Play and Learn: Designing Educational Tools for Children

Kalpana Nand

Unitec Institute of Technology
School of Computing & Information Technology

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Pedagogy is a dynamic science and needs to constantly change with time. During the last decade, there has been a substantial jump in terms of communications technology, the ubiquity of electronic devices capable of running applications, and having access to information on the internet. The technological developments have been able to grip a major part of society, particularly in the form of entertainment. One technology that has gripped society, particularly children, is playing of Computer based games, simulating either a real life scenario or a completely fictional one. The success rate of computer games in engaging and motivating children has prompted educational researchers to see if similar techniques can be used to engage children into learning related tasks. This thesis is one such study.

In this thesis, we investigate what the appealing characteristics of effective computer games for children are, whether adding these appealing characteristics to an educational tool enhances children’s learning and whether children enjoy using the proposed educational tool with those characteristics embedded. Then we present the results of an experiment done on primary school children, in which a computer game was used as an educational tool to teach primary school curriculum areas of Numeracy and Te Reo. The study used computer gaming industry research works, in conjunction with primary school children’s perception of computer games, to identify the three most prominent features that make them popular. The identified features were feedback, challenge and graphics. These features
were then embedded in an open source game, Who Wants to be a Millionaire, based on a popular TV game, and modified to teach the two curriculum areas to 9 and 10 year old children in a primary school in Auckland, over a period of 4 weeks. The effectiveness of the educational tool was measured using a pre-test and a post-test, as well as other indicators such as the frequency and duration of time on playing the game.

The results showed that the features enriched game was more effective as an educational tool in both Numeracy and Te Reo curriculum areas, when compared to the version with minimal features, that is, feature devoid version. In the case of Numeracy, the increase in scores was twice as much as the feature devoid version and in the case of Te Reo it was five times as much. Similar results were also shown by other indicators such as time and frequency.

In summary, the results of this thesis establishes evidence on aspects. Firstly, it identifies the most appealing characteristics of computer games from primary school children’s point of view, as well as literature. Secondly, the results show that the identified features can be effectively used to develop educational tools, similar to computer games that can enhance children’ learning. Finally, the results prove that the feature enriched game was more popular with children and they were more inclined to play this version of the game in future compared to the feature devoid version.
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This thesis is dedicated to

Parma and Pranav

My inspiration and my strength.
Attestation of Authorship

I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person (except where explicitly defined in the acknowledgements), nor material which to a substantial extent has been submitted for the award of any other degree or diploma of a university or other institution of higher learning.

The thesis work was conducted from Jan 2012 to Nov 2012 under the supervision of Dr Nilufar Baghaei and Dr Aaron Chen at Unitec Institute of Technology.

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Chapter 1

Introduction

Teachers, parents and researchers, as well as the government, have been continually challenged with looking for better ways of educating children in a constantly changing environment. It is widely accepted that students’ success in learning is dependent on several factors such as the education level of parents, quality of teachers, availability of resources and techniques/tools used, amongst other factors. Out of these, learning techniques/tools such as educational computer games have been shown to have a significant impact on learning (Prensky, 2001). With recent technological advancements, children are spending increasing amounts of time playing games on computers or other specialist devices such as a Playstation. This has generally been seen in a negative light, as playing computer games promulgates prolonged sessions of physical inactivity and a large proportion of games are based on violent themes. Several studies (for example, Anderson and Dill, 2000; Walsh et al., 2004) have investigated the negative effects of computer games on children, as well as generally on society, and have confirmed their detrimental effects. However more recently, researchers (for example, Liu and Chu, 2010; McKenney and Voogt, 2010; Mitchell and Savill-Smith, 2004; Prensky, 2001) have looked at playing of computer games in a positive light. That is, if
the factors from computer games can be used to entice children into spending similarly extended periods of time on learning tasks, as they do on computer games. Computer games are a big industry today and a lot of resources in terms of money and research has gone into making it successful and ubiquitous, especially among children. The success of the game industry among children is now attracting the attention of educational researchers, in terms of whether aspects of gaming industry advancements can be used for learning purposes.

According to Prensky (2001) one of the prerequisites for successful learning is motivation. He notes that a lot of children struggle to get motivated for learning while the same children have exactly the opposite reaction towards playing video games. Yet both activities are similar in nature. Prensky (2001) argues that one way of getting children motivated towards learning is to deliver a curriculum using learning tools which integrate the motivation features borrowed from the computer gaming industry. This thesis describes the results of an experiment in which school curriculum was integrated into a computer game and tested on a group of students in a New Zealand primary school.

The overall aim of this research is to firstly investigate what the appealing characteristics of effective computer games are for children. Secondly, this research seeks to find out if adding these characteristics to an educational tool enhances children’s learning. The final aim of this research is to find out if children enjoy using the proposed educational tool with the appealing characteristics embedded. We firstly identified a number of appealing characteristics of computer games by examining the relevant literature and surveying a group of 120 school children aged between 9-10. We selected the most prominent features to design a computer game, integrating parts of mathematics and Maori curriculum for the same age group. The educational tool was then tested on the same group of children by splitting them into a control group using conventional means of teaching, and a test group using the educational tool. The results showed that the test group enjoyed using the educational tool and showed better learning outcomes.
The rest of the thesis is organized as follows. Chapter 2 presents a review of studies in the areas of computer game design as well as existing work that has used aspects of computer games for the purpose of learning. Chapter 3 discusses details of how the research was carried out, including the design and development of the computer game which was used as the educational tool. Chapter 4 presents the results of the experiment. Finally Chapter 5 describes some immediate and long term future work emanating from this thesis followed by concluding remarks.
Chapter 2

Related Works

Use of technology in enhancing students’ learning is a current topic among educational researchers today. Technology can be used in various ways, example:

- **Communication** - For example, emails, social networks and blogging sites can be used for faster and more effective communication between an educator and learner as well as among learners themselves.

- **Representation and Delivery** - Tools such as Powerpoint and Photoshop used for better representation of information by both educators and learners.

- **Information Access** - Quicker access to relevant information such as use of search engines and specialized databases.

- **Adaptive Educational Tools** - Software written specifically to teach something and personalizes its instructions based on learner’s abilities and knowledge.

The concept of using software (instead of a human) for the purpose of teaching is not novel. In fact, some of the first tools were designed more than 20 years ago (Eck).
2.1 Theory of Learning

Computer games are based on the constructivist learning theory, which is “characterized by discovery and experiential learning” (Rieber, 1992). The underlying assumption of constructivism is that learners are the creators of their own knowledge. In other words, learners actively construct their knowledge by attaching the latest information to their current knowledge base. Therefore, learning becomes an active process of integrating information with prior knowledge. In a constructivist learning environment, learning needs to be meaningful to effectively engage students. Furthermore, learners should also have the ability to look back at their own learning and be able to interact with other learners. The design of modern computer games implement most of the...
2.1 Theory of Learning

requisites of the constructivist learning theory. When playing computer games, participants are able to engage in activities through interaction and familiarity. A player is able to learn and understand the consequences of their activities while being engaged on “realistic” matters. The ability of a computer game to intimately engage participants makes it an extremely suitable tool which can be used for learning using the constructivist theory.

The second requisite of the constructivist theory which applies to computer games is collaboration. Collaborative learning is an important aspect of constructivist learning. Apart from being learner-centered, constructive learning is about constructing knowledge with others. According to Seitzinger (2006), learning is the result of groups of people working together in order to tackle problems and not in isolation, away from others. Computer games are similar, where participants play games by themselves as well as with and against others. They constantly engage and learn from others about tactics and strategies in order to win. This is again a requisite of the constructivist approach, except in this case, the objective is collaboration to learn rather than to win.

Further, researchers Ausubel et al. (1986), Papert (1998) and Provenzo (1991), have argued that when children play computer games, not only does learning become more meaningful, games are also able to create a learning environment that is more in tune with what children are interested in. They have pointed out that computer games must be interesting and relevant to students in order for the games to be successfully utilized.

A related but separate school of thought is that children, especially primary and early childhood children “learn through playing”. Note that playing here refers to any type of child play, which also includes non-computer related games. Researchers (for example, Csikszentmihalyi 1990, Provost 1990, Rogoff 1990), propagating this school of thought argue that game playing makes up a vital element of a child’s cognitive and social development. These studies assert that children learn more from playing and carrying out “hands-on” activities than by being simply asked to “recite” information from books. According to Vygotsky (1976), children learn by playing with others, creating and improving their zone of proximal development. He believes that this is
2.2 Using Games as Educational Tools

because when children play, they are more involved in carrying out complex activities than those that the child may come across in day to day activities. Bruner (1985)’s findings also support this idea. He says that children engage in playing by participating in the games. The games that children play vary widely, such as, board games, games involving teams, fantasy games, adventure games, challenge games, discovery type games or even on the spot made up games. However, the common thing in all games is that they have rules and procedures that the players need to know and follow. Playing games comes naturally to children and according to Choi and Hannafin (1995), Oliver and Herrington (1999), Rogoff (1990), games are said to be a good example whereby “situated” or “anchored” learning is able to be achieved when children take part in realistic tasks. This is further supported in a recent paper by Chen et al. (2011), in which they state that, “learning through doing in the form of games offers a powerful learning experience”.

2.2 Using Games as Educational Tools

There are a number of studies which have substantiated claims of children’s learning occurring by playing computer games. Fisch (2005) discusses various studies that have reported children learning about diverse subjects such as prehistory and asthma by playing computer games. A similar and more recent study that used computer games for the purpose of attaining medical knowledge is reported in Chen et al. (2011). In this study, subjects were made to play games integrated with diabetes knowledge and the results indicated that the users enjoyed playing the games and thought it could be a valuable asset in improving diabetes knowledge. Some other examples of educational and health-related games are reported in Consolvo et al. (2006), Fujiki et al. (2008) and Alankus et al. (2010).

Knezek (1997) and Kulik (1994) have reported strong evidence showing the positive effects of using computer games as instructional tools. Kulik (1994) used a research
method called meta-analysis to sum up findings from more than 500 individual research studies on computer based instruction. He found that on average, students who used computer based instruction, including games, scored at the 64th percentile on tests compared to those students who were in the control conditions and scored at the 50th percentile. 

