

Using Culturally Relevant Game-based Education Strategy

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STRUCTURED ABSTRACT

CONTEXT

Computer science education is increasingly becoming a compulsory part of schooling. In the United Kingdom, the government has recently changed Information and communication technology (ICT) education to computer science and New Zealand has recently decided to include computer science in the curriculum in schools from 2018. Therefore, students will be exposed to computer programming and its concepts at an earlier age than they have previously. This change naturally presents new challenges. Within the NZ context, there is the unique challenge of providing relevant teaching material and learning experiences for children with a Māori and Pasifika background. It is the perception that there is a lack of Māori/Pasifika material in this area and that eLearning tools (ranging from full courses to individual tools) based on Maori/Pasifika cultural concepts could be created to support and engage this demographic better. Also, the New Zealand government aims to increase the number of Māori and Pasifika students to engage with computer science engineering as a future career. Currently, Māori and Pasifika students are an underrepresented group in computer science engineering in universities across New Zealand. In order to encourage and increase their active participation, there is an opportunity to develop teaching and learning material that considers their cultural backgrounds.

PURPOSE

The purpose of this research is to assess the use of culturally relevant digital tools, games in order to introduce computer science education to school students. The research investigates how games can utilize to empower and encourage pupils to learn computer science concepts and native language (Te Reo Māori) at schools within a Māori cultural context. The goal of this research is to motivate and establish a culturally relevant learning climate in which school children from underrepresented populations are intrinsically encouraged to engage in a discipline where they historically are underrepresented.

APPROACH

We aim to utilize the learner's cultural referents as a medium to develop the e-Learning tools to ensure school children gain access to study coding while maintaining their cultural integrity.

RESULTS

The digital game's underlying "programming language" has been developed in collaboration between computer scientists and the Te Reo speaking academics. It can be used to introduce simple programming constructs like sequence, variable, conditional statements, constructs and loops. We set to test the game Te Reo speaking schools in Wellington. Based on the tests results the game will be developed further for adoption in schools.

CONCLUSIONS

An educational digital game is developed to expose and teach simple programming constructs to children from a Māori background using Te Reo commands and a backstory about Kupe and his hunt for the giant octopus Wheke. It has been co-designed and validated in collaboration with a Māori academic. This process has indicated that the proposed idea is expected to target the children well.

WORDS

Computer science education, Cultural relevance, Interactive learning environments, Programming, Gamification in education.

Introduction

Computer science education is increasingly becoming a compulsory part of schooling. For example, in the United Kingdom, the government has recently changed ICT education to computer science, and New Zealand (NZ) has decided to include computer science (CS) in the curriculum from 2018 (Sentance, 2013). Therefore, students will be exposed to computer programming and its concepts at an earlier age than they have previously. This change naturally presents new challenges. For example, within the NZ context, there is the unique challenge of providing relevant teaching material and learning experiences for children with a Maori and Pasifika background. The New Zealand government aims to increase the number of Maori and Pasifika students to engage with computer science engineering as a future career (MinistryofEducation, 2017), (MicrosoftNZNewsCentre, 2016). Currently, Maori and Pasifika students are an underrepresented group in computer science engineering in universities across New Zealand. In order to encourage and increase their active participation, there is an opportunity to develop teaching and learning material that considers their cultural backgrounds. Therefore, instead of teaching computer science from a traditional (i.e. western) viewpoint, you could consider the learner's values and perspectives to develop modern interactive learning approaches and experiences based on their own cultural setting. The purpose would be to engage students with computer science concepts in a way that is culturally relevant. The aim is to integrate the teaching and learning with cultural concepts to enable learning.

The motivation behind the approach is not only that it might minimize or possibly avoid the problems that specific ethical backgrounds might have, but that it might give opportunities to do it better, potentially also for other students by providing a new focal point for computer science concepts. The use of computer and smart phone games (from now on referred as "games") in computer science education is not a new concept. They have been used to improve learning processes for the students and make them engage in computer sciences (Clark, 2016), (Papastergiou, 2009). This paper will present a literature review of the motivation behind using games in computer science education in culturally diverse settings. A game design-based method to teach key computer science concepts through using everyday commands in te reo Maori (the language of the Maori people) using a Maori story to develop the learning paths is discussed. Also, this paper presents the validation of the research by consulting various subject experts. The interview help validates the approach that is taken and the design, thus providing further ideas and opportunities to expand the research scope.

