete the level with no mistakes and hopefully pay more attention to the splash screen

Aspects of Theory Employed

- virtual presence created by player character and virtual world
- learner creating conceptual understanding through discovery and action in the game world

• the movement and relative positioning of animals relative to other objects with corresponding adjectives was used as a substitute for Cuisenaire rods from The Silent Way method • learning facilitated by accompanying physical objects; the relative position of • differentiated learning through different levels of achievement
Game Mechanics Developed
• levels • 3 star ratings • level selection screen with locks and display of star ratings • score and error counters • killable enemies
Key Observations
• forcing students to match all vocabulary with no mistakes created a split between motivated users who pushed themselves to pass the levels and a small minority of users who gave up as they could not complete a perfect score • while the majority of users did manage to perfect the levels in order to progress these users typically repeated levels to gain 3 stars in previous iterations
Feedback from Testers
• students who were able to perfect the vocabulary and progress through the levels found it challenging but reported that they preferred to be able to choose when they repeated levels • A couple of younger users who happily progressed through levels in previous iterations but struggled to achieve a perfect score and progress in this iteration reported a negative view of the experience
Action taken
• it was planned to return to the original format of allowing users to progress even with a 1 star rating • in order to incentivise memorisation of vocabulary and perfection of tasks more game mechanics were planned to reward higher star ratings • a more interactive version of the splash screen was planned so uses had to actively practise vocabulary before entering a level

`Iteration 9
Mode of Testing
• whole class in groups of 4 testing a 6 level progression • quantitative testing of vocabulary knowledge before and after levels with a 12 word vocabulary set
Features Tested in Iteration
• 6 level progression • a completely new 12 word vocabulary list

- static vocabulary learning screen at the entry into each level changed to a more interactive screen in which users had to connect drag and drop words to corresponding pictures
- time bonus given for quickly matching vocab in entry screen but no penalty given for making mistakes

Aspects of Theory Employed

- virtual presence created by player character and virtual world
- learner creating conceptual understanding through discovery and action in the game world
- the movement and relative positioning of animals relative to other objects with corresponding adjectives was used as a substitute for Cuisenaire rods from The Silent Way method
- learning facilitated by accompanying physical objects; the relative position of
- differentiated learning through different levels of achievement

Game Mechanics Developed

- time bonuses
- levels
- 3 star ratings
- level selection screen with locks and display of star ratings
- score and error counters
- killable enemies

Key Observations

- the new entry screen forced users to practise vocabulary before entering the level
- the time bonus on the entry screen gave users who knew the vocabulary well a good reason to
- the quantitative testing showed a clear improvement in vocabulary learnt but students did

Feedback from Testers

- students reported that the vocabulary matching practise screen was useful

Action taken

- level progressions were redesigned to teach less words with more repetition
- the number of different words taught in the first 6 levels was reduced from 12 to 10

Iteration 10

Mode of Testing

- whole class in groups of 4 testing a 6 level progression
- quantitative testing of vocabulary knowledge before and after levels with a 10 word vocabulary set

Features Tested in Iteration

- 6 level progression

• completely new 10 word vocabulary list for quantitative testing • the same vocabulary practising screen as before
Aspects of Theory Employed
• virtual presence created by player character and virtual world • learner creating conceptual understanding through discovery and action in the game world • the movement and relative positioning of animals relative to other objects with corresponding adjectives was used as a substitute for Cuisenaire rods from The Silent Way method • learning facilitated by accompanying physical objects; the relative position of • differentiated learning through different levels of achievement
Game Mechanics Developed
• time bonuses • levels • 3 star ratings • level selection screen with locks and display of star ratings • score and error counters • killable enemies
Key Observations
• quantitative testing showed new words were learnt within a 10 minute playing session • further reducing the number of words practised in each level helped users learn the words by increasing the repetition
Feedback from Testers
• students reported that the vocabulary matching practise screen was useful
Action taken
• level progressions were designed to teach less words with more repetition • the number of different words taught in the first 6 levels was reduced from 12 to 10

4.4 Summary of Iterative Design Cycles

The iterative design cycles were invaluable to creating and evaluating a range of features. The overall focus on knowledge creation rather than the completion of the final product within the limited timeframe allowed the repeated implementation of new features rather than volume of content; this created valuable findings relating to the use of and effectiveness of game mechanics and the virtual game world.

Using concepts from The Silent Way provided a valuable framework for creating a learning tool in a virtual world. The focus on learning through physical interaction in the applied method created valuable ways to approach virtual presence and interaction in the learning experiences. The virtual environment was effective at structuring vocabulary learning tasks; the process of the learner developing their own understanding of vocabulary through interacting with the environment appeared to be effective; although older self-motivated learners are good at developing strategies to learn vocabulary, the younger learners naturally wanted to match vocabulary when it gave them a sense of progression between levels. Through the limited testing of tasks that taught more advanced sentences, it appeared that game objects in the software could be conceptually substituted for Cuisenaire Rods from applied classroom methods. Students who had some understanding of locative prepositions understood the activities and were observed to focus and try very hard to make meaning from sentences in order to position objects relative to each other. This indicated that the combination of virtual game worlds and game mechanics could involve learning that was facilitated by virtual objects in a similar way to how The Silent Way method uses Cuisenaire Rods. This supported the idea that teaching the structures and syntax of language by structuring tasks around their propositional meaning rather than their immediate communicative value is a viable method when developing learning experiences in virtual game worlds.

A range of knowledge about how a range of different game mechanics can be combined with a virtual game world and applied to Māori language learning experiences. Observing users within the sequence of iterative cycles meant that the users' interaction with a range of different combinations of features was observed; this meant that things like level progression and content could be adjusted according to observations that were made over several weeks. The nature of the

game world and game mechanics that were developed over the iterations are detailed in the next section.

4.5 Game Mechanics and the Game World

At the conclusion of the iterative development cycles the basic structure of learning tasks and game mechanics had been developed as a result of repeated cycles of evaluation and design. Importantly the specifics of these features were created with the design partners as they were progressively created over several design cycles rather than tested on them at the conclusion of the project. Specific game mechanics and features of the simulated game world were completed and are presented below as part of the knowledge that was created from the design research process.

4.5.1 The Game World

The game world was developed to be as interactive and diverse as possible. From early iterations learners showed a desire to explore and interact with it. For this reason more dynamic content was created when possible. Making the levels seem large enough to explore and real enough to give the impression of virtual presence was important. Users regularly referred to the location of objects or their character in the game world and talked about actions they were performing showing the sense of space, movement and interaction that can be created. Features such as moving birds, a variety of trees, bouncy mushrooms were added as shown in Figure 8.

Figure 8. Example of the simulated game world

4.5.2 Scaffolded memorisation

In Iteration 9, in order to scaffold the memorisation of words a splash screen was developed in which users are required to unlock each level by matching written words with their corresponding pictures. The time taken to match the words is measured and bonuses supplied so users who already know most of the words can still have a sense of challenge; similarly there is no penalty in the unlocking phase for dragging pictures onto the wrong translations. The unlocking phase of the level was created during testing because only a portion of users were actually making use of a static splash screen which showed a picture dictionary of the words in the level. As the software is designed to be useable by a wide range of users, the software itself has to teach users to practise words before entering the level while simultaneously appearing challenging and meaningful to more advanced learners.