Wenglinsky (1998) looked at the effects of simulations and learning games on 6227 fourth grade students and 7146 eighth grade students in the US. He found that those 8th grade students who had used simulations and applications in maths learning showed improvements in their math results of up to 15 weeks above the actual grade levels. Moreover, his findings revealed that higher order uses of computers and professional development of teachers in using the technology worked together to produce gains on student achievement levels in maths for both the 4th grade students as well as the 8th grade students. More evidence of effective learning using computer games is reported in McFarlane et al. (2002). Through their project, the researchers were, amongst other things, seeking to explore the notion of the computer game and to identify what particular types of games might contribute to the development of learning related skills or the knowledge of content. The games selected were primarily of the simulation or quest-based genres. In these studies children performed better in algebra when they played computer games aligned with the algebra curriculum. Moreover, from the project, the researchers concluded that quest and simulation games contributed to childrens learning and this learning was universal across the levels. According to the researchers, the nature of the learning that occurred from using the games could be divided into three types; learning that occurred due to doing the tasks in the games, knowledge that increased through the content of the game and skills improvement due to playing the game. Similarly Din and Caleo (2000) reports an improvement in spelling and decoding of grammar when taught by integration in computer games. Their study looked at whether kindergarten students who played Sony PlayStation (Lightspan) computer games learned better than students who did not play such games. For this study 47 African-American kindergarten students were selected from two classes of an urban school in the Northeast, US. The experimental group played the games for 40 minutes per day in school for 11 weeks. Findings from the
data analysis showed that the experimental group made considerable improvements in the spelling and decoding areas. In a study carried out by Squire et al. (2004), the researchers examined what learning occurs when an electromagnetism simulation game is used by students. In this study, the researchers created Supercharged! an electromagnetism simulation game. This study occurred in an urban/suburban middle school in the US and included a total of 96 students in five separate classes. Two classes served as a control group, which consisted of 35 students, and three classes played the game and were the experimental group, consisting of 61 students. Each group (control and experimental) was expected to learn the same content. The study revealed that the experimental group performed better than students in the control group on measures for understanding. Furthermore, the researchers found that the active nature of computer game play, the goal-based nature of the activity and the way that visual representations are used to solve problems may be useful in getting students to think about scientific representations. According to the researchers, simulation computer games can be effective tools in helping students understand complex topics.

Apart from these studies, which have tested computer games using part of a curricula, there are those which have tested computer games on specific student outcomes, irrespective of curricula. For example Keller (1992) reports that playing computer games helps in developing children’s thinking skills when carrying out generic problem solving activities. In her paper titled ‘Children and the Nintendo”, Keller (1992) discusses four reports which examined the effects of the Nintendo Entertainment System (NES). High school students who played Nintendo had higher results on critical thinking skills tests compared to students who did not play. Through the study, it was revealed that the children thought that NES assists them to think, and they were using the skills learnt in other areas of life. Fitzgerald (1990) and Jenkins (2002) did experiments to prove that learning using computer games also caters for different learning styles among children.

In a recent study conducted in New Zealand by Brand (2012), it was discovered that parents are progressively accepting of the notion that computer games have an important role as an educational tool. There was a recognition by parents and teachers that
games support the development of a wide range of skills which are essential for developing students to become independent learners. Commissioned by the Interactive Games & Entertainment Association (2012), this Digital New Zealand 2012 report found 79% of parents with children under the age of 18 play video games, and a further 90 per cent of this group do so together with their children (Brand, 2012, pg.13). This report shows an increase from 2010, when these figures were 63 per cent and 59 per cent, respectively (Brand, 2010, pg. 34-35). The report showed that generally parents are actively involved in the choice of games, especially for younger players. Furthermore, they found “92 per cent of parents believe video games are educational, with three-in-four actively using games as an educational tool with their children” (Brand, 2012, pg. 13). These findings show an increase from 2010, when 64 per cent of parents used video games as an education tool (Brand, 2010, pg. 35). The report showed that video games are increasingly embraced as teaching tools not only by parents but also by teachers at schools and tertiary environments. Teachers are becoming more accepting of using games in their classrooms and are using games in their lessons to generate active discussion amongst students. Moreover, another reason why some teachers favour games is because games have the capability to be used by students of different abilities in a classroom, since the level of challenge in games can be adapted for pupils of different ability levels. Thus the report has shown that parents and teaching communities have witnessed the potential for learning through their own participation. By doing this, they have come to recognize games as vehicles through which knowledge can be increased through the content of the game (depending on the type of game), and where skills are enhanced as a result of playing the game.

2.3 Computer Game Design Features

This section describes the various features that have been used in the design of computer games that have contributed to their prevalence and popularity. These features
2.3 Computer Game Design Features

include Flow, GamePlay, Feedback, Challenge and Narrative aspect, discussed below.

2.3.1 The Notion of “Flow” in Games

The notion of “Flow” was introduced firstly in the 1970s by Mihaly Csikszentmihalyi, who was a professor of psychology at the Calremont Graduate University in California [Chen (2007)]. Csikszentmihalyi came up with this concept in order to explain what “happiness” was. In Csikszentmihalyi’s earlier studies he mainly looked at people who were specialists in their occupations. These included artists, musician, athletes, chess masters and surgeons. What the research showed was that people, regardless of what age they were, what gender they represented or what culture or country they were from, all defined their best experiences in terms of Flow. Later in Csikszentmihalyi (1990), he defines Flow as that which embodies the feeling of contentment and pleasure one gets when one is fully animated and engrossed in an activity. When a person is in the state of Flow, one is said to lose sense of time and instead is fully immersed in the activity he or she is doing. Comparing this notion of Flow to games, Csikszentmihalyi (1990), proposed that those games which are able to facilitate this Flow effect are the most successful. Therefore, those games in which a player is in a state of Flow are games where players are able to be totally absorbed in the game, hence having utmost pleasure while playing the game.

Csikszentmihalyi states the following eight factors as requirements to generate Flow in a computer game.

- A challenging activity requiring skill
- Merging of action and awareness
- Clear goals
- Direct, immediate feedback
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- Concentration on the task at hand
- A sense of control
- A loss of self-consciousness
- An altered sense of time.

Chen (2007) used Csikszentmihalyi (1990)’s notion of flow and summed up that the flow experience can be equated to what players encounter when they are totally engrossed in games, thus not having any idea of the time or having any interest in other activities. However, Chen also argued that not all of the above factors as identified by Csikszentmihalyi are required at the same time to give users the experience of Flow, as too many choices can also have an effect of overwhelming them. Chen (2007) proposed a four step methodology for designing games:

- mix and match the components of flow
- keep the user’s experience within the user’s flow zone
- offer adaptive choices, allowing different users to enjoy flow in their own way
- embedded choices inside the core activities to ensure flow is never interrupted

There have been other studies that have investigated Flow in terms of slight variations of the eight factors defined by Csikszentmihalyi (1990). Malone (1980) looked at challenge, fantasy, and curiosity as being key aspects of design that fostered engagement. According to Malone, the conditions likely to induce the flow state are:

- the activity should be structured so that the player can increase or decrease the level of challenges faced, in order to match exactly personal skills with the requirements for action.
- it should be easy to isolate the activity, at least at the perceptual level, from other stimuli, external or internal, which might interfere with involvement in it.
2.3 Computer Game Design Features

- there should be clear criteria for performance; a player should be able to evaluate how well or how poorly (s)he is doing at any time.

- the activity should provide concrete feedback to the player, so that (s)he can tell how well (s)he is meeting the criteria of performance.

- the activity ought to have a broad range of challenges, and possibly several qualitatively different ranges of challenge, so that the player may obtain increasingly complex information about different aspects of her/himself. (p 14).

2.3.2 The Notion of “Gameplay” in Computer Games

The term Gameplay is ubiquitous among game designers and is perceived to be an essential component of a good game (Costikyan, 2002). Prensky (2003) describes Gameplay as the actions and tactics that are incorporated in a game in order to keep the player focussed and motivated to keep playing the game. Johnson et al. (2005) further expanded on this and stated that Gameplay actually comes from the actions the players make during the course of the game and not from visuals and sound effects. They argue that it is actually the Gameplay which makes a player motivated enough to keep playing the game.

Federoff (2002) also discusses the notion of Gameplay in her studies. In her research, she views Gameplay as the method through which a player is able to reach the goal of the game. Furthermore, she defines Gameplay as encompassing the problems and challenges a player must face in order to win the game. Federoff came up with the following features of Gameplay.

- There should be a clear overriding goal of the game presented early.

- There should be variable difficulty level.

- There should be multiple goals on each level.
2.3 Computer Game Design Features

- The game should have an unexpected outcome
- Artificial intelligence should be reasonable yet unpredictable
- Game play should be balanced so that there is no definite way to win
- Play should be fair
- The game should give hints, but not too many
- The game should give rewards
- Pace the game to apply pressure to, but not frustrate the player
- Provide an interesting and absorbing tutorial
- Allow players to build content
- Make the game replayable
- Create a great storyline
- There must not be any single optimal winning strategy
- Should use visual and audio effects to arouse interest
- Include a lot of interactive props for the player to interact with
- Teach skills early that you expect the players to use later
- Design for multiple paths through the game
- One reward of playing should be the acquisition of skill
- Build as though the world is going on whether your character is there or not
- If the game cannot be modeless, it should feel modeless to the player
2.3 Computer Game Design Features

2.3.3 Clear Goal/s

Several studies (for example, Bowman [1982], Malone [1981], Provenzo [1991]) describe Clear Goal/s as another crucial feature of game design. Bowman (1982) analyzed the popular Pacman™ game, by Namco, in which he saw that the players were in control of their actions and were actively pursuing their own goals. From this study he argues that having clear goals to win the game has the effect of placing the players in a Flow state. The study states that the inclusion of a goal in a game adds focus and measurable results, which helps in engaging the player for longer periods of time.

This view is further backed up by researchers such as Waraich (2004) and Zagal et al. (2000). These researchers agree that most games engage players by providing a clearly stated and reasonably challenging goal that needs to be achieved to win the game. These goals can be in various forms such as rescuing a princess, defeating an enemy or winning a rugby game. Usually, there is no misgiving about whether a goal was achieved or not. The studies further note that the goals in games are clear and observable. For example in the popular game, Tetris™ developed by Nintendo, which is a tile-matching puzzle video game, the objective or the goal is to stop the blocks from getting to the top of the screen. While playing the game, one’s progress is shown on the screen and thus the player knows how well they are performing at anytime in the game. The progress towards the goal keeps the game flowing which guides the player’s behaviour in the game.

According to Swartout and van Lent (2003) goals of varying levels have the effect of motivating the players so that they remain playing. These authors state that “game designers often seek to keep players engaged by creating three levels of goals: short-term (collect the magic keys), lasting perhaps, seconds; medium-term (open the enchanted safe), lasting minutes; and finally, long-term (save the world), lasting the length of the game”. The study further states that the interplay between these levels is crafted to draw players into the storyline of the game. This view is further supported by Crawford (1997), who states that the goals must be set up in such a way that it will create
an effect on the player. Crawford argues that it is not sufficient to assert that a game will be enjoyable to the player. He believes that a game needs to have goals which would “create the fantasies that the game will support and the types of emotions it will engender in its audience”.

Costikyan (2002) believes that it does not matter what goals game designers incorporate into the game, the crucial factor is that the players must apply effort to accomplish their goals. The game should be structured in such a way that a player is constantly considering his/her objectives, thinking about his/her next options as well as thinking about the end goal. In doing so, the player responds as best as he can do in order to accomplish the goal. Costikyan goes on to say that games have a “win-state” or a “set of victory conditions”. The players are made to believe that achieving victory is extremely important and this commitment guides player behavior.

Several other researchers (for example, Amory et al., 1999; Denis and Jouvelot, 2005; Jennings, 2001), also support the importance of goals and rewards in the game as an enabling factor to grasp the participant’s interest. In Amory et al. (1999), the authors explored four games and examined which components of these games the participants enjoyed the most. The participants were asked to rate how they found the various aspects of the four games, i.e. the fun aspect in games, sounds, visual effects, the type of game it was, whether the game was easy or difficult to play and if they were able to increase their performance by playing them repeatedly. The authors report that the participants were more inclined to play those games which had as an objective, using higher order thinking skills and those that had creative problem solving aspects in them. After reviewing the literature, these researchers came up with a set of features, one of which included rules and goals.