Review of Literature

Computer science and engineering as a discipline constantly face challenges in recruiting students who have been traditionally underrepresented, in New Zealand particularly young Maori and Pasifika students (Ebner, 2007), (Mohaghegh, 2016). Culturally relevant education is a responsive approach to these students that bring culture and diversity to the learning experiences, and it ought to be part of good teaching (Ladson-Billings, 1995). Unfortunately, often this does not happen, and indigenous children develop a dualistic approach to their learning. They separate what they know from home from what they learn. They can be good at school, but what they learn is separated from the knowledge that has been passed to them through their upbringing (Lee, 1992). Culturally contextualizing the content, the critical learning process leads to a situation where the learner creates their own plans of action in which they will lead some change or transformation in their learning process (Gay, 2013). This emphasizes that educators ought to teach the concepts of computer sciences through their students' cultural beliefs rather than to them from their own cultural background (Prieto, 2016). The topics of interests generated in the context of the students' cultural and language backgrounds, living experiences and verbalized concerns should be identified and material and learning exercises should be developed in that context (Ladson-Billings, 1995). This culturally relevant approach is more likely to encourage students to generate further inquiries on the subject that are being taught and develop an understanding within their own world-view (National Science Foundation, 1996), which could perpetuate some of the students to empower and encourage others in their group to learn the concepts. Designing education in this way can increase the success among traditionally underrepresented students and has helped the design of effective computer sciences courses around the world. Often learning computer programming is perceived by many students to be hard to understand and learn (Yadin, 2011). This concurs with numerous surveys that have been performed in several educational institutes (Thompson, 2013). It is still not clear why some students understand and learn to program easily whereas others do not (Zaharija, 2013). According to Piaget's theory of cognition, children develop logical, abstract thinking and problem-solving dexterities through their school level education (Wadsworth, 1996). Learning to program in a programming language requires

that the child has developed hypothetical and abstract thinking (Kirriemuir, 2004). Evidence suggests that children lacking hypothetical and abstract thinking can only solve problems associated with real-life experiences or something they relate with (Meluso, 2012), whereas in the case of programming a high level of abstraction is required and thus introducing students directly to pure programming might become a stop block for further interest into the field (Ebner, 2007). Introducing computer sciences programming concepts to school going children can have benefits of developing cognitive skills (Bell, 2009), however without having a cultural relevance the populations might not engage with it. The lack of experiences, that could help school students see the relevance of learning or applying computer programming to their interests and aspirations, contributes to alienation and, potentially, a decreased likelihood of engaging with and persisting in computer sciences learning related endeavours (Joseph, 2017), (Yuen, 2016).

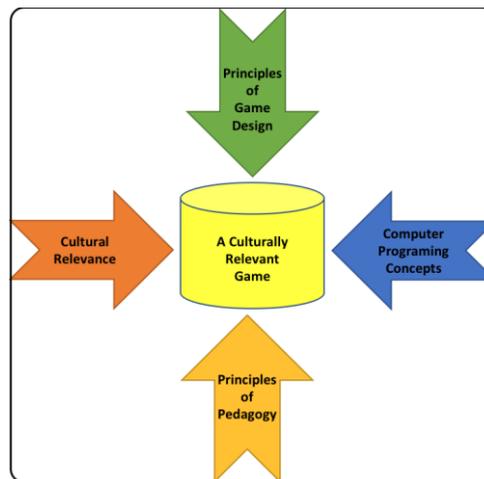


Figure 1: Captions for figures are displayed below the graphic

As shown in Figure 1, the games that are designed to teach the concepts of programming using culturally relevant issues and stories could be used to engage with the students (Aronson, 2016). Due to the extensive availability of the smart mobile technology devices, many educators are working on methods to improve students' learning in many disciplines (Maurial, 2002). Because of associated cost and reach with student's smart mobile technology has transformed into the next stage of the computer revolution.

Method

The goal of the research is to create an educational game that teaches programming concepts using te reo Maori commands as a simple programming language within the game. The design of the game has been validated through discussions and interviews with a Maori academic educationalist with a research interest in computer education.

Game Idea

"*Te Kaihoopara*" (the explorer) is a game based around a Maori mythological character called "*Kupe*". According to the narrative, Kupe was the first Polynesian who discovered the islands of New Zealand. He had problems with a great octopus – "*Te Wheke-a-Muturangi*" belonging to Kupe's competitor - "*Muturangi*". As Kupe set out on a quest to kill the octopus the length of the pursuit brings him to New Zealand. The game is designed so that students can relate to the Maori culture and learn CS concepts using the Maori language. The main character in the game, Kupe, can be programmed by the students to navigate through the game scene to achieve certain goals as shown in Figure 2.



Figure 2: Screenshot of the Mobile Game

By programming the character - Kupe, the player learns basic CS concepts such as variables, conditionals, loops, among others. To program the character, the player presses on Kupe and this brings up an overlay where the player can give several commands. When finishing giving commands to Kupe, he will then start to move according to the commands given. The player can then see how the commands give control to Kupe and he might, or might not, go to Wheke.