Figure 9: Screenshot of the splash screen which scaffolds memorisation of vocabulary through timed word matching

4.5.3 Stars, achievements and bonuses developed within the iterative development cycle

In the current project stars, achievements and bonuses provide users with a variety of feedback and rewards. Each level consists of 4-7 word or sentence based tasks. Early levels are structured so that users can fairly easily find their way through the level with trial or error by connecting words through the process of elimination; however, this will only gain the user one star and a smaller amount of points. This means that users ranging from those that know none of the words to most of the words can all have a sense of challenge. Stars and time bonuses are rewards and incentives available within a level; further rewards and bonuses are required across levels and chapters/groups of levels to maintain motivation. A valuable observation was made when the threshold for unlocking levels was increased during one iteration; to unlock the next level users were made to gain 3 stars rather than just one meaning they could not make any errors during a play through. This resulted in a couple of younger users who struggle to perfect the vocabulary give up very quickly; this reinforced the 3 star system as a valuable mechanic that serves to motivate a much wider range of users than a more narrowly defined measure of success would.

Figure 10. Screen shots showing different levels of achievement over levels

Image: Screenshots showing the star system that structures level progression allowing for different levels of feedback and feedforward to different users

Figure 11. The transition scene at the end of the level which displays correct and incorrect word matches and the corresponding number of stars earned.

4.5.4 Achievements and bonuses implemented after iterative development

Because of the practicalities of testing within short development iterations, there were only limited longer term rewards developed within the study. Longer term rewards are important incentives for perfection or repetition of tasks and retention of learners. Another common feature is the creation of a star threshold required to progress beyond a group of levels; this means that users must perfect a certain number of levels beyond one star but have some freedom as to when and which levels. Cumulative points, game currency and achievements are equally as important; related to these are level-ups, special abilities and in game purchases with game currency; importantly these are exponential. While in a lot of commercial games there exists premium in game currencies that are

usually purchased with real money; in this app it is simply a form of accumulated points that the user can trade for in game rewards. The overall score accumulates towards level-ups where a user's character progresses in rank. A home level was also added so that users have a visual representation of their progress. In game currency can be spent on rewards to decorate the home level. The in game currency provides a redeemable reward while the score provides a continually progressive measure. Tiered achievement badges, another common feature in mobile games, can offer recognition of specific game tasks and like all other aspects can be fine-tuned to encourage specific usage patterns that relate to specific learning outcomes. Importantly a lot of these longer term rewards can be used to shape longer term motivation and shape usage patterns; due to the time constraints in test and development longer term usage patterns were not investigated within the project. An important observation is that users did show an interest in progressively increasing the bonus counters that did exist despite having nothing to earn or redeem them for during testing cycles; the addition of redeemable awards and progressive achievements would foreseeably increase existing interest in scores and bonuses.

Figure 12: Screen shots of the home level in which users buy rewards with the money they have accumulated across levels

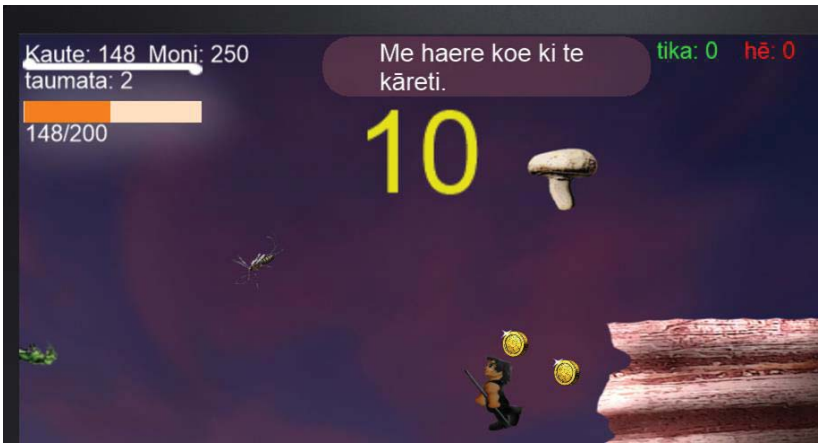

Figure 13. Screenshot showing the draft graphical user interface implemented after iterative development that displays the number of correct and incorrect word matches, score, money, rank and a visual representation of the progress towards the next rank.

4.5.5 Feedback intervals and exponential progress markers

Rewards are effective when based on something close to exponential progression; for example: a character levels up in rank at 500, 1,000 and 2,000 points etc or the cheapest purchasable reward costs half the price of the second cheapest. This is not a random basis for rewards, it is a good formula for a reasonable and effective level of feedback that is conducive to motivation and retention. Think of a new employee starting at an unfamiliar workplace; they will want to know whether they are carrying out a task correctly within the first few minutes; they would probably be keen to know at the end of the first day whether they have worked effectively; however, minute by minute or even day to day feedback would not be necessary in the longer term. Longer term, a sense of longer term progress towards greater goals is important; such as promotions or pay rises in the work place. The exponential nature will often plateau at some point either due to a predetermined cap on the amount of points between each level or the continual increase of the users ability to accumulate points. In games these tiered levels of reward help create progress markers that are more meaningful than just accumulating points. Ideally the task required to accumulate these points should be intrinsically rewarding and educational. The value of points attributed to separate tasks can be adjusted so as to encourage usage patterns that are designed to be more conducive to learning; for example, repeating a level until no errors are made. Repetition for the purpose of perfection is something that is hard to encourage some learners to do but is

important for learning languages. After the iterative development cycles in this project, a simple rank progression system was implemented in which users level up progressively. Levelling up and rewards that can be purchased with in-game currency were based on exponential progression meaning the more users play the longer it takes to reach the next milestone. The thresholds for progression are stored in arrays in the code allowing them to be adjusted after testing, as shown in Figure 14.

```
36  ---------------------------------------
37  levelup = { 100,200,500,1000,2000,5000,10000,20000,50000,100000,200000 }
38  levelupcumulative = { 100,300,800,1800,3800,8800,18800,38800,88800,188800,388800 }
39  mlevel = { 0,0,1,1,1,1,0,0,0,0,0,0,0,0,0 }
40  rewardtable = { 0,0,0,0,0,0,0 }
41  --rewardtable = { 4,2,2,1,1,1,1 }
42  rewardavailable = { 4,2,2,1,1,1,1 }
43  rewardcost = { 50,100,200,350,500,1000,2000 }
44
```

Figure 14. The code that runs the cumulative levelling up process and purchasable rewards

4.5.6 Different Dialects

One continually recurring suggestion from teachers and other adults who were consulted as design partners was that dialect was important. Having content in different local dialects was a preference many expressed. This is because for language rejuvenation reviving languages as spoken in particular regions is very important; when creating a general second language learning tool this is not so much of a concern as the most widely understood dialect is normally taught. Across New Zealand there are around seven different regional dialects of Māori still spoken. Some of the differences lie in pronunciation and this would only be relevant to design when/if audio is included; however, much vocabulary also varies from region to region. This presents a rather tricky design hurdle in that you either pick one dialect to design for or you try to include an option to select different dialects. Existing paper resources normally follow one set dialect. With software the option exists to have multiple versions of the vocabulary that can be substituted into activities; this would only create problems with file sizes if the activities were audio based. The easiest way to do this would be to store the different dialects in arrays; a prototype of this was trialed by creating two separate arrays for the nouns in the game as shown below.