Garris et al. (2002) was another researcher who stated that a good game contained obvious and explicit goals. Moreover according to these authors, having specific rules and objectives in the game contributed to the motivation of the participants as well.
2.3 Computer Game Design Features

2.3.4 Feedback

Feedback has been identified as another factor which contributes to a good computer game. Due to the digital nature of computer games, progress towards both intermediate as well as final games can be provided instantly. For example in the game Super Mario Rescues Princess Peach™, developed by Nintendo, the gameplay is based on rescuing Princess Peach from the enemy Bowser. The players are provided feedback about their progress towards the goal of the game, how far they are towards rescuing the princess, how many life years they have left, how much time they have to complete the task or whether they made a correct or an incorrect response.

Feedback as an essential feature is investigated in detail in [Choi and Kim (2004)] and [Johnson et al. (2005)]. These studies argue that feedback is essential in a good game since it is through feedback that the players would know how they are performing in the game. Moreover, it is through feedback that the players are able to uplift their performance in the game. [Bowman (1982)] did a study on the Pacman™ game, developed by Namco. In the game, the player controls Pac-Man through a maze, eating pac-dots or pellets. When all pac-dots are eaten, Pac-Man is taken to the next stage. In this game there are four enemies whose objective is to catch Pac-Man. If an enemy touches Pac-Man, a life is lost. When all lives have been lost, the game ends. In his study, Bowman argued that one of the reasons for Pacman’s™ by Namco popularity is the frequency and the levels of feedback given during a game. He goes on to say that feedback offers players with valuable knowledge which in turn helps them to make decisions about their actions in a game. These decisions are crucial since they ultimately determine whether a player remains playing a game or not. One way in which feedback is given, as mentioned earlier, is in terms of what the players need to do to perform better. Another way feedback is given is when players are shown how well they are performing in a game. If the players are not able to see how well they are doing in a game or if they feel like they can’t possibly win, it is natural that the players eventually lose interest and as a result could even stop playing. [Howland (2002)] refers to these types of cues that the players receive in the form of feedback as “hooks”. He states that hooks are
“anything that requires the players to make decisions that relates to the game and hence keeps them playing”. It is the instant feedback which advises the players if they have carried out the correct response or not. In the case of the player choosing an incorrect response, appropriate feedback is given including clues and further information which guides the player towards the final goal. For example, when playing the popular game *Call of Duty™*, developed by Infinity Ward, if the player enters a building, a spy plane or a motion sensor alerts them to the enemy lurking around. This makes them become aware of their surroundings and enables them to look for alternative options so that they can get away from the enemy. In this game the player is in control of a soldier. Each mission features a number of objectives which are marked on the heads-up display’s compass; the player needs to complete all objectives in order to proceed to the next mission.

According to Fisch (2005) games proven to be effective are the ones which offer feedback and suggestions embedded in the game for effective gameplay. He argues that when designing games, designers need to pay close attention to how the feedback mechanism is built into the game. Fisch argues that feedback is a mechanism built into games in order to provide support to enhance learning of unknown concepts. Furthermore, he states that through feedback, a player is able to be supported and thus is successful in accomplishing a task in a game. He says that when designing games, the intention of feedback should not be to disclose the correct answer as soon as it has been first attempted. Rather, the players should be given appropriate clues so that they can arrive at the correct response themselves. Feedback can thus encompass an important role as an educational tool instead of just existing to provide simple responses. Computer game designers have coined the word “juicy” to describe effective feedback. According to Hunicke (2009), “juicy” feedback has the following features:

- **Tactile** - the player can almost feel the feedback as it is occurring on screen.
  Feedback is not forced or unnatural within the game play.
2.3 Computer Game Design Features

- **Inviting** - It’s something the player desires to achieve, as the player interacts with the game, they want the feedback and work to get the positive feedback. The player is given just the right amount of power and rewards.

- **Repeatable** - the feedback can be received again and again if the goals, challenges or obstacles are met.

- **Coherent** - the feedback stays within the context of the game. It is congruent with on screen actions and activities as well as with the storyline unfolding as the interactions occur.

- **Continuous** - it is not something that the player has to wait for, it occurs as a natural result of interacting within the context of game environment.

- **Emergent** - it flows naturally from the game, it unfolds in an orderly and well sequenced fashion. It feels like it belongs within the context of the environment, it is not distracting.

- **Balanced** - the player knows they are receiving feedback and they are reacting based on the feedback but they are not overwhelmed by the feedback or thinking of it as direct feedback.

- **Fresh** - the feedback is a little surprising, contains some unexpected twists and is interesting and inviting. The surprises are welcomed and congruent with the continuous feedback.

2.3.5 Challenge

Challenge has been identified in most literature as another feature crucial in the design of computer games. Computer games provide various forms of challenges for their players. Designers have to carefully consider the element of challenge when developing games. If a game is too difficult to play, the players will get frustrated and
2.3 Computer Game Design Features

quit playing. On the other hand, if players find a game too easy, they tend to lose
interest and switch off from playing it. Thus, game designers have to find the right
level of balance to keep players sufficiently challenged to continue playing the game.

Sweetser and Wyeth (2005) proposed a model of enjoyment named as Game Flow
based on Csikszentmihalyi’s idea of Flow. Their proposed model has eight features;
concentration, challenge, skills, control, clear goals, feedback, immersion, and social
interaction. Each of these features has a set of conditions for attaining game enjoy-
ment. These researchers reviewed two strategy games, one which was high rating and
one which was low rating. By using their model, they discovered that they were able
to distinguish why a certain game succeeded and why one failed.

Using their model, the researchers reported that the challenge feature in computer
games should have:

- challenges suitable to the skills of the player.
- varying levels of challenges as a player advances in the game.
- new challenges for different game sessions.

The study stresses that it is important that the challenges are not un-achievable. Since
players come to games with varying levels of skills, the level of challenge needs to
adapt to the skill level of the player. One way of doing this is by offering different levels
in a game, beginner level, intermediate or advanced. In this way, there are options for
the player to choose whatever difficulty level they wish to and are suited for, and keep
them motivated to play and progress in the game. This adds to the excitement of a
game. This technique has been used successfully in a lot of games. For example in
a popular game for girls, Woobies™ developed by Neue Kreative, the objective is to
match at least 3 “woobies”, which are little creatures, of the same colour so they can
fly away. The more woobies that fly away and the more combinations a player can
make in a row means the higher the score the player has. This game has three options
for players: easy, normal and expert. Thus the challenge is there but at the same time,
options are also available for the players. Players are able to keep a pace in the game and it is also fun at the same time, without it becoming too intimidating. Games are invented so that they are challenging. There are diverse tactics which can be utilised to adjust the level of challenge in the game. This is done so that skilled and unskilled players can be supported in the game. There are numerous methods game designers use to balance the difficulty of the game. The most common practise is to let players select the difficulty level themselves.

### 2.3.6 Narrative Aspect

Stories are told through words, art, dance, music and movies. There are numerous examples of computer games which narrate a story in some form. The way in which stories in computer games differ to other mediums of story telling is that in computer games, the player has the option of intimately interacting with the story. In other forms, such as movies and narration, there is one way communication where the participant passively consumes the story without giving a reaction that can have an impact on the narrative aspect of the story.

Several researchers (for example, Dickey, 2005, 2006; Fisch, 2005; Waraich, 2004) argue that the narrative aspect is the key feature which is able to keep the participants engaged in a computer game. According to Dickey (2005), game designers weave stories into a game and at the same time permit players to affect and change the story. Players are thus eager to play since they have opportunities to create their own narrative experiences within the game environment. Dickey further asserts that narratives, which have a long history of being entrenched in games, can be either plot based or character based. In plot based narratives, which consist of a number of scenarios and numerous characters, the players carry out actions which support the advancement of the plot of the game. On the other hand, in character based narratives, which involves the development of detailed characters, the players take on the role of a character within the game. Thus players enjoy narrative based games since they are able to interact with
the game environment and have an input in building the storyline of the game. Fisch (2005) believes that children enjoy playing games where the objectives of the game are embedded in the game. An example he provides is that of the game Sim City™, developed by Maxis. In this game, players learn how to build and design a city, by changing and manipulating diverse features and observing the result. In games such as these, the educational content, ie., learning how a city works and about its different systems, is at the center of the plot. Thus children see the educational content as fun and useful and engaging.

Dondlinger (2007) carried out a survey of research works on design features of successful computer games and found that there is general consensus among the researchers that narrative contexts embedded in the game are a crucial feature. In her study, she quotes Waraich (2004) who states that a game which incorporates a strong narrative has the potential to motivate the participants to perform the tasks of the game satisfactorily. In his study, Waraich looked at the role of the narrative context and goals as elements for motivating and learning in a 2-D interactive learning environment. According to Waraich, a learner needed to have appropriate conditions for learning as well as motivation so that he or she could carry out the learning successfully. He came to the conclusion that games which included a strong narrative could in fact meet these requirements provided the learning activities were properly designed and attached with the narrative. There are a wide variety of games in the market today with varying degrees of embedded stories in them. However most contain some level of storyline. For example in a popular children’s game, Scooby Doo and the Scary Stone Dragon™, a Windows XP game by Encore, players join Scooby and other characters on an exciting adventure in China. While in China, during the Chinese New Year celebration a huge stone dragon statue comes to life and frightens all of the visitors. Players look for clues and hunt for the suspects behind the scary stone dragon. Another popular children’s game, based on the popular cartoon, titled SpongeBob SquarePants’ Battle for Bikini Bottom™, developed by Heavy Iron Studios, also has a story line which captivates younger players. In this game, the main character, SpongeBob needs to save the under-
2.3 Computer Game Design Features

water world of Bikini Bottom where he and his friends live. Players have to fight off evil creatures, slide down mountains, bungee jump off cliffs, amongst other things, in order to save the underwater world. Adventure type games, such as the two discussed above are a genre of games in which narrative plays an important part. In these types of games, the player is placed in a first person perspective of having to solve problems in order to advance in the game.

This notion of games being narratives is a hugely debated topic among players of games, its designers and scholars. There are two schools of thought about whether or not computer games are story telling mediums or not. One school of thought is that computer games should only concentrate on game play while the other school of thought is that computer games are in fact story telling mediums. Proponents who argue that computer games are not story telling mediums state that traditional forms of stories do not allow the audience to get involved with the stories whereas in computer games, the players are interacting with the game all the time and changing the story line. While most researchers argue that the narrative aspect is a key engaging and motivating feature of computer games, there are others who disagree. For example Costikyan (2000) argues that “there is a direct conflict between the demands of a story and the demands of a game”. He says that as a consequence of following the story line, a player’s freedom to carry out certain actions is restricted which makes the game less enjoyable. The school of thought which Costikyan adheres to is of the view that not all games are created to tell stories and that there are abstract games as well as games in the experiential forms which do not have any story line or a narrative.
Chapter 3

Research Design

This chapter presents our research question, design principles and gives details of how the study was carried out. Section 3.1 describes the research agenda. 3.2 describes the open source game that was modified to be used as an educational tool. This section first discusses the proposed features to be implemented in the modified game, followed by a description of the game as it exists. Section 3.3 describes the experimental setup and methodology used to conduct the study. This section is divided into subsections which firstly details the methods and materials used in the study, followed by details of how the game was modified in order to test the hypothesis of this study.