The commands are based on everyday te reo as shown in Figure 3. These have been designed by an English-speaking computer science academic who is studying te reo as a hobby and been verified and further developed by a te reo speaking Maori academic.

```
Huri [maui , matau]
kāti
haere
ko te ūnga [empty == tuatahi, tuarua, tuatoru,...]
ka tūpeke [tahi, rua,...,iwa] ki te ūnga, [tua...]
[raki, tonga, rāwhiti, uru] te [pangoro tahanga, marae, "kupe"]
```

Figure 3: Commands Based on Everyday Maori Language Te Reo Maori

The simplest construct in the language is movement. For instance, *Haere* is the word used for the command for moving a step forward. *Huri* will be used to turn Kupe, the direction depends on the next command, *matau* (right) or *maui* (left). These are the first commands, and simplest, and several of these can be made after each other to make many moves in sequence. The next learning step is to introduce the concept of a conditional, i.e. if there is something in the way, e.g. a *rakau* (tree), then do something. This is achieved using the command *mena* (if, therefore). So, for instance, *mena he rakau ki mua ka huri matau* will instruct Kupe that if there is a tree in front of him then turn right.

Loops are achieved by introducing a “stop” in the commands, in te reo called *tunga* that can be used to repeat following code. (If more are needed in the commands a number can be given to the stop.) For instance:

- ⇒ **tunga tuatahi** (first stop)
- ⇒ **haere** (go forward)
- ⇒ **mena he ara ki mua ka hoki ki te tunga tuatahi** (if there is a path in front jump to first stop)

With this code Kupe will start moving forward. After taking the first step he will check if there is a path in front of him (*mena he ara ki mua*), and if this is the case then the execution of commands will jump to the “first stop” (*ka hoki ki te tunga tuatahi*). In this way Kupe will continue going forward while there is a path in front of him.

Software & Language

A huge number of different software platforms are available for developing software game applications running on current mobile devices. These include Corona SDK, Unity, Construct2, Unreal Engine, Stencyl among others. Stencyl was chosen because it is widely adopted in basic 2D mobile game development and because of its intuitive drag-and-drop design (shown below in Figure 4).

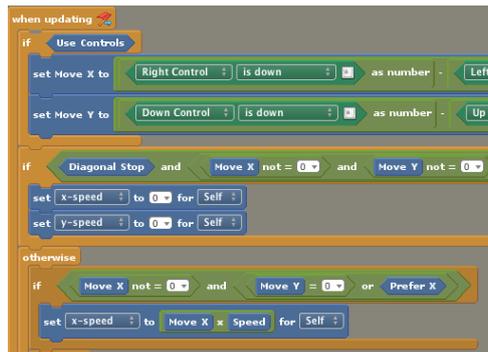


Figure 4: Stencyl Drag-and-Drop Programming

Stencyl provides a flexible environment for developing mobile games and it is written in the programming language Haxe. This has been chosen because it allows fast multi-platform development of games.

Validation of the Research through Interviews

Interviews were conducted with a Maori educational academic who has experience researching the use of eLearning in education for Maori children. This series of interviews provided a mutual understanding of the game idea and focus on the cultural appropriateness of the game within teaching and learning of Maori school children. It also identified the reasoning processes that are needed for developing an educational tool (i.e., the game) and the required knowledge sources that might be useful for the students to complete the given tasks. As part of the research it was identified that by conducting small-scale, qualitative interviews with subject experts would give us an insight and also validate the whole process. Refer to Table 1 with an extract of the interview questions along with the responses. Through the interview the team was encouraged to pursue the development, and that it is an interesting research area to investigate the use of culturally relevant games in the Maori context.

Table 1: Interview Question & Answers

Question	Responses
<i>Are there any factors that limit schools to teach CS with the gamifying approach in Maori medium?</i>	The teachers are eager to embrace this concept of teaching CS but the resources they have are only in English language and very limited software tools based on Te Reo Maori. This creates a disconnecting between the students who already struggle to understand the CS concepts. Also, there are no CS teaching tools which are based on Maori concepts.
<i>Is there any correlation between the decile scores (a measure of the socio-economic position of a school's student community relative to other schools) of the schools and the interest shown to teach/learn CS at schools?</i>	Most of the schools are eager to teach CS concepts and provide/procure CS tools/digital technologies (computers, tablets, software tools ect.,) to their students with partial funding from the government. However, the schools with lower decile scores at present have limited tools, resources like computers. But the students in these schools have a good access to mobile phones. So, using game applications which run on phones can be a great advantage to teach CS concepts in these schools. So, having a software education tool that is independent of the operating system and have cross-compatibility i.e., which can run on or developed on various operating system platforms would be a great advantage.
<i>Will coding in Te Reo Maori (language of Maori) encourage students to take up CS as a future career path?</i>	It is a research question by itself and there is a need for future research to understand this correlation. By collecting and analysing the user data from the proposed Te Reo Maori based tools would give a clear