Figure 15. Example of different dialects stored in separate arrays; this was only a prototype to test the structure so there was not a complete second dialogue added to the array

4.5.7 Culturally and Nationally Significant Game Content

When consulting teachers and other design partners a common feature that was reported to be important was culturally significant content. Having ideas, themes, assets, audio that represented New Zealand and Māori culture and scenery was frequently suggested. These features were included in the app during development in the form of vegetation, structures, animals, design elements and characters. One commonly mentioned feature was the idea of relating different levels or features of the game to common Māori conceptualisations of the natural environment; specifically, earth, air, sea, forest and sky in relation to the deities/gods of these regions; this represents a common theme in visual art, performing arts and traditional stories. Importantly it represents a conceptual understanding of the natural world around us. The concept of the gods of these natural regions was not fully incorporated into the iterative design cycles; however, rideable flying objects and undersea levels were created to enable the inclusion of these regions into the game. It is planned to structure the levels across these regions when more content is created upon the conclusion of the research.

Figure 16. View of underwater content showing uniquely New Zealand features

New Zealand plants and animals were also important in creating culturally and national relevant content. The underwater scene in Figure 16 shows uniquely New Zealand fish and seaweed that is familiar to many. The natural environment is an important part of Māori culture; many teachers who were interviewed expressed a desire to see uniquely New Zealand content as students were so often consuming multimedia that had generic international content.

Another culturally significant feature is the abstract patterns and designs used as graphics in the game; Māori culture has many intricate and complex visual designs that are not often seen in digital media; these designs generally engage young people and the inclusion of culturally appropriate designs in relevant digital media would be a good step for a variety of reasons. Specific to this project the incorporation of designs into menus and buttons creates a uniquely New Zealand and uniquely Māori feel to the software; it is probable that attractive and culturally significant design elements will help make the software engaging and subsequently a better learning tool but it also relates to wider goals of developing more cultural content in interactive media and encouraging more people to author uniquely New Zealand and Māori software; also it should encourage more people to see themselves as potential authors of software.

The important thing is that culturally relevant visual themes and content were consistently reported as important by teachers and other adults who were interviewed as part of the research process.

Great care also has to be taken in choosing designs that are appropriate. While they are unlikely to be final designs developed into any widely distributed version of the software, the designs shown in figure 17 are original designs developed by people involved in the project. At no point were designs taken or copied. The grey design in the background was given by a wood carver who created it and chose it as an appropriate design to use in the software. The manaia figures were designed by the researcher and carved by students at the school where the research took place. The appropriateness and meaning behind designs is a very important consideration.

Figure 17. Example of draft designs

4.6 Quantitative/evaluative pre-testing and post-testing

The Design Science Research Process aimed to create knowledge through the creation of an artefact. The software tool was not developed to a level where detailed summative, quantitative testing could take place as the main focus of the project was on generating knowledge about a wide range of features. During the last two iterative cycles of classroom observations, quantitative pre-tests and post-tests were used to evaluate how much vocabulary was being learnt in the testing sessions.

The quantitative evaluation of the software tool was based on a paper by Vlugter (2009) in which a dialogue based CALL tool was developed for Māori language learning. They used a pre-test and post-tests with an experimental and control group to gauge the effectiveness of the software they developed. The class was split to get the test and control groups; the control group was given a traditional tutor based lesson focusing on the language skill and the experimental group using CALL. The current study uses a similar methodology except with smaller test groups. Smaller test groups were used because of the scale of the project and availability of devices to test the software on. The tests consisted of connecting twelve words with their definition in the first pre-test and post-test in Iteration 9 and ten in the second pre-test and post-test in Iteration10. Individual results and averages were compared and graphed. A control group with a human tutor instead of the software was not used in this test as the comparison was not considered important as the software is not intended to be used in place of human instruction. Additionally there was no resourcing available to have a human teacher give a comparable lesson to a control group at the same time.

The tests were carried out on a group of students that had a wide range of abilities; they were not offered any extra instruction relating to the vocabulary or any special instruction on how to use the software; although they had used it before with different vocabulary lists. During both sets of testing the users played through 6 levels which required them to learn the required words in 2 smaller vocabulary groups and repeat them across revision levels. A total of 12 words were tested in the first test and 10 in the second. The change from 12 words in the first test down to 10 words in the second test was made in order to repeat the vocabulary more often over the same amount of levels. While this meant that the results of the 2 tests could not be compared, there was little value in comparing separate iterations of the software anyway as other features were changed between the iterations. The amount of words that learners already knew in the first test is far greater as more effort was put in to finding completely unfamiliar vocabulary in the second test. In the first test, vocabulary that hadn’t been used in previous iterations and user testing was used; however, many of the students had some existing knowledge of vocabulary. In the second pre-test and post-test completely unfamiliar vocabulary was used; the 2 correct words achieved by 4 students represent words that were possible to guess.

Table 7

Results of First Quantitative Pre-test and Post-test

Pre-test	Post-test
9	12
4	6
7	11
4	7
7	10
9	12
6	10
9	12
Average	Average
6.875	10