3.1 Research Agenda

In this thesis, we investigated three research questions:

1. What are the appealing characteristics of effective computer games for children?
3.2 Game Design

2. Can adding those characteristics to an educational tool enhance children’s learning?

3. Do children enjoy using the proposed educational tool with those characteristics embedded?

3.2 Game Design

3.2.1 Proposed Features

The first step of the research was to select appealing features of popular computer games which would then be embedded in the proposed educational tool. This selection was carried out by examination of the relevant literature followed by a survey of a group of primary school children. We selected a group of 120 children aged between 9 to 10 years, at Glen Eden School in Auckland, New Zealand. They were given a questionnaire (Appendix A.2) and were asked to choose 3 features from a given list of computer games that they found as most appealing.

The following game attributes were singled out as most appealing:

- Challenges (CH): having different levels in the game
- Feedback (FB): knowing how many points were scored
- Graphics (GH): having realistic graphics

In order to further understand children’s perception of realistic graphics, an additional questionnaire was designed and given to children. In this questionnaire, children were asked to select three attributes which described their perception of realistic graphics.

The children identified the following attributes:
3.2 Game Design

Figure 3.1: Graph Showing the Student Responses to Questionnaire 1 - The bar graphs represent the desirable features in a game.

- Colourful images
- Real life characters
- High definition

For the purposes of this study, the three key features selected to be integrated into the game were: feedback (FD), challenge (CH) and graphics (GH).

Furthermore, children were asked to select the curriculum area in which they preferred to use an educational tool.

The graph in figure 3.3 shows that a high proportion of children indicated that they were interested in playing numeracy games. Some of the reasons for this were given as “I want to get better at maths” “I want to learn my multiplication facts”, “Learning maths in a game will be a fun way to learn” and “I dont like maths so playing a game and learning will be better”.

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3.2 Game Design

Figure 3.2: Graph Showing the Student Responses to Finer Features Identified in Questionnaire 1 - The bar graphs represent the finer features corresponding to Graphics.

Figure 3.3: Graph Showing the Student Responses to the Preferred Curriculum Area - The Pie Chart Represents the Preference for a Game in Different Curriculum Areas.
3.2 Game Design

From these responses it was decided that numeracy would be used as one of the curriculum areas and the second one was chosen as Te Reo (Maori language). The reason for including Te Reo curriculum is explained in section [3.3.4].

3.2.2 Game Overview

In order to design an educational tool with the characteristics discussed in [3.2.1] the same group of children were surveyed to find out what types of computer games they preferred playing. The three most popular type of games identified were action, trivia and adventure games. Keeping this in mind, we researched the web for an open source game which could be easily modified, to incorporate extensive amounts of feedback (FD), challenge (CH) and graphics (GH) as well as easily modified to include numeracy and Te Reo (Maori language) curriculum. After a survey of a number of games, we chose a trivia game, Who Wants To Be a Millionaire from http://quizshow.sourceforge.net/download.html

![Figure 3.4: Original Game Screen Shot - typical question screen of the Who wants to be a Millionaire open source game](image)

The game is based on a television game show in which the participants are offered
large cash prizes for correctly answering a series of multiple-choice questions in the order of increasing difficulty levels. This game can be configured easily to include any content. New content can be added by including the questions at various levels as a text file.

For this study, two domains were integrated into the game, Numeracy and Te Reo (Maori language). To play the game, a player has to answer questions displayed on the screen by selecting one of the 4 possible answers. On answering a question correctly, the player wins $100. There is a 60 second time limit to answer a single question. Once an answer is selected, it cannot be changed. For example, in the Te Reo version of this game, a question will appear as follows: The question reads:

“Ann has netball practice every Monday. What is the Te Reo word for Monday?”

A. rahina  B. ratapu
C. ramere  D. rohori

The correct answer is option A. When a player chooses option A as the answer, he or she will receive immediate feedback about whether the answer was correct or not. If the selected answer is correct, the player receives both visual and aural feedback before moving to the next question. The player will also receive feedback in the form of another prompt which tells him/her how much money has been won so far. Moreover, on the top right hand side of the screen (can be seen in figure 3.5), the score screen highlights the winnable amount in a bright red color.

Choosing an incorrect answer at any point in the game ends the current session of the game, with a feedback message saying the game can be played again from the beginning. Note that depending on when the incorrect answer is given, the player can leave with either no money or a certain amount. The amount a player can leave with is dependent on the level reached.

The game designed for this study had three levels indicated by an amount written in white font compared to the rest of the amounts which are written in yellow font (see
3.2 Game Design

Figure 3.5: Modified Game Screen Shot - a sample integrated narrative aspect on the top right corner for a Te Reo learning task.

Once a player passes a level\(^1\) indicated by the amounts $1,000, $32,000 and $1 million, the player can leave anytime with the money associated with the highest previous level reached. This applies in both cases: when a player voluntarily chooses to leave the game and when the player gets an incorrect answer.

There are five chances for the player to leave with nothing. The first being if he or she were to give a wrong answer before obtaining the first guaranteed amount and the other four being if he/she gets an answer incorrect even before reaching the first level, that is, $1000. After reaching $1000, this amount is guaranteed and subsequent questions are played for increasingly large sums (roughly doubling at each turn). The complete sequence of prizes is as follows:

$100, $200, $300, $500, $1,000, $2,000, $4,000, $8,000, $16,000, $32,000, $64,000, $125,000, $250,000, $500,000 and $1,000,000.

\(^1\)The difficulty level of the questions increases with increase in level
Note that incorrectly answering intermediate level questions, e.g. $4,000, does not enable the player to leave with $4,000, but the last level reached, that is, $1,000.

### 3.3 Experimental Setup and Research Methodology

The subjects used in this research were a group of 120 primary school students of Glen Eden School in Auckland, New Zealand. In order to use the pupils for this study, firstly permission was obtained from the Board of Trustees of the school, after which a consent form was sent to the parents to be signed. Once permission was granted by the Board, the group of students to be used for the research was chosen. The students used in the research were of ages 9-10 from four different classes. Out of the 120 students, 69 were girls and 51 were boys. All this information was then presented to Unitec Ethical Approval Committee in order to be able to carry out a study on human subjects. After these preparatory tasks, the study was carried out over a period of 4 weeks during normal school days with the permission of the classroom teachers.

Two versions of an educational tool were developed. The first version was a feature enriched game (FEG) which had extensive use of the three identified features and the second version, a feature devoid game (FDG) had overt absence of the same features. Both versions of the game were installed in the 12 available computers in the school library and as time permitted, pupils in groups of 12 were given the games to play in a separate room with the computers. The Control group played the FDG game and the Test group played the FEG version. Both groups played at different times and were not able to see what version of game each group was playing. There was a deliberate attempt to keep the two group’s playing times separate. The students were allowed to play the game for about 20 minutes without any interference from the researcher or any of the other teachers. At the end of a maximum of 30 minutes the students were stopped and allowed to go back to their classrooms.
3.3 Experimental Setup and Research Methodology

The rest of the chapter is structured as follows. Subsections 3.3.1, 3.3.2 and 3.3.3 discuss how each of the design features were implemented in the educational tool. Subsection 3.3.4 describes the chosen curricular that was used. Subsection 3.3.5 describes how the data for the study was collected. Subsection 3.3.6 summarizes the series of steps used to conduct the study in order to test the main hypothesis of this thesis.

3.3.1 Feedback Feature Implementation

In order to study the impact of feedback in the game, the feature was used multiple times, almost after every stage in the game. Feedback was implemented using floating dialogue boxes as well as part of the permanent fixture of the game. A sample of the different types of feedback is shown in figures 3.6, 3.7 and 3.8.

![Figure 3.6: Correct Response Feedback Screen Shot](image)

Apart from the transient feedback, permanent feedback based on the level of question being answered and the amount of money in the bag is provided on the score screen on the top right hand corner of the screen as shown in figure 3.9.
3.3 Experimental Setup and Research Methodology

Figure 3.7: Winning Feedback Screen Shot - sample feedback for winning an X amount of money.

Figure 3.8: Incorrect Feedback Screen Shot - the feedback dialogue for an incorrect answer.
3.3 Experimental Setup and Research Methodology

Figure 3.9: Score Level Feedback Screen Shot - on the top right corner, the feedback for the current amount of money won so far is highlighted in red.

Figure 3.10: Icons Used for Help - the three icons on top represent respectively fifty-fifty, phone a friend and ask audience options on help available in the game. The corresponding icons at the bottom show which help has been used.
Similar to the real TV game, feedback was also provided in the form of help from three different types of sources. If at any point a player is unsure of the answer to a question, he or she can use one or more types of “help” available in the game. After using the “help”, a player can either answer the question, use another “help”, or walk away and keep the money in the bag so far. Each “help” can be used only once. The “help” options were in the form of fifty-fifty, phone a friend and ask the audience. These were slightly different to the actual TV game the computer game is based on. The help options were made available using the three icons in figure 3.10 and their implementation is described as follows:

- **Fifty-Fifty**: The player can choose to have the computer randomly eliminate two of the incorrect answer choices, leaving the player with a choice between the correct answer and an incorrect choice. Based on these two choices, he or she then makes the answer selection.

- **Phone-A-Friend**: Players can ask one out of three pre-arranged friends for an answer. These three friends can be arranged before commencing the game. In the television game, the player can actually phone one of three pre-arranged friends. Since this not possible in a classroom setting, the player could ask one of three pre-arranged classmates for an answer. The conversation between the friend and the player is timed in the game, with a configurable time, and a value of 60 seconds was used. If the time expires then the game is ended.

- **Ask the Audience**: The player can ask any of their classmates. In the television game, the players get to ask the actual audience for help. In a classroom setting, we chose to let the players ask any of their classmates. This can involve shouting the question over to a friend in another corner of the room, building up even more excitement in the game.

In the FDG version, feedback was minimal. When a player selects an option, the answer is highlighted with a white box around the answer. If the option selected is
correct, then the answer is highlighted again in a basic white color. A prompt with the dollar amount won is shown next. The player is not given any feedback about what to do next. If a player selects an incorrect answer, then a prompt appears with $0 displayed on it. The player is not informed about what to do next. On the score screen displayed in the top right hand corner of the main screen, the dollar amounts are displayed. There is no indication during the game about how much the player has won. Also there is no indication of what the guaranteed amounts in the game are. Additionally, the FDG did not have any additional “help” options as in the FEG version, i.e. fifty-fifty, phone a friend or ask the audience.

3.3.2 Challenge Feature Implementation

In the FEG version, challenge exists in the form of the difficulty level of the questions. The number of levels players can have is configurable and for the purpose of this study three levels were used. Each level contained a set of 5 questions, with level 1 being the easiest set. The game starts with level 1 questions asked 5 times after which $1,000 level is reached in terms of the money earned. At this point $1,000 becomes a guaranteed take-home amount. The next set of 5 questions are then asked from level 2 after which $32,000 becomes a guaranteed take-home amount. Finally, the most difficult set of questions were asked from level 3 after which the player takes home 1 million dollars. The increasing level of difficulty challenges the students to come back and play the game again if they get an answer incorrect in order to achieve a higher level. There is a catalog of questions stored in the game so that different questions are asked each time a player plays. New questions can be added to the catalog.