	picture. From the holistic perspective, it is expected to encourage a student to take up software engineering as a carrier, as the learning process is close to the learner's culture and identity.
<i>Do you think by developing tools or games to teach CS concepts based on Maori tales, stories would retain the traditional, the culture and the identity?</i>	Definitely, it will encourage young Maori students to understand their culture and their identity (<i>pepeha</i>). It will also inspire and encourage the students to be more creative with the game development, learning CS concepts. The storyline of the game should be respectable to the traditional values and stories, this would be advantageous to students learning CS concepts to embrace, understand the cultural background.
<i>Learning CS concepts through mobile games environment would it cause too many distractions to the students?</i>	Clear rules and regulations must be placed down to avoid this.

Teaching Basic CS Concepts Using the Game

Encouraging and utilizing pupil's prior cultural knowledge and learning preferences (i.e. cultural learning styles) is a new way to learn computer programming. This approach could enhance pupil's motivation and acceptance to learn programming. Also integrating game-based approach would increase the student's acceptance levels and thereby encourages them to learn programming in their own intellectual style and preferences.

The Game as a Learning Environment

It is the expectation that the game will be playable without any additional material on a mobile device, as a standalone learning experience, or play it as a puzzle game. In a school setting with tangible learning outcomes of programming concepts, the game can be used to give pupils the first experience of how coding works. It is the expectation that in schools learning will involve pupils going through handouts that explain the topic, the required game goals, and the te reo commands with English translation for the students that are not te reo speakers (the game can then also be used to teach simple te reo commands to non-speakers of the language).

The pupils will be provided with the game (Figure 3) which they will play. The top left block on the screen contains the Maori control command buttons that are needed to navigate Kupe. The top right on the screen contains a block that stacks up against the commands when the user clicks on them. When the game application is opened a splash screen gets displayed and demonstrates how to code the game towards the solution for the topic (e.g., the needed actions and programming sequence). The introduction splash screen "walk-through" a sample of the required code development to accomplish the given goal and move to the next level in the game. While the commands are modified by the user, the command stack block on the top right of the screen changes instantly to display the new stack of commands. To avoid syntax errors in the commands only syntactically correct commands are available to the player, although that does not exclude the player from making mistakes semantically. Once the user clicks on the "Go" button the stack of commands are executed and the pupil can observe how "Kupe" is following the given commands, maybe going where they expected him to go or perhaps wandering off to unknown places.

The given task in the game will be completed, once the code is corrected semantically. The first game level begins with a simple navigation (e.g., left, right, up, down, etc.) commands, then the task at each level explains to the students how to create the code in order to learn a new CS programming concept. After the student has succeeded an introduction level and thereby learned a new programming structure harder levels are introduced where they use the same construct to solve harder problems. Once the construct has been learned a new construct is introduced and the above process repeats to teach this new concept.

The pupils will later be presented with examples of how the same programming concept is used in the programming language that they are going to learn. Therefore, the game will introduce a concept, they will experience what it does within the game, and then they will see how the same structures are achieved in the “real” programming language. In this way, they will first experience the concept, build the knowledge by seeing the effects of the commands, and thereby see the effect of the programming construct rather than have to understand it cognitively first.

Conclusions and Future Work

The paper has presented the design of an educational game to teach simple programming constructs to children from a Maori background using te reo commands and a backstory about Kupe and his hunt for the giant octopus *Wheke*. It has been co-designed and validated in collaboration with a Maori academic. This process has indicated that the basic idea is expected to target the children well.

The game's underlying “programming language” has been developed in collaboration between a computer scientist and the te reo speaking academic. It can be used to introduce simple programming constructs like sequences, variables, conditionals and loops. These can be put together to solve complex situations that Kupe might find myself in. The game is currently implemented as a prototype. The next step is to test it with te reo speaking children. Based on the tests results the game will be developed further for adoption in schools.

It is expected that more elaborate computer science concepts can be taught through the game by introducing more functionalities. For instance, functions can be introduced to allow common behaviours instead of repeating the same code each time it is needed. Game characters with behaviours can be introduced to create more difficult puzzles where more elaborate algorithms can be shown, such as search and sorting algorithms. Multi-character scenarios, where each character needs to receive commands to solve the puzzle, can be used to introduce issues of multi-threading and multi-agent collaboration. To make the game more playable and make the game experience last longer, it is expected that multi-player game levels can introduce collaborative and competitive gameplay between pupils. It would also be interesting to introduce user-generated puzzles, where pupils can challenge each other and learn new concepts from each other.

The game is at the beginning of its life cycle and it is expected to develop into a learning tool that can attract more Maori children to computer science or at the very least give them knowledge about what programming involves.

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