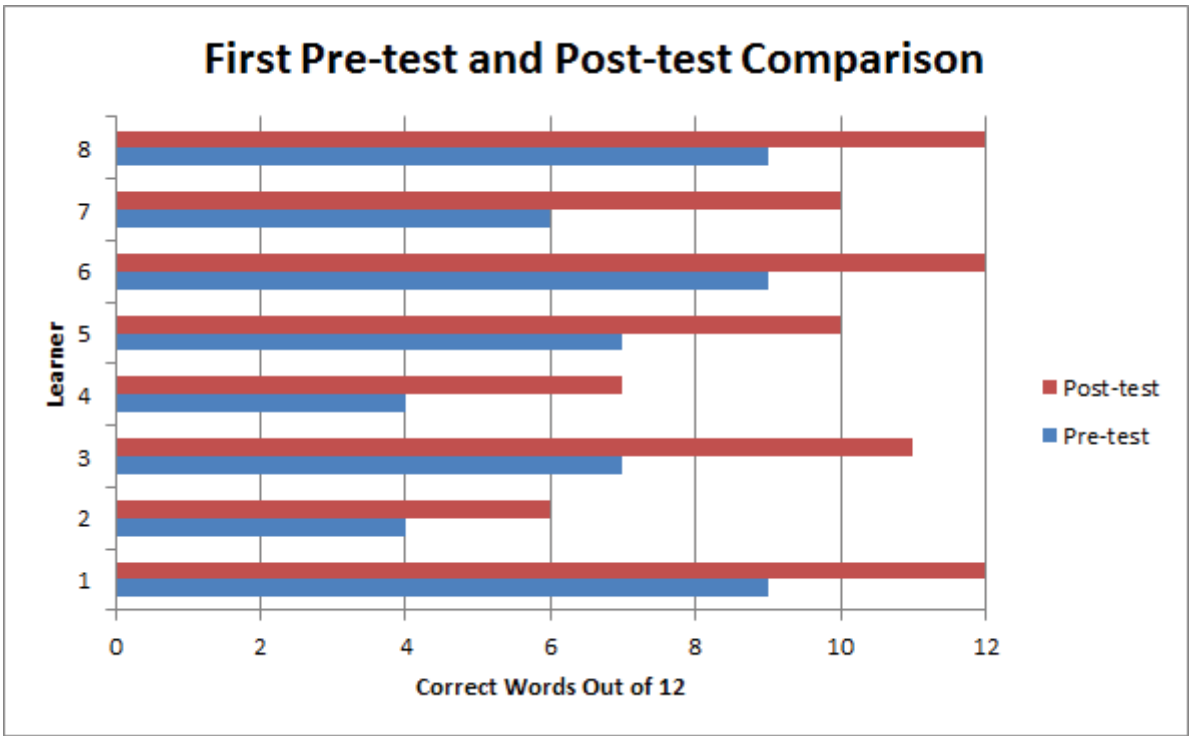

Figure 18. Graph of first pre-test and post-test results

Table 8

Results of Second Quantitative Pre-test and Post-test

Pre-test	Post-test
0	4
0	7
0	10
2	10
2	7
2	8
2	7
0	5
0	4
0	5
0	4
0.7272727273	6.454545455

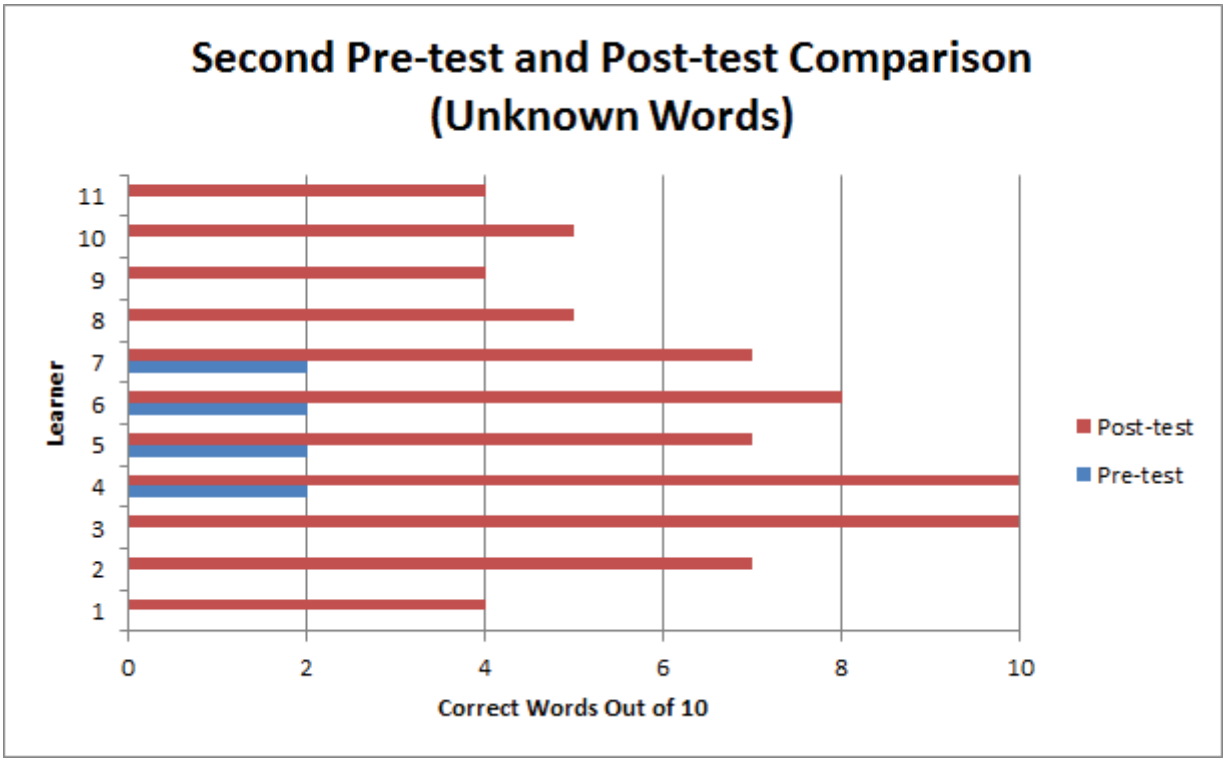

Figure 19. Graph of second pre-test and post-test results

Paired T-Test Calculation of **P** and **T**	
First pre-test and post-test	
T value	Two tailed **P** value
T is 12.0499	< 0.0001
Second pre-test and post-test	
T value	Two tailed **P** value
9.7583	< 0.00001

Figure 20. P and T values

The results of the two different tests showed some variation. This was because they involved different vocabulary and were tested during different iterations. The first test used a word set that students already partially knew; this is not a problem in itself as sometimes learning tools are used to reinforce vocabulary that is already known. The results showed an average improvement of 6.875/12 to 10/12. The second quantitative test tested a vocabulary set that was unknown to the students; there were still two words that some students knew or managed to guess in the pre-test. This test showed an average improvement from 0.72/10 to 6.45/10. The T values and P values of the results were calculated by putting the original paired pre-tests and post-tests into a paired t test calculator. The P value indicated that there was a low probability that the variations between pre-tests and post-tests were coincidental and that the learning session was likely to have affected the results. The T value indicated that there was a substantial difference between the pre-test and post-test scores in both testing sessions. The results are good overall considering a lot of the users were younger students who did not have a lot of existing strategies for memorising vocabulary. It can be hard to recall more than 7 items from memory at once so the 12 word and 10 word vocabulary sets for a 10 minute playing session were on the higher side. It is notable that there were no users that did not show improvement.

The results of testing showed clear improvement in vocabulary learnt. Over the iterations preceding the quantitative tests users had been observed to work until they achieved 3 stars on most or all of the levels; this is something that required users to connect vocabulary sets with no

errors. While users achieving 3 star ratings offers some insight into whether users are learning vocabulary it does not provide a quantifiable result like the pre-test and post-test does. The pre-test and post-test also tests whether users can remember the vocabulary outside of the application. Further pre-testing and post-testing could focus on testing longer term retention after longer playing periods. The 10 minute tests were chosen as the software developed within the iterative cycles did not have a large amount of content due to it being redesigned every week; every time game mechanics were redesigned all of the content and levels had to be redesigned to incorporate the new mechanics. The class who did the quantitative testing had also been using the software during other iterations so all new content had to be created for the tests; even when doing this the first quantitative test used vocabulary that was partially known to the students. This was not seen as a problem as it still measured how many new words were learnt. To quantitatively test more thoroughly it would be good to develop a greater depth of content in the future; this greater depth could not easily have been developed within the same amount of iterative cycles without reducing the amount of changes to game mechanics tested each week.

The quantitative testing offered valuable formative data of the tool in the last 2 iterative development cycles. While the artefact at this point was not a completed tool to be summatively assessed, the quantitative testing did offer a valuable insight into the effectiveness of content that could be implemented at that level of development. Given that all users showed improvement in vocabulary learnt after 10 minutes of use, it would be foreseeable that longer usage sessions could produce good results on larger vocabulary sets and other language skills. Game mechanics designed to incentivise longer term usage patterns and revision of vocabulary learnt would foreseeably affect vocabulary acquisition and language learning.