It was difficult to design a version of the game without a challenge feature as the core part of the game is to win increasing amounts of money, which in itself is a challenge feature. However, in the FDG version of the game, the challenge in terms of the difficulty level of the questions was minimised. This was done by randomizing the difficulty level of questions instead of a gradual increase. Hence a player could
3.3 Experimental Setup and Research Methodology

encounter a level 3 (most difficult) question to start with and get a relatively easy question towards the crucial part closer to the end of the game dealing with winning a large sum of money. The randomization of the level of questions was based on the premise that players encountering difficult questions at the start would feel discouraged and abandon the game in the early stages and after a while stop playing altogether. Conversely, players answering a relatively easy question at the point of winning a major prize would not feel the same sense of achievement as they would if they won the same money by answering a difficult question.

3.3.3 Graphics Feature Implementation

Graphics includes both colour and sound. In terms of colour, the FEG version had a lot of attractive colours in all the parts of the persistent screen as well as the transient dialogues. The main screen has a black background and the questions appear in a blue framed box. The questions are displayed in white font while the optional answers are displayed in yellow font against a black background. When a player selects an answer, this selection gets highlighted in orange. If the option selected is correct, then the correct answer gets highlighted in green. If an option is selected and it is the incorrect option, then the correct answer gets highlighted in green while the incorrect answer remains highlighted in orange. The dollar amounts that appear on the score screen on the top right hand corner of the main screen appear in a yellow font. The guaranteed amounts of $1,000, $32,000 and $1,000,000 appear in a white font. When a player wins an amount of money, this amount is highlighted in bright red.

In contrast to the use of the bright colours, the FDG version was done in the two basic colours of black and white.

In terms of sound, in the FEG version, there is a soft, continuous background tune played while the game is being played. When a correct answer is selected, a short, high musical note is played to indicate that this is the correct answer. If an answer selected is incorrect, then a short, low musical note is played to indicate that this is
3.3 Experimental Setup and Research Methodology

the incorrect answer. At the completion of the game, a clapping sound is played to congratulate the player. In the FDG version all music was muted.

3.3.4 Curricular Used

The two subject areas chosen for the study were Numeracy and Te Reo (Maori Language). Numeracy was chosen because a large number of students had identified numeracy in Questionnaire 1 (included in appendix, Section A.2) as one of the areas they wanted to play games in. Some of the reasons why they wanted to play numeracy games were: “I want to get better at maths”, “I want to learn my multiplication facts”, “Learning maths in a game will be a fun way to learn” and “I don’t like maths so playing a game and learning will be better”. Te Reo (Maori Language) was chosen to be the second learning area since this was an area of learning in which there were very limited educational games from the experience of the primary researcher. A second reason was that non-Maori students seemed less motivated to learn Te Reo, since they did not seem to see its usefulness.

The contents of both the games were carefully selected according to the appropriate curriculum level for children at ages 9-10. The actual content is described below:

**Numeracy Game:** For this game, the New Zealand Numeracy Curriculum document was used in order to determine the level of question suitable for the children selected for the study. In order for the game to be enjoyable and engaging, it was necessary that the players were given the type of questions of which they had prior knowledge and which were not extremely difficult or “boringly” easy (e.g. a good solution was to provide a progressive level of skills). Their teachers were consulted and the numeracy levels of the children were taken into consideration. It was revealed that the children in the target group were on level 5 according to the New Zealand Numeracy Curriculum. Three levels of questions were therefore developed at level 5 on the following topics:

- Level 1: Addition/Subtraction
3.3 Experimental Setup and Research Methodology

- Level 2: Multiplication/division
- Level 3: Combining all the above operations

**Te Reo (Maori Language) Game**: Te Reo (Maori Language) is a component of the NZ Primary School curriculum and basic Te Reo is taught at the primary school level. The teachers of the selected group of students were again consulted to find out what competency level the students were in Te Reo. The questions designed for the Te Reo game were then compiled in line with the children’s competence. The questions were based around identifying everyday items, recalling numbers, naming the color range, as well as naming the days of the week. The children in the study group were expected to have prior knowledge on these topics.

3.3.5 Methods Used to Collect Data

There were various steps in the whole study and accordingly different techniques were used to collect the data. The steps are summarized in Subsection 3.3.6 and the data collection techniques are listed below in chronological order:

1. Consent Form (attached in Appendix, Section A.1) was used to ask for parental consent for the children to participate in the study. Out of 150 forms sent, 120 parents approved their children to participate in this study.

2. Questionnaire 1 (attached in Appendix, Section A.2) was given to 120 students at the commencement of the exercise to get feedback on students’ favorite games. The responses, in conjunction with the literature review, were used to extract the 3 most popular features to be integrated in the tool designed for this study.

3. Pre-test and post-test (attached in Appendix, Sections A.3 and A.4) on numeracy and Te Reo given to the children to assess their pre-game playing knowledge of the curricula and post-game playing knowledge of the same curricula. Note that the same test was used as pre-test and post-test.
4. All the information pertaining to game session was collected automatically through log files. A sample log file is shown in figure 3.11. Some examples of information contained in the log file include the duration of the game session, the question attempted and whether the questions were answered correctly, the levels attained and the number of feedbacks given. The log files were then analysed to extract the relevant information for the research.

5. For subjective evaluation, a post-game playing Questionnaire 2 (attached in Appendix, Section A.5) was given to the students to get feedback about the game. This questionnaire was given to both groups after they had each played a version of the educational tool.

### 3.3.6 Summary of the Sequence of Steps for the Whole Study

The various steps of the study are summarised below in chronological order.

1. An extensive literature review was done in order to extract a set of 6 most appealing characteristics identified by researchers and game designers in the area of computer games.

2. Questionnaire 1 was used to determine the most popular features found by children used in the study.

3. The results of Questionnaire 1 and features from the literature review were used to select the three most popular features to be integrated in the game to be used as a educational tool for this study.

4. Two versions of an educational tool in the form of a game were developed. The first version was a feature enriched game (FEG) which had extensive use of the three identified features and the second version, a feature devoid game (FDG) had overt absence of the same features.
3.3 Experimental Setup and Research Methodology

Figure 3.11: Sample Log File Contents
5. The participants were divided into a Control group and a Test group of approximately 60 students each.

6. Both groups were pre-tested firstly on the Numeracy learning outcomes.

7. The Test group was given the Numeracy FEG version to play over a period of two weeks and the Control group was given the Numeracy FDG version to play over two weeks.

8. Both groups were given post tests on the Numeracy learning outcome.

9. Both groups were then pre-tested on the Te Reo learning outcome.

10. The test group was given the Te Reo FEG version to play over a period of two weeks and the Control group was given the Te Reo FDG version to play over two weeks.

11. Both groups were given post tests on the Te Reo learning outcome.

12. Both groups filled in Questionnaire 2 which was designed to get a general feedback about the effectiveness of each version of the game.

### 3.3.7 Evaluation Metrics

Improving children’s learning is the main dependent variable for our research questions. To measure that, we used a pre-test, post-test and interaction logs. The pre-test was conducted to measure student knowledge before using the educational tool and the post-test was used to measure the learning outcome after using the educational tool. Separate tests were conducted for both the curriculum areas: Numeracy and Te Reo. The questions in the tests were similar to the ones used by teachers in assessing their students in these two curriculum areas. The pre-testing and the post-testing for each of the curriculum areas were done using the same tests. This gave us a direct
3.3 Experimental Setup and Research Methodology

measurement of the change in the learning outcome. Other factors that were used as indicators of enjoyment of the game were:

- time spent playing the game
- number of attempts at the game
- number of correct responses
- level of the game reached

In addition a post-game questionnaire was also used to measure qualitative aspects of the effectiveness of the educational tool. The questionnaire is attached in the Appendix in A.5.
Chapter 4

Results and Discussion

This chapter describes the results obtained from research conducted on a group of approximately 120, 9-10 year old primary school children separated into control and test groups. The test group were given the feature enriched game (FEG) described in chapter 3.2 while the control group played the feature devoid game (FDG). The data for the whole study was collected using log files and a pre-test and post-test. These results are presented and discussed in section 4.1. Further qualitative data was collected using a questionnaire at the end of the 4 week study period. The results from the response to this questionnaire are discussed in section 4.2.

4.1 Analysis of Game Playing Data

This section describes the dependent variables that were used to determine the effectiveness of using the *Who Wants To Be A Millionaire* game as an educational tool. The most direct indicator is the learning outcome, which was determined using a set of pre-test and post-test questions on the two subject areas, Numeracy and Te Reo (Maori
### 4.1 Analysis of Game Playing Data

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Control Group</th>
<th>Test Group</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre Test</td>
<td>Post Test</td>
<td>Pre Test</td>
<td>Post Test</td>
</tr>
<tr>
<td>Count</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>Average</td>
<td>12.12</td>
<td>12.97</td>
<td>12.87</td>
<td>14.77</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>4.30</td>
<td>4.21</td>
<td>4.55</td>
<td>3.51</td>
</tr>
<tr>
<td>Relative Std. Dev. (%)</td>
<td>35.5</td>
<td>32.5</td>
<td>35.4</td>
<td>23.8</td>
</tr>
</tbody>
</table>

**Table 4.1:** Table showing the Statistics for the Pre and Post scores for the Numeracy Experiment.

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Control Group</th>
<th>Test Group</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre Test</td>
<td>Post Test</td>
<td>Pre Test</td>
<td>Post Test</td>
</tr>
<tr>
<td>Count</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>Average</td>
<td>8.35</td>
<td>8.85</td>
<td>10.52</td>
<td>14.18</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>3.47</td>
<td>3.41</td>
<td>3.22</td>
<td>3.42</td>
</tr>
<tr>
<td>Relative Std. Dev. (%)</td>
<td>41.6</td>
<td>38.6</td>
<td>30.7</td>
<td>24.1</td>
</tr>
</tbody>
</table>

**Table 4.2:** Table showing the Statistics for the Pre and Post scores for the Te Reo Experiment.

Language). The statistics for learning outcome scores for the Numeracy experiment is shown in table 4.1. The corresponding statistics for the Te Reo experiment is shown in table 4.2. Firstly, note that the average scores for both Numeracy and Te Reo have increased after playing both versions of the game. For example, for the Numeracy experiment, the average for the control group has increased from 12.12 to 12.97 and for the test group it has gone up from 12.87 to 14.77. Also observe that the absolute score for the These equate to an increase of 0.85 or 7% for the control group and an increase of 1.9 or 14.8% for the test group. Hence, for Numeracy, the percentage increase in the mean score is twice as much for the FEG compared to the FDG game. Comparison of the post-test scores for the control and the test groups (12.97 compared to 14.77) also shows that the FEG was more effective in raising the performance level of the students. The T-Test values (shown in table 4.4) for the Numeracy game are $3.63 \times 10^{-10}$ for the control group and $1.31 \times 10^{-31}$ for the test group. Both the values are orders of magnitude smaller than 0.05, testifying that the change in the learning outcome was not due to chance. Additionally, observer that the test group T-Test value is orders
of magnitude smaller than both 0.05 and the control group T-Test value, implying a significant effect of the FEG.