4.7 Final Outcome of Development Cycles and Quantitative Testing

The classroom observations carried out during iterative development created valuable input into the iterative development of the tool and valuable understanding of the composite parts of the tool. There was bi-directional feedback involved as observations helped inform the design decisions which created the next iterations to be observed. The development cycles allowed a range of game

mechanics and learning activities to be developed within the tool. The range of structures and mechanics that have been mentioned were all based on effective game mechanics from modern, mobile games and developed within the current learning tool as a result of iterative development and observation/evaluation. The game world was observed to create the intended perception of virtual presence; it created a learning environment in which exploration and discovery could form part of the learning process which is important to the theory of constructivism. The process of iterative development meant that knowledge about how the novel combination of game world and mechanics in Māori language learning shaped the learning experience.

5. Discussion

5.1 The Effectiveness of the Learning Tool

The question of whether a Māori language learning tool can be developed within a simulated game world was answered reasonably effectively. Both classroom observations and quantitative testing showed that students were engaged and were learning new vocabulary. All students were able to learn the tasks with little or no instructions; mainly because controls and features of the software followed familiar formats from games they had played. Many students using the software did not have existing strategies for memorising vocabulary; the software was able to effectively scaffold the users experience so that they were required to learn vocabulary to progress. Importantly, the simulated game world created a feeling of virtual presence and an observable desire to explore and unlock new content that served as a motivating factor that would appear to be instrumental in engaging and motivating a range of learners. It was not quantified exactly how much of the observed engagement and motivation was a result of the actual simulated game world but it seems very likely it played significant role in increasing motivation and engagement because users verbally reported wanting to be able to find and explore a variety of new environments and expressed many ideas relating to actions the player character could carry out. The simulated game world also created a unique opportunity to have a sense of movement and location in learning tasks that would otherwise have been impossible. The research also begs the question of whether motivation and engagement are significant factors to be considered in learning tools and how they could be measured. Students seemed to be absolutely captivated by the game world even when it had few tasks. Once the learning tasks were implemented across multiple levels no student ever put the device down without finishing all of the available levels. The ability for young learners to pick up a tool and learn with it without lengthy instructions or coercion is invaluable; especially if, in the case of the scaffolded memorisation, it helps build strategies for future learning in other contexts. The way users were challenged was important as certain formats in some iterations frustrated some users while other formats seemed to engage all users simultaneously; this is mainly

a result of carefully using game mechanics to create the user experience of easy to learn hard to master which has long been a principle of game development.

5.2 Knowledge Generated from the Design Science Research Process

The focus primarily on knowledge generation from artefact creation rather than focusing on completing the artefact helped generate more understanding of how aspects of game mechanics in a virtual world could affect Māori language learning experiences. Key findings relate to the nature of the game mechanics that were developed over the 10 iterations. Repetition of vocabulary was found to be more affective across levels than within levels; users didn't like matching the same words more than once within a level; however, if words were repeated in a new level it they enjoyed being able to pass the level more easily because they knew the words from previous levels. In practicality this process gets learners to repeatedly revise vocabulary which is something that some users struggle to do without support and strategies. The knowledge generated about how to create a process in which users can have a positive perception of repeatedly revising vocabulary is an example of how knowledge can be generated in the Design Science Research Process. Different amounts of vocabulary repeated in different ways were tested over various iterations to observe the effect it had on learning experiences. If the focus had have been on completing a finished tool as it would have been if this was standard design project, it may not have been justifiable to spend as much time testing one feature instead of reaching development goals. If the project had aimed to create a much larger quantity of content there would have been no way to test the variety of the more fundamental game mechanics that were tested under the conceptual framework of knowledge generation and the Design Science Research Process. Other key areas of knowledge generation were game mechanics relating to the 3 star system, enemies and scaffolded practising of vocabulary.

5.3 Structured Language Learning Within Virtual Worlds

This project combined aspects of gamification; structured vocabulary and sentence learning tasks; and a 2D virtual world. The question of whether the virtual world offered any measurable benefit

to learning outcomes is difficult to answer for certain under the current project structure as the quantitative testing did not involve any control group that did not work within the virtual world. The qualitative observations showed that students enjoyed the virtual world and they were consistently observed wanting progress through the tasks to discover new levels and virtual spaces. The perception of progression and exploration through a virtual environment offers a unique way to structure learning experiences. Most importantly the virtual world allowed a perception of space that was key to teaching locative prepositions as they require learners to have a conceptual understanding of how the language refers to the relative location of objects. The teaching of adjectives is another area that is enhanced by the virtual world. In this project the key adjectives developed related to the colour of objects. Users had to make meaning from sentences describing the relative position of coloured objects and then recreate them in the virtual world; this is based on the way physical objects are used to construct understanding in The Silent Way method of language learning where learners interact with real world objects based on positions and adjectives. This was fully developed into the software but only trailed within one of the iterations due to the amount of time and content required to scaffold these more complex sentences. The virtual world provided a good way to structure activities relating to these language concepts that would be hard to do on paper or verbally. In this particular project, when the activity relating to locative prepositions and adjectives was run, learners who knew the basic vocabulary for colours and locative prepositions had to concentrate to make meaning from them in more complex sentences in order to complete the game tasks; learners were observed to carefully read the sentences which showed that the concept of requiring them to make meaning from a sentence in order to construct the corresponding actions in the virtual world could help in learning. The ability of the virtual world to automatically sense the relative location of objects with different properties provides a very practical way to automatically teach and test users understanding of these sentence structures and subsequently get them to improve their understanding of these concepts.

In terms of motivation and engagement, the virtual world was very effective. The first iteration in which very few aspects of gamification were implemented into the game world showed that the students were engaged simply by moving around the world. The virtual world is not a prerequisite for gamified learning. The addition of game mechanics like star systems, points and progressive ranks do not require a virtual world. The benefit of the virtual world over implementing game

mechanics into simpler text based activities is worth examining as a virtual world requires a lot of extra resources to create. As mentioned in the literature review, the expertise and resources required to create more complex games means that there are few complex games specifically created for formal education. While the benefits to engagement and motivation were observed there are several other considerations that should be made when considering the development of virtual worlds for learning. Ways to augmenting existing learning should be considered rather than simply ways to complete traditional activities within a virtual world; in the current project, the vocabulary matching is cognitively not much different to flash card based learning; the tasks involving riding objects to positions relative to other objects involved activities that would have been difficult to do without some virtual representation of the objects in space and were a step towards leveraging the affordances of modern game engines rather than simply placing what are essentially paper based activities within an app. As creating game engines from scratch is a lengthy process some of the best opportunities for creating learning experiences in virtual worlds can potentially be found in creating content for existing games or using well-resourced development kits. In this case a development kit and several plugins were used to aid development; efficient workflows for creating and implementing game assets such as animations and images also speed up the process.

While the simulated game world proved to be an effective context for structuring a purpose built gamified learning tool it is definitely an approach that requires a lot of extra time and resources. The aforementioned prevalence of studies involving virtual worlds to center around the use of pre-existing virtual worlds rather than creating worlds for the purpose of language learning indicates that there are practical reasons for the lack of purpose built virtual worlds but that there is also potential for further developments in purpose built virtual worlds.

5.4 Knowledge Creation through Artefact Development

It is important to review the effectiveness of creating the artefact with the current study. Developing the app within the scope of the project posed several challenges in terms of working with particular time and resourcing constraints. It was conclusively shown that a functional application with a reasonable amount of original content and assets can be created within a short

timeframe. Currently, there is not a substantial amount of indigenous language learning applications for mobile devices that are truly gamified or involve the use of a virtual game world; as there is a lack of existing tools to evaluate; this study indicates that it is at least possible to develop and evaluate a new tool within the scope of an academic project for the purpose of creating knowledge about this combination of features. The investigation and evaluation of different development kits and the subsequent development of an efficient pipeline for creating and integrating game assets was an essential part of this process. By using an efficient workflow between image and animation creation programs and plugins for the SDK, assets could be created and optimised by one person within short development iterations. More focus on reviewing and evaluating the effectiveness of existing applications could have been more beneficial to developing the field of mobile indigenous language learning if there was a critical mass of dynamic interactive applications that utilised features of popular mobile games. Given the vast majority of existing applications did not have the features proposed to be developed and evaluated within this project, the combination of development and evaluation allowed the investigation of a relatively new type of language learning tool. The major advantage was the ability to create a an original tool as a result of the research that was being undertaken rather than evaluating a range of pre-existing tools that have not necessarily been designed within a similar conceptual framework to the evaluation. The subsequent trade-off meant that there was less depth in the evaluation than a project that worked entirely with pre-existing tools; however, this is an entirely necessary trade-off when tools do not exist.

6. Conclusion

Through the Design Science Research Process this project has created a novel combination of existing features of modern games and learning tools. Through reviewing existing developments in industry and academic literature a proposal to develop the learning tool within a simulated game world was created in the initial phase of the research process.

The iterative design cycles in the development phase of the project were a practical way to create a new artefact for the purpose of knowledge creation which created the possibility to observe novel features and mechanics applied to a Māori language tool that had not previously been combined together or studied. Students were observed to be consistently engaged while using the software and commonly reported features they wished to see in the game world.

Game mechanics seemed to enhance the tool by allowing various levels of learners to find individual challenges within the structure of the game. Students who learned the vocabulary reasonably easily consistently aimed to perfect their knowledge of the vocabulary to gain three stars for the level while other users still found a sense of progression and returned later to try to improve star ratings.

The combination of a simulated game world and game based mechanics applied to indigenous language learning appears to be a good option for research. Because educational software is often made on limited budgets it means that recent video games and other interactive media developed with larger budgets will contain a wide range of features not yet trialled in educational software; this presents a continually evolving set of tools that can be tested and applied. In this project, the learning tool appeared to engage students in a similar way to more traditional games; specifically, they did not need to be taught how to use the tool or have the task instructed to them. Users definitely seemed to have a sense of virtual presence in the game which created a perception of space that is potentially instrumental in teaching locative prepositions and other concepts involve space and interaction.

6.1 Limitations Further Research

There are some clear limitations to this research. The focus on continually developing and testing new features rather than creating a finished software tool with less features meant that a summative evaluation of the tool was not possible. Testing was only carried out on short user sessions rather than longer term usage patterns. This meant that retention of learnt vocabulary was not tested and also that game mechanics that develop over a longer time frame were also not tested. The software was tested on a small group of students over different iterations of development and testing with observations of their usage contributing to the features developed in the next iteration; this had advantages but also meant that there was no deeper analysis of a single tool.

Further research could focus on progressing towards a finished tool in order to analyse longer term usage patterns and a more summative and quantitative evaluation of the effectiveness of the tool. Game mechanics relating to longer term usage were developed but not tested due to the impracticality of adding enough content to allow for longer term usage within the timeframe of the iterative cycles in the Design Science Research Process. During the iterative development phase, fundamental parts of the structure of the game were being tested and redesigned on a weekly basis; this meant that the whole level progression had to be rebuilt in order to incorporate new structural features to test in the next week. This was considered a strength of the research as many of these fundamental structural features like the user interface, interaction with objects, enemies, the introductory splash screen and other game mechanics were the key area of knowledge generation so they could not be studied without redesigning them regularly. In further research, if the more fundamental structures are no longer the focus, more attention can be given to investigating vocabulary retention and how longer term game mechanics like rank and currency systems affect user engagement.

Another clear area for further research is further investigating how locative prepositions can be taught with the software and further developing the conceptual framework from The Silent Way method. While locative prepositions were tested in one iteration it became obvious that they would have to be scaffolded over many levels and would require more time to learn than was typically available in classroom testing sessions. Additionally, scaffolding tasks that used more complex

sentences with locative prepositions, would have required a progression across many levels and creating these extra levels within the iterative development phase would have made it a lot more difficult to iteratively redesign the structure of other mechanics on a weekly basis. Teaching more complex sentences is important and something that not all language learning apps do so it is a clear area for further research; it also provides a clear structure for the progression of learning tasks from focusing on just nouns, just locative preposition, just adjectives and on to increasingly complex sentences that combine them all. A clear avenue for research would be investigating whether users improve their ability to solve these types of tasks improve their ability to construct spoken or written sentences of a similar structure. In a broader context, the connection between progression in game based learning tasks and spoken or written language skills outside of the application would be a valuable area to study.

6.2 Future Opportunities for Thorough Quantitative Evaluation

While the quantitative testing of the software during the design research was limited clear opportunities for more thorough quantitative testing were identified for future development in the software. Data logging of a more finished product would provide a more efficient way of collecting quantitative data. As the focus of the masters was more on how to balance game mechanics and features of the game world to create an effective learning tool more focus was put in this area than actually quantitatively comparing the learning tool to other methods of learning. As mobile devices are used in a wide variety of contexts there is no longer as much relevance in comparing a mobile application to a human tutor as they will often be used in different ways, times and places. When the learning tool is completed - beyond the scope of this Masters project - data logging usage patterns will be a useful way to evaluate the effectiveness of the tool and create more summative knowledge about the artefact. A variety of measures could be used to infer the effectiveness of various features related to various outcomes. As mentioned in earlier sections, several studies that have measured the effectiveness of CALL software have used pre-tests and post-tests to evaluate to ability of the software to teach language concepts and vocabulary (Howland et al, 2012), (Vlugter, 2009); similar pre-tests and post-tests could be presented and logged within the structure of the game. The post-completion splash screen on levels already relays and logs information about

how many correct and incorrect word matches the user has made; completing a level without any incorrect matches is a way to measure the learning of vocabulary lists. Additionally, mini-games upon the entry or exit of levels could test vocabulary acquisition in a more formal way; a written test could essentially be presented within a splash screen. While these options would offer ways to collect data relating to the effectiveness of vocabulary learning there would be questions remaining as to how that data would relate to the users ability to use vocabulary outside of the game; however, it is important to note that many existing studies use one off paper or verbal tests to measure the effectiveness of software which is not very different in nature to tests that could be given and logged within the software. In both cases the relevance of test results to wider learning outcomes has to be carefully reviewed in relation to the validity of findings and test conditions.