The corresponding figures for the Te Reo game is 0.5 or 6% increase for the control group compared to 3.66 or 34.8% for the test group. This gives us an approximately 6 fold increase in the learning score for the Te Reo experiment. The results in the case of the Te Reo curriculum also show a similar pattern to the Numeracy curriculum, in that the test group performed better compared to the control group. However, observe that in this case, the results are much more pronounced - a 6 fold increase compared to a 2 fold increase.

The standard deviation figures for both Numeracy and Te Reo show a consistent decrease from control group to test group. For example, for Numeracy, standard deviation for the control group decreased from 4.30 to 4.21 and for the test group it decreased from 4.55 to 3.51. On its own, this essentially shows that the scores are more closely clustered near the mean, however note that the mean has also increased in value. Hence the decrease in the standard deviation value in combination with the increase in the mean value shows that playing the computer game in between the pre-test and the post-test had the effect of increasing the scores of the subjects. The relative changes in the standard deviation values of the control and test groups show that the effect was comparatively more pronounced for the test group, indicating the effectiveness of the FEG version of the game. These results are also consistently reflected in the Te Reo experiment, where the results are even more pronounced when compared to the Numeracy experiment.

The learning outcome scores for both Te Reo and Numeracy indicate two things. Firstly, that the students who played the FEG version performed better compared to the students who played the FDG version. This means that the three identified features (feedback, challenge and graphics) in a learning tool is effective in achieving better educational outcomes.

Secondly, the much greater increase in the learning outcome score for Te Reo indicates that the educational tool was especially effective for this curricular. This can be
attributed to the difference in the types of learning involved in the two curricula. Te Reo involves fact based learning where the student is required to learn and recall facts. According to Sutherland (1969), factual learning focuses on the attainment and storage of information to be retrievable on demand. The type of questions asked in the Te Reo version of this particular game were based on having a prior knowledge about the topic. Hence the children were asked to recall specific information, i.e., factual information that they had prior knowledge about. They were able to retain this information after playing the game for a period of four weeks. With this task, there is no higher level manipulation involved, hence this can make the learning task boring and non-motivating. Using games to teach the curricula helps in motivating the students as well as keeping them engaged through the duration of the learning task. The results show that enriching the educational tool with certain features goes even further in improving the learning outcomes.

On the other hand, the Numeracy learning task involves more fact manipulation operations. This involves various intermediate steps in order to arrive at the final answer. The intermediate steps were not fully supported in the game designed for this study, hence the game was not entirely suitable for the Numeracy learning task. In spite of this, the FEG version significantly improved learning outcomes for Numeracy, which can be even further improved by adapting the game for more fact manipulation or cognitive-based curricula. Cognitive learning is defined as "learning that is concerned with acquisition of problem-solving abilities and with intelligence and conscious thought" (Cognitive Learning, 2012). Numeracy learning is based on problem solving and the game used in this research did not give children an opportunity to practice problem solving skills. To learn mathematics, students must be engaged in exploring, estimating, and thinking rather than recall based learning. Numeracy learning involves understanding the concepts and meanings underlying the operations, as opposed to merely applying rules. So the most important premise of numeracy learning is that when students understand the concepts and reasoning underlying a process, they are more likely to be able to correctly apply that process. This game reinforces previously introduced
4.1 Analysis of Game Playing Data

<table>
<thead>
<tr>
<th></th>
<th>Control Group</th>
<th>Test Group</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre-test</td>
<td>Post-test</td>
<td>Abs. Inc.</td>
</tr>
<tr>
<td>Numeracy</td>
<td>12.12</td>
<td>12.97</td>
<td>0.85</td>
</tr>
<tr>
<td>Te Reo</td>
<td>8.35</td>
<td>8.85</td>
<td>0.5</td>
</tr>
<tr>
<td>Average</td>
<td>10.23</td>
<td>10.91</td>
<td>0.66</td>
</tr>
</tbody>
</table>

Table 4.3: Table showing the Learning Outcome Shifts for Test and the Control groups.

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Numeracy Control</th>
<th>Test</th>
<th>Te Reo Control</th>
<th>Test</th>
<th>Numeracy plus Te Reo Control</th>
<th>Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observations</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>P(T^1=t)one tail (t=0.05)</td>
<td>3.63 x 10^{-19}</td>
<td>1.31 x 10^{-31}</td>
<td>5.45 x 10^{-4}</td>
<td>2.4 x 10^{-19}</td>
<td>5.17 x 10^{-9}</td>
<td>1.6 x 10^{-23}</td>
</tr>
</tbody>
</table>

Table 4.4: Table showing the T-Test Results on the Pre Test and Post Test Scores for the Numeracy, Te Reo and Combined Experiment Results.

skills and concepts. It doesn’t teach students new concepts. Constructivist theorists like Piaget (1970), Vygotsky (1978) and Bruner (1960) assert that when students construct personal knowledge derived from meaningful experiences, they are much more likely to retain and use what they have learned. Hence any learning tool, such as the game designed for this study, should be able to suitably support this.

Table 4.3 shows a summary of the shifts in the scores for learning outcomes for Numeracy and Te Reo. Columns 4 and 8 show the absolute increases in the learning score and columns 5 and 9 show the corresponding percentage values. The last row shows that the average shifts for the two curriculum areas. There was an increase of 24.75% for the test group compared to an increase of 6.7% for the control group. This gives us an average effectiveness index of 4 for the feature enriched game compared to the feature devoid game. The index can reasonably be expected to be even higher if compared to conventional teaching methods such as only with pen and paper.

Table 4.4 shows the results of paired, one tail T-Test computations corresponding to the learning outcome scores. The first and the second columns show the values for the control and test groups for Numeracy and Te Reo, and the third column shows the combined values for both experiments. Observe that values for both the control groups as well as the test groups for all experiments lie well below 0.05, which means that for both the groups the change in characteristics (in this case change in the learning
### 4.1 Analysis of Game Playing Data

<table>
<thead>
<tr>
<th>Av. per participant</th>
<th>Numeracy Control</th>
<th>Test</th>
<th>Te Reo Control</th>
<th>Test</th>
<th>Numeracy plus Te Reo Control</th>
<th>Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of participants</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>No. of questions attempted</td>
<td>9</td>
<td>11.5</td>
<td>8</td>
<td>13.5</td>
<td>8.5</td>
<td>12.5</td>
</tr>
<tr>
<td>No of correct responses</td>
<td>8</td>
<td>10.5</td>
<td>7</td>
<td>12.5</td>
<td>7.5</td>
<td>11.3</td>
</tr>
<tr>
<td>Time spent playing game (mins)</td>
<td>9.19</td>
<td>10.44</td>
<td>9.21</td>
<td>10.5</td>
<td>9.2</td>
<td>10.5</td>
</tr>
<tr>
<td>Level reached</td>
<td>1.8</td>
<td>2.3</td>
<td>1.6</td>
<td>2.63</td>
<td>1.7</td>
<td>2.5</td>
</tr>
</tbody>
</table>

**Table 4.5:** Table showing Other Game Playing Statistics for the Numeracy, Te Reo Experiment and Combined Statistics.

The outcome score (mean learning score) of the sample did not occur by pure chance. This means that even for the learning score, change for the control group can reasonably be attributed to playing the game, albeit it was a feature devoid version. However, note that the T-Test values for the test groups for both Numeracy and Te Reo are orders of magnitude smaller than the corresponding control group values, suggesting even stronger evidence that the change in the score was not due to any random activity in the experiment population.

Table 4.5 shows the average values of some of the other attributes of the experiments that were extracted from the log files. All the attribute values from rows 2 to 5 show higher values for the test group compared to the corresponding control group, indicating that the feature enriched version was better utilized compared to the FDG version. For example, more questions answered indicates the participants were motivated to play the game for longer durations, which can translate to higher amount of learning, supporting the hypothesis of this research. Similarly, the attributes “No of correct responses”, “Time spent playing game” and “Level reached” were also interpreted to be positive indicators of learning. Another fact apparent from table 4.5 is that the values of the attributes are slightly higher for the Te Reo test group compared to the Numeracy test group. This affirms the results from the learning outcome scores; that the game was more effective for the Te Reo curriculum compared to Numeracy. The possible reasons for this have already been discussed earlier in this section.

The bar graph in Figure 4.1 shows the maximum level reached by the subjects instead of the average as shown in the last row of table 4.5. These results from figure 4.1
4.1 Analysis of Game Playing Data

Further illustrate that the game features integrated in the learning tool were effective in achieving better learning outcomes, in terms of higher levels of questions attempted between the control and test groups. The higher levels attained indicate that the students effectively learned more by being at the learning task for longer. Conversely, the students in the control group were not able to progress as much, probably because of lack of motivation.

![Figure 4.1: Graph Showing the Maximum Game Levels Attained by Test and Control Groups for both Numeracy and Te Reo](image.png)
4.2 Analysis of Post-Game Questionnaire Responses

After playing the FEG and the FDG versions of the game over a period of four weeks, the students were given a questionnaire (included in the appendix, section A.5) to fill, in order to collect information about their perception of the game. Altogether, there were 7 questions in the questionnaire. The students could respond to the question by ticking one of the following responses:

1. Yes, definitely.
2. Yes, maybe/a bit.
3. Not sure.
4. No, not really.
5. No, not at all.

Graphical summary of the responses to each of the question is presented in figures 4.2 to 4.8.

**Question 1: Did you enjoy playing this game?** Figure 4.2 shows that in the Control group, 33 students said that they did not enjoy playing the game at all and 24 children said that they did not really like playing the game. No child in the control group said that they enjoyed playing the game. For the test group, 41 children said that they definitely enjoyed playing the game, 13 students said maybe a bit and one child said that they did not enjoy playing the game at all. The trend was reversed for the control group. In this case, more students (Not at all - 31 and Not really - 22) said they did not enjoy playing the game. An almost negligible number enjoyed playing the feature devoid game. The response of students to this question provides further evidence for the effectiveness of the computer game features that were integrated into the educational tool.

**Question 2: Are you likely to play this game again?**
4.2 Analysis of Post-Game Questionnaire Responses

Figure 4.2: Graph Showing the Student Responses to Question 1 of Questionnaire 2

- Did you enjoy playing this game?

Figure 4.3 illustrates that in the Test group, (33) students indicated that they were definitely, and (24) possibly going to play the game again while in the Control group none of the students indicated this and instead, just over half (44) of the students in this group (Control) pointed out that they were not at all likely to play the play game. By comparison, only 1 child in the Test group said that they were not at all likely to play the game again. In the Control group, half (15) of the students said that they were not really likely to play the game again in comparison to only 1 student in the Test group. The results of this question demonstrates that the children in the test group were more likely to play the game again as a result of the specific features, i.e, FD, CH and GH present in the game. The Control group played a game which was devoid of the features hence explaining why such a high proportion of children from this group were not at all likely to play again.

**Question 3:** Did the sound effects in the game contribute to your enjoyment of the game?
4.2 Analysis of Post-Game Questionnaire Responses

Figure 4.3: Graph Showing the Student Responses to Question 2 of Questionnaire 2
- Are you likely to play this game again?

Figure 4.3 reveals that a high proportion of students in the Test group agreed that the sound effects definitely (34), and possibly (15) contributed to their enjoyment of the game. The FDG version did not have any sound present hence a lot of students agreed that sound did not definitely (48) and not really (12) play any role in their enjoyment of the game. Even though sound was a feature in the FE version of the game, it is interesting to note that 2 students in the Test group indicated that the sound effects did not really contribute to their enjoyment. The above results illustrate that sound effects were a contributing feature to the overall game enjoyment as shown by the Test group. The Control group did not share a similar enjoyment as the Test group since the FDG version did not have any sound. This result proves that sound effects are indeed a crucial feature which is significant to players enjoyment of a game.

Question 4: Did the feedback in the game contribute to your enjoyment of the game?
4.2 Analysis of Post-Game Questionnaire Responses

Figure 4.4: Graph Showing the Student Responses to Question 3 of Questionnaire 2
- Did the sound effects in the game contribute to your enjoyment of the game?

Figure 4.5 demonstrates that a large number of students in the Test group agreed that feedback was crucial to game enjoyment, with 31 students saying it definitely contributed and 23 students indicating that it possibly contributed to their enjoyment. On the other hand, not even one student in the Control group agreed that feedback contributed to their enjoyment of the game, as shown by 27 students saying it did not contribute at all and 21 students saying it did not really contribute to their enjoyment. The above results show that feedback is yet another feature which contributes to whether or not a game is an enjoyable experience. The absence of feedback in the FDG version played by the Control group is a major indicator why a higher proportion of children in this group did not enjoy the game. This is in contrast to the Test group who played the FEG version in which feedback was an essential component of the game. Thus, as the results indicate, a majority of students from the Test group agreed that feedback did indeed make the game an enjoyable experience.
4.2 Analysis of Post-Game Questionnaire Responses

Figure 4.5: Graph Showing the Student Responses to Question 4 of Questionnaire 2

- Did the feedback in the game contribute to your enjoyment of the game?

![Bar Graph](image)

**Responses to Question 4 of Questionnaire 2:**
"Did the feedback in the game contribute to your enjoyment of the game?"

<table>
<thead>
<tr>
<th>Student Responses</th>
<th>Test</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>definitely (Yes)</td>
<td>30</td>
<td>25</td>
</tr>
<tr>
<td>maybe (Yes)</td>
<td>20</td>
<td>15</td>
</tr>
<tr>
<td>not sure</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>really (No, not)</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>at all (No, not)</td>
<td>10</td>
<td>20</td>
</tr>
</tbody>
</table>
4.2 Analysis of Post-Game Questionnaire Responses

Figure 4.6: Graph Showing the Student Responses to Question 5 of Questionnaire 2
- Did the level of challenge in the game contribute to your enjoyment of the game?
Question 5: Did the level of challenge in the game contribute to your enjoyment of the game?

Figure 4.6 illustrates that a lot of students from the Test group (28 definitely and 21 possibly) responded favorably to challenge being a feature which led to game enjoyment. A similar number of students shared the opposite view in the Control group (31 did not at all and 19 did not really) and not a single student from this group believed that challenge contributed to their enjoyment. It is interesting to note that no one from the Test group shared the same views as the Control group. The results again demonstrate that challenge is another essential feature which contributes to game enjoyment. We can see that the Test group who played the FEG version comprising of 3 different levels enjoyed the game more than the Control group who played the FDG version in which the level of challenge was not obvious and thus did not have the same satisfaction.

Question 6: Did the visuals (i.e. colour) in the game contribute to your enjoyment of the game?

The graph in figure 4.7 displays that there were a lot of students in the Test group (33 definitely and 14 possibly) who agreed that the visuals i.e. colour contributed to their game enjoyment. By comparison, the Control group (44 not at all and 16 not really) indicated that this feature was not a contributing factor to their game enjoyment. This result has shown that children perceive visuals, i.e. colour, to be a key feature for game enjoyment. The Control group played the FDG version, which consisted mostly of two primary colours, black and white, while the Test group played the FEG version which had a lot more colours in it.

Question 7: Would you recommend the game to your friends?

Figure 4.8 shows that the students in the Test group were more likely to recommend the game to their friends (38 definitely and 17 possibly). On the other hand, very few students in the Control group were likely to do so (1 definitely and 9 possibly). When it came to the issue of recommending the game, a little more than half of the students in
4.2 Analysis of Post-Game Questionnaire Responses

Figure 4.7: Graph Showing the Student Responses to Question 6 of Questionnaire 2:
- Did the visuals (i.e. colour) in the game contribute to your enjoyment of the game?

Figure 4.7: Graph Showing the Student Responses to Question 6 of Questionnaire 2
- Did the visuals (i.e. colour) in the game contribute to your enjoyment of the game?
4.2 Analysis of Post-Game Questionnaire Responses

Figure 4.8: Graph Showing the Student Responses to Question 7 of Questionnaire 2
- Would you recommend the game to your friends?
the Control group (17 not at all and 24 not really) said they would not. In contrast, there was only 1 student in the Test group who said that they would not at all recommend the game.

The results from Questionnaire 2 shows that the Test group students were more likely to play the game again. The presence of the 3 features, i.e., FB, CH and GH, as the results above have indicated, makes it likely that students from the Test group would be more inclined to play the game again. Moreover, the Test group students were also most likely to recommend the game to their friends after having a favourable experience playing the game themselves. On the other hand, the absence of the features resulted in the students in the Control group not wanting to play the game again. The version of the game that the Control group played, the FDG version, was devoid of the 3 features, mainly FB, CH and GH. It was the absence of these features which resulted in them not wanting to pay the game again nor wanting to recommend this game to their friends.

Moreover, visual observations of students while playing the game showed that the Test group were more engaged and excited with the sound and the graphics compared to the control group. Their expressions and body language demonstrated that they were motivated to keep on playing, in fact they had to be stopped at the end of the session. For example, the students were heard to shout in delight when they were given feedback about their answers, smiled and talked to their friend sitting next to them and shared how they were progressing in the game. On the other hand, the students playing the FDG version looked less interested, and some of them kept asking if they could leave the game. The game did not seem to hold their attention as they were seen to be fidgeting and their attention seemed to drift from the game to observe what others in the room were doing.
Chapter 5

Conclusions and Future Work

In this thesis we identified the most appealing characteristics of computer games by using a combination of literature survey as well as from primary school children’s point of view. We did this by firstly conducting a survey among children aged 9 and 10 years old to identify three features of computer games that make them popular. This resulted in isolating graphics, feedback and challenge as the key features contributing to the success of a game. Then we added these three most appealing characteristics to an educational tool to find out if these characteristics could enhance children’ learning, i.e these features were overly emphasized in an open source computer game modified to be used for 120 primary school children in two curriculum areas, Numeracy and Te Reo. A second version with minimal features was used as a control. Finally we sought to find out if children enjoyed using the educational tool with the characteristics embedded.

The results of testing the tool showed that the features were effective in improving learning outcomes in both the curriculum areas. The dependent variables used to measure effectiveness were:

- Amount of learning - measured with the use of pre-test and post-test
- Amount of enjoyment - measured using questionnaire at the end of the study.

The T-Test results on the learning outcome scores also showed that the learning outcome was not achieved by random chance, confirming the effectiveness of the learning tool. The T-Test values for the FEG version were orders of magnitude smaller than the FDG version, although both values were less than the accepted critical value of 0.05, implying that while learning outcomes were influenced by both game versions, the FEG version was more influential.

Although there was a demonstration of the effectiveness of the learning tool in both curriculum areas, it was more pronounced in the Test group for the Te Reo learning task where the increase in score between the pre and post test was a difference of 3.7 compared to an increase of only 1.9 between the pre and post tests for the Numeracy task. It was identified that the design of the game was more suited to a fact learning task like Te Reo, rather than a cognitive task such as the Numeracy task.

The results from the post-game questionnaire showed that the FEG version played by the test group was more popular with children and they were more inclined to play this version of the game in future compared to the FDG version. Apart from this, the children playing the FEG version on average spent more time and did a higher number of attempts at the game compared to the FDG version.

An immediate future work identified from this study is to adapt the game for more cognitive based learning tasks such as Numeracy. Numeracy learning task involves more fact manipulation operations which involves various intermediate steps in order to arrive at the final answer. The support for such intermediate steps was not fully supported in the game designed for this study, hence the game was not entirely suitable for the Numeracy learning task. As a future work, a more comprehensive set of questions with intermediate questions can be developed in the game to guide the user to a final answer. A wider and more long term further research work would be to see if the effectiveness of the feature enriched educational tool is also valid in other scenarios such as for secondary school children and in other curriculum areas. It is also proposed that
a long-term (3-6 months) study be conducted on a similar group of children to see if there is significant increase in learning outcomes as opposed to a four week study.

In summary, this study strongly indicated that feedback, challenge and graphics features can be effectively used in educational tools to increase enjoyment and improve learning outcomes. The use of computers are immensely changing most aspects of our lives today, including the ways in which children learn. The results from this research showed that computer based educational tools have the potential to be successfully used in classrooms not only to make learning fun, but more importantly, to enhance learning outcomes.
Appendix A

Appendix
A.1 Participant Consent Form

**Participant Consent Form**

A research to find out whether characteristics of computer games that make them enjoyable and engaging can also be applied to the development of learning tools.

I have had the research project explained to me and I have read and understand the information sheet given to me.

I understand that I don’t have to be part of this if I don’t want to and I may withdraw at any time prior to the completion of the research project.

I understand that everything I say is confidential and none of the information I give will identify me and that the only persons who will know what I have said will be the researcher and her supervisor. I also understand that all the information that I give will be stored securely on a computer at Unitec for a period of 5 years.

I understand that I can see the finished research document.

I have had time to consider everything and I give my consent to be a part of this project.

*Participant Signature: .. Date:*

*Parent/Guardian Signature Date*

*Project Researcher: Kalpana Nand 8th May, 2012*

**UREC REGISTRATION NUMBER: (2011-1239)** This study has been approved by the UNITEC Research Ethics Committee from (9.1.12) to (9.1.13). If you have any complaints or reservations about the ethical conduct of this research, you may contact the Committee through the UREC Secretary (ph: 09 815-4321 ext 6162). Any issues you raise will be treated in confidence and investigated fully, and you will be informed of the outcome.
A research to find out whether characteristics of computer games that make them enjoyable and engaging can also be applied to the development of learning tools.

My name is Kalpana Nand and I am a MComp student at Unitec. I am currently involved in a research towards my MComp degree. The research topic aims to find out whether characteristics of computer games that make them effective can also be applied to the development of educational tools. I am doing the research at Glen Eden School and have the approval of the school to carry out the research.

What I am doing
I want to find out whether characteristics of computer games that make them enjoyable and engaging can also be applied to the development of educational tools. By taking part in this research project you will be helping me to investigate this research question.

What it will mean for you

- You will take part in answering 2 sets of questionnaires and doing a pre and post-test.
- Two groups will be using a learning tool designed by me at school.

I will be setting up the research task in the school with a group of children. All features that could identify you will be removed and your names will not be used in any material.

If you agree to participate, you and your parent/guardian will be asked to sign a consent form. This does not stop you from changing your mind if you wish to withdraw from the project at any stage. Your parent/guardian can also ask for you to be withdrawn from the study at any stage if they wish to.
Your name and information that may identify you will be kept completely confidential. All information collected from you will be stored on a password protected file and only you, me and my supervisor will have access to this information.