There would be two distinct models for data logging; both very different in relation to ethics and implementation. Data could be logged locally on test devices in structured testing sessions or anonymous data could be logged and uploaded as public users used the software. In the case of unstructured testing by end users, larger sets of data on wider usage patterns could be collected and hopefully there could be useful information relating to how users perform on particular tasks over time. There would be no way to infer the conditions under which users were completing the tasks; although, a large amount of data relating to the time taken to complete tasks could be taken. In the case of controlled testing where data is logged locally onto devices, test devices could be given out to students or users under controlled conditions and the only thing that would distinguish it from a trial that involved a paper or verbal based pre-test and post-test would be the fact that the knowledge of target vocabulary before and after the tasks were completed would be measured within the device. While there are potential problems relating to experimental conditions and validity raised by internally pre-testing and post-testing software, it also has many potential benefits in that it would be a less obtrusive method of testing. Additionally individual usage patterns that are logged could be compared with results to see if there are any common usage patterns related to low or high performance.

6.3 General Further Research in the Field

More generally, there is a lot of room to develop the combination game worlds and mechanics in indigenous language learning. In relation to further research not directly related to this project, there is also room for more creation of dynamic tools in academia. The Design Research Process allowed for the study of the novel combination of features in this project; the alternative approach of evaluating tools that are developed within a more traditional development environment is very restrictive; it creates a self-fulfilling prophecy in that you cannot measure the potential effectiveness of interactive media in language learning while the most effective implementation has not been developed. The fact that there is an aspect of craft in software development is often ignored in the premature scepticism directed at the potential effectiveness of game based learning and gamification of learning. You cannot quantitatively measure effect without qualitatively crafting effectiveness. There is somewhat of a dichotomy at present in the literature between creative and evaluative investigations in mobile language learning; while both are important they are evolving in the context of a field in its infancy. Modern mobile devices have only existed since the creation of the iPod touch in 2007; interactive media is still evolving very quickly. Gamification, a concept that can potentially be effectively implemented into learning tools, has only been widely used in academic literature since 2012 (Hamari et al 2014). The majority of early mobile language learning applications are largely reference tools or basic vocabulary matching activities that incorporate few unique features of more dynamic interactive, mobile media. Existing evaluative research on these early applications that still involve traditional software features is promising for the benefits of mobile learning consistently reporting mobility, 'handheldability' and the anytime anyplace aspect of mobile learning as benefits. A future focus on evaluating the wide range of new features and mechanics available in well-resourced commercial software and implementing them into learning tools would eventually create something substantial to measure the effect of.

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Appendix A – Data Table of Indigenous Language Apps

Name of app	Type of activity	Gamified	Game world
Arikara	vocab activities and reference	no	no
Chemehuevi	multimedia reference material	no	no
Chickasaw	multimedia reference material	no	no
Cree	vocab activities and reference	no	no
Dakota	vocab activities and reference	no	no
Diné Bizaad	multimedia reference material	no	no
Diné, Lakota, Mvskoke and Ponca	multimedia reference material	no	no
Ehattesaht	multimedia reference material	no	no
FirstVoices Chat	Texting app; unique characters	no	no
Halq’emeylem	multimedia reference material	no	no
Hlgaagilda Xaayda Kil	multimedia reference material	no	no
Ho-Chunk (Hoocąk)	vocab activities and reference	no	no
Iwaidja	multimedia reference material	no	no
Ktunaxa	multimedia reference material	no	no
Kwak’wala	multimedia reference material	no	no
Lakota	vocab activities and reference	no	no
Myaamia	multimedia reference material	no	no
Nakota	vocab activities and reference	no	no
Nazko-Dakelh	multimedia reference material	no	no
Nisga’a	multimedia reference material	no	no
Northern Stʔátʔimcets	multimedia reference material	no	no
Omaha	vocab activities and reference	no	no
Saulteaux	vocab activities and reference	no	no
Secwépemc	multimedia reference material	no	no
SENĆOŦEN	multimedia reference material	no	no
Sliammon	multimedia reference material	no	no
Tłı̨chǫ Yatıì	multimedia reference material	no	no
Xeni Gwet’in	multimedia reference material	no	no
Yugambeh	multimedia reference material	no	no
Māori Dictionary Project	multimedia reference material	no	no
Nyoongar culture	multimedia reference material	no	no

My Cree App	vocab activities and reference	no	no
Te Pūmanawa	vocab activities and reference	no	no
Kūra	substantial gamification	yes	no
Hika	vocab activities and reference	no	no
uTalk Māori	matching vocab and reference	no	no
Puna	substantial gamification	yes	no
Ma! Iwaidja	multimedia reference material	no	no
Paakantyi	multimedia reference material	no	no
Talk Mohawk	multimedia reference material	no	no
Navajo Toddler	matching vocab and reference	no	no
Speak Navajo	multimedia reference material	no	no
Hawai'an Words	multimedia reference material	no	no
Touch Hawai'an pocket dictionary	multimedia reference material	no	no
Trivia in Hawai	multimedia reference material	no	no
Olelo Hawai'i Dictionary -	multimedia reference material	no	no
Hawaiian Alphabet	multimedia reference material	no	no
uTalk Hawaiian	vocab activities and reference	no	no
Ke Ao Hula	multimedia reference material	no	no
Speak Hawaiian Phrases	multimedia reference material	no	no
Aloha Animals	vocab activities and reference	no	no
Hawaiian Word of the Day Lite	multimedia reference material	no	no
Hawaii for Kids - Oahu	vocab activities and reference	no	no

APPENDIX B – Low Risk Ethics Notification

(All notifications are to be typed)
(Do not modify the content or formatting of this document in any way)

Massey University
Te Kunenga ki Pūrehuroa

NOTIFICATION OF LOW RISK RESEARCH/EVALUATION
INVOLVING HUMAN PARTICIPANTS

Staff researchers and supervisors are fully responsible for ensuring that the information in this form meets the requirements and guidelines for submission of a Low Risk Notification

SECTION A:

1.	**Project Title**	Software Tools for Maori Language Learning			
	Projected start date for data collection	01/07/2014	**Projected end date**	01/02/2015	
	(Low risk notifications must not be submitted if recruitment and/or data collection has already begun.)				
2.	**Applicant Details** *(Select one box only and complete details)*				
	ACADEMIC STAFF NOTIFICATION				
	Full Name of Staff Applicant/s				
	School/Department/Institute				
	Region *(mark one only)*	**Albany**		**Palmerston North**	**Wellington**
	Telephone		**Email Address**		

STUDENT NOTIFICATION			
Full Name of Student Applicant	Tyne Vaughan Harvey Crow		
Postal Address	246 West Coast Road		
Telephone	09 4067545	**Email Address**	tyne141@yahoo.com
Employer	Taipa Area School		
Full Name of Supervisor(s)	Dr. David Parsons		
School/Department/Institute	School of Engineering & Advanced Technology		
Region *(mark one only)*	**Albany** *	**Palmerston North**	**Wellington**
Telephone	x43135	**Email Address**	D.P.Parsons@massey.ac.nz

GENERAL STAFF NOTIFICATION			
Full Name of Applicant			
Section			
Region *(mark one only)*	**Albany**	**Palmerston North**	**Wellington**
Telephone		**Email Address**	
Full Name of Line Manager			
Section			
Telephone		**Email Address**	

3	Type of Project *(provide detail as appropriate)*				
Staff Research/Evaluation:		**Student Research:**			**If other, please specify:**
Academic Staff		**Name of Qualification**		**MInfSc**	
General Staff		**Credit Value of Research**		**120**	
Evaluation		**(e.g. 30, 60, 90, 120, 240, 360)**			

4.	**Describe the process that has been used to discuss and analyse the ethical issues present in this project.** *(Please refer to the v website)*

Ethical issues relating to the study were discussed with the supervisor, with reference to the screening questionnaire. Issues of anonymity and parental consent for under 16s were specifically addressed in the research design.

Potential ethical issues identified were:

- The time commitment from teachers participating
- The interruption of learning programs
- The time commitment from students
- Students receiving different lesson content and potentially being more or less advantaged
- Information gathered during research that could be used as grades in the course as well
- Protecting the anonymity of participants
- Participants under the age of 16

Solutions chosen to minimise the risk of these ethical issues were:

- Teachers will participate as volunteers and every effort will be made to interview them outside of times that interfere with lesson preparation and running
- Where possible collection methods like online surveys will be used that allow participants to respond at a time that is convenient to them
- Student participants will be involved only for short activities
- When testing the language learning aspects of the software it will relate to activities that are part of students' learning programs
- Any testing of the effectiveness of the software will involve short activities that do not last longer than a single lesson so as not to risk any disruption of the overall learning program
- All data will be kept anonymously and results of any tests will not relate to course grades
- In class testing of software tools will not be done close to classroom assessments so participation is unlikely to affect results in course assessments and students do not feel like their involvement has interfered with lessons
- The software involves activities that are already in the teaching and learning programs so most of their participation with the software should add to the learning programs
- All data gathering activities will be aimed at assessing the software artefact being evaluated, not at assessing the participants themselves.

5.	**Summary of Project** **Please outline the following (in no more than 200 words):** **1. The purpose of the research, and** The purpose of the research is to develop and test software tools for Maori language learning. **2. The methods you will use.** The project will involve the co-design and testing of the software with design partners. The software will relate to simple interactive language learning activities. The main activity within the software will be placing objects with different colours and properties in certain locations; this follows the teaching of nouns, adjectives and prepositions and is similar to traditional paper based and spoken activities within teaching. Students and teachers will participate at several steps of the co-design process so that the software adapts to meet their teaching and learning needs at different steps of the iterative development cycle. Research methods involved in co-designing with other teachers will be: • Interviewing – basic interviews asking what software tools are currently used and what tools staff would like to use • Surveys – a basic online survey or paper survey (depending on location of participant) asking about teacher's experience using mobile applications in learning and what applications could be useful. • Co-operative prototyping – allowing teachers to use working prototypes of the software and collecting feedback on good points and possible improvements. • Pre-testing and post-testing software – a target group of students will participate in a lesson run by their normal class room teacher which will involve a pre-test before using the software and a post-test after using it. Research methods involved in co-designing with students will be: • Co-operative prototyping – allowing students to use working prototypes of the software and collect their feedback. • Surveys – a basic survey collecting information on how students currently use mobile devices for learning and how they would like to in the future. Survey responses will be kept anonymously. • Pre-testing and post-testing software – a target group of students will participate in a lesson run by their normal Maori language teacher which will involve a pre-test before using the software and a post-test after using it. This will be limited to normal lesson time and the software will be teaching a skill that is already present in their learning program. All results from the pre and post-tests will be kept anonymously and will not be kept as grades relating to their course. Parental consent will be obtained for any students under 16.
	(Note: ALL the information provided in the notification is potentially available if a request is made under the Official Information Act. In the event that a request is made, the University, in the first instance, would endeavour to satisfy that request by providing this summary. Please ensure that the language used is comprehensible to all)

Please submit this Low Risk Notification (with the completed Screening Questionnaire) as follows:

1. For staff based at either the Palmerston North or Wellington campus; and students whose Chief Supervisor is based at either the Palmerston North or Wellington campus:

External Mailing Address
Ethics Administrator
Research Ethics Office
Massey University
Private Bag 11222
Palmerston North 4442

Internal Mailing Address
Ethics Administrator
Research Ethics Office
Courtyard Complex, PN221
Turitea
Palmerston North

2. For staff based at the Albany campus and students whose Chief Supervisor is based at the Albany campus:

External Mailing Address
Ethics Administrator
Research Ethics Office
Massey University
Private Bag 102904
North Shore City 0745

Internal Mailing Address
Ethics Administrator
Research Ethics Office
Room 1.29
Study Centre
Albany Campus

SECTION B: DECLARATION *(Complete appropriate box)*

ACADEMIC STAFF RESEARCH

Declaration for Academic Staff Applicant

I have read the Code of Ethical Conduct for Research, Teaching and Evaluations involving Human Participants. I understand my obligations and the rights of the participants. I agree to undertake the research as set out in the Code of Ethical Conduct for Research, Teaching and Evaluations involving Human Participants. My Head of Department/School/Institute knows that I am undertaking this research. I confirm that this submission meets the requirements set out in the Guidelines for Low Risk Notifications and that the information contained in this notification is to the very best of my knowledge accurate and not misleading.

Staff Applicant's Signature		Date:	

STUDENT RESEARCH

Declaration for Student Applicant

I have read the Code of Ethical Conduct for Research, Teaching and Evaluations involving Human Participants and discussed the ethical analysis with my Supervisor. I understand my obligations and the rights of the participants. I agree to undertake the research as set out in the Code of Ethical Conduct for Research, Teaching and Evaluations involving Human Participants. I confirm that this submission meets the requirements set out in the Guidelines for Low Risk Notifications and that the information contained in this notification is to the very best of my knowledge accurate and not misleading.

Student Applicant's Signature		Date:	12/05/2014

Declaration for Supervisor

I have assisted the student in the ethical analysis of this project. As supervisor of this research I will ensure that the research is carried out according to the Code of Ethical Conduct for Research, Teaching and Evaluations involving Human Participants. I confirm that this submission meets the requirements set out in the Guidelines for Low Risk Notifications.

Supervisor's Signature		Date:	
Print Name			

GENERAL STAFF RESEARCH/EVALUATIONS

Declaration for General Staff Applicant

I have read the Code of Ethical Conduct for Research, Teaching and Evaluations involving Human Participants and discussed the ethical analysis with my Supervisor. I understand my obligations and the rights of the participants. I agree to undertake the research as set out in the Code of Ethical Conduct for Research, Teaching and Evaluations involving Human Participants. I confirm that this submission meets the requirements set out in the Guidelines for Low Risk Notifications and that the information contained in this notification is to the very best of my knowledge accurate and not misleading.

General Staff Applicant's Signature		Date:	

Declaration for Line Manager

I declare that to the best of my knowledge, this notification complies with the Code of Ethical Conduct for Research, Teaching and Evaluations involving Human Participants and that I have approved its content and agreed that it can be submitted.

Line Manager's Signature		Date:	
Print Name			