Please contact us if you need more information about the project. At any time if you have any concerns about the research project you can contact my supervisor:

Nilufar Baghaei, PhD Lecturer, Dept. of Computing
Unitec Institute of Technology
Auckland 1142, New Zealand
Tel: +64 9 8154321 ext 6038
Email: nbaghaei@unitec.ac.nz

UREC REGISTRATION NUMBER: (2011-1239)) This study has been approved by the UNITEC Research Ethics Committee from (9.1.12) to (9.1.13). If you have any complaints or reservations about the ethical conduct of this research, you may contact the Committee through the UREC Secretary (ph: 09 815-4321 ext 6162). Any issues you raise will be treated in confidence and investigated fully, and you will be informed of the outcome.
A.2 Questionnaire One

Student Questionnaire 1

Name: Age:

Please complete the questions as honestly as you can.

1. What is currently your most favorite computer game?

2. What particular features in this computer game makes it your favourite game?
   - □ Knowing what to do to win
   - □ Challenges in the game
   - □ Story line
   - □ Knowing how many points you have scored
   - □ Good sound effects
   - □ Realistic graphics

3. Which computer games do you like playing at school?

4. What is your favourite computer game at school?
5. Why do you like playing this game at school?

6. If you had a chance to develop a learning game, what kind of game would you develop?

Thank you for your time.
Pre/Post-test: Numeracy

Name: Age:

**Learning task:** To learn addition facts

For the following problems, choose the correct answer by circling one of the letters below.

1. Jesse had 5 pieces of oranges in his lunch box. Then his friend Peter gave him 4 more pieces of oranges. How many pieces of oranges did Jesse have altogether?
   - (a) 9
   - (b) 10
   - (c) 11
   - (d) 8

2. Max bought 8 bananas from the local vegetable shop on Monday. The next day he bought 6 more bananas. How many bananas did Max have altogether?
   - (a) 10
   - (b) 13
   - (c) 14
   - (d) 2

3. Hannah lived on a farm with many animals. Her job was to collect eggs laid by the hens on the farm. On Saturday morning she collected 9 eggs. In the evening she collected 11 more eggs. How many eggs had she collected by the end of the day?
4. T.K. and Josh decided to go to the park. At the park they saw a lot of ducks by the pond. Josh counted 10 ducks with grey feathers and T.K. counted 8 ducks with green feathers. How many ducks did they count altogether?

(a) 4
(b) 2
(c) 18
(d) 14

5. Sina had 3 apricots in her bag. Christian had 5 apricots in his bag. Their friend Anna had 2 apricots in her bag. How many apricots did Sina, Christian and Anna have altogether?

(a) 11
(b) 10
(c) 16
(d) 24

6. When Sarah when shopping, she decided to buy fruits and lollies. She spent $13 on fruit and $10 on lollies and sweets. How much did she spend altogether on her shopping?

(a) $32
(b) $3
(c) $23
7. There were 26 monkeys in an enclosure at Auckland Zoo. There were more monkeys hiding inside the cages. Altogether there were 85 monkeys at the zoo. How many monkeys were hiding inside the cages?

(a) 49  
(b) 59  
(c) 95  
(d) 58

8. The Auckland Car Museum had 63 classic cars in their warehouse. They were given some more classic cars as a gift by the Wellington Car Museum. Now they had 103 classic cars altogether. How many cars were they given by the Wellington Car Museum?

(a) 41  
(b) 20  
(c) 169  
(d) 40

9. The tigers at Hamilton Zoo get meat for dinner. Their keeper fed the female tigers 75 kilos of meat. Altogether he fed all the tigers 170 kilos of meat. How much meat did the keeper feed the male tigers?

(a) 95  
(b) 59  
(c) 245  
(d) 196
10. Aroha ran cooking classes at a local school in the evenings. She charged each customer $36 for ingredients, $24 for using pots and pans and $20 for her lessons. How much did she charge each customer altogether?

(a) $85  
(b) $60  
(c) $80  
(d) $71

11. Sammy’s family drove 56 km to the service station. After filling the car with petrol, they drove another 30 km to their aunt’s house. How far did they drive altogether? A: 96 km

(a) 80 km  
(b) 86 km  
(c) 26 km

12. Tane went to the shop. He bought a radio for $150. He also bought 5 cd’s for $70. How much money did he spend at the shop?

(a) $200  
(b) $220  
(c) $30  
(d) $210

13. Two years ago, Abby weighed 52 kg. She now weighs 20 kg more. How much does she weigh now?

(a) 72 kg  
(b) 67 kg  
(c) 70 kg
14. Monica had 30 ducks. Each duck had 3 ducklings. How many ducklings were there altogether?

(a) 60
(b) 33
(c) 93
(d) 90

15. Jodie put 15 songs in each playlist on her MP3 player. How many songs would be in 5 playlists?

(a) 45
(b) 75
(c) 57
(d) 73

16. Moana was making necklaces for her 5 cousins. On each necklace, she had 18 beads. How many beads does she need in total for the 5 necklaces?

(a) 100
(b) 25
(c) 95
(d) 90

17. “Cuddly Pets Hotel” looks after cats and dogs for people when they are on holidays. The cat cages are in 17 rows of 7 cages in each row. How many cat cages are there?

(a) 191
18. Freddy keeps his cd collection in a cabinet. The cabinet has 16 rows with 8 cd on each row. How many cd’s does Freddy have in his cabinet?

(a) 182  
(b) 130  
(c) 112  
(d) 128

19. Tracy works part time at a supermarket. She gets $14 an hour. Last week she worked for 7 hours. How much did she earn?

(a) $98  
(b) $89  
(c) $108  
(d) $96

20. The “Fearsome” ride at a fun park has 20 carriages. Each carriage carries 7 people. How many people can go on each time?

(a) 141  
(b) 140  
(c) 104  
(d) 100
A.4 Pre/Post-Test Learning Outcome Questionnaire - Te Reo

Pre/Post-test: Te Reo

Name: Age:

Learning task: To recognize the Re Reo equivalent of English words.

For the following problems, choose the correct answer by circling one of the letters below.

1. Tane lived on a farm. One day picked 5 apples from the apple tree. What is the te reo word for 5?
   (a) lima
   (b) rima
   (c) tahi
   (d) ono

2. The All Blacks team is New Zealand’s National rugby team. They wear black jerseys and black shorts. What colour is this in te reo?
   (a) pango
   (b) ma
   (c) whero
   (d) mango

3. Farmer Jim had cows and horses on his farm. There were 7 horses in a paddock. What is the te reo word for 7?
   (a) tekau
4. Lester decided to do some renovations in the holidays. He painted his house green. What colour is this in te reo?

(a) kowhai  
(b) kahurangi  
(c) karaka  
(d) kakariki

5. Ana loves playing netball. She has netball practice every Monday afternoon. What is the te reo word for Monday?

(a) ramere  
(b) rahina  
(c) ratapu  
(d) rohoroi

6. Mrs Smith had just finished her washing. There were 10 t-shirts hanging on the clothes line. How do we say 10 in te reo?

(a) tahi  
(b) toru  
(c) tekau  
(d) wha

7. Jenny misplaced her pencil. The teacher asked Jenny to buy a new pencil. What is the te reo word for pencil?
A.4 Pre/Post-Test Learning Outcome Questionnaire - Te Reo

(a) pene rakau
(b) pene
(c) pene tae
(d) pikitia

8. Mana lives on an Island. There is a big mountain behind Mana’s house. What is the te reo word for mountain?

(a) rangi
(b) moana
(c) motu
(d) maunga

9. Sear was really excited about her birthday. She received a dog for her birthday from her parents. What is the te reo word for dog?

(a) koura
(b) kuri
(c) kahu
(d) kau

10. Nancy’s teacher asked Nancy to put her book on the table. What is the te reo word for table?

(a) tepu
(b) turu
(c) rakau
(d) rorohiko

11. Colin played rugby for his school team. One Saturday, while he was playing rugby, he bruised his left knee. What is the te reo word for knee?
12. Bart woke up late. He was running late for school. Bart quickly glanced at the clock and saw that he could just make it on time for the bus. What is the te reo word for clock?

(a) peke
(b) ini
(c) karaka
(d) kuaha

13. In the fairy tale, Goldilocks and the Three bears, Goldilocks liked sitting on baby bear’s chair the most. What is the te reo word for chair?

(a) turu
(b) pene
(c) tepu
(d) pukapuka

14. Sandy asked her mum to take her to the bookshop to buy her the latest copy in the Harry Porter series. What is the te reo word for book?

(a) re irirangi
(b) pukapuka
(c) pene rakau
(d) rakau
15. After playing a game, the teacher told her class to sit down on the mat. What is te reo for “sit down”?
   (a) e tu
   (b) e noho
   (c) kia kaha
   (d) titiro

16. Stevlyn’s mum read him a story every night and then she tucked him in. She said good night to him before turning the lights off. What is te reo for “good night”?
   (a) po marie
   (b) haere mai
   (c) kia ora
   (d) tena koe

17. Mere’s aunt came for a visit to her home. After spending a few days with her family, her aunt decided to go back. As her aunt was leaving, Mere shouted out “see you again” in a loud voice. What is te reo for “see you again”?
   (a) nau mai
   (b) e noho ra
   (c) kua haera au
   (d) ka kite ano

18. The Principal greeted the school assembly by saying hello. What is the most appropriate te reo word to use when saying hello to a group of people?
   (a) tena koe
   (b) tena koutou
   (c) haere mai
19. Peni’s teacher was very impressed with his story writing. She put a sticker which said “great” on his book. What is the te reo word for great?

(a) tumeke
(b) kia kaha
(c) ka pai
(d) ka rawe

20. The Captain of the soccer team told his players to be strong as they came face to face with their opponents. What is te reo for “be strong”?

(a) tai ho
(b) e moe
(c) kia ora
(d) kia kaha
A.5 Questionnaire Two

Student Questionnaire 2

Name: Age:

Please complete the questions as honestly as you can. Tick the box which best suits your answer.

1. Did you enjoy playing this game?
   □ Yes, definitely
   □ Yes, maybe/a bit
   □ Not sure
   □ No, not really
   □ no, not at all

2. Are you likely to play this game again?
   □ Yes, definitely
   □ Yes, maybe/a bit
   □ Not sure
   □ No, not really
   □ no, not at all

3. Did the sound effects in the game contribute to your enjoyment of the game?
   □ Yes, definitely
   □ Yes, maybe/a bit
   □ Not sure
   □ No, not really
   □ no, not at all
4. Did the feedback in the game contribute to your enjoyment of the game?
   □ Yes, definitely
   □ Yes, maybe/a bit
   □ Not sure
   □ No, not really
   □ no, not at all

5. Did the level of challenge in the game contribute to your enjoyment of the game?
   □ Yes, definitely
   □ Yes, maybe/a bit
   □ Not sure
   □ No, not really
   □ no, not at all

6. Did the visuals (i.e. colour) in the game contribute to your enjoyment of the game?
   □ Yes, definitely
   □ Yes, maybe/a bit
   □ Not sure
   □ No, not really
   □ no, not at all

7. Would you recommend the game to your friends?
   □ Yes, definitely
   □ Yes, maybe/a bit
   □ Not sure
   □ No, not really
☐ no, not at all